DYNAMICS IN ARTISANAL GOLD MINING AND ITS IMPACTS ON COMMUNITY LIVELIHOODS AND THE ENVIRONMENT: A CASE OF NANDI AND WEST POKOT COUNTIES, KENYA

Eliud Kibet Yego

A Thesis Report Presented to the Institute of Postgraduate Studies of Kabarak University in Partial Fulfilment of the Requirements for the Award of the Doctor of Philosophy Degree in Environmental Science.

KABARAK UNIVERSITY

NOVEMBER, 2017

DECLARATION

The research thesis is my own work and to the best of my knowledge it has not been presented for the award of a degree in any university or college.

Signed: ________________________ Date:________________________

Eliud Kibet Yego

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RECOMMENDATION

To the Institute of Postgraduate Studies:

The research thesis entitled **“Dynamics in Artisanal Gold Mining and its Impacts on Community Livelihoods and the Environment: A Case of Nandi and West Pokot Counties, Kenya’’** and written by **Eliud Kibet Yego** is presented to the Institute of Postgraduate Studies of Kabarak University. We have reviewed the research Thesis and recommend it be accepted in partial fulfilment of the requirement for award of the degree of Doctor of Philosophy in Environmental Science.

Signed:____________________________ Date:____________________

Dr. Sellah Kebenei

Senior Lecturer, Department of Environmental and life Sciences,

School of Science, Engineering and Technology

Kabarak University

Signed:____________________________ Date:____________________

Dr. Grace Cheserek,

Senior Lecturer, Department of Applied Environmental Science,

School of Environmental Studies

University of Eldoret.

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ACKNOWLEDGEMENT

I am grateful to my supervisors, Dr. Sellah Kebenei and Dr. Grace Cheserek for their guidance throughout the study period. Their dedication to research is unequivocal and I greatly appreciate the time, the advice and the feedback, both on content and on process. I have gained and benefited greatly though their experience and expertise. Thank you. I would also like to thank all the respondents, key informants and research enumerators for their significant contribution towards the study. I am greatly indebted to my family for the financial support during data collection, data analysis and writing of the thesis. Finally, I am grateful to Kabarak University for giving me a chance to enroll in the programme and undertake this study.

DEDICATION

This work is dedicated to my late parents George Yego and Lilian Yego for the untiring support in my academic life, my wife, Dr. Anne Yego and sons; Gideon and Kelvin for their encouragement, motivation and prayers.

ABSTRACT

Many studies on Artisanal Gold Mining have estimated that it employs an estimated 13 Million people worldwide, with another 80 to 100 million people directly or indirectly benefiting. In sub Saharan Africa it is viewed as an economic mainstay activity providing direct employment to over two million people. Artisanal gold mining uses rudimentary processes to extract valuable minerals from primary and secondary ore bodies, and is characterized by the lack of long-term mine planning. In Kenya, less is known about how different artisanal gold mining communities operate and it is organised. The artisanal gold mining has negative environmental effects and limited positive transformation on the livelihoods of the local communities involved in Nandi and West Pokot counties. The objectives of the study were to determine the impacts of capital assets accessibility in artisanal gold mining on community livelihoods and their environment, evaluate the impacts of artisanal gold mining organizational dynamics on community livelihoods, examine the impacts of artisanal gold mining value chain on the community livelihoods and determine the concentration levels of selected heavy metals at the mining sites. Social capital theory and sustainable livelihoods framework were utilized in conceptualizing the study. The study employed a descriptive and experimental research design. Simple random sampling was used to select the respondents for interview. Primary data was obtained by using questionnaires, interview schedules, focus group discussions guide, key informants guide, observations, and photography with the laboratory tests for heavy metals being done using Atomic Absorption spectroscopy. Questionnaires were pretested before the actual field survey and the Information gathered during this pre-trial were used to modify the survey tools. Factor analysis upheld the construct validity of the instrument. Study variables had a Cronbach's alpha coefficient of 0.60 thus the instruments were considered acceptable for explanatory purposes. Descriptive statistics and inferential statistics were used in the analysis of data and the results were presented by use of frequency tables, pie charts and graphs. The findings showed that respondents had low access level to capital assets and the ASM gold value chain is informally structured leading to low earnings and negative environmental impacts. Artisanal gold mining activities were disorderly in nature thereby preventing improved livelihoods and environmental conservation. The concentration levels of the selected heavy metals were: Cr, 0.4195 ppm, Zn, 0.5511 ppm, Cd, 0.2470 ppm, Fe, 3.4950 ppm and Pb, 0.6300 ppm in Nandi county and Cr, 0.1790 ppm; Zn 0.8470 ppm; Cd, 0.0050 ppm; Fe, 2.795 ppm; and Pb, 0.7400 ppm in West Pokot County. In conclusion respondents had low access levels to financial support, technology and unclear market channels. Therefore, study recommends improved access to capital assets for production, organized artisanal sector and a clear structured value chain.

Keywords: Artisanal Gold Mining, Capital assets, Organizational dynamics and Value

chain

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LIST OF SYMBOLS

As: Arsenic

Au: Gold

Bi: Bismuth

CH_3Hg: MethylMercury

Cd: Cadmium

Cu: Copper

Cr: Chromium

Fe: Iron

Hg: Mercury

P^H: Potential of Hydrogen

Pb: Lead

Zn: Zinc

ABBREVIATIONS AND ACRONYMS

AAS:	Atomic absorption spectroscopy
ASM:	Artisanal mining
BIOX:	Biological Oxidation
DHHS:	Department of Health and Human Services
EIA:	Environmental Impact Assessment
EIR:	Extractive Industries Review
EPA:	Environmental Protection Agency
IIED:	International Institute for Environment and Development
GDP:	Gross Domestic Product
GPS:	Global positioning system
IARC:	International Agency for Research on Cancer
ILO:	International Labour Organization
ISSER:	Institute of Statistical, Social and Economic Research
LULC:	Land use and land cover
NEMA:	National environment management authority
NGO:	Non-Governmental Organization
UN:	United Nations
UNEP:	United Nations environment programme
UNIDO:	United Nations Industrial Development Organisation
WHO:	World Health Organisation
AUC:	African Union Commission

OPERATIONAL DEFINITION OF TERMS

Dynamics: Refers to unique, changing operations and organization of activities carried out in mineral extraction processes by different communities.

Artisanal Mining: Refers to the informal sector in gold extraction and separating Desired mineral from the valueless earth materials **.**

Mining sites: Refers in this study as places where extraction and separation of the desired mineral takes place.

Livelihood: Refers to a person's means of making a living, their incomes and their tangible assets (Chambers and Conway 1992 and Siegel and Veiga 2010).

Formalization: Refers to the integration of artisanal mining activities into Kenya's legal, economic, and institutional framework.

Capital assets: Refers to Ingredients to Livelihood production which included; physical, technological, human, financial and social capital.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter contains the background of the study, Statement of the problem, Purpose of the study, Objectives, Research/Hypothesis, and Justification/Significance, scope, limitations and Assumptions of the study.

1.2 Background to the Study

Mining is a fundamental human development activity which creates wealth (Acheampong, 2004).In the year 2001, the mining industry produced over 6 billion tons of raw product valued at several trillion dollars. The USA, Canada, Australia, South Africa and Chile dominate the global mining scene in terms of mining exploration methods and technology 2004).Mining involves removal of ores from the earth's crust and selecting precious materials. It involves a number activities with potential impacts on the environment, society, health and safety of mine workers depending on the proximity to mining operations.

Artisanal gold mining is defined as the use of rudimentary processes to extract valuable minerals from primary and secondary ore bodies, and is characterized by the lack of long-term mine planning. It can be illegal or legal, formal or informal, encompassing individual gold panners to medium-scale operations employing thousands of people (Shen & Gunson, 2006). It is seen an economic mainstay activity providing direct employment to over two million people in rural sub Saharan Africa (Hilson, 2009).

In Zimbabwe, the definition of artisanal gold mining covers both legal and illegal operators, mechanized and semi-mechanized miners of varying sizes in terms of output, employment and capitalization, which are classified into four categorize: mines operated by experienced individuals, those operated by unsophisticated groups, registered gold panners, and cooperative miners (Maponga & Ngorima, 2003).Artisanal gold mining covers a broad spectrum of activities which are principally characterized by exploitation of marginal or small gold deposits, lack of capital, labour intensive and poor access to markets and support services (IIED, 2002). Operations and organization of activities in artisanal mining adversely affect its productive capacity, capability and compliance with mining, safety and environmental regulations, causing threats to both mining communities and their environment.

In Ghana, unlicensed ASM miners are referred to as galamsey, a term that originated from the phrase 'gather and sell'. There are few differences organizationally or technologically between unregistered illegal and registered small-scale miners, with the exception that the latter have security of tenure, or legal entitlement to work a plot of land (Carson*et al.*, 2005). These illegal small-scale mining is certainly not only restricted to Ghana, because an ILO report in 1999 indicate that up to 80% of small-scale miners worldwide operate without formal authorization (Tschakert & Singha, 2007).

Artisanal gold mining ranges from formal, responsible artisanal gold mining communities which are pillars of the local economy to chaotic and uncontrollable mining sites where negative impacts are experienced. Due to this reason, Fold, Jønsson & Yankson (2014), considers that ASGM should be freed from the tentacles of the state and should be directed towards development and consolidation of the ASGM value chain through the formalization of actors in the production segment. On the other hand,Weber-Fahret., (2002) categorized and distinguished artisanal mining into: permanent artisanal mining which is a full time, year round economic activity; seasonal artisanal mining composed of alternate switching of economic activities or seasonal migration of people; gold rush-type artisanal mining where massive migration is based on the perception that the expected income opportunity from recently discovered deposit far exceeds the current actual income of the people who are lured into it; and shock-push artisanal mining, a poverty driven activity, emerging after loss of employment in other sectors, conflicts or natural disasters.

According to 1999 ILO report, the artisanal gold mining sector employs an estimated 13 Million people, with 80 to 100 million people worldwide being directly or indirectly engaged as a source of livelihood (Tschakert & Singha, 2007.Artisanal gold mining has not been successful in achieving socio-economic development and environmental conservation through the exploitation of non-renewable resource. UNIDO estimates that there are over a million people directly involved in artisanal and small-scale gold mining operations in Latin America, with the number rising to over six million artisanal miners world-wide, if Africa and Asia are incorporated (UNIDO, 2001). For instance, Miserendino et al., (2013) reports that there are approximately 6,000 gold miners using mercury and cyanide in gold extraction process in Portovelo-Zaruma regions, Ecuador.

A World bank report of 2008 on Democratic Republic of Congo estimated that between 500,000 to 2 million Congolese are directly involved in the artisanal extraction of minerals making up the largest segment of the country's mining sector and accounting for approximately 90% of the total mineral production in the country (Bashwira *et al.,*2014). In Senegal, eight primary hard rock sites account for more than half of the total estimated ASGM population of 67,000 individuals (Persaud *et al.,* 2017) while in Mozambique, Drace *et al.,* (2012) estimated 60,000 ASGM miners. Most of the ASGM activities in Mozambique are largely unregulated due to the remoteness and inaccessibility of the gold deposits.

Geenen (2012) noted that ASM contributes to about 90% of mineral production and informal exports in Eastern Democratic Republic of Congo, while in Central Mozambique, 20,000 people are involved in ASM producing 480 to 600 Kg of gold annually of which 85 to 90% of this production remains in informal economy. This indicates that almost all of the minerals being mined can be categorized as ASM, however, all these ASM activities provide direct employment to the local while generating a substantial number of indirect jobs in other sectors in the economy (Amankwah & Anim-Sackey, 2003), however, the artisanal miners are often marginalized or operate on the peripheries of the society (Teschner, 2013).

The artisanal gold mining in Agusan River Basins, Philippines produces significant gold amounts globally (Appleton *et al.,* 1999) while in Tanzania, the mining sector contributes about 2.3% of the GDP in year 2000 (Kitula, 2006).In Ghana, the ASM has expanded dramatically thereby making, Ghana the second largest gold producer in Africa after South Africa with exports accounting for over 40% of the total export earnings. The gold from ASM activities has risen tenfold over the last decade accounting for estimated contribution of USD 461.1 million to the national economy with about 300,000 to 500,000 individuals being involved in it (Tschakert & Singha, 2007).Artisanal mining sustains the livelihood of at least two million people in Zimbabwe, directly and indirectly through ancillary services and secondary economic activities (Maponga & Ngorima, 2003).

Global workforce of artisanal miners is 30 percent composed of women, with the highest percentage (40 to 100 percent) found in Africa. Socio-cultural inequities play a role in hindering access to information for women participation. As early as 2001, both the legalized and illegal ASM sector in Ghana comprised of 15% and 50% women respectively, while in Guinea, 74% are female and in Madagascar, Mali and Zimbabwe, women comprise 50% of the ASM workforce. The share of women employed in the sector in Asia amounted to 10% while it ranges between 10% to 20% in Latin America. This indicates that African women are engage more in the ASM sector than their global counterparts principally due to their comparatively higher unemployment rates (Yakovleva, 2007). This gender-differentiated participation brings added challenges and considerations to addressing needs within the ASM sector, as well as unique opportunities to improve the quality of artisanal miner’s livelihoods.

Teschner (2013) reported that the motivation and reasoning of ASM miners in Ghana is unclear and thus the ASGM activity can be explained by two perspectives: either, an activity that is driven by greedy criminals in get-rich quick schemes or a deeply rooted activity driven by poverty. Other views assert that the ASGM sector in Sub-Saharan Africa is largely poverty - driven activity that is intrinsically self-perpetuated (Childs, 2008) and extrinsically by mining sector reforms advanced by the World Bank. United Nations Industrial Development Organisation (UNIDO) considers joblessness and landlessness to have forced people into small-scale gold mining (UNIDO, 2001) while Miserendino *et al.* (2013) assert that ASGM operations results from the entrepreneurial efforts but driven by immediate profits. Other drivers include, the economic reforms such as structural adjustment programme which are linked to increase in unemployment, concurrent privatization of state-owned enterprises leads to few employment prospects (Banchirigah, 2008).Inflationary pressure and modified trading and farming patterns have combined to drive millions of people of varying skills and background to take up employment in the ASM sector (Yakovleva, 2007).

ASGM is the main source of subsistence for millions of people living in developing countries and perhaps is the only livelihood alternative for those communities (Saldarriaga-Isaza, Villegas-Palacio & Arango, 2013). Thus, UNECA & AUC (2011) argues that ASGM makes a positive contribution to African economies and more particularly to sustaining rural livelihoods, yet it faces a myriad of challenges that prevent it from attaining its full potential as a vehicle for socio-economic development. The benefits of the increased mining sector investments in Ghana's economic reforms:

foreign exchange earner, government revenues, generates direct and indirect employment, provides capital and social infrastructure to the communities while contributing to community development in mining areas and social security (Akabzaa & Darimani, 2001).

Artisanal mining communities are forever connected to their innate operational activities such that any interventional activities such as formalization, alternative livelihood projects and military intervention advanced by the government to tackle its illegality have failed to meets the objective (Banchirigah, 2008). Informality in the artisanal gold mining sector is the core of the problems faced by the artisanal miners. Widespread illegality in artisanal mining activities in Ghana and elsewhere in the world is being associated with risks, posing substantive challenges to new policy initiatives that aim to alleviate poverty (Childs, 2008). Kambani (2001) recorded that from a structural and technical perspective, ASGM is conducted on a very rudimentary level using basic tools such as picks, shovels, hoes, picks and wheelbarrows. Accessibility to capital assets, value chain and organization which are dynamic in artisanal gold mining contribute to the poor performance in terms of environmental conservation and the livelihoods of the communities engaged within the sector. In South America, Miserendino *et al.* (2013) noted that due to the complexity of ASGM sector in Ecuador, there are significant numerous challenges of measuring, monitoring and addressing ASGM impacts.

According to Labonne (2003), ASGM is typically practiced in the poorest and most remote rural areas by a largely illiterate, poorly educated populace. The sector is highly labour intensive providing employment and incomes to large numbers of people who are generally uneducated, whose understanding of the importance of environment management is below par, poor and live in remote areas where no opportunities exist for formal employment (Shoko, 2003). In most African countries like Ghana, Madagascar and Zimbabwe, small-scale gold mining has become important due to escalating poverty and lack of employment opportunities in the formal sector (Logan & price, 2004). In many ways, small-scale mining has become an integral part of the rural economy and lubricates regional economic development through employment and income multipliers (Maponga & Ngorima, 2003).

Artisanal gold mining is becoming increasingly popular with the African youth because of the diminishing employment prospects, a fact that is attributable to its structural dynamism, low entry barriers and its ability to finance new start-ups (Hilson & Osei, 2014). Increase in local unemployment and underemployment combined with a lack of a workable or enforceable legal framework, ineffective national policing, and a weak decentralized institutional capacity to implement policy and regulate the ASM sector have further exacerbated the problem of artisanal gold mining (D'Souza, 2005). For instance, Ghana was ranked second in Africa and ninth largest producer of gold in the world with 3.8% global production with ASM contributing a significant amount. On the same lengths, ASM is perceived negatively yet it is contributing much more in terms of public revenue, employment and localized development (Bloch & Owusu, 2012).

A study by Childs (2008) reported that in Sub-Saharan Africa, artisanal gold mining activities cause a range of environmental, social and economic problems which include chronic soil degradation, chemical contamination, and air pollution. This is as a result of low level of mechanization and use of mercury in amalgamation process. Ghose (2003) points out that these operations feature poor environmental management practices and safety conditions. Another study by Kitula (2006) showed that environmental deterioration occurs through inappropriate and wasteful working practise such as tailings disposal and lack of rehabilitation measures. The study further recorded that mining extraction activity in Geita District, Tanzania cause regional land degradation destroying agricultural and grazing land.

The activities surrounding the artisanal mining operations are dangerous, exploitative and non-transformative to the livelihoods. Artisanal gold mining is often seen to perpetuate poverty through high sensitivity to physical hazards, illness, and accidents, and lack of knowledge about more efficient, safer, and environmentally friendly techniques (Tschakert & Singha, 2007).Empirical evidence show that the increasing socio-economic and environmental impacts serve as impediments to the regulation and formalization in Sub-Sahara Africa (Nyame & Blocher, 2010).

The nature and extent of the environmental effects from both formal and informal ASM sectors depends on several factors which include the locality, the mining and processing methods used, and the nature of material mined and processed (whether ore or reef), the concentration of panners /miners (Maponga & Ngorima, 2003).Land degradation caused by the gold mining activities include chemical contamination from the gold extraction process which impose double burden on the environment creating harmful health effects for the mining communities. Environmental effects are categorized into two broad categories: physical effects (vegetation destruction, wastage of resources, and river siltation) and chemical effects (mainly pollution from mercury). The failure of sector governance by the government authorities coupled with sectoral formalization exacerbates environmental degradation, health problems and resource conflicts (Childs, 2008). Fundamental to the legal framework is the basic condition that artisanal miners are given formal property rights (Geenen, 2012).

Mercury use in ASGM is entwined with multiple environmental, socio-economic and health related challenges in the ASM communities (Tschakert & Singha, 2007) and its costs are often externalized on local communities hosting the mining operations (Kumah, 2006). The environmental and human exposure to elemental mercury occurs through burning and amalgamation process which are said to be the largest source (Drace *et al.*, 2012).The basic driving force for the use and misuse of mercury in ASGM includes poverty, lack access to alternative technologies and lack of education of proper use and long-term health consequences of exposure to mercury(Veiga & Metcalf*et al.*,2006; Balistreri & Worley, 2009). Poverty is also a limitation why persons don’t use protective gear; they cannot afford them and those that can, accessibility seems to be the problem, hence miners have to travel long distances to acquire basic protective gears at high transportation costs(ERD,2010).

According to Siegel & Veiga (2010), artisanal and small-scale miners lack the most basic social and economic infrastructure needed to break out of extreme poverty hence making them unable to successfully educate their children, build upon their productive assets, and move ahead economically (Carter *et al.,* 2007). McSweeney (2004) noted that local livelihoods are embedded within markets and social relationships that extend well beyond the narrow community borders. Capital assets access is integral components to livelihood systems that intersect to provide opportunities for communities. Inappropriate technologies, poor information, low levels of environmental awareness and a low asset base perpetuate this poverty trap in artisanal mining (Buxton, 2013).

1.3 Statement of the Problem

The unique nature of ASGM operations and organization tend to constantly vary over time and as such it is difficult to understand. These dynamic nature of artisanal gold mining hinder mining communities from maximum utilization of the natural resource and sustainable management of the environment. D'Souza (2005)added that the artisanal gold mining activities have negative environmental effects and limited positive transformation on the livelihoods of the local communities. Although the ASM sector has received extensive coverage in studies, its organizational dynamics and labour issues continues to be poorly understood (Yakovleva, 2007), with several academic studies and research projects show conflicting messages about what ASM is or should be, which are sometimes potentially damaging.

Artisanal miners use environmental unfriendly extraction and processing technologies affecting it negatively while limiting their earnings. The artisanal gold mining process degrades the environment without uplifting the social and economic status of those involved. The accumulated negative impacts of numerous artisanal mining operations and activities create problems for ecosystems and local communities. It was noted by Maponga & Ngorima (2003) that ASM communities face a host of technical, financial and socio-economic problems which adversely affect its productive capacity, capability and compliance with mining, safety and environmental regulations. On the converse, environmental impacts of the ASM operations are determined by the economic, technical, legal and operational aspects which vary according to the methods and scale of operation (Aryee, Ntibery & Atorkui, 2003). In Kenya, less is known about how the different artisanal gold mining communities operate while there is no documentation on the dynamics and challenges on ASGM. Despite prevalence of ASGM activities in Nandi and West Pokot counties, there have been no studies done on the impacts of ASGM on community livelihoods and the environment.

1.4 Purpose of the study

To establish the dynamics in artisanal gold mining and its impacts on community livelihoods and their environment in Nandi and West Pokot counties

1.5 Objectives of the study

1. To determine the impacts of capital assets accessibility in artisanal gold mining on community livelihoods and their environment in Nandi and West Pokot counties

2. To evaluate the impacts of artisanal gold mining organizational dynamics on community livelihoods in Nandi and West Pokot counties
3. To examine the impacts of artisanal gold mining value chain on community livelihoods in Nandi and West Pokot counties
4. To determine the concentration levels of selected heavy metals at the mining sites in Nandi and West Pokot counties

1.6 Hypothesis

H_{01}:Accessibility to capital assets in artisanal gold mining has no significant impacts on community livelihoods

H_{02}:artisanal gold mining organizational dynamics have no significant impacts on community livelihoods

H_{03}: The artisanal gold mining Value chain has no significant impacts on community livelihoods.

Research question

1. What are the concentration levels of selected heavy metals in the mining sites?

1.7 Justification for the Study

Artisanal gold mining activities are carried out by communities within the areas endowed with mineral resources. They engage in mineral extraction processes to gain economic benefits and make a livelihood out of it while ignoring the environmental issues associated with mining activities. It is important to understand the dynamics in artisanal gold mining in Nandi and west Pokot counties and how it impacts on the environment and community livelihoods.

No studies on the impacts of artisanal gold mining dynamics on community livelihoods and the environment in western Kenya. Dynamics in artisanal gold mining and the extents to which it impacts the environment and community livelihoods needed to be determined. This research helps in ensuring that interventions and strategies are done in ways that have positive impact on both the environment and community livelihoods. An information database on the dynamics in artisanal mining that has been created by the study is necessary in explaining the prevailing situation in terms of community livelihoods and environment. Against this background, a detailed scientific research work was carried out in Nandi and west Pokot counties gold mines sites. Strategies and policies geared towards artisanal gold mining should consider the dynamics within the sector otherwise it will continue to impact the environment negatively and impoverish mining communities. Understanding Artisanal gold mining dynamics is crucial so that intervention stake into consideration each community' particular challenges and unique incentives. The research came up with improved knowledge to address the challenges in artisanal gold mining sector through policy innovation.

Both National and county governments need to take appropriate action to address the identified challenges and dynamics in order for artisanal gold mining to make positive contributions to mining communities and the environment. Artisanal gold Mining can be undertaken in a way whereby contributions to community livelihoods are maximized and environment degradation is reduced. There was a pressing need to better understand artisanal gold mining dynamics with its structural challenges and come up with mitigation measures.

The research intended to document the underlying operations and organizational dynamics that are hindering the ability of artisanal gold miners to improve their processes and practices and better their livelihoods. This research work is to recommend policy to improve the already instituted mining policies to address challenges and dynamics that were identified. This will reduce the rate of negative environmental impacts in artisanal gold mining activities while improving the community's livelihood. Assessment on the dynamics in gold panning is critical to decision-making, planning and implementation of artisanal mining activities.

This research is important to the local community, government, policy makers and environmental managers in that it provides a step towards good artisanal gold mining management practices that are crucial in sustainable natural resources management and promoting community livelihoods. The study yielded information important for determining the most sustainable way in which the gold deposits can be exploited. It provides useful information needed for the development of a sustainable planning and management strategy for exploitation of gold by the communities. Findings and recommendations will serve as guide to other artisanal gold mining in the country with characteristics similar to the study area.

1.8 Scope of the study

The study pointed out the unique changing operations and organizations of activities in artisanal gold mining sector in Nandi and west Pokot Counties which hinders it from achieving sustainable development. It critically analysed their impacts on community livelihoods and the environment. The study also did evaluate regulatory and policy framework in artisanal mining, while exploring existing knowledge including experiences on artisanal gold mining.

1.9 Limitations of the study

The study was constrained by the limited related studies conducted in Kenya. The research overcomes the limitation by using other studies on artisanal miming in other African countries. Although the study focuses on artisanal mining in Nandi and West Pokot counties, it is believed that the recommendations emanating out of this study would generally be applicable and useful for the rest of the country.

Respondents were reluctant to give required information due to fear of being victimized in engaging in artisanal gold mining without having mining licences and permits. To overcome this inhibition the researcher and the data enumerators carried with them research permit acquired from NACOSTICS so as to assure the target population of confidentiality and that the data was to be used for academic purpose.

1.10 Assumptions of the study

The study was based on the following assumptions:-

i) Communities in mining areas do not have access to capital assets

ii) The study focused on the dynamics and assumed that any other factors have no impacts on environment and community livelihoods.

iii) There was monopoly of middle men in Artisanal gold mining value chain.

iv) The mining activities and chemicals use in mining processes enhances high concentration of heavy metals in the mining sites.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The Current study aimed to establish dynamics in Artisanal gold mining and its impacts on community livelihoods and their environment in Nandi and West Pokot Counties, Kenya. In this chapter review of literature in Artisanal gold mining on global, Regional National and its impacts on community livelihoods and the environment. Also reviewed were related literature on Artisanal Gold Mining and Economic Development**,** Processes and Methods of Mining, Impacts of Mining on livelihoods and the Environment, effects of mining on health, Legal Framework and International Law, accessibility to capital assets in Artisanal gold mining, Organizational dynamics in Artisanal mining, Value chain of Artisanal mined gold and Heavy metals associated with mining. The chapter ends with review on theoretical framework and a diagrammatic conceptual framework.

2.2 General overview of Literature Related to the main concepts

2.2.1 Artisanal Gold Mining and Economic Development

The ASM activities have for centuries provided rural inhabitants of impoverished regions of Africa with a wealth of employment benefits and more recently economic growth through mineral wealth and foreign exchange earnings (Hilson, 2009). It also impacts negatively on agriculture and cost of living, while positively impacting on trade and commerce, employment, personal income, and infrastructure (Garvin *et al.*, 2009). A study conducted in Tanzania by Kitula (2006), 42% of respondents benefit from sources of mining employment; 20.3%, from improved road networks, water and school construction; 11% from food crop sales; and 8.1% from subsistence (petty) business within mining. The further showed that only 8.1% of respondents in non-mining areas benefit from direct mining activities as a source of alternative employment, while 37.8% benefit indirectly from food crop sales and 25.7% from subsistence (petty) business.

The ASM has made significant socio-economic impact on individuals and communities as it provides both part-and fulltime jobs for people and in some case the only source of income (Amankwah & Anim-Sackey, 2003). In addition, the mining operations are useful in basic skill development and contribute to the transformation of unskilled labour into semi-skilled and skilled workers. More importantly, due to the low barriers to entry in terms of capital needs and formal educational requirements, small-scale mining operations offer excellent opportunities for the evolution of indigenous entrepreneurs. In rural areas where other jobs are low paying or non-existent, small-scale mining appears as a valuable source of employment.

Interviews, data and information from Ghanaian ASM communities affirmed that mining operations negatively interfered with agriculture in that it draws the available pool of labour from the agriculture thereby denying the economic mainstay of its importance (Garvin *et al.,* 2009). On the aspect of cost of living the development of ASM mining tend to draw in more people into the mining area necessitating an increase in the demand for food, supplies, and housing. Separately, the ASM communities affirm that ASM positively impacts on the economy in three ways; increase in some form of new employment, income levels and infrastructural development. The ASM workers in Ghana were either paid daily, weekly or monthly salaries, or they get a share of output which is either in ores or in gold. In cases, of payments in kind the miners typically have to pay the claim owner to process the ore and even sell the gold to the claim owner between 10 and 30 per cent below the prevailing price offered by the agent, buyers (Fold *et al.*, 2014).

The exploitation of natural resources has traditionally been seen as a vital part of economic growth. It is now well recognized that concern for environmental consequences must be included as a key component of development activities (Garvin *et al.*, 2009). As a result, the mining sector, while sometimes strengthening the economy at the national scale, may present an entirely new set of problems at the scale of the local community. For instance, ASM induces resource conflict within the communities either through gang related violence (Tschakert & Singha, 2007) theft and forage on farmers' produce as a result of the uncertainty of finding minerals (Kitula, 2006). The small scale mining has significant impact on the socio-economic lives of people and communities who are directly or indirectly involved in the sector (Amankwah & Anim-Sackey, 2003). However, it exposes the poor communities to several social risks: first, the rapid migration to mining areas leads to price inflation and secondly, these population influxes contribute to social tensions and new forms of poverty (Pegg, 2006).

2.2.2 Processes and Methods of Mining

Mining methods are of four basic types. Firstly, materials may be mined from surface mines, open pits, quarries, or other diggings open to the atmosphere. This group constitutes by far the greatest number of mines in the world. Secondly, there are underground mines, entered through shafts or tunnels. Thirdly, there is the recovery of minerals and fuels through boreholes. Finally, there is underwater mining or dredging, which is now extending to the potential mining of the deep oceans (Encarta, 2005).

The mining methods employed in ASM vary according to the type of deposits being exploited and its location and can be characterized into three groups: Shallow alluvial mining, deep alluvial mining and hard rock (lode) mining (Aryee *et al.,* 2003). For instance, in Ghana, panning is the most predominant method for both alluvial and hard rock (Tschakert & Singha, 2007).

The shallow alluvial mining popularly known as dig and wash are used to mine shallow alluvial deposits which do not exceed three metres found in valleys or low lying areas. These operations involve clearing vegetation, soil excavation until gold-rich layer is reached, then the mineralized material is removed and transported to nearby streams for sluicing after which amalgamation process is used (Aryee *et al.,* 2003).The deep alluvial mining techniques are used to mine deep alluvial deposits found along the banks of major rivers and involves pit excavation to the depths of 7 to 12 metres. Once the gold bearing gravel horizon is reached, the gold bearing gravel is removed and sluiced for gold recovery (Aryee *et al.,* 2003).

The hard rock mining techniques are used to mine gold bearing reefs, which can be located close to the surface or deep. Holes are sunk in the ground to intercept the gold reefs. If the reefs are weathered the miners use chisel and hammers to break the core, however, explosives are commonly used when the ore is hard. Once the mineralized material is collected, it is crushed into small pieces which are then sluiced for gold recovery (Aryee *et al.*, 2003).

Tschakert & Singha (2007) acknowledged that hard rock mining involves digging of shafts with picks, shovels, hammers and chisels or blasting with dynamite which is then followed by the crushing and grinding of the ore core with mechanized metal mortars and pestles. This type of mining is used in Geita region, Tanzania where pits and underground excavations are done either manually with a pick if the ground is soft or with an aid of explosives if it is hard or with bedrock. The ASM extraction activities generate a number of pits lying between 100 and 1000 having shafts lengths of between 10 and 100m (Kitula, 2006).

Gold-containing material is washed on sluices where the heavier gold particles are caught and concentrated on carpets or towels due to gravity. The concentrate from the sluice box is re-assembled in rubber dishes or wooden pans. Through panning, the undesirable sediments are separated from the gold particles until the latter clearly appear in the final concentrate (Tschakert & Singha, 2007).

Next, a carefully gauged quantity of mercury is poured into the miner's palm and added to the concentrate in the pan. Mercury is usually mixed by hand with the concentrate, forming a lump or ball of mercury–gold amalgam. Water is added several times to discard tailings and remove lighter particles until only the amalgam remains. The amalgam is then squeezed into a piece of cloth to recover excess mercury which is often rebottled and reused (Maponga & Ngorima, 2003;Tschakert & Singha, 2007).Due to impurities and trapped mercury, the gold often undergoes a refining process off site that involves additional heating steps and the use of acid, borax, and soda ash. It is estimated that one or two grams of Hg is lost for every gram of gold produced in ASM (Veiga & Baker, 2004).

2.2.3 Impacts of Mining on the Environment

The environmental impacts of mining activities have been documented though emphasis has been directed towards the impacts of large scale and small-scale gold mining activities on the environment. The land degradation caused by the gold mining is pronounced, chemical contamination from the gold extraction process imposes a double burden on the environment, with harmful health implications for mining communities and people residing in close proximity to such activities (Yelpaala & Ali, 2005).

Due to the informal nature of gold-mining in the South (Africa and Latin America), most studies concentrate on mercury exposure and intoxication incurred in the extraction and processing stage of mining (Rojas, Drake *et al.,* 2001). Results of studies indicate patterns of mercury intoxication during the gold amalgamation process (Drasch, Bose-O'Reilly *et al.,* 2001). Concerns about the impact of mining on forests and protected areas (World Rainforest Movement, 2002) have focused on: rising levels of mining in sensitive areas; uncontrolled mining that is not organised, often leading to political abuse and manipulation that reduce self-determination of miners; environmental degradation typical of ad hoc development and exploitation; sedimentation and contamination of water catchment; negligent use of mercury compounds and lack of reclamation.

Absolute dependence on large amounts of water for mining operations dictates that ASM be located as close to water source as possible. Alluvial ore is a result of river deposition and is therefore part of a river system. The use of water for mineral concentration results in accelerated evaporation of surface water, drainage of wetlands and siltation of rivers and dams in countries like Mozambique, South Africa and Zimbabwe (Shoko, 2003).

One of the most significant environmental impacts arises from the use of mercury (Hg). This pollutant is known to have long-term impacts on ecosystems and human health. In contrast to other sectors where mercury utilisation is decreasing, ASM remains a significant source of mercury pollution (UNIDO, 2009). Despite the risks, it is a preferred chemical employed by artisanal gold miners. However, the general population is unaware of the effects of mercury and does not attribute such pollution to ASM. Moreover, individuals in positions of political or economic influence tend to be negatively biased towards artisanal mining; consequently, government policies do not effectively address its activities. Affected communities have been ignored, and mistrust towards outside parties is high. Not surprisingly, miners are suspicious of externally crafted solutions to reduce mercury emissions and therefore are unlikely to employ them (Hinton & Veiga, 2002).

Mining is a geographically concentrated activity which results in a number of negative impacts on both the immediate vicinity and distant areas. These effects include water and air pollution, river and dam siltation and loss of biodiversity (deforestation, overfishing and poaching). As a result, there are a number of extinct and threatened species within the Zambezi Basin (Shoko 2003). It is important that individuals accurately understand the risks and benefits associated with mining, so that they may make informed decisions about living and working in a mining community. However, community perceptions of risk can differ significantly from those of company representatives, policy makers, and the scientific community (Hadden, 1991).

ASM operations leads to the destruction of arable and grazing land, accelerates soil erosion, landslides, unsafe tailings disposal, the lowering water tables, air contamination due to dust mines and tailings and increasing load sediment loads and flooding or rivers (Shen & Gunson, 2006). Often, the Ghanaian government views ASM as a source of environmental degradation and safety risk, with illegal mining being the underlying cause of brutal conflicts between rural communities and LSM (Yakovleva, 2007). In other countries such as Tanzania, typical environmental impacts caused by ASM activities include diversion of rivers, water siltation, landscape degradation, deforestation and widespread mercury pollution (Kitula, 2006).

The physical effects of gold mining in Zimbabwe is the tailings which include large amounts of sand and numerous pits resulting from the movement of around 8 million tonnes of material annually and in the process destroy the riverbanks and the results is destruction of vegetation (Maponga & Ngorima, 2003). The deforestation that has emanated from surface mining has long-term effects even when the soil is replaced and trees are planted after mine decommissioning. The new species that might be introduced have the potential to influence the composition of the topsoil and then determine soil fertility and fallow period for certain crops. In addition to erosion when surface vegetation is depleted, there is deterioration in the viability of the land for agricultural activities and loss of habitat for birds and other animals. This has degenerated into destruction of the luxuriant plant life, biodiversity, cultural sites and water bodies. It is predictable that by the time the mining companies would have mined out all their concessions, a total of 16 ridges ranging between 120 m and 340 m high would have been twisted into huge craters (Akabzaa & Darimani, 2001).

2.2.4 Effects of Mining on Health

Studies of mining and health by type of mine process are divided into deep and open cast mines. Deep mines produce severe harms for employees in terms of their risks of high blood pressure; heat exhaustion; myocardial infarction and nervous system disorders. Studies of surface mining focus on coal, granite and rock mining and health risks related to dust breathing. In all levels of mining health risks occur with dust exposure (Stephens & Ahern, 2001).

At the onset of the extraction process, eexposure to ASGM chemicals results in increased population morbidity leading to loss of productivity (Miserendino *et al.*, 2013), Past studies have indicated an elevated Hg exposure among residents of artisanal mining communities in Asia, Africa, and South America; particularly in countries such as Peru and Brazil, however, an examination of artisanal miners in Colombia indicated that mercury exposure has effect on kidney function (Rodríguez *et al.*, 2017)

Several studies on effects of mercury on the environment and humans have been conducted. However, reports indicated that there were higher in water, soil, and sediments in the Pra River in Ghana but these levels were below World Health Organization safe guideline values, thus current state of affairs poses a serious environmental threat. Tschakert & Singha (2007) reported that the laboratory samples show mercury levels in the surface water samples ranged between 0 to 67 ngL^{-1} while borehole samples were as high as 286 ngL^{-1} which were all below the WHO safe drinking water standard of 1000 ngL^{-1}. The statistics showed that there was no marked difference in mercury in soil between mining and non-mining sites, and rather low levels of mercury in the top 0–10 cm sediment layer.

The statistics in Ghana estimate that the occupational injury rates were between 45.5 and 38.5 injuries per 100 person-years in the years 2011 to 2013. Lower limb injuries which were caused by fall were most prevalent, with other injuries being cuts/lacerations, burns and scalds, contusions and abrasions. The use of protective gear among the ASGM in Eastern Ghana is virtually non-existent while report indicate that mine collapses followed by drowning and falls were the most common reported incidents among ASGM communities (Long *et al.*, 2015).

Respiratory impacts are the most studied and problematic of health impacts for mine workers. Injuries have declined in importance but continue to be an important safety issue in mines. Long-term effects include cancers, mental health impacts and some proof of impacts on genetic integrity of workers. The heated discussion on the impact of the mining and minerals sector on both worker and community health is polarized. On the one hand the industry tends to underscore the supposed benefits of the sector, whilst on the other, community groups and NGOs suggest that the sector is injurious to health and sustainable development (Stephens & Ahern, 2001).

Biostatistics obtained from Obuasi hospital in a survey by Friends of the Earth-Ghana (FOE-Ghana) showed a high prevalence of upper respiratory tract infection (URTI) in the area which medical experts linked to the mining activities and associated pollution (Awudi, 2002). Clinical symptoms similar to arsenic poisoning have been reported in patients in AGC hospital at Obuasi and have been associated with aerial pollution from mineral procession by the AGC (Awudi, 2002) while in Tanzania, Several case of acute intoxication, muscular atrophy, seizures and mental disturbance have been reported in Geita district, Tanzania (Kitula, 2006).

In Ghana, mining impacts are related to diseases such as malaria, diarrhoea, upper respiratory tract infections, skin disease, acute conjunctivitis and accidents and constitute the top ten diseases in the area according to biostatistics, obtained by FOE - Ghana in Korle-Bu Hospital in a survey in 2001. The area has the highest incidence of malaria in the Western Region and the country as a whole. Skin rashes are widespread particularly among communities living along rivers and streams which regularly receive leaked cyanide waste waters and other mining wastes within concessions (Akabzaa & Darimani, 2001).

There is evidence of long-term impacts of mining on health of workers and communities. This implies that the sector's activities currently undermine the human objectives of sustainable development, which are to protect the health of current and future generations. There is still a long way to go before mining becomes a healthy work or a healthy development activity to take place in a community. There is also a long way to go before the industry, the workers and the community agrees over the real health impacts of the sector and the real responsibility of each of the actors in the sector (Stephens & Ahern, 2001).

In Ghana, there are no official medical records of individuals dying from mercury intoxication, moderate to severe mercury can be presumed due to the fact that the miners do not use any protective gear and the problem is compounded by consumption of CH_3Hg-contaminated food and water (Tschakert & Singha, 2007). Hinton *et al.*(2003) points out that with increased exposure a number of complications arise: visual constriction, numbness of extremities, impaired hearing, speech and gait; muscular atrophy, seizures, mental disturbance; spontaneous abortion and sterility. In Ecuador, the ASGM occupational related injuries are often severely underreported with no official statistics, with some deaths being as a result of cave ins of the mines (Miserendino *et al.*, 2013),

The widespread use of mercury in gold processing represents a serious public health risk as prolonged exposure to this substance can cause permanent brain damage and may induce vomiting, diarrhoea and/or sensory impairment (Siegel & Veiga, 2010. Some mercury is also absorbed directly through the skin when amalgamation is done by hand. Typically, amalgamation and burning are done with no protective measures (such as retorts or gloves) and often in the presence of children or even in the home. Mercury dust is also carried on the clothing of miners and brought back to their homes in this manner (Maponga & Ngorima, 2003). In Philippines, a study showed that directly exposed group of miners had significantly higher mean blood total mercury and methylmercury levels when compared to their compatriots (Maramba *et al.,* 2006).

Where alluvial gold overlaps with jungle or other heavily wooded areas, deforestation is a serious issue. For instance, in the Madre de Dios region some 7,000 hectares of pristine forest and wetlands were cleared by miners between 2003 and 2009 (Swenson *et al.*, 2011). Long hours of wading through water make artisanal miners vulnerable to waterborne disease. Miners are exposed to these risks, and yet usually do not wear any safety equipment, such as hard hats, gloves and boots (World Bank, 2010).Abandoned open pits and disrupted watercourses can create pools of stagnant water that serve as mosquito breeding grounds hence malaria (World Bank, 2010). Water pollution of streams reduce accessibility of the local community to clean water.

Where excavation often takes the form of pit mining there are health problems for the miners themselves. Medical conditions associated with this type of mining include gas emission poisoning and silicosis, a respiratory disease (UNEP, 2011). Contamination of the surrounding area remains risk because of a process known as acid mine drainage. This is essentially where dangerous substances, latent within the rock, are brought to the surface and released as a result of extractive operations (Veiga, 2011). According to Maponga and Ngorima (2003), remnants of gold panning include large amounts of sand. The panned waste chokes river channels and may result in flooding during the rainy season.

Women are often involved in processing waste disposal, which exposed them to harmful chemicals, with severe consequences for family well-being and health, including during pregnancy (Eftimie *et al.,* 2012). Degradation of nearby natural resources needed for food, firewood and medicine particularly affects women (Dreschler, 2001). According to (ILO, 1999) Occupational and community health and safety tends to be very poor in ASM. Self-employed miners in the smallest underground mines typically work in unsupported drilling, removing rock with hand tool and carrying the ore to the surface in sacks.

The most common accidents are trips or falls, being hit by machinery or a moving object, and cave-ins or rock falls (ILO, 1999). Other environmental impacts of ASM's include erosion, deforestation, biodiversity loss and water pollution from dumped tailings, alluvial river damage, acid rock drainage, river siltation. These have effects for health by contaminated drinking water, stagnant water that attracts mosquitos, increasing malaria etc. A study in Ghana identified a total of 25 risks and hazards to miners with the most serious hazard being collapsing sediments, pits, or shafts, with other life-threatening risks dynamite rock blasting and underground heat/high temperature and reduced oxygen in shafts up to 45 feet in depth), being slipping and falling into pits and conflicts among the miners. Other significant risks were eye problems resulting from muddy water on the alluvial site and rock particles and smoke from crushing and grinding at the hard rock site, fractures and respiratory tract infections (Tschakert & Singha, 2007). Accidents due to ASM often go unreported due to its illegality/informality of most ASM operations, with an 1999 ILO report estimating that non-fatal accidents are 6 to 7 greater than those of formal mining sector (Shen & Gunson, 2006).

2.2.5 Impacts of Mining on Livelihoods

Evidence suggest that individuals working in mining or related services are less likely to be poor than those with other occupations. The income derived from mining helps reduce poverty and buffer individuals from livelihood shocks. However, the individual's inability to obtain a formal mineral claim to effectively exploit their claims, contributes to insecurity (Fisher *et al.,* 2009). The rise in artisanal gold mining activity has been a result of distress-push diversification, fuelled largely by the potential of gold mining as an opportunity-driven activity; therefore, it presents an interesting alternative in a land that offers few opportunities to youth and impoverished rural people (Maconachie & Hilson, 2011). Other significant impacts of ASGM include direct earning which is illustrated by the average income of the miners in Senegal is between US$4 and US$7 per day translating to about US$600 to US$1100 per year (Persaud *et al.,* 2017).

ASGM activity in Mozambique is largely seasonal due to rainy season and the most common methods is the use of rudimentary techniques and amalgamation process (Drace *et al.,* 2012). In striving to achieve sustainable livelihoods, artisanal mining should not be viewed as an alternative livelihood; much more, it should be recognised and valorised as a complementary livelihood. Artisanal gold mining has, with the capital that is produced from it, the potential to act as a catalysing force in reinvigorating small-scale agriculture by bringing it beyond a subsistence state. There is a close relationship between artisanal mining and farming that can complement each other in their seasonal characteristics (Maconachie *et al.*, 2006). ASGM mining in Senegal is an alternative source of livelihood since, households are engaged in more than one livelihood source such as agriculture, and the same miners were involved in at least more than one job. Evidence from Senegal point out that ASGM is a complementary and supporting sector to the traditional agrarian livelihood (Persaud *et al.*, 2017). Many have lobbied for ASM to be used as a tool for rural and community development and as a springboard for people-centred development (Bayah *et al.*, 2003). Artisanal mining can be a primary source of employment for citizens who are disadvantaged in the labour market.

As explained by Hentschel *et al.* (2002), small-scale mining communities are with few exceptions located in remote rural areas, where they constitute the principal source of economic activity, create complementary opportunities for national micro-, small- and medium size enterprises, and provide the required infrastructure to the miners and their families. The sector has the potential to generate significant local purchasing power and create demand for locally produced goods and services (food, tools, equipment, housing and infrastructure).Where poverty-driven ASM is undertaken on a subsistence basis and as a safety net. Labonne argues that there is unlikely to be the opportunity to save and invest in productive ventures (Labonne, 2002).

The UN Special Rapporteur on Contemporary Forms of Slavery and the Peruvian Human Rights Ombudsman have also highlighted instances of child labour within the sector (Defensoría del Pueblo, 2007). Economic benefits derived from ASM both for those directly involved and for the country as a whole is generation of employment since it is a labour intensive nature, offering a route out of poverty for the country's poorest group (Veiga, 2011). From literature review, the main impacts are: deforestation and land degradation; open pits causing animal traps and health hazards (including acting as mosquito breeding grounds due to stagnant water collection after being abandoned by the miners); mercury runoff from gold amalgamation; waste accumulation from inefficient extraction; dust and noise pollution; underground instability and long-term hazards.

2.2.6 Legal Framework and International Law

There are a number of international environmental agreements relevant to artisanal gold mining such as the Minamata Convention and Basel Convention but often artisanal gold mining is often regulated by the same legislation for the environment, labour, mineral rights, exploration and permitting as in the formal mining industry. However, its compliance is generally low, due to the low education, lack of finance and poor levels of technology available to the miners (Shen & Gunson, 2006).

The Minamata convection was founded by government representatives from ninety-two countries in October 2013 and sought to curtail the trade, use and emission of mercury in a wide range. The convention affirmed that mercury toxicity is a transnational issue that is a health and environmental risks (Willis, 2000). The Convention seeks to reduce mercury pollution across many sectors, including ASGM, by prohibiting trade of certain mercury-added products and by requiring national plans to reduce anthropogenic mercury emissions. Article 7 of the Convention is devoted entirely to mercury emissions from ASGM, which the Convention defines as gold mining conducted by individual miners or small enterprises with limited capital investment and production. Countries with ASGM activities must take steps to reduce or eliminate the use and emissions of mercury from mining and processing. The Convention also encourages cooperation among signatories on the development of strategies to reduce mercury use in ASGM; education, outreach and capacity-building initiatives; research into sustainable non-mercury alternative practices; technical and financial assistance; and the promotion of best practices and alternative technologies that are environmentally, technically, socially, and economically viable. The Convention regulates trade in mercury and it does not ban mercury use in ASGM.

The Basel Convention controls the transboundary movement of hazardous wastes. Basel further regulates the intrastate storage of wastes that contain mercury. Under the Convention, the generation of mercury waste should be reduced to a minimum, taking into account social, technological and economic aspects. Countries must also provide adequate disposal facilities to ensure environmental sound management (BaselConvention 1992). Under these two provisions, appropriate storage and management practices hold the potential to prevent mercury use, including in ASGM activities.

All Nigerian states have environmental agencies and environmental laws. These state agencies act under the principle of cooperative federalism, where states have concurrent authority over most environmental matters, established by regulations promulgated by the Ministry of Mines and the Ministry of the Environment. State agencies often monitor and enforce the EIA process, conduct surveys, engage in outreach and issue permits.

Ghana established the legal framework for registration of small-scale gold and diamond mines, mineral production and sales in 1989 called the small – scale mining law, Act 218 of 1989. This act lead to the establishment of the Small-scale Mining Project within the Ghana Minerals Commission, under the now called the Small-scale Mining Department which is responsible for providing technical assistance to prospective and registered small-scale miners in Ghana and promoting their activities (Amankwah & Anim-Sackey, 2003).

Concurrent to this act is the Mercury law, Act 217 of 1989 which legalized the purchase of mercury for gold recovery purposes from authorized dealers and the Precious Minerals Marketing Corporation (PMMC) Law, Act 219 which created an authority to buy and sell gold and diamonds. The PMCC purchases gold and diamonds in addition to licensing buying agents and subagents through the mining areas. However, upon implementation of the PMCC act, two types of small scale miners emerged, legal and illegal. The legal ASM acquire mining licences from the PMCC while the illegal ASM mine without requisite mining licence and operate on concessions of LSM and are referred to as galamsey (Amankwah & Anim-Sackey, 2003).

In Ghana, ASM miners seeking official registration encounter bureaucratic and procedural hurdles with registration taking 6 to 8 months. This is in addition to about USD2500 fees for EPA and local authority for the first year and about USD 600 for each subsequent prospecting year. With inadequate geo-prospecting and no guarantees for long-term mining rights exploitation, many small scale operators forgo registration and illegally mine gold in unoccupied areas. Further, the gold produced can be openly sold to buying agents licenced Precious Mineral Marketing Corporation (Tschakert & Singha, 2007). Ghana formally recognized ASGM in its legal framework in the minerals and minich act of 2006, while ASGM in Tanzania was given legal recognition in the country's mining policy act of 2009 (Hruschka, 2015).

The current legislation governing ASM in Mozambique is considered inadequate as it designates specific mineral deficient locations to ASM miners who are expected to obtain individual mining licence/pass from the provincial authorities. Through the Artisanal miners' associations which represents less than 30% of the workforce, miners have been able to draw support from Mining development fund, however, the viability of these institutions depends on ore exploration (Dondeyne *et al.,* 2009). In terms of regulation and monitoring, the Ecuadorian government official lack capacity to enforce environmental regulation or establish regulatory measures (Miserendino *et al.*, 2013).

Lack of government regulation in Ecuador fuels the use of inefficient technologies in gold extraction and mishandling of waste and tailings leading to environmental impacts. The mining Act of 2009 in Ecuador requires that all miners whether industrial or small scale acquires a mining title from the ministry concern, perform an environmental impact assessment, obtain an environmental license from the ministry of environment and a resource development contract. The act specifies that artisanal miners only acquire an exploration license, do not undertake an environmental impact assessment and are not taxed (Miserendino *et al.*, 2013).

In Zimbabwe, the government introduced two regulations that control environmental damage from panning: issuance of permits to approved local persons, cooperatives and partnerships and regulations outline and specifying where panning is legally permitted (Maponga & Ngorima, 2003). In Tanzania, all mining activities are regulated by the mining Act of 1998, with its associated regulations. The act incorporated the legal and regulatory, fiscal and environmental frameworks for mining with clear guidance for administration and enforcement. The legislation prioritized the mining sector as one of the important economic segments and made for provision for the private sector to take a leading role in mining (Mutagwaba, 2006).

Kenya's mining industry has for decades, been guided by a 1940 Act. The Mining Act 1940 (chapter 306 of the Laws of Kenya) regulated all mining activities in Kenya. The Commissioner headed the Department of Mines and Geology and was responsible for overseeing mining research and policy as well as implementing the Mining Act. The ownership of all mineral deposits vests in the Government. In order to carry out mining activities, an investor had to apply to the Commissioner for the required licence or lease The Mining Act 1940 criminalized artisanal mining and also totally disregarded artisanal miners, thus ignoring their contribution to the extractive industry and the economy as a whole.

On May 6th 2016 the President of the republic of Kenya assented to the Mining Act, 2016, which replaced the Mining Act Cap 306 of 1940s, the Trading in Unwrought Precious Metals Act and the Diamond Industry Protection Act and provide a more progressive comprehensive Mining Act. The new Mining Act takes cognizance of artisanal miners, their operations while defining artisanal mining through the lens of traditional tools and methods used to mine, which paints a picture of salient features of artisanal mining (ROK, 2016).

The new act introduces artisanal mining permit in section 95 (a) (b)(c) whereby the Qualification of applicants is a citizen of Kenya, who has attained the age of maturity and may be a member of an artisanal mining cooperative association or group. New law recognizes artisanal mining giving processes for establishing safe operations, a departure from the old legislation which outlawed artisanal mining. The changes allow communities to undertake mining activities in safer environments. Mining act 2016 has moved forward in the Operations of Artisanal Miners in section 98 (1) and (2) whereby a holder of an artisanal permit may mine and produce minerals in an effective and efficient method. More so the holder of an artisanal permit shall observe good mining practices, health and safety rules and pay due regard to the protection of the environment (ROK, 2016).

Kenya's Mining Act 2016 is quite progressive in its effort to encourage formalization of artisanal mining. Section 93 (f) requires facilitation on the formation of artisanal association groups or cooperatives; Section 93 (b) of the Mining Act requires development of a register of artisanal miners in the country with section 93 (f) requiring that the Ministry of Mining facilitate the formation of artisanal association groups or cooperative. Kenya's mining Act 2016 address issue of supervision and monitor the operation and activities of artisanal miners; Section 93 (d) require advise and provide training facilities and assistance necessary for effective and efficient artisanal mining operations; Section 93(g) of the Act advocates for Promotion of fair trade of artisanal miners (ROK, 2016)

2.2.7 Challenges facing artisanal gold mining

ASM is frequently driven by vulnerability, offering a (often short-term) coping mechanism for poverty. Gold mining is no longer just a boom and bust activity, but one driven by the inherent vulnerabilities of poverty although there are some who continue to be driven by opportunism. Its high margins and low barriers to entry make it a highly lucrative activity for those with little human, physical and financial capital.

Artisanal and small-scale miners, regardless of their exact size, level of mechanization faces the same marginalisation as other small-scale sectors. Many miners operate in remote regions with poor transport and market access, suffering geographical marginalisation that makes them less able to access information, key technologies and inputs.

Small-scale producers may be marginalised in terms of access to markets, forced to sell through informal, illegal or less lucrative channels. Miners have insufficient assets or income to purchase adequate food for themselves or their dependents. Many small-scale producers in natural resources sectors operate informally. In Bolivia people use the term popular 'economy'or people's economy'(Hivos 2012). This resonates with a definition by ILO (1972) which defined informality by:

- Low entry barriers to entrepreneurship in terms of skills and capital requirements;
- Family ownership of enterprises
- Small scale of operation
- Intensive production with outdated technology
- Unregulated and competitive markets.

Often, informality dominates because of formidable obstacles to formalization. These processes tend to be overly complicated and bureaucratic, centrally determined and managed, reliant on the state for regulation, and lacking social relevance. This is both symptomatic of and exacerbates geographic, political and social marginalization. Informal systems often have rules and processes based on years of social and cultural tradition. Regulation is through cultural norms and social contracts a form of legal pluralism in which traditional, informal and formal rules overlap and operate simultaneously (Cleaver, 2000).

2.3 Impacts of Capital Assets Accessibility on Community Livelihood

The ASM sector of Sub-Saharan Africa is plagued with the lack of working capital and credit facilities, lack of suitable equipment and minimal wages compounded with low prices (Amankwah & Anim-Sackey, 2003). Thus, the sector is comprised of individuals trapped in vicious cycle of poverty, lacking necessary financial and technological means to improve their lives (Hilson & Pardie, 2006). This point is illustrated in Tarkwa and Damang mines in Ghana, where most artisanal miners use rudimentary techniques with no access to financial facilities to mine for gold (Teschner, 2013). This lead (Hirons, 2014) to conclude that the ASGM activities in Ghana is deeply rooted activity characterized by extraordinary but chaotic growth The financial environment indicates that ASM lack working capital and credit facilities, lack of suitable mining equipment and inappropriate wages that is further exacerbated by low prices for the gold process by the middlemen (Amankwah & Anim-Sackey, 2003).

Evidence points to the fact that the formal access to land is essential for the broader acceptance such that ASM operators' access (or lack of access) to mineralized land but current initiatives in Tanzania and Ghana indicate that land is being genuinely allocated for mining; however, the richness of these deposits, however, still remains unclear(Fold Jønsson & Yankson, 2014). Further, there are disparities in the distribution of the assets, such that mineral -rich lands in Ghana, are frequently traded between local landowners and miners or interested groups, thereby contributing significantly towards proliferation of the illegal ASM activity (Nyame & Blocher, 2010).Findings from Ghana's ASM sector as captured by Tschakert, (2009) indicate that illegal miners hold expectation of legitimately acquiring small parcels of land for gold extraction; however, they are not willing to commit to new and modern alternative livelihood options being introduced by external agencies. However, ASM miners in Ecuador have improved their operation through mechanization of the processing plants (Miserendino *et al.*, 2013).

ASM is defined to include both the exploitation of mineral deposits using fairly rudimentary techniques and/or at low levels of production with minimal capital investment (Aryee *et al.*,2003).It is viewed as a low technology, labour intensive mineral processing and excavation activity in that it relies on inadequate technology that causes human and environmental health degradation, low productive output with the resultant low levels of income (Childs, 2008), It is therefore a low technology mineral extraction and processing of many precious metals and stones (Hilson, 2010), with the dominant environmental discourse in Ghana being that of mercury contamination caused by the surging numbers of illegal miners who irresponsibly use mercury to extract gold, thereby wrecking the environment and endangering their own and other people's health (Tschakert & Singha, 2007).

Due to the low financial base of the ASM, majority rely solely on traditional/manual methods of mining, which are largely artisanal and feature simple equipment like shovels, pick-axes, pans, chisels and hammers (Aryee *et al.*, 2003). For instance, In Tanzania, the small-scale mining activities use manual, low technology, subsistence activities to extract gold from rich and near surface deposits (Van Straaten, 2000). Since small-scale mining uses low technology mineral extraction and processing techniques (Hilson, 2009).In Ghana, there is increased dependence upon mercury for amalgamation (Hilson & Pardie, 2006).

Ghana has seen tremendous growth in the technologies being used in ASM such that current technological advances in the mining and mineral extraction process are leading to an increase in surface mining activities which are relatively more capital intensive and less labour intensive than deep, underground mining (Yelpaala & Ali, 2005). However, the levels of poverty among the miners make it impossible for the miners to acquire such technologically advanced methods. Due to the use of rudimentary technologies, the gold amalgamation process associated with ASM forms a significant source of mercury to the environment, with as much as 800 tonnes/year of metallic mercury being released into the environment worldwide, with China alone releasing about 120 to 240 tonnes (Shen & Gunson, 2006).Therefore, artisanal mining communities in Africa are often trapped in vicious cycles of poverty that make it difficult for them to improve technologies and reduce mercury pollution (Spiegel, 2009).

Although small-scale mining is often associated with deleterious environmental effects, experience in Zimbabwe's gold panning has shown that with appropriate measures, ASM may be encouraged or persuaded to develop environmentally friendly methods for gold recovery and mining (Maponga & Ngorima, 2003). This is largely made up of a combination of legislation; education and promotion of an appropriate technology which has enhance environmental management. However, in some instances introduction of new technologies has been largely driven by investments in the ASGM sector, such that some some firms in Mozambique have introduced new process which eliminated the use of mercury gold extraction process. This involves gold isolation through centrifugation and use of magnetism to remover gangue materials (Drace *et al.*, 2012).

2.4 Impacts of ASM Organizational Dynamics on Community Livelihoods

Organizational dynamics in artisanal gold mining vary within different communities, areas and even countries. The starting point in ASGM is he low entry barriers, which allows any individual with no previous experience to quickly acquire simple skill and techniques to become a miner (Teschner, 2013). Due to this Buxton (2013) acknowledges that the local knowledge and understanding the exact nature of organizational dynamics is crucial in artisanal gold mining. For instance, in Ghana, the ASM formalization process has been termed to ne bureaucratic and costly (Teschner, 2013).

In Africa, there has never been any attempts to promote formalization of the ASGM sector by the market institutions and private actors (Fold *et al.*, 2014) thus a research carried out in Easter Region of Ghana indicated that artisanal mining is deeply rooted activity which is explained by four reasons: a heavy involvement of traditional leaders in operations; the mind-sets of many operators toward alternative income-earning activities; the numerous and diverse range of employment opportunities provided by the sector; and the level of investment in operations (Banchirigah, 2008).

The galamsey in Ghana are officially excluded and marginalized from governmental programs that support mercury risk communication and loans to purchase safer technologies (Tschakert & Singha, 2007). Being trapped in vicious cycle of lack of access to information and alternative technologies, the galamsey perpetuate the environmental pollution and endangering their own life as well as others. The government continues to marginalize galamsey activity through forced eviction from concession areas and inappropriate assistance programmes (Childs, 2008).

Illegal small-scale mining is certainly not only restricted to Ghana, but an ILO report in 1999 indicate that up to 80% of small-scale miners worldwide operate without formal authorization (Tschakert & Singha, 2007). Due to ASM activities, mining communities in Ghana do not view other formal ways and means of earning livelihood (Banchirigah, 2008) thus these growing informality of ASM hampers the development of the sector in terms of economic growth, environmental safety and gender relations (Yakovleva, 2007). Majority of state officials, environmental bureaucrats, and representatives of civil society are slow in recognizing the legitimate role of ASM as a livelihood, there is persistent lack of willingness to reconsider the dominant narrative which not only reveals an embedded discrimination against the predominantly poverty-driven ASM sector but further perpetuates poor social and environmental conditions from which ASM communities attempt to escape (Tschakert & Singha, 2007).

In Tanzania, ASM is considered as peripheral activity to large segregated from district level planning but is only gradually being addressed within national poverty reduction policies (Fisher *et al.*, 2009). In Uganda, most ASM activity occurs outside mainstream legal economies and occupies an informal yet essential economic activity (Siegel &Veiga, 2009). In Ghana, licenced/registered small-scale mine employ between 5 and 20 groups of tributes consisting of 10 workers each to excavate and process gold with women comprising around 10% (Amankwah & Anim-Sackey, 2003). In Zimbabwe panning is not been fully incorporated into recognized activities which deserve support from government structures and thus support for gold panners remains measly (Maponga & Ngorima, 2003).

In Ghana, the common mentality sees ASM miners has illegal miners (galamsey) who are criminalized both politically through resource conflicts with large scale miners and environmental through land degradation and irresponsible/ignorant use of mercury. Discursively, ASM miners are stereotyped as security risk and societal threat, thereby condemning, marginalizing and criminalizing the ASM sector (Childs, 2008). People depending on small-scale gold mining are usually members of poor rural households in developing countries, (Heemskerk & Oliviera, 2003) hence regarded as a source of livelihood for the rural poor despite the complex dynamics and structural challenges. According to Metcalf, (2008) some rural populations depend on mining as a primary source of income or as a critical supplement to meagre farming revenues.

Evidence shows that the failure of the government in poverty alleviation strategies in the mining areas has led to the perceptions that mineral revenue stream deliberately bypasses key communities. Increased in local unemployment and underemployment, combined with a lack of a workable or enforceable legal framework, ineffective national policing, and a weak decentralized institutional capacity to implement policy and regulate the ASM sector has further exacerbated the problem of ASM (D'Souza, 2005). Empirical evidence from past studies show that the informality of the ASGM sector can only be address by matching the gold prices to the world market prices and through the provision of financial facilities (Fold *et al.*, 2014).

The ASGM activities in Senegal are low capital, labour intensive activities executed by individuals playing distinct roles in the mining site. For instance, there are shaft groups composed of rope pullers, diggers, and shaft owners/leaders, with other economic jobs being crusher, mill operators, gold buyers, traders and other secondary service. The ASGM activity in Senegal is controlled by customary governance structure which is a sophisticated organization governing the gold resources in that it allowed for direct taxation, highly responsive to the miners' needs, provide services and maintain law and order (Persaud *et al.*, 2017).

The organization of the ASGM communities in Senegal is headed by the village chief, with the oversight function be done by mine site chief (*Diourakountigu)* while *Tombouloma* are responsible for the ASGM site and village security and their assistants enforce rules and safety. Those seeking exploration of new mining shaft or new mining sites must seek permission from *Diourakountigu*, typically via the *Tombouloma* (Persaud *et al.*, 2017).

In Tanzania, the ASGM is organized into a three – tiered structure composing of: primary mining license (PML) owners who hold the exploration rights of the mining activities including hiring and paying labour, organizing the mining, and adherence to safety and environmental regulations; the pit holders who informally lease out the mining activities to PML owners; and diggers who are either traditional drillers (*waponjaji)* and puller (*vutafelo)* (Hruschka, 2015).

2.5 Impacts of Gold Value Chain on Community Livelihood

Empirical evidence from studies indicates that ASM gold value chain can be split into two main chains: downstream operations for buyers and consumers of the products and upstream which involves production segments. This classification has been highlighted by a study in AMS operations in Tanzanian which suggest that downstream interventions in the buyer segment of the supply chain facilitate upstream formalization in the production segment (Fold *et al.,* 2014). However, Amankwah & Anim-Sackey (2003) reported that the mineral supply and general economic environment of the small-scale mining sector has four basic components an exploration environment, a market environment, a financial environment and a policy environment, that provide both opportunities and constraints.

But the starting point in the gold value chain is the output from the ASGM activities which Miserendino *et al.,* (2013) affirm that the use of mercury amalgamation results in less than 40% gold recovery therefore there are sufficient quantities of gold in the tailings that can reprocessed the amalgamized tailings, thus the ASGM activities in Ecuador takes two forms; the primary aspects of ore extracting ore coupled with amalgamation process that recovers 30% to 40% of gold, the secondary aspects of reprocessing of the amalgamated tailings or mineral extracts through further amalgamation, smelting, floatation and refining

In the explorative environment, the ASM cannot survive on the basis of current reserves and that is why it requires investments in exploration activities while in the market environment the ASM is the main supplier of gold to the local economy (Amankwah & Anim-Sackey, 2003), while Fold *et al.*,(2014) disentangles the ASM market into intertwined relationship between tenants (smallholders), landowners and traders in agricultural inputs, crops and consumer goods. These interactions occur when the poor and resource-less people are linked to and sell their labour services to landowners with a direct exploitation in terms of low payment. For instance, all the ASM mine workers in Tanzania are paid ore or in gold while ignoring the various sharing systems between mine worker, pit holder and the claim owner. The transactional aspects suggest that the worker would pay claim owner to process the ore and then sell the gold to the claim owner at between 20 and 30 per cent below what the owner would sell the gold for (Fold *et al.*, 2014).

Artisanal mining can create linkages with other sectors, with forward linkages to related gold and jewellery related industries and backward linkages to local support industries (Amankwah & Anim-Sackey, 2003). In Tanzania, buyers have networks of agents, who they sponsor and typically operate without licence and stay outside towns and use the proximity to the ASM zones of activities to attract customers by providing operational loans of between 200 and 3000 US dollars on a monthly basis to ASM operators (Fold *et al.*, 2014).

Research in South Kivu of Democratic Republic of Congo showed that women play a significant role in ASM either as managers or intermediaries between mineral buyers on one hand and artisanal miners on the other hand. These intermediation occurs when mineral buyers want to acquire certain amount of minerals, they provide the women with enough cash to go to the mines and make purchases which in return they earn about USD 5.0 from the buyers (Bashwira *et al.,* 2014).In Tanzania, the division of the revenue from the gold bearing ores varies but in general the rule of thumb is that pit holder gets 40% with the remaining 60% being distributed equally between the PML owners and diggers *(vutafelo)* (Hruschka, 2015). Some of the gold mined in Tanzania is sold to 10 main buyers in Chunya, Mkwajuni and Makolongosi, of which 5 are significantly bigger than others and typically buy at around 10 – 15 per cent below the world prices. However, some ASM operators (pit holder and/or claim owner) travel to Dar es Salaam on their own in case they have extracted large gold quantities (*Fold et al.,* 2014).

In Tanzania, the ASM ends up in the jewellers, which are the main buyers of ASM gold and who buy the gold at a price between four and ten per cent below the world market price mainly depending on the predictability of the period's price development (larger profit margins necessary in periods with an unpredictable price curve) and the quantities of gold on offer. The ASM supply chain starts from ASM operators then the African gold brokers and to the jewellers' shops, with the main cities being Dar es Salaam. In Ghana, for several decades, the state institutions were heavily involved in ASM gold chain, with the Precious Minerals Marketing Company (PMMC) being the key buying and exporting actor (Fold *et al.,* 2014).

The ASM gold chain in Ghana starts from both galamseys and formal ASM operators who sell gold to licence buying agents (LBAs) who are licence by the PMMC or non-licensed buyers (Fold *et al.,* 2014). The PMMC in Accra buys ASM gold at a price somewhere between one and two per cent below the world market price (for 99.99% purity). The remaining margin covers costs for administration, export, insurance and profit. The agents purchase gold from both galamseys and formal ASM operators, none of the buyers (including the PMMC) have any concerns over the origin of the gold and do not distinguish between gold from formal and informal ASM operations. The ASM operators may work individually or in small groups, in which case they sell their gold themselves (Fold *et al.,* 2014).

The traders operating in Tanzania and Ghana's ASM gold chain profit in three main ways, namely 1) through exploitation of price margins, 2) through provision of credit, and 3) through provision of various goods and services (mercury, smelting and purification of gold). The price margins Gold buyers purchase gold from ASM operators (or small-scale up-stream purchasing agents) at lower prices than the going market price they are able to obtain. The price margins become smaller as the market matures and competition stiffens, which forces buyers to seek ways to purchase higher volumes (Fold *et al.,* 2014).Buyers operating in the proximity to ASM areas provide operational loans to miners so that they are able to cover running costs and sometimes investment costs for equipment and lastly the buyers provide miners with a number of support services such as smelting the gold with Borax and cleaning it with nitric acid. Upstream in the ASM settlements, buyers commonly sell mercury to miners while some invested in leaching plants.

Table 2.1: Gold-Producing Africa countries

Countries	Average Production(kg) 2005 -2009	Countries	Average Production(kg) 2005 -2009
South Africa	245,968	Cameroon	1,520
Ghana	77,346	Zambia	1,219
Mali	45,639	Morocco	1,200
Tanzania	43,181	**Kenya**	**942**
Guinea Conakry	19,135	Burundi	750
Zimbabwe	7,985	Liberia	314
D. R. Congo	5,580	Gabon	300
Burkina Faso	5,270	Equatorial Guinea	200
Mauritania	4,207	Sierra Leone	146
Ethiopia	3,927	Nigeria	130
Niger	3,064	Chad	130
Sudan	2,737	Republic Congo	104
Botswana	2,734	Madagascar	46
Côte d'Ivoire	2,662	Eritrea	30
Namibia	2,427	Benin	21
Senegal	1,600	Rwanda	16
Uganda	1,600	Central African Republic	11

Source: US Geological Survey, 2011.

2.6 Concentration of heavy metals

A comparative study in Tanzania using gravimetric analysis indicated that between 70 to 80% of the Hg used in gold amalgamation process is lost to the atmosphere, while 20 to 30% are lost to tailings, soils, stream, sediments and water, such that for every 1 g of gold produced, 1.2 to 1.5g of Mercury is lost to the environment (Van Straaten, 2000). It is estimated that 6 tonnes of mercury is used annually in Zimbabwe by illegal panners, with a 50% (3 tonnes) being lost on amalgam plates, barrels, to the atmosphere and during retorting and thus is a direct threat to the environment (Maponga & Ngorima, (2003).

Drace *et al.* (2012) reports that vast majority of ASGM miners in Mozambique use mercury in the gold mining process. The use of mercury in gold amalgamation process in ASGM is supported by the fact that the process is less time-consuming and minimizes gold losses, and Hg is easily transported, used and inexpensive relative to the selling price of gold (Howard, 2010). Use of mercury in the gold extraction process is driven by two factors namely; the low education levels of the miners and the lack of requisite skills to operate efficient technologies (Saldarriaga-Isaza, Villegas-Palacio & Arango, 2013). There are further compounded by lack of credit facilities, minimal savings and distrustful attitude towards technologies. For instance, several incidents of human mercury poisoning were reported in Philippines and the results showed that the filtered surface water mercury levels were 2906µgL^{-1} way far above the recommended WHO levels of 1000 ng$L^{-1}$for a downstream distance of more than 14 Km, however, it appeared that the wider population in the basin has not been affected (Appleton *et al.*, 1999).

The ASM activities in Mozambique has resulted in the siltation of rivers with unchecked heavy metal pollution (Dondeyne *et al.*, 2009) while widespread use of mercury, in the gold amalgamation process, many non-miners in mining towns blame galamsey for recklessly polluting drinking water and other natural resources with earlier studies in Dumasi region indicating that the average mercury concentrations in ground and surface water were 165ngL^{-1} and 280ngL^{-1} respectively (Tschakert & Singha, 2007). More typical environmental impacts caused by ASM activities in Tanzania include diversion of rivers, water siltation, landscape degradation, deforestation and widespread mercury pollution (Kitula, 2006). According to Van Straaten (2000) tailings in the mining sites in Tanzania contain high proportions of As, Pb, Cu and Hg, however, the lateral dispersions of Hg concentration is about 260 Metres while vertical dispersion being less 20cm.

The concentration of mining operations has been a chief cause of both surface and groundwater pollution. Four main problems of water pollution have been identified in mining areas. These are chemical pollution of ground water and streams, siltation through increased sediment load, increased faecal matter and dewatering effects (Akabzaa and Darimani, 2001). Many ores contain pyrites and sulphur-containing inorganic compounds that can make controlling pH extremely difficult. Variations in pH in tailings dams or effluent streams may increase the solubility of metal cyanide complexes and thus create the potential for heavy metal contamination of the ground water, surface water, and soil (Muezzinoglu, 2003).

Land degradation caused by the gold mining is significant, chemical contamination from the gold extraction process imposes a double burden on the environment, with harmful health outcomes for mining communities and persons residing in close proximity to such activities (Yelpaala & Ali, 2005). Releases and failures of tailings dams have been documented across the globe. The majority of major mining- related environmental incidents worldwide have been the result of dam overtopping, breaching, geotechnical failure, or earthquake (Akcil, 2006). In the year 2000, the Aural gold mine in Romania experienced a dam failure that caused leaching of mine wastes into the Danube river system (Stenson, 2006). In Ecuador, ASGM is associated with degradation of water quality and aquatic ecosystems such that river Puyango systems has high concentration of toxic metals (mercury, cadmium, copper, manganese, lead, and arsenic) due to regular dumpings by highly mechanized miners (Miserendino *et al.*, 2013).

Anecdotal evidence in Ghana links the occurrence of this equipment to Chinese operators while in Tanzania; the technological know-how for the leaching plants has come primarily from Zimbabwe. Furthermore, it is estimated that there are more than 50 leaching plants all over Tanzania, many of which do not live up to the required safety standards (Fold *et al.,* 2014). Further the open mercury amalgamation roasting process releases mercury vapours into the atmosphere with studies indicating the presence of mercury in soot at a roof of a gold roasting house with concentration levels of 324mg/Kg and 104 mg/Kg in Katenter, Tanzania and Tafuna hills, Zimbabwe respectively and 62mg/Kg in a goldsmith shop in Tanzania (Van Straaten, 2000).

Mining activities and mining support companies discharge particulate matter into the ambient air. The grievances of the affected communities on air quality have been the airborne particulate matter, emissions of black smoke, noise and vibration. Airborne particulates of major concern within the mining area include respirable dust, sulphur dioxide, nitrogen dioxide, carbon monoxide and black smoke. The activities that produce this particulate matter include site clearance and road building, open-pit drilling and blasting, loading and haulage, vehicular movement, ore and waste rock handling as well as heap leach crushing by companies during heap leach processing. Others include fumes from the roasting of sulphide ores by assay laboratories and in refining processes (Akabzaa & Darimani, 2001).

The discharge of airborne particulate matter into the environment -principally minute dust particles of less than 10 microns poses health threats to the people within mining area. All fine dust at a high level of exposure has the potential to cause respiratory diseases and disorders and can exacerbate the condition of people with asthma and arthritis. Dust from gold mining operations has a high silica content which has been responsible for silicosis and silico-tuberculosis in the area (Akabzaa & Darimani, 2001).

Black smoke from fuel burning, fumes from the assay laboratories and ore roasting make up additional sources of airborne pollutants in the mining district. Black smoke also contained absorbed polyanomatite hydrocarbons (PAH) which are caranogenic with high concentration smoke when inhaled causing cancer diseases. There are cases where the values recorded for smoke exceeded the acceptable and tolerable levels of the EC, WHO and EPA. The uppermost value recorded was 207 gm^{-3}as against the tolerable levels of 100 $gm^{-3}$for the EC, 85 $gm^{-3}$for the WHO and 40 $gm^{-3}$for EPA-Ghana (Akabzaa and Darimani, 2001).

The sources of noise and vibration in the area comprise mobile equipment, air blasts and vibration from blasting and other machinery. The impact of high-pitched and other noises is known to include damage to the auditory system, cracks in buildings, stress and discomfort. Communities within the mining area have lodged a number of complaints on the noise aggravation which include terrify animals hindering their mating processes and also cause abortions, therefore adversely affecting the animal population (Akabzaa & Darimani, 2001).

2.7 Theoretical and Conceptual Framework

The study used two theories namely social capital theory and Sustainable livelihoods theory.

2.7.1 Social Capital theory

Social capital has been defined as the expectations of social interactions traded through interdependencies (Anderson *et al.,* 2007) as the norms which govern relationships; and as a function (Anderson *et al.,* 2007). From these definitions social capital acts as a catalyst within a system of relations and social belonging in which individuals are embedded (Barbieri, 2003). It is a catalyst because it facilitates relationships in order to gain access to resources and its presence encourages social interactions. Social capital theory determines networks of relationships as a valuable resource for conducting the entrepreneurial process and for potentially sourcing other resources (Nahapiet and Ghosal, 1998). Past research argues that high levels of social capital allow entrepreneurs to gain access to resource holders such as venture capitalists and market information providers.

Social capital theory is a concept that predicts higher associational activities inside a community which are able to foster a sense of civic engagement where cooperation, reciprocity and mutual trust are developed and used in order to solve collective action and asymmetric information problems (Andriani 2013).It is resource based in social relations who facilitate collective action and networks of association representing any group which gathers consistently for a common purpose**.** This theory was used to understand that in artisanal mining, organization contributes to individual's access to capital assets within various institutions and also information from the government. Social capital enhances accesses to capital assets which is vital in artisanal mining as noted by Lin (2001) that access to capital can make the individual better off in terms of wealth and well-being.

Social capital is one resource which is used alongside other resources such as their own skills and expertise (human capital), tools (physical capital), or money (economic capital). This theory was used to understand how to increase accessibility to capital assets thus a potential solution for marginalized artisanal miners transforming artisanal gold mining communities in Nandi and west Pokot. It was explained by (Narayan and Woolcock, 2000) that strong in-group connections help the members to deal with socio-economic problems such as providing loan to somebody with very poor or inexistent material collateral. Social capital theory helped to understand that artisanal gold miners can be changed to look beyond themselves and engage in supportive actions through structural institutions, networks and relationships which will make them more productive as they work together than individually. Social capital or groupings will help in providing support and lobby against exploitation in the pricing of gold by the middle men by exploring better value chain whereby the members can reach their full potential.

2.7.2 Sustainable Livelihood Framework

Sustainable livelihoods framework was developed on the basis of longstanding cooperation between the Department for International Development (DFID, 1999) and Institute for Development Studies in Sussex, England (Chambers and Conway, 1992; Scoones, 1998). Sustainable Livelihood Framework was advanced by the Department for

International Development (DFID), the British state development cooperation agency and emphasized that poor people build their livelihood strategies on a set of vital resources called capitals, usually arranged in the form pentagon (de Haan 2000, 344). This theory helped explain the different capitals that are the fundamental resources to artisanal gold mining.

Scoones (1998) suggested that there are five principal capital assets that are important to livelihood and these includes: human, social, physical, natural and financial. Natural capital include**s** natural resource stocks (soil, water, air, genetic resources etc.) and environmental services (hydrological cycle, carbon sinks etc). Human capital are skills, knowledge, labour(includes good health and physical capability). Economic or financial capital are capital base (cash, credit/debt, savings, and other economic assets) Social capital are social resources (networks, social claims, social relations, affiliations, associations). Physical capital includes Infrastructure (buildings & roads), production equipment and technologies).

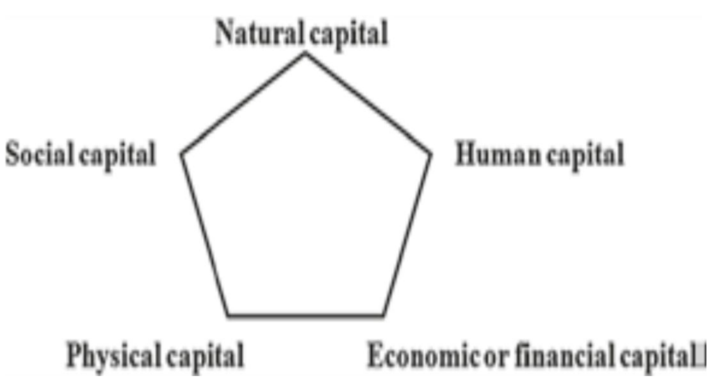


Figure 2.1: The Five Capitals of Sustainable Livelihood

Source: (Adapted from Scoones, 1998)

According to Bebbington (1999), People's assets are not merely means through which they make a living: they also give meaning to the person's world. Capital is therefore a means by which people can "engage more fruitfully and meaningfully with the world, and most importantly the capability to change the world". Thus they are not just 'things' that go into a production process but also a basis for power to act and ultimately to bring about change in society. The study further suggested that these capitals take on three distinct roles:

• Vehicles for instrumental action (making a living)

• hermeneutic action (making living meaningful)

• emancipatory action (challenging the structures under which one makes a living).

The livelihood theory helped to understand that capital asset may not necessarily be owned by a household or an individual for it to be an important contributor to livelihood but as long as the household has access to it then it will help. This theory helped to understand that Improvement of livelihood sustainability such as artisanal gold mining is by making capital more accessible thus enhancing the contributions that these capitals can make to the households. There was need to know and understand access levels of these capital assets in artisanal gold mining so that interventions can be put in place to enhance livelihoods and their sustainability. Capitals assets can be held in private or as common property, rented, borrowed, grabbed, stolen or conquered but what matters is that the poor have access to them when needed and use them in practice. "Access is the process that brings stakeholders from endowment to entitlement" (Geiser *et al.*, 2011a).

This theory helped to understand that it is not necessary for the artisanal gold mining communities to replace their current livelihood but improve their sustainability. It is also important to note that a livelihood does not refer to one activity but includes complex, contextual, diverse and dynamic strategies developed by households to meet their needs. These assets are embedded in structures and governed by institutions and constraints in these structures would prevent the poor from organizing effective livelihood strategies. This was considered fundamental because it is an important part of the poverty alleviation.

Sustainable Livelihoods framework as utilized was as an analytical structure for understanding complexity of artisanal gold mining and identifying where interventions can best be made. The framework pre-supposes that local communities pursue a livelihood outcome by drawing on a range of assets to pursue artisanal mining activities. Access to assets determines livelihood opportunities and the way in which these can be converted into outcomes (Farrington *et al.,* 1999).

The two theories were used to strengthen the study and enhanced the understanding on the dynamics in artisanal gold mining in west Pokot and Nandi County.

2.8 Conceptual Framework

The researcher conceptualized the impacts of artisanal gold mining on community livelihoods and the environment as shown in Figure 2.2. The conceptual framework used for the study shows the impacts on community livelihoods and the environment due to access levels to capital assets, unstructured value chain of gold and organizational dynamics in artisanal gold mining. Access to capital asset in artisanal gold mining determines the technology and processes used in mining. Unstructured value chain of gold brings about poor marketing channels and low prices of the final product leading to minimal earnings from their hard work hence no much positive change to their livelihoods.

Low access levels to capital assets leads to technologies which have low recovery rate and productivity which will have a bearing on the impacts to community livelihoods and the environment. It leads to use of poor technologies with its end result being degradation of the environment and destruction of agricultural land. The negative environmental impacts include use of mercury and presence of heavy metals at the mining sites which through leaching will contaminate water and soil pollution. Spillages of mercury which is highly used in Nandi County into the nearby water bodies cause pollution destroying water bodies and aquatic life while exposures of such chemicals will be harmful to human health. Use of explosives to blast hard rock's under the tunnels lead to air and noise pollution that affect the people within the surrounding areas. Impacts on these natural and environmental resources to a larger extent influence the quality of life of the people in the community in one way or the other.

The intervening variables in the study was the government policies in artisanal mining such has formalization of the miners, institutional functions for example implementing , enforcement of the regulations and laws, ICT use in artisanal mining for information flow on prices and government requirements, participation of NGOs in areas of incentives to the sector conceptualized in Figure 2.2

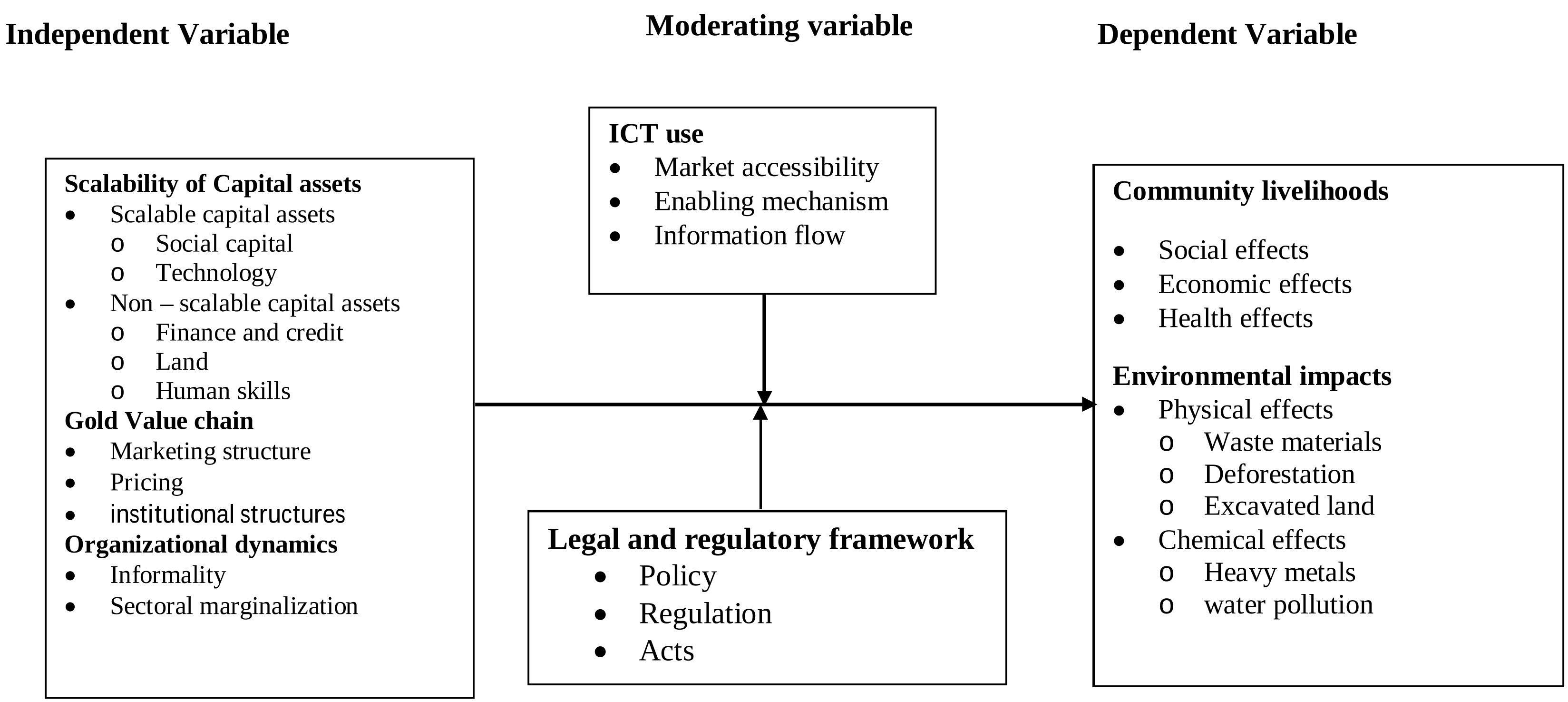


Figure 2.2: Conceptual Framework

Source: (Author, 2016)

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter presents the research design, study area, study population along with the sample size and sampling procedures, data collection, instruments used to collect. The next section discusses the reliability and validity of the study instruments, laboratory analysis for heavy metals, data analysis and ethical issues.

3.2 Research Design

A research design is a basic plan that made it possible and valid to draw conclusions. The study employed a mixed method designs of descriptive research design and experiment research design. Descriptive research design portrays an accurate profile of persons, events or situations. It involved collections of quantitative information that was tabulated along a continuum in numerical form as scores on a test. The use of description in the study provided an explanation to phenomenon of interest (Saunders *et al.*, 2009). This study was carried out using the sociological survey undertaken in two counties in North rift region. This design was considered because it was possible to collect data from wider respondents. Experimental research design involved collection of samples from the study are and taken to laboratory for analysis. The design allowed analysis of heavy metals in the tailings and sediments within the mining sites to determine the concentration level.

Through literature review and public records the researcher identified Nandi and West Pokot counties as areas were artisanal gold mining was taking place in North rift region.

In Nandi county artisanal gold mining is taking place in two wards namely Kapsaos and Chemase while in West Pokot it is taking place along river Murruny passing through sekker and wewiei wards. After identifying two wards in each county where artisanal gold mining was taking place, random sampling was carried out to select one ward in each county for the study. Kapsaos was randomly selected in Nandi County and sekker in West Pokot for the study.

3.3 Location of the Study

3.3.1 Geographical Scope of the West Pokot County

The county has four constituencies, 13 divisions, 61 locations and 222 sub locations. It covers an area of 9,169.4 Km^2.The county has four constituencies namely: Kapenguria, Kacheliba, Sigor and Pokot South and a total of twenty county wards. Kapenguria and Kacheliba constituencies have six wards, while Sigor and Pokot South have four wards each (ROK, 2002).

3.3.2 Physical and Topographic Features

The county is characterized by a variety of topographic features. On the Northern and North Eastern parts are the dry plains, with an altitude of less than 900 m above sea level. On the Southeastern part are Cherangani Hills with an altitude of 3,370 m above sea level. Landscapes associated with this range of altitude include spectacular escarpments of more than700 m. The high altitude areas have high agricultural potentials while medium altitude areas lie between 1,500 m and 2,100 m above sea level and receive low rainfall in addition to being predominantly pastoral land. The low altitude areas include

Alale, Kacheliba, Kongelai, Masol and parts of Sigor. These areas are prone to soil erosion due to flash floods (ROK, 2002).

The main forests in the county are found in Cherangani Hills. The gazetted forest, which forms part of the Cherangani Hills in Lelan, covers an area of 20,857 ha. The un-gazetted forest covers 15,719 ha and consists of rain forests blocks scattered all over the county. These are natural forests dominated by tree species like cedar (*Juniperous procera*) and bamboo (*Aredinaria alpina*). Plantation forests cover an area of 662 ha of which approximately 34 ha are indigenous and the rest exotic (ROK, 2002).

The main rivers in the county are Suam, Kerio, Weiwei and Muruny. Cherangani Hills are the main source of Muruny and Weiwei rivers, while Mt Elgon is the main source of river Suam. River Muruny, Kerio and Weiwei drain northwards into Lake Turkana, while other small rivers join and drain into River Nzoia which in turn drains into Lake Victoria. River Suam drains into Turkwel dam that generates hydro-electric power (ROK, 2002).

The county has a bimodal type of rainfall. The long rains fall between April and August while the short rains fall between October and February. There is, however, great variation in the total amount and distribution of the rainfall received in the county. The lowlands receive 600 mm per annum while the highlands receive 1,600 mm per annum.
The county also experiences great variations in temperature with the lowlands experiencing temperatures of up to 30^0 C and the highlands experiencing moderate temperatures of 15^0 C. These high temperatures in the lowlands cause high evapo-

transpiration which is un-favourable for crop production. The high altitude areas with moderate temperatures experience high rainfall and low evapo-transpiration hence suitable for crop production (ROK, 2002).

The County has limited gold deposits along river Muruny, Seker and parts of Alale, limestone deposits in Sebit, Ortum, Muino and parts of Alale. However, the deposits have not been commercially exploited. Sand harvesting is carried out in most parts of the county but is mainly in Kongelai Division (ROK, 2002).

The county mineral potentials remain untapped. The following minerals are unexploited: limestone, gold, and ruby. Massive limestone deposits are found in Sebit, Ortum, Muino, and Alale. There is a proposed cement industry to be established in Sebit to fully exploit the limestone deposits. In addition to these potentials, the County has prospect of oil reserve in parts of Pokot North and Central Pokot. All these minerals in the county have the potential of generating additional revenue to the county government (ROK, 2002).

3.3.3 Geographical Scope of Nandi County

Nandi County is in North Rift of Kenya, occupying an area of 2,884.4 Km^2. The County is bordered by Kakamega County to the west, Uasin Gishu County to the North East, Kericho County to the South East corner, Kisumu County to the South and Vihiga County to the South West. Geographically, the unique jug-shaped structure of Nandi County is bound by the Equator to the south and extends northwards to latitude $0^0 34'$N.

The Western boundary extends to Longitude $34^0$45'E, while the Eastern boundary reaches Longitude $35^0$25'E (ROK, 2002).

3.3.4 Physical and Topographic features

The physiographic outlook of Nandi County is composed of Four types of land terrain and these are:

Mountainous: The land generally has rather steep slopes especially on parts of Meteitei and Tinderet areas to the south-east; Kemeloi, Bonjoge, Kaptumek, Kapkures, Kapkerer areas to the South; and Kamwega and Soimining to the Northwest. This type of topography has made transport network very difficult to establish. This factor alone has created a drawback in provision of development facilities in the affected regions.

Steep Slopes: This includes parts of Chepterwai, KipkarenSalient, Kabiemit, Ndalat, Sarora and Kabiyet areas to the North and Kapkangani areas to the West. Afforestation is required on the hills. Development of the main economic activities has been affected by the factors noted for the mountainous regions.

Rolling or Hilly Land: These include parts of Nandi Hills, Kaptel, Kaptumo and Kobujoi areas. Farming and other economic activities are well developed and mostly mechanized. This is attributed to the ease of communication both on the roads and on the farms.

Gentle to Moderate Slopes; this covers parts of Kilibwoni, Kaplamai, Kosirai, Mutwot, Lelmokwo and Itigo areas. The topography of this region has influenced the type and scale of economic activities in the region just as in other areas. Farming productivity is high due to high soil productivity and less capital injection towards soil conservation activities (ROK, 2002).

Ecological Conditions

The variation between the ecological zones within the county is insignificant. Therefore, the altitude and rainfall are the main determinants of the agriculture activity in any given zone of the county. The other determinants include the soils and topography. The wind pattern is of no consequence in the County although strong winds are experienced at the beginning of the long rains. These are known to cause damage to crops or other economic activities. The effect of evapo-transpiration is felt in the dry months of December and January.Much of the County consists of forest, derived grasslands, shrubs and scrubland. The natural grassland consists of the Kikuyu grass species suitable for cattle grazing (ROK, 2002).

Forest area has gradually reduced from about 16 percent of the total county land area to around 12 percent. The North and South Nandi Forest Reserves are at an altitude below 1,900 meters above sea level, being a major contrast to North Tinderet Forest Reserve which lies between 2,300 meters to 2,500 meters above sea level.

The Nandi Forest is an extension of the tropical Kakamega forest characterized by high rainfall and diverse species of trees. The forests are composed of mixed indigenous hardwoods, besides 2,635.8 Ha of exotic plantations at Kimondi and Serengonik forest stations. The total boundary length of forest in the county is about 363.8km up from 205.81km.

The medium potential areas are covered by shrubs and bushes. These grasslands cover mainly the Eastern plateau parts, and portions lying below the scarp on Nyando plains at 1,300m.Wood, bushes and savanna grassland are found in Songhor and extreme northern areas. Some land contains swamps, rocks and hills (ROK, 2002).

Climatic Conditions

The hilly and undulating topographical features of Nandi County coincide with a spatial distribution of ecological zones that define the agricultural and overall economic development potential of the area. The Northern parts receive rainfall ranging from 1,300mm to 1,600mm per annum. The Southern half is affected by the lake basin atmospheric conditions receiving as high as 2,000mm per annum.

Generally, the County receives an average rainfall of about 1200mm to 2000mm per annum. The long rains start in early March and continue up to end of June while short rains start in mid-September and end in November. Only rarely is there a month without some rainfall. The dry spell is usually experienced from end of December to mid-March. The lowest rainfall is experienced in the Eastern and North eastern parts of the county. The highest is recorded in the Kobujoi-Tindinyo area in Aldai Division. Across Nandi, the highest rains are experienced in Kaptumo in Nandi South, Nandi Hills and Kapsabet alongside Kobujoi.

The rainfall distribution and intensity has a direct relationship to economic activities in the county. Areas with 1500mm (and above) of rainfall per annum form extended Agro-Ecological zone for potential tea cultivation. The relatively drier areas to the East and Northeast which receive an average rainfall of 1200mm per annum are suitable for maize growing, sugarcane and coffee. Dairy activity is carried out throughout the entire county. Due to the reliability of the rainfall in the entire county, Nandi has a high potential to produce various agricultural crops ranging from tree crops, horticultural crops, pyrethrum, cereals, and fruit trees.

Most parts of the County experience mean temperatures between 18^0C-22^0C during the rainy season, but the part adjacent to the Nyando Escarpment at 1,300m above sea level experience temperatures as high as 26^0C. During the dry months of December and January the temperatures are as high as 23^0C and during the cold spell of July and August the night temperatures are as low as 14^0C. The County in general has a moderate to warm climate with no cold and hot extremes throughout the year (ROK, 2002).

3.4 Population of the Study

The study population was composed of individuals in Kapsaos ward, Nandi County and Sekker ward in West Pokot County as illustrated in Table 3.1 below. The population census of 2009 showed that there were 929 households with a projected increase of 10% as at 2015.The projected figure was 1021 households in the study area and their distribution are illustrated in the table 3.1 below. It was assumed that mining activities are more likely to affect the livelihoods of respondents, their households and their environment.

Table 3.1: Population statistics

County	Ward	Location	Number of households	Projected increase as 2015 (10%)
Nandi	Kapsaos	Kapsaos	199	219
		Kaborogin	163	179
West Pokot	Sekker	Sostin	385	423
		Takar	182	200
			929	1021

Source: (KNBS, 2010)

3.4.1 Population Size and Composition of Nandi County

The County has a population of 813,803 comprising of 406,907 males and 406,896 females (as per the 2012 projections). The county's inter-censual growth rate stands at 3.1 percent which is slightly higher than the national growth rate of 3.0 percent. As per the 2012 projections the dependent population constituted a total of 381,583 persons. On the other hand, the labour force constituted 418,823 persons (KNBS, 2010).

There is a disproportionately higher concentration of the population between the ages of 0-9 years (31.7 percent) which explains the high population growth rate (KNBS, 2009).

As per the 2012 projections the dependent population constituted a total of 381,583 persons. On the other hand, the labour force constituted 418,823 persons. This translated to a dependency ratio of about 91:100 which meant that the dependency ratio stood at 91 percent. The reproductive age population is high which explains the high inter-censual growth rate of 3.1 percent (KNBS, 2010).

3.4.2 Population Size and Composition of West Pokot County

The population of the county is estimated at 631,231 persons as per 2013 projections. This population consists of 313,746 males and 317,484 females giving sex ratio of 100:101. The county inter-censal growth rate is 5.2 percent which is higher as compared with the national average of 3.0 percent. If current trends prevail, the county population is expected to grow to 700,414 and 771,180 in 2015 and 2017 respectively. It is also worth noting that the youth (aged 15-34 years), who's population estimate is 196,830 forms 31 percent of the County population. The proportion of the population aged below 14 years and above 64 years comprises about 55 percent. These age groups are dependants and their proportion is higher than the population in the labour force (15-64 years) which constitutes 45 percent. These dependants are therefore likely to exert pressure on the workforce to provide for their basic needs (KNBS, 2010).

Population Density and Distribution

Population distribution in the county is influenced by climatic conditions and socio-economic development. Urban areas and high potential agricultural areas have high population distribution and density. The population density for the county is expected to increase from 69 in 2013 to 76 and 85 persons per square km in 2015 and 2017 due to the high population growth. Population density is high in Pokot south estimated at 127 persons per km^2 while Kacheliba is lowest with a density of 49 persons per km^2 as per 2013 projections. The high population density in Pokot South is due to high agricultural potential of the area (KNBS, 2010).

3.5 Sampling Procedure and Sample Size

3.5.1 Sampling Procedure

After identifying one ward in each county the researcher through random sampling selected two locations in each wards for the study. They are namely Kapsaos and Kaborogin in Nandi County and in West Pokot are Sostin and Takar locations for the study. The two locations in each ward were reflective of artisanal gold mining and were selected for the study as clusters. The selected locations both in Nandi and West Pokot counties were taken to be clusters and samples of household for study were picked from them. Samples were calculated proportionately according to each clusters population. A single number was assigned to each household using county statistics records for each cluster and a table of random numbers was then used to select the household for the interview. Households were selected at random to ensure randomization of the selection of respondents for the interview (Kirubi *et al.,* 2000).The respondent in each household was the father and in-case of his absence the mother would respond. If both were absent any other mature person in the household would respond.

Sampling of tailings in Nandi County

Reconnaissance visits was done in active artisanal gold mining sites with ore processing activities taking place in Nandi County in order to establish the dumping sites for tailings. From the tailing disposal site, sample was randomly collected. The collected sample was put in a polyethylene container which had been rinsed with nitric acid, put in a cool box and delivered to the University of Eldoret laboratory for Analysis. Each sample was labelled with a reference for record purpose.

Sampling of sentiments in West Pokot

Reconnaissance visits was carried in order to establish the spots were artisanal gold mining were taking place along River Murruny in West Pokot. Once the researcher had identified the sites were artisanal gold mining was taking place sample of sentiments were collected. Samples of sentiments collected were put into polyethylene container which had been rinsed with nitric acid, put in a cool box and delivered to the University of Eldoret laboratory for Analysis. Each sample was labelled with a reference for record purposes.

3.5.2 Sample size

The sample size was determined through the use of the modified Cochran formula. For large, populations, Cochran's formula is used to yield a representative sample for proportions (Barlett, Kotrlik & Higgins, 2001).

$$n_0 = \frac{Z^2pq}{e^2}$$

$$n_0 = \frac{1.96^2(0.5)(0.5)}{0.05^2}$$

n_0 = 384 individuals

where n_0 is the sample size, Z^2 is the abscissa of the normal curve that cuts o□ an area α at the tails (1 – α equals the desired confidence level, 95%) 1, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1-p. However, since this sample size exceeds 5% of the population (1021×0.05 = 51), Cochran's (year) correction formula was used to calculate the final sample size.

$$n = \frac{(n)}{(1 + n/\text{Population})} = \frac{(384)}{(1 + 384/1021)} = 279$$

The final sample size was 279 elements which were distributed proportionately as per the number of households in each cluster as shown in Table 3.2

Table 3.2: Sample size proportion

County	Division	Location	Number of individuals	Proportion	Sample size proportion
Nandi	Kapsaos	Kapsaos	219	0.214	60
		Kaborogin	179	0.175	49
West Pokot	Sekker	Sostin	423	0.414	115
		Takar	200	0.195	55
			1021	1	279

Source: (KNBS, 2010)

3.6 Instrumentation

The study used two data sources namely; primary data and secondary data. The primary data sources included the questionnaires, interviews schedules, key informants' guides, focus group's guides, non – participant observations and photography.

Structured Questionnaires

A structured questionnaire was the major tool for collection of primary data during the study. The questionnaires which were both open ended and closed-ended type were administered by research enumerators to avoid apathy associated with self-administered questionnaires to the sampled households in both Nandi and West Pokot Counties. The instrument was preferred because the researcher was able to obtain responses from a large cohort within a short time period. Further, this form of instrument allowed for statistical analysis to be carried describing the phenomena of interest.

Plate 1: Research interview in river Murruny, West Pokot County (a) and Research interview in Nandi County (b)

Source: (Author, 2017)

The survey tool (questionnaire) was used to collect information such as individual characteristics such as the age of respondents, education levels, occupation, gender, and characteristic feature of the mining activity in the locality, the accessibility of mining resources, the ASM organizational dynamics and the gold value chain. Data obtained through questionnaire were fundamental for the study being quantitative and analysed statistically. The limitation of the use of questionnaires was time consuming which was taken care by use of two research enumerators.

Interviews of Key Informants

Interview schedules were used to interview respondents and it allowed the researcher to control the content and sequencing of the questions to be asked. Interview of key informants was preferred because it gives liberty to the researcher to ask specific questions depending on the specific theme. It further allowed asking additional questions that explore research questions and objectives given the nature of events within that particular context.

The key informants in this study included officials of the Nandi County government, the National Environmental Management Authority, the Ministry of Lands, Kenya Forestry Service and ministry of mining, member of the county assembly (MCA), chief, assistant chief, religious leaders and political leaders and opinion leaders for relevant information. These individuals were purposively selected based on their knowledge on mining activities, regulations, their understanding of the area in terms of social and economic issues and land ownership. Data collected from key informants gave in depth information on how artisanal mining activities were carried out and suggested measure which can be put in place to improve the activities of artisanal gold mining. This method had limitations in that it takes longer durations of time, does not allow for comparison or responses within groups and lacked quantification. To mitigate this, the researcher used transformed qualitative data into quantitative data through tallying to get frequencies.

Focus Group Discussion

This method involved discussions in social units with more than one individual or a cohort of individuals sharing similar diagnostic conditions. Focus group discussions were carried out in each location of the study and organized in youth, women and elders' groups. The focus group discussion was used in the study to explore the topic, experience of the artisanal miners collectively on the issue of artisanal organizational dynamics and gold value chain activities. Through, this method the researcher was able to observe group dynamics, and the symbolic exchanges among the group members. The focus group discussion set the tone for a naturalistic inquiry and is deductive in nature and aids in checking for the reliability of the information collected which helped in improving the quality of the data collected.

Non-participant Observation

Non- participant observation is one of unobtrusive methodology which involves the observation of objects and environment bearing the phenomenon of interest (Depoy & Gitlin, 2011). The study utilized non – participant observation on the mining sites. Observation occurred within the natural context, and involved the researcher situating himself in the ASM mining areas and observing what was presently occurring. The method was used to obtain an understanding of the natural context with which ASM occurs.

The method gave a chance to the researcher to assess the effects of mining on the environment and conditions of both the mining sites. Non- participant method gave more additional information on how artisanal mining is carried out and cross checked on the information collected through questionnaire. The advantage of the observation method was that the researcher was able to collect data directly from the site when mining was taking place with the use of mercury depicting what was happening currently on the ground. This method was used because subjective bias was eliminated and was independent of the respondent's willingness to respond.

Photography

The researcher was able to confirm through this method the destruction of the environment due to artisanal mining activities such as abandoned holes and shafts which are dangerous to both human and their domestic animals. Photography confirmed waste rocks and hips of tailings within the mining site, workers handling of mercury and carrying out other activities of mining without protective ware.

Secondary data

Secondary data sources included review of relevant journals, books, magazines reports prepared by research scholars at Kabarak University library, University of Eldoret library, Moi University and internet. More information was gathered from public records within the department of geology and mines and NEMA. The purpose of secondary data was to collect documented information from research or observations made by other scholars.

3.6.1 Pilot study

Questionnaires were pretested before the actual field survey and the Information gathered during this pre-trial were used to modify the survey tools. This pilot testing was necessary to avoid raising sensitive issues that may have resulted to respondents giving biased responses. It was carried out on the questionnaire with the purpose to refine so as to reduce errors during data collection, coding, recording and processing procedures. A pilot study was carried on one of the clusters in both Nandi and West Pokot counties in order to obtain assess of the questions' validity) and the reliability of the data to be collected.

3.6.2 Validity of the instrument

Validity addressed the critical issue of the relationship between a concept and its measurement. It was also concerned with the issue of the authenticity of the cause-and-effect relationships (internal validity), and their generalizability to the external environment (external validity). Validity tests are grouped under several broad headings that include content validity and construct validity.

Content validity was obtained through the specification of the domain of the concept through a thorough literature search and the submission of the constructed items or draft for a review by a university panel (Depoy & Gitlin, 2011) while factor analysis was used to affirm construct validity (Sekaran & Bougie, 2010; Garson, 2013;Cooper & Schindler, 2014).

According to Hair *et al.* (2010), factor analysis is a multivariate method used to recognize common underlying variables called factors within a larger set of measures and testifies to how well the results obtained from the use of the measure fit the theories around which the test was designed. The study used factor analysis to affirm construct validity. The rules of thumb for upholding construct validity was standardized loading estimates of 0.5 or ideally or 0.7 higher for construct validity while the average variance explained was 0.5 or greater to suggest adequate convergent validity (Hair *et al.*, 2010; Garson, 2013).

3.6.3 Reliability of the instrument

Reliability is an indication of the stability and consistency with which the instrument measures the concept and helps to assess the goodness of a measure (Sekaran & Bougie, 2010). The study used Cronbach's alpha coefficient with a minimum cut off criteria of 0.70 which is consider adequate for explanatory purposes as indicated in Table 3.3 (Garson, 2013).

Table 3.3: Reliability Coefficients after Piloting

Variables	N of cases	No of items	Reliability Coefficient
Capital Asset accessibility	16	6	0.7760
ASM gold value chain	16	8	0.8740
ICT use	16	8	0.9660
Regulatory aspects	16	7	0.8550
Socio-economic effects	16	6	0.6640
Health effects	16	6	0.7940

The Cronbach's reliability coefficients after piloting show that the instruments were valid for study in that all the study variables had an alpha coefficient of > 0.700 surpassing the recommended cut-off criteria of 0.7.

3.7 Data Collection Procedure

Before data collection, the researcher used introduction letter from Kabarak University to apply for the research permit from the Ministry of Education through the National commission for Science, Technology and innovation(NACOSTI). The permit was presented to county chief officers, both in Nandi and West Pokot Counties. The researcher then proceeded to the mining sites at Kaptumo division Nandi South district and along river Murruny in West Pokot for data collection. With the aid of trained research assistants, the researcher administered the research instruments to the respondents. After data collection, cleaning was done to improve the quality of the responses.

3.8 Data Analysis

3.8.1 Qualitative data analysis

Qualitative data analysis was done by sorting, grouping into three main types of processes: summarizing (condensation) of meanings; categorization (grouping) of meanings and structuring (ordering) of meanings using narrative. Once the data was transcribed, summarized, categorized and structured, qualitative data was analysed by combination of deductive and inductive approaches. Deductive-based analytical techniques used include pattern matching and explanation building while inductive based analytical techniques encompass template analysis and narrative analysis (Saunders *et al.*, 2009).

3.8.2 Quantitative data analysis

Data preparation was carried out in a number of significant steps which included data editing, coding and entry using statistical package for the social sciences (SPSS). Data was converted from raw form to reduced and classified forms that are more appropriate for analysis (Cooper & Schindler, 2014). Data was analysed through descriptive and inferential statistics.

3.8.3 Descriptive statistics

Descriptive analysis was the elementary transformation of data in the way that described the basic characteristics such as central tendency, distribution, and variability. Nominal and ordinal scaled data was analysed by the use of statistical package for the social sciences (SPSS) and draw frequency table proportion (percentages) mode or frequency distribution. Interval and ratio scaled data was analysed through the use of measures of central tendencies for instance means and standard deviation. The findings were presented in form of tables and charts.

3.8.4 Diagnostic tests

Diagnostic test is a requirement before any classical regression analysis is conducted. These tests are based on the assumptions of the regression analysis which includes: linear relationship between parameters, random sampling was used, no perfect collinearity, the relationship is specified and data is normally distributed and homoscedastic (Wooldridge, 2013).

The study utilized both graphical methods and Shapiro-Wilk test for normality to assess the actual degree of departure from normality (Hair *et al.*, 2010), in that Shapiro-Wilk's is recommended for small and medium samples size n = 2000 (Garson, 2013). The decision criterion used to access assess departures from normality were 'W is significantly smaller than 1, the normality assumption is not met with W = 1 showing perfect normal distribution. In the case of non-normality from the Shapiro-Wilk test, reference was made to graphical plots.

The test for homoscedasticity for two metric variables is best examined graphically or through the use of Breusch-Pagan-Godfrey test. A finding of significance means the null hypothesis is rejected and homoscedasticity cannot be assumed. Heteroscadastic variables can be remedied through data transformation similar to those used to achieve normality or be dealt with through the use of weighted least squares regression in a linear regression context (Garson, 2013).

Two techniques were used concurrently to access incidence of multicollinearity; tolerance and variance inflation factor. However, variance inflation factor (VIF) was used in lieu of tolerance with the rule of thumb is that VIF>10 (Sekaran & Bougie, 2010; Saunders *et al.*, 2009) when multicollinearity is a problem. In cases of multicollinearity, the variable in question was eliminated from regression analysis.

3.8.5 Inferential statistics

χ^2 - test

It is one of the basic tests for statistical significance that is particularly appropriate for testing hypotheses about frequencies arranged in a frequency or contingency table and it shows the relationship between two categorical variables. The chi-squared statistic was used to test whether there were significant differences between the different groups.

Factor Analysis

Factor analysis is a multivariate method used to recognize common underlying variables called factors within a larger set of measures (Hair *et al.*, 2010), it has four steps in the factor analysis technique. The first step involved evaluating the suitability of the data for structure detection using Kaiser-Meyer-Olkin or KMO and Bartlett's tests of sphericity (Pallant, 2005). The KMO test is based on an index that compares correlation and partial correlation coefficients to measure the adequacy of sampling and takes values between 0 and 1. A high value (close to 1) with 0.05 significance level indicates that factor analysis may be suitable for the data.

The second step involved the determination of the factor extraction method to be used. The study utilized principal component analysis as a way to confirm a proposition/theory and/or build models. The third step involved the selection of the number of factors retained, which used latent root criterion where only the factors having latent roots technique or Eigen value greater than 1 were considered significant and all factors with Eigen value less than 1 are considered insignificant. The fourth step involved the rotation method that maximizes the relationship between variables and factor. Varimax rotated solution was used as it is easy to identify each variable with a single factor (Garson, 2013).

T-test analysis

An independent samples t-test checks for any significant differences in the means for two groups from Nandi and West Pokot Counties in the variable of interest and is appropriate when the researcher had a single interval dependent variable and a dichotomous independent variable.

Pearson's Correlation analysis

A correlation coefficient is a statistical measure of co-variation, or association between two variables which indicates both the magnitude of the linear relationship and the direction of that relationship. The study utilized the bivariate correlation which test for the relationship between the independent and dependent variables while holding the other effects constant (Coopers & Schindler, 2014).

Multiple regression analysis

Multiple regression analysis is a general statistical technique used to analyse the relationship between a single dependent variable and several independent variables. In order to reduce reliance on a single item or variable, the study used a scale or an index composed of multiple variables as the sole representative of a concept (Garson, 2013).Though, there is no single best method (either sequential search, stepwise or forward and backward elimination techniques), prudence calls for the employment of a combination of approaches to capitalize on the strengths of each to reflect the theoretical basis (Hair *et al,* 2010).

3.8.6 Model specification

Direct relationship

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon, \quad (3.1)$$

Where; β_1, β_2, β_3 and β_4 is the coefficients for the corresponding **Xi** and are considered to be the overall effect of the independent variable on Y; β_0, is the intercept for the linear equation and ε is error term that accounts for the variability in Y that cannot be explained by the linear effect of the predictor variables.

Where: Y= Socio-economic effects

X_1= Non-scalable capital assets

X_2= Scalable capital assets

X_3= Organizational dynamics

X_4= ASM gold value chain

3.8.7 Laboratory analysis for selected heavy metals

. Samples were collected at the mining sites for tailings and sediments to determine the concentration levels of selected heavy metals. They were taken to University of Eldoret laboratories to analysis for Iron (Fe), Zinc (Zn), Lead (Pb), Cadmium (Cd) and chromium (Cr) using Atomic Absorption spectroscopy (AAS).

Laboratory methods analysis and Procedure

The samples were first shaken well and a volume of 50ml was pippeted into a conical flask followed by adding 5ml of nitric acid.it was then digested to almost dryness on a hot plate. The samples were filtered using 541 whatman filter papers and washed using warm water. The filtrate volume was made to 50 ml using distilled water. The sample was ready to be aspirated by atomic absorption spectrometer.

The analysis of metals present in the samples was done using Atomic Absorption spectroscopy (AAS). The instruments model is Varian spectrAA-200. AAS is simple, sensitive and selective and has the advantage of being a fast method of analysis (Katz, 1984). This technique was introduced for analytical purpose by Walsh and Alleemade, Mihaz in the year 1956 under the designation Atomic absorption spectroscopy (Nordberg, 2007). It is found to be superior to other techniques as it can be used to determine 50-60 elements from trace to large quantities. It involves use of a flame to convert the sample into free atoms of the element being analysed. A beam of monochromatic radiation is passed through these atoms from a hallow cathode lamp source of a wavelength specific to each element. The technique was based on absorption of defined quantity of energy from electromagnetic radiation produced by deuterium lamp, which causes the excitation of electrons of atoms of element into a higher energy level (excited state). The amount of energy absorbed had a specific wavelength which was a characteristic to one particular element. The amount of energy absorbed was proportional to the number of atoms of element excited. Therefore, the energy of a specific wavelength was absorbed by the atoms of element; there was decrease in the intensity of the radiation. The intensity of the absorbed energy (radiation) was proportional to the concentration of element in the sample. Therefore, AAS was used in determining the concentration of the element in the sample by measuring the absorbance (optical density) of the radiation.

Absorbance (denoted by A) is expressed in terms of the incident and transmitted intensities of the radiation according to the following equation:

$$A = -\text{Log}\ I_t / I_o$$

Where; I_t = Intensity of transmitted radiation after passing through the sample cell

I_o = Intensity of the incident radiation before the entrance to the sample cell.

A = Absorbance.

According to Beer-Lambert Law, Absorbance is directly proportional to the concentration of the absorbing element according to the following equation:

$$\text{Absorbance} = \varepsilon.\ c.\ l$$

Where, c = Concentration of the element in the sample

L = Path length of the sample cell

ε = proportionality constant called molar absorptivity.

The radiation intensities without the sample (I_o) and the intensity after passing through the sample (I_t) were measured using a detector, and the negative logarithms of the ratio between the two values of intensities (absorbance) were converted by logarithmic amplifier into the concentration of the element in the sample using the Beer-Lambered Law shown above. The concentration measurement of the element was determined from a calibration curve generated by running several samples of standard element of known concentration at the same conditions as the unknown. The calibration curve is a graph showing absorbance against concentration of the standard element as shown in figure 3.3.

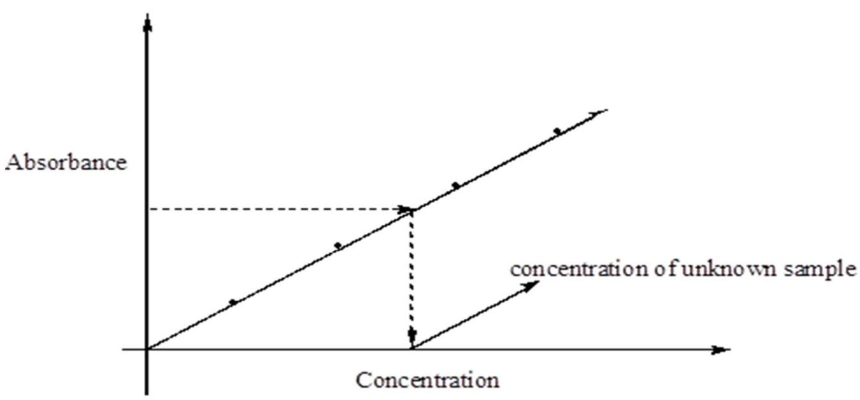


Figure 3.3: Graph of Absorbance Verses Concentration

The sample of the unknown element is fed into the instrument and the concentration of the unknown element is displayed on the calibration curve as shown in the graph (Figure 3.3)

3.9 Ethical considerations

Due attention was paid to ethical issues and confidentiality aspects in relation to the respondents. The researcher took his own identification as an important ethical consideration. It was important to identify as a researcher to the respondents and the reason for the research. A full disclosure of all the activities concerning the study was provided to the respondents and the authorities; this included the study intention which is only for learning purposes. Further the researcher took ethical issues into consideration by ensuring that that those who participated in the study did so voluntarily. Regardless of their volunteer the researcher ensured that people being studied are never injured in any way and this was done by not revealing information that would embarrass them and endanger their life and their work. The respondents were assured of anonymity by not putting their names on the questionnaires by use identification numbers. A high level of confidentiality and privacy was observed and the findings of the study are submitted to the University and the caution was taken to ensure that the information leakage does not occur.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND DISCUSSION

4.1 Introduction

This chapter presents the study findings and discussions on the impacts of artisanal gold mining dynamics on community livelihoods and the environment. The data analysis, presentation and discussions were based on the objectives, research hypothesis and a research question:-

i) To determine the impacts of capital assets accessibility in artisanal gold mining on community livelihoods and their environment in Nandi and West Pokot counties

ii) To evaluate the impacts of artisanal gold mining organizational dynamics on community livelihoods in Nandi and West Pokot counties

iii) To examine the impacts of artisanal gold mining value chain on community livelihoods in Nandi and West Pokot counties

iv)To determine the concentration levels of selected heavy metals at the mining sites in Nandi and West Pokot counties

The research hypothesis and question were:

H_{01}: Accessibility to capital assets in artisanal gold mining has no significant impacts on community livelihoods

H_{02}: artisanal gold mining organizational dynamics have no significant impacts on community livelihoods

H_{03}: The artisanal gold mining Value chain has no significant impacts on community livelihoods.

1. What are the concentration levels of selected heavy metals in the mining sites?

This section also entails demographic characteristics of the respondents. The demographic characteristics of the respondents included; age, gender, marital status and their residency, duration in mining, methods and processes of mining, seasonality in mining and other economic activities they engage in. The respondents who responded were 212 translating to 75% return rates.

4.2 General and Demographic information

4.2.1 General information

The expectation of the researcher was that respondents cooperated and readily provide information on questions asked in the questionnaire, but the response rate was 75%.

The problems encountered in this research include the harsh road terrains which proved quite a challenge to both the researcher and his assistants. To overcome this challenge the researcher used motorbikes and where not possible they had to walk. There was hostile environment for research in terms of security especially in west Pokot County and the researcher had to become extra vigilant and received assistants from village headsmen.

Qualitative Data Analysis

Key Informants

Most of the key informants were male with a ratio of 3:1. These individuals comprised of 10 chiefs including assistant chiefs from all the locations where study was carried, six county government offices that the two county executive committee, two chief officers in charge of environment issues and two wards administrators for Kapsaos, Nandi County and Sekker, West Pokot County. Others included two NEMA officials from both counties.

This key information categorized the impacts of artisanal mining into two groups: positive and negative. The most common positive impact was that artisanal mining provided the mining community with a source of livelihood through the employment and monetary income which was as a result of being involved in ASGM activities.

One interior government official from Nandi County said that “These activities provided the community with direct earnings and thus it is beneficial to the community at large”.

One county government official in West Pokot County affirmed that the community is reliant and dependent on the gold panning in River Murruny and thus it is the most significant economic activity being undertaken by the residents.

The negative impacts of artisanal mining in Nandi county on the environmental are in form soil erosion, water pollution and air pollution. Other significant negative effects of pit excavation are the disturbance of agricultural land, loss of vegetation and destruction of semi-permanent houses made of bricks, cement blocks through cracks. The blasting of the rocks sometimes leads to earth tremors which appear to shake the foundation of that house leading to appearances of cracks in the walls.

The informants listed a number of significant problems affecting the mining communities include: exploitation by the middle men which are the main consumers of the gold produced, low prices of the gold produced, exploitation of the miners by the mine owners, under compensation for labour, lack of appropriate technology for geo-sensing/mapping or locating the gold ore in the mining locality.

Majority of the information accented to the fact that that some of these problems bedevilling the mining community can be solved through a number of ways and means: Top on the list of solutions is financial aid to the miners which enable them access appropriate mining technology, provision of mining technologies such as crushing machines, separation machines, regulation of the sector, training of miners on the safety issues and formation of cooperatives to help the miners with marketing efforts. Evidently, there was a broad consensus that the critical consensus that improvement in appropriate mining technologies, access to financial facilities such as loans and aids and social networks in form of cooperatives that can pool the resources.

The informants reported that the government can aid the mining communities by providing financial assistance to the miners so that the miners can be able to prosper in mining. At the same time the government can control the ASGM sector by introducing the necessary legislative measures to regulate the sector like any other economic sector.

The environmental challenges brought about by artisanal mining include; land degradation, air and water pollutions. These challenges are brought by land clearing and pit excavation which rids up the vegetation and trees leaving the land without any vegetative cover that can protect against erosion. The underground pits are always left unfilled after exhaustion of the gold ores thus degrading the land rendering it unusable for any agricultural activity. Secondly, use of water during sluicing and washing operations degrades water quality while at the same time gives a bad taste and colour to water thus rending it unfit for human and animal consumption. Lastly, blasting and grinding operations results in air pollution by increasing noise pollution and solid particles in the air.

The informants confirmed that virtually all miners in Nandi County use an acronym "dawa" for the methylmercury fluid that is used in amalgamation process. In general, the term 'dawa' refers to medication to which the miners use it to denote the treatment of the ore containing mixture in order to obtain an amalgam. This would them confirm the use of mercury use in Nandi County, however, in West Pokot county, no chemicals are used during the amalgamation process.

Most of the key informants affirmed that environmental management is critical due to the following reasons: securing the future of the mining communities, improve on the environmental conservation and better the lives of the miners. Though environmental management, the miners would be able to understand and appreciate how ASGM activities are detrimental to the environment and thus seek ways to improve on the methods used in gold production, for instance appreciate the harmful effects of mercury use on the soil, water and air. Secondly, by understanding the nature of ASGM, the communities can be able to alter their production methods and thus improve on the productivity of gold produced thereby improving on the returns while securing the environment. Through other significant efforts of changing the production technology, the individuals may be able to reduce the use of mercury and thus reduce on water and soil pollution. These steps may go a long way in securing the livelihood of the ASGM mining communities and the environment as well.

Other significant effects of the ASGM mining community in Nandi County include health effects which fall in physiological injuries. Some of the physiological effects of the mining include physical injuries arising from cave ins, falls, equipment; coughs and fungal infection arising from long durations in damp conditions. Secondly, social effects which include alcoholism, prostitution and family neglect which are usually associated with allure of financial gain. The cash regularly derived from the mining activities seem sufficient and surplus for the poor miners and thus they viewed it as a windfall which can be spent inappropriately.

Majority of the informants affirmed that NEMA act forms the foundation of the laws and policies governs the artisanal mining, however, artisanal mining falls under the new mining act of 2016. Further, there has been no policy governing the artisanal mining sector because the mining act of 1940 considered the activity as illegal. As per the opinions and views from key informants, the current legislation governing artisanal mining is inadequate and ineffective because the ASGM activities is considered as an illegal.

The informants considered the ASGM activity to be informally structure, disorderly but somewhat elementary organized. The artisanal mining sector is not regulated by any law or any act of parliament and thus it is self-regulating with its own structures which cannot be compared with a formally structured economic activity.

It would take enactment and operationalization of the new mining act of 2016 and enforcement in order to formalize the workings of the ASM sector. Whereas the law would regularize and reorganize the sector by licensing the players in the sector, the enforcement aspects would ensure that environmental aspects are considered, other components like registration of the miners into cooperative movements would bring and reign in on the chaos.

Focus Group Discussions

The study held four focus group discussions with the community being composed of individuals made up of youth, women and community elders from each of the location from the mining communities in Nandi and West Pokot counties. The focus group discussion was held up on the months of March to May 2016, in Marich shopping centre, West Pokot County and Kapsaos shopping centre. The researcher sought the help of community leaders in assembling the mining community together on the specific dates and then with the help of the research assistants moderated the discussions while recording the proceedings in written and speech format. There were approximately 30 individuals in West Pokot county while the number were greater than 40 in Nandi County.

The discussions with the community unveiled the core elements of the ASGM mining as loosely organized structures that is controlled by land owners and middle men in Nandi county and all mining participants in West Pokot County. The arrangement in Nandi County is that the mining is either undertaken by the land owner or the lessee to the land therefore determines what occurs during the extraction, processing, amalgamation processes. This end product of the artisanal mining would then be taken over by either the middlemen or the land owner who serves as the intermediary for the marketing of the product.

The cry of the community is the low prices encountered by the miners are one of the major problem cited by the community as a hindrance to the artisanal mining. The community would prefer government involvement in setting up of the prices for the product. Secondly, the community sought for the protection of the government from extortion and exploitation by the middlemen who offered low prices for the gold produced. Thirdly, is the development of a good road infrastructure in the place so that it may open up the place for investments.

The community in Nandi County uses rudimentary technologies which are labour intensive and include simple tools like hoes, spades, wheelbarrows, machetes, shovels for excavation and hammers for crushing. In pit excavation, explosives are mainly to blast the ore containing ore, ropes and slings for pulling the ore manually from the pits. Lastly, in some places crushing has been mechanized by fabricated crushing machine as illustrated in plate 9 which is powered by diesel. In West Pokot, the mining is main alluvial and thus hoes for digging and metal basins are mainly used for the mining purposes.

From the discussion, a list of main obstacles facing artisanal mining in both counties and these include; lack of recognition by the government, lack of access to financial facilities, lack of alternative marketing channels, low prices for the gold produced, and exploitation by the intermediaries. Some of the solutions proposed by the community include; government involvement in terms of pricing and market mechanism, provision of appropriate technology for extraction of gold such as mechanical compressors, crushers etc., and geo-sensors for locating mineral ore.

As reported by one of the participants in the artisanal mining managed to bring his relatives together to form a group of sort and collectively run the mining operations within their farm. The group was so successful in bypassing the intermediaries (middlemen) and were able to sell the gold produced to a processor in Nairobi getting higher prices for the gold. He earlier attempted to carry out an environmental impact assessment with the aid of the researcher before the study.

The artisanal mining has a positive impact on the gold mining communities in that it is a source of livelihood for the community in West Pokot County but it is seen as an alternate source for the community in Nandi County. It provides earnings and employment to the impoverished community in West Pokot County, while providing supplementary income to the community in Nandi Community. The earnings from the gold mined by the community are utilized in many ways: basic needs such as food, medical, clothing, school fees etc., and leisure activities.

The major concern from the community was the land degradation that is as a result of excavation and extraction process, noise and dust pollution which result from the use of explosives and crushers, water pollution from the sluicing process and panning and general neglect of the environmental management. Other significant concerns include the disposal of the tailings which can either be further refined or disposed far from the mining locality.

The mining community in Nandi County have several alternative sources of livelihoods when compared to those in West Pokot County. These include subsistence farming, crop farming, animal husbandry and other commercial activities while the mining community in West Pokot County do not have any other source.

4.2.2 Demographic Data

The characteristics included the gender type, marital status and residency.

Table 4.1: Gender of the respondents

Gender of the respondent	County of origin		Total
	Nandi	West Pokot	
Male	101(70.2%)	43(29.8%)	144(67.9%)
Female	28(42.2%)	40(58.8%)	68(32.1%)
Total	129(60.9%)	83(39.2%)	212(100.0%)

Chi-Square test			
Pearson χ^2	Value	df	p-value
	14.923	1	.000

Gender of the respondents is shown in Table 4.1 indicating that 67.9%of the respondents were male while only 32.1 % were female. In Nandi county, majority of the respondents (70.2%) were males 42.2% were females. In West Pokot, 58.8% and 29.8% were females and males respectively. This result implies that males dominate mining in Nandi County while in West Pokot County, both genders participate in mining. Male domination in Nandi County is attributed to patriarchal nature of Nandi community in terms of land ownership and the type of mining activity which was gender oriented demanding males than females hence gender insensitive.

Findings from the study showed that male domination in mining was particularly clear in Nandi county where mining was done on privately owned land. This could be attributed to the fact that male are the owners of land and had the rights to use it for mining activities while women did not own land. Women in west Pokot were able to access river Murruny as a resource for mining with no restrictions since it is a public utility not owned by any member of the community hence free for all. On river-based deposits at river Murruny the panning of gold is a common activity for local women of different ages. These results clearly demonstrated gender-based inequalities in mining communities in Nandi and west Pokot counties of which female do not have equal ownership or rights over land resources. In addition, women lose a livelihood and economic opportunities due to lack of access to landownership. Role of women in the social framework of ASGM communities hold the potential to induce positive change in their communities if their participation in artisanal gold mining activities is strengthened. Hinton and Veiga (2003) reported that when women are organized as a group, they are likely to raise concerns about rights and safety and may be more willing to adopt alternative technologies.

The type of mining also explains the reasons for fewer female male in Nandi and more women participation in mining in west Pokot County. In west Pokot mining is alluvial or dredging which require simple processes of scooping and panning, an activity which can easily be done by women. In Nandi County, its underground mining involving a lot of masculine work which require male, such as going down the tunnels and pulling up the rocks to the surface. This finding concurs with Shoko (2003), where Artisanal Gold Mining is predominantly manual and a domain of men. Digging by women was close to the surface (not exceeding 10m) while that done by men could go to depths beyond 30 metres. Other causes for the imbalance in gender are due to cultural perceptions of appropriate work for men and women's access to capital assets to engage in mining.

Significant relationship between gender participation and the county was reported in the present study, χ^2 (df =1, N = 208 = 14.923, $p < 0.05$) (Table 4.1). This indicated that there are higher chances of males dominating the artisanal gold mining in Nandi county more than those in West Pokot County. The present findings are in agreement with other studies. In Tanzania, the ratio of male to females in ASM communities in Geita, Tanzania is approximately equal (Kitula, 2006), while half of those employed in the ASM sector in Ghana are women, making it one of the highest rates in Africa (Tschakert & Singha, 2007).Women miners in west Pokot are driven further to engage in artisanal gold mining activities due to absolute poverty and a lack of alternative income generating activities. This fact is attributed to economic challenges facing the artisanal gold miners in West Pokot. Being Arid and semi-arid. West Pokot County offers its residents limited source of livelihood forcing individuals to engage in artisanal gold mining activities whereas individuals in Nandi County have other alternative sources of livelihood such as agriculture.

Plate 2: Women panning gold along river Murruny in West Pokot

Table 4.2: Marital status of the respondents

Marital status	County of origin		Total
	Nandi (F/%)	West Pokot(F/%)	(F/%)
Single	29(78.4%)	8 (21.6%)	37(17.5%)
Married	93(56.0%)	73(44.0%)	166(78.3%)
Widowed	0(0.0%)	2(100.0%)	2(0.9%)
Undisclosed	7(100.0%)	0(0.0%)	7(3.3%)
Total	129(60.8%)	83(39.2%)	212(100.0%)

Results on marital status of the respondents are summarized in Table 4.2. Majority of the respondents (78.3%) were married, 17.5% single, 78.3%, 0.9% widowedwhile3.35% did not disclose their marital status. This result implies that majority of the respondents in both Nandi and West Pokot were married thus they have to cater for their families. These findings are contrary to a study done in Ghana where single individuals comprised over 50% of the miners (Tschakert & Singha, 2007).

Table 4.3: Age of the respondents

Age of the respondent	County of origin		Total
	Nandi(F/%)	West Pokot(F/%)	(F/%)
18 to 25 years	15(88.2%)	2(11.8%)	17(8.0%)
26 to 33 years	67(75.3%)	22(24.7%)	89(42.0%)
34 to 41 years	12(31.6%)	26(68.4%)	38(18.0%)
42 to 49 years	15(45.5%)	18(54.5%)	33(15.5%)
50 to 57 years	14(50.0%)	14(50.0%)	28(13.2%)
Above 58 years	6(85.7%)	1(14.3%)	7(3.3%)
Total	129(60.8%)	83(39.2%)	212(100.0%)
Chi-Square test			
Pearson χ^2	Value	df	P-value
	32.742	6	0.000

Results on age of respondents are summarized in Table 4.3. Respondents aged between 18 - 25 years were 17%, 26 - 33 years were 89%, 34 – 41 years were 38%, 42 - 49 years were 33%, 50 -57 years were 28% and above 58 years were 7%. In Nandi and West Pokot counties, the majority age group distribution was 26 - 33 years (89%) and 34 - 41 years (38%) respectively. This result implies that in Nandi County, there were younger people engaging in artisanal mining as compared to west Pokot who are more elderly.

In the tunnel based gold mining sites in Nandi County young people are engaged in moving ore and waste rocks deep down the shafts to the surface. Due to the manual nature of the work and the hardness of the parent rock, digging is primarily a young men's task. As these youths grow older they wear out and they do not see much returns and hence move to other available options of income generating activities which require less energies like farming. New young people come in with false expectations of a higher returns from artisanal mining activity or a get-rich-quick mentality however when the reality of ASM hits hard many individuals quit the mining activity altogether. In West Pokot County, the type of mining is alluvial along the river and the type of mining requires scooping of sediments and simple panning in that the gold deposits are accessible at near-surface levels within the river, unlike Nandi gold deposits which require the removal of much more material before the gold ore are found. Alluvial mining in west Pokot does not require as much energy as the underground mining; thus it can accommodate up to an older age group participating in mining along river Murruny in west Pokot. The demographic characteristics of ASM in Ghana indicated that their ages ranged from 15 to 42 years for women and 16 to 46 years for men with an average age of the miners is 28.3 ±9.6 years for men and 26.1±7.8 years for women (Tschakert & Singha, 2007).

The relationship between the age of the respondents and the county was significant χ^2 (df=6, N = 212) = 32.742, p <0.01), indicating that individuals in Nandi County were younger than their counterparts in West Pokot County. In Tanzania most individual's engaged in artisanal mining aged between 31 to 43 years with their numbers significantly dropping as the age of the individual rises (Kitula, 2006). More so the crushing process needs energy for hammering and those with such characteristics are the young of age 26-33 (67%) of the miners in Nandi County.

Table 4.4: Educational levels of the respondents

Level of education attained	County of origin		Total (F/%)
	Nandi (F/%)	West Pokot (F/%)	
No formal education	11(14.3%)	66(85.7%)	77(36.3%)
Primary level	86(82.7%)	18(17.3%)	104(49.1%)
Secondary level	25(100.0%)	0(0.0%)	25(11.8%)
Technical level	3(100.0%)	0(0.0%)	3(1.4%)
Tertiary level	4(100.0%)	0(0.0%)	4(1.8%)
Total	129(60.1%)	83 (39.9%)	212(100.0%)
Chi-Square test			
Pearson χ^2	Value	df	p-value
	106.826	4	.000

The educational levels among the mining communities in both Nandi and west Pokot Counties are shown in Table 4.4. The results indicate that respondents who had no formal education were 36.3%, primary level were 49.1%, secondary level were 11.8%, technical level were 1.4% and tertiary level 1.4%. This result implies that those who participated in artisanal gold mining in both counties had either no formal education or had basic education. This agrees with Hilson (2002d) who describes many Ghanaian artisanal gold miners as having low educational levels and low technical know-how. This result further implies that artisanal mining communities lack critical capacity levels to grow their mining activities. With low education levels they usually lack knowledge on the policy requirements on environmental conservation, on occupational health and safety in mining.

According to UNEP (2006), literacy affects the type of information one accesses, the opportunities available and their livelihood choices. This is also linked to poor knowledge of marketing and business development which are important skills for any sustainable business operations. Education is important for other avenues of income earning such as employment and therefore with no formal education or with basic education it means that option of getting employment is difficult. The only available alternatives for this group of individuals are manual jobs like the ones found in artisanal gold mining.

According to Labonne (2003), Mining (ASM) is typically practiced in the poorest and most remote rural areas by a largely illiterate, poorly educated populace, men and women with few employment alternatives. The sector of artisanal gold mining is highly labour intensive providing employment and incomes to large numbers of people who are generally uneducated, whose understanding of the importance of environment management is below par, poor and live in remote areas where no opportunities exist for formal employment (Shoko, 2005). In most African countries like Ghana, Madagascar and Zimbabwe, small-scale gold mining has become important due to escalating poverty and lack of employment opportunities in the formal sector (Logan, 2004).

The Chi-Square statistics in Table 4.4 reported a significant relationship between the level of education and the county, χ^2 (df=4, N = 212) = 106.826, $p <0.01$), which indicates majority of the respondents from West Pokot county had lower levels of education compared to their colleagues in Nandi county. This distribution is attributed to economic hardships and marginalization of individuals from social investments in West Pokot County. Other factors like cultural traditions have conspired against individuals from West Pokot to having basic level of educations and as such lack formal education. Artisanal gold mining can be said to be permeated by individual who have no formal education or basic level of education, however, in some studies, majority of individuals had secondary level of education and technical education as indicated by Tschakert & Singha (2007) who asserted that high unemployment rates within the Ghana has driven professionals, semi-skilled labourers and university graduates into ASM sector.

Table 4.5: Residency of the respondents

Residency	**Frequency**	**Percentage**	
Resident	205	96.7	96.7
Non – residents	7	3.3	100
Total	212	100.0	

Findings on residential status of those involved in mining are shown in Table 4.5. Majority of the respondents (96.7%) were residents of the respective counties only 3.3% were non-residents. This result suggests that artisanal gold mining was dominated by the local residents in both west Pokot and Nandi County, the activities of artisanal mining are not associated with any significant migration. This result further implies that there were no inter community competition related to artisanal mining hence increased local communities benefit from artisanal mining activities. The present findings are similar with those reported by Drechsler (2004) which showed that minerals often mined on the outskirts of big towns do not attract large influxes of people therefore not common to have a mixture of indigenous and migrant workers at sites. It is the very nature of ASM that induces migration to begin with both internally and internationally (Heemskerk, 2000).

Table 4.6: Number of dependents per respondent

Number of dependents	County of origin		Total
	Nandi (F/%)	West Pokot (F/%)	(F/%)
1 to 3	44(68.8%)	20(31.2%)	64(30.2%)
4 to 6	53(54.6%)	44(45.4%)	97(45.8%)
7 to 9	23(63.9%)	13(36.1%)	36(17.0%)
Above 10	9(60.0%)	6 (40.0%)	15(7.0%)
Total	129(59.9%)	83(40.1%)	212(100.0%)
Chi-Square test			
Pearson χ^2	Value	df	p-value
	3.470	3	0.325

Results on dependency rates of the respondents are shown in Table 4.6. Findings indicated that 30.2% of the respondents had between 1-3 dependents, 45.8% had 4-6 dependents, 17% had 7-9 dependents and 7% had more than 10 dependents. The results imply that the respondents in both counties of Nandi and west Pokot tend to have large families and therefore the need for them to engage in artisanal mining to complement their income so that they can provide for the large families. This agrees with the Studies in Tanzania that the average household size for ASM mining communities was 6.6 individuals (Kitula, 2006). Therefore, there is no significant differences between families in various regions.

Table 4.7: Significant economic activities in the locality

Other economic activities	County of origin		Total
	Nandi (F/%)	West Pokot (F/%)	(F/%)
Dairy farming	6(100.0%)	0(0.0%)	6(2.8%)
Subsistence farming	78(98.7%)	1(1.3%)	79(37.3%)
Cash crop farming	24(100.0%)	0(0.0%)	24(1.3%)
Trading	5(71.4%)	2(28.6%)	7(3.2%)
Others	2(50.0%)	2(50.0%)	4(1.9%)
None	14(15.2%)	78(84.8%)	92(43.4%)
Total	129(59.9%)	83(40.1%)	212(100.0%)
Chi-Square			
Pearson χ^2	Value	df	p-value
	34.454	4	0. 000

Other economic activities that the respondents were involved apart from mining are shown in Table 4.7. Only 2.8% of the respondents were engaged in dairy farming,37.3% were doing subsistence farming, 1.3% cash crop farming, 3.2% were in trading and 43.4% were not engaged in any other activity. In West Pokot County, majority of the respondents engaged in other economic activities while minority of them were involved in subsistence farming and trading. In converse, respondents in Nandi County were involved in dairy farming, subsistence farming, cash crop farming and trading. This results indicated that respondents in Nandi County pursued other economic activities such as such as dairy, tea or subsistence farming and commercial activities apart from mining, while their counterparts from West Pokot County were heavily involved in the mining as a significant economic activity .This agrees with other studies particularly in Geita, Tanzania were only 33% of respondents in the study within ASM mining communities were fully engaged in mining as primary occupation with other diverse economic activities being mainly agriculture, subsistence business activities and livestock rearing (Kitula, 2006). Respondents in Nandi County were driven to artisanal gold mining to compliment household income therefore during the rainy season and harvesting most artisanal miners leave the mines to pursue agricultural activities. In west Pokot there was limited engagement to agricultural activities due to unfavourable weather conditions.

Chi-square results in Table 4.7 reported significant relationship between economic activities and the county, χ^2 (df=2, N = 120) = 34.45, $p < 0.01$). This indicated that respondents from Nandi County pursue other economic activities unlike their counterparts from West Pokot County. This could be attributed to the agro-ecological zone which is favourable to farming and other activities in Nandi County. It further implied that communities in Nandi County made their livelihoods from agriculture and livestock management thus mining was not the major economic activity but rather a complimentary source of income while in west Pokot there was limited engagement to agricultural activities due to unfavourable weather conditions. This concurs with results reported by Midende (2010) where income from mining is a livelihood strategy therefore an important contributor to many households' budgets, complementing their income from agricultural activities. As such it increases and diversifies their incomes and hence improves their standard of living.

Table 4.8: Earnings from other economic activities

Earnings from activities mentioned	County of origin		Total
	Nandi (F/ %)	West Pokot(F/%)	
Not mentioned	10(11.1%)	80(88.9%)	90(42.5%)
Below Kshs. 10,000	80(96.4%)	3(3.6%)	83(39.2%)
Kshs. 10,001 to Kshs. 20,000	26(100.0%)	0(0.0%)	26(12.3%)
Kshs. 20,001 to Kshs. 30,000	5(100.0%)	0(0.0%)	5(2.4%)
Above Kshs. 40,001	8(100.0%)	0(0.0%)	8(3.8%)
Total	129(59.9%)	83(40.1%)	212(100.0%)
	Chi-Square		
Pearson χ^2	Value	df	p-value
	1.445	3	0.695

The monthly earnings from other economic activities are shown in Table 4.8. The respondents in mining indicate low earnings per month. Respondents (3.6 %) in West Pokot County earned below KShs. 10,000, while Nandi County those who earned below 10,000 were 96.4% per month. This result implies that respondents in Nandi County were earning much more income from other economic activities and did not depend only on mining as a source of income unlike their counterparts in West Pokot County, a fact that is attributable to the different sources of livelihood or different income sources. In comparison with a study in Tanzania, mining contributes about 3% or USD 15.00 of the total annual income to non-mining communities with agriculture and other activities contributing the 97% or USD 465.60 (Kitula, 2006).

The relation between income distribution and the county was insignificant, χ^2 (df=3, N = 120) = 1.445, $p > 0.05$. This indicates that inhabitants from both Nandi and West Pokot Counties were not different in the income distribution, a fact that is explained by their prevailing economic activities. On one part, the inhabitants from Nandi county could partake in other economic activities but individuals from West Pokot County could not because of the agro-ecological zone, cultural ways of life.

Table 4.9: Roles in the mining community

Role played in mining	County of origin		Total
	Nandi	West Pokot	
Mine owner	5(100.0%)	0(0.0%)	5(2.4%)
Mine worker	124(59.9%)	83(40.1%)	207(97.6%)
Total	129(60.8%)	83(39.2%)	212(100.0%)
Chi-Square			
Pearson χ^2	Value	df	p-value
	3.852	1	0. 000

Roles in the mining community are shown in Table 4.9. Findings indicated that majority of the respondents (97.6 %) were mine workers while only 2.4 % were mine owners. This result implies that artisanal gold mining is fundamental rent seeking activity, thus there are very few owners and the majority of individuals seeking to draw out a living from the activity without owning it.

Table 4.10: Mining Methods Used

Mining methods in the locality	County of origin		Total
	Nandi	West Pokot	
Surface mining	22(95.7%)	1(4.3%)	23(10.8%)
Underground mining	107(100.0%)	0(0.0%)	107(50.4%)
Dredging	0(0.0%)	82(100.0%)	82(38.8%)
Total	129(60.8%)	83(39.2%)	212(100.0%)
Chi-Square			
Pearson χ^2	Value	df	p-value
	185.864	2	0. 000

Respondents were asked about the mining methods used and their responses were summarized in Table 4.10. Majority of the respondents (50.4%) used underground mining, 38.8% used dredging while only 10.8% employed surface mining. In Nandi

County, respondents affirmed underground mining and a few surface mining while respondents in West Pokot affirmed dredging and a few surface mining.

Plate 3: Alluvial gold mining along river Murruny, West Pokot County

Plate 4: Active Underground shaft in mining sites, Nandi County

Table 4.11: Chemicals Used in Amalgamation Process

Chemicals used in mining process	County of origin		Total
	Nandi	West Pokot	
No chemicals	0(0.0%)	66(100.0%)	66 (31.2%)
Mercury	129(60.8%)	0(0.0%)	129(60.8%)
Others	0(0.0%)	17(100.0%)	17(8.0%)
Total	129(60.8%)	83(39.2%)	212(100.0%)
Chi-Square			
Pearson χ^2	Value	df	p-value
	209.000	2	0.00

Results on the types of chemicals used in during mining are shown in Table 4.11. Majority of the respondents (60.8%) used mercury, 8.0% other chemicals while 31.2% of them did not use chemical. Virtually all the miners who indicated use of mercury were from Nandi. Mercury was affirmed being used in the amalgamation process in Nandi County whereas their counterparts from West Pokot County asserted that they do not use any chemicals in the process. This is attributed to the nature of mining process used such that in West Pokot County the type of mining is alluvial which does not require the use of mercury while in Nandi county it is underground mining which uses mercury for amalgamation. It implies that the use of chemicals dependent on the type of mining such that underground mining which involve processes like digging, crushing and amalgamation are associated with chemical use whereas surface mining or dredging is associated with panning.

Empirical evidence from a study by Hilson & Pardie (2006) indicates that ASM communities deal with monopolistic middlemen who supply mercury and lack of appropriate safeguards and alternatives to amalgamation. In West Pokot County, the main process was panning along river Murruny which is associated with dredging and surface mining with no chemicals being used in the process. Gold found in river terraces were harvested from the surface with basic tools, after vegetation has been removed and pits dug to reach the gold bearing beds. This practice also stems from the fact that miners are only interested in obtaining mineral (gold) and are not really concerned about the environment (Aryee *et al.,* 2002; Lovitz, 2006).

Plate 5: Use of mercury in amalgamation process, Nandi County

Plate 6: Excavation for gold bearing ore at river Murruny

Table 4.12: Number of years in mining activities

Mining experience	County of origin		Total
	Nandi	West Pokot	
Less than a year	1(100.0%)	0(0.0%)	1(0.5%)
1 to 5 years	78(78.0%)	22(22.0%)	100(47.2%)
6 to 10 years	29(56.9%)	22(43.1%)	51(24.1%)
11 to 15 years	8(38.1%)	13(62.9%)	21(9.9%)
16 to 20 years	9(81.8%)	2(28.2%)	11(5.2%)
Above 21 years	4(14.2%)	24(85.8%)	28(13.2%)
Total	129(60.8%)	83(39.2%)	212(100.0%)
	Chi-Square		
Pearson χ^2	Value	df	p-value
	47.799	5	0. 000

Number of years in mining activities by respondents are shown on Table 4.12 and indicate that 0.5 % had been involved in mining activity for less than 1year, 47.2 % (1 - 5 year), 24.1 % (6-10) years, 9.9% (11-15) years, 5.2% (16-20) years and 13.2% were above 21 years . According to this result majority of respondents in Nandi County had participate in the artisanal gold mining for less than 10 years and this tallies up with the findings from a study by Tschakert & Singha (2007) which indicated that the time spent by men varied from 0.5 to 10 years while women typically spent 0.1 to 5 years with an average of 7.1±6.2 years for men and 1.2±1.3 years for women. This result implies that respondents in Nandi County have alternative sources of livelihood and their participation in artisanal gold mining is only for a shorter periods of time before the lure of instant riches fizzles out. This is attributed to the dangers and physical demand in underground mining, hence the older people tend to plan to exit and quit artisanal gold mining activities. It is further attributed to money which was not always flowing in as expected fluctuating and affecting their incomes and obligations to meet their daily basic needs.

In West Pokot respondents participated in artisanal gold mining activity for longer periods of time before quitting and this was attributable to a phenomenon of lack of alternative livelihoods particularly being a marginalized area with limited economic alternatives. It was more so with economic hardships which increased unemployment and reduced rural livelihood choices. These is exacerbated by droughts and conflicts such as cattle rustling, competition for resources like water and pastures in west pokot. The idea of a possibility of getting gold and life transformation to the better and escape poverty make miners to stay longer in mining.

The relation between the duration period of engagement and the county was significant, $\chi^2(df= 5, N = 212) = 47.799$, $p <0.05$. These indicates that individuals in Nandi County participate in artisanal gold mining for shorter period of time of less than 10 years than individuals in West Pokot county who participate for longer periods of up to over 21years.

Table 4.13: Preoccupation with mining activity

Seasons of mining activity	**County of origin**		**Total**
	Nandi	**West Pokot**	
All year round	35(32.1%)	74(67.8%)	109(51.4%)
Seasonal	81(90.0%)	9(10.0%)	90(42.5%)
Temporary	13(100.0%)	0(0.0%)	13(6.1%)
Total	129(60.8%)	83(39.2%)	212(100.0%)
	Chi-Square		
Pearson χ^2	Value	Df	p-value
	76.750	2	0.000

Preoccupation with mining activity is shown on Table 4.13 and indicates that in 51.4 % of the respondents participate in mining all year round and 42.5% were involved on a seasonal basis, while 6.1% were temporary.

This result implies that those who have limited sources of livelihood participate in artisanal mining all year round or on a full time basis while those with other sources of livelihood participate on seasonal or temporary basis. The implication of these results were that communities in West Pokot who have limited source of livelihoods tend to participate in artisanal mining activity on a full time basis while in Nandi with diversified source of livelihoods participate on a part time basis due to the belief of higher earnings to supplement their incomes. Yakovleva, (2007) indicated that ASM is extensively practised as an alternative economic activity in times of economic stress and takes the following categories (a) gold rush; (b) temporary operations fuelled by economic recessions; (c) isolated and remote operations with little or no involvement with nearby communities; (d) seasonal ASM activities within an agricultural cycle and (e) traditional year around activities that are generally associated with stable communities.

The relationship between the seasons of engagement in mining activity and the county was significant, χ^2 (df=2, N = 212) = 76.750, $p < 0.01$. It indicates that individuals in West Pokot County participate in artisanal gold mining as a whole year round activity than individuals in Nandi County who participate on a seasonal or temporary basis. In West Pokot County which is arid and semi-arid land, miners participate in mining activity along the river on a full time basis or all year round and this is attributed to limited access to alternative livelihood activities. With diversified source of livelihoods in Nandi County they participate in artisanal gold mining on a part time basis or seasonally due to the belief that earnings from mining complement their incomes. As Maponga & Ngorima, (2003) noted panning in Zimbabwe in the 1980s and 1990s was primarily done during droughts/dry season and served as an alternative source of livelihood, but in the last decade it has evolved into a year-round activity and has become a primary source of livelihood in many rural communities.

The nature of the harsh climate in the arid and semi-arid of West Pokot pushes the community to artisanal gold mining activity in search for a livelihood, an activity that they engage themselves throughout the year. Dreschler (2001) argued that development of artisanal gold mining has been further aggravated by poor agricultural yields due to erratic rainfall patterns. Artisanal gold mining therefore presents an opportunity for alternative in an area that offers limited livelihood opportunities to rural households. Artisanal gold mining in west Pokot should be viewed as an alternative source of livelihood to rural household.

Table 4.14: Occupation with mining

Occupation in mining	County of origin		Total
	Nandi	West Pokot	
Fulltime	0(0.0%)	79(100.0%)	79(37.3%)
Part time	129(97.0%)	4(3.0%)	133(62.7%)
Total	129(60.8%)	83(39.2%)	212(100.0%)
Chi-Square			
	Value	df	p-value
Pearson χ^2	191.837	1	0.000
Likelihood ratio	244.147	1	0.000
Continuity correction	187.818	1	0.000

Results on occupation with mining are shown in Table 4.14. Approximately 37.3% of the respondents engaged in mining on a full time and 62.7% did it on a part time basis. Majority of the respondents in West Pokot County participate in mining activity on a full time basis while majority in Nandi County participate on a part time basis. The implication is that those respondents who have limited alternative sources of livelihood participate in the mining activity on a full time basis while those who have other source of livelihood participate on a part time due to the allure of higher and complimentary incomes. Mining is not considered a major economic activity to the local people in Geita district, Tanzania but rather a complimentary source of income (Kitula, 2006).

The chi-square statistic reported a significant relationship between the occupation with mining in the county χ^2 (df=1; N = 212; $p < 0.01$). This indicated that individuals from West Pokot County are involved in mining activity on a full time basis while individuals from Nandi County are involved on a part time basis. Mining communities within Nandi County engaged in artisanal mining on a part time basis either seasonally or temporarily alongside other formal economic activities (Table 4.14). During the dry season, when farming requires much less work, many individuals engage in mining activities.

Artisanal gold mining complements the activities of agriculture seasonality by engaging in farming during the rainy season when it is planting season. Rainy season is not conducive to mining due to interference of water inside the tunnel which calls for increased pumping out of water making the mining operations more, risk and expensive. Mining activities are reduced during planting season for maize and harvesting of maize and coffee. It implied that Artisanal mining in Nandi County is not a livelihood alternative but a livelihood complement. Artisanal gold mining gives opportunity to the communities in Nandi County a chance to complement their livelihood activities. This has been described by (Hilson, 2010) that Livelihood diversification into the artisanal mining sector in rural areas is generally pursued with the intention of miners to branch out into the nonfarm economy because they believe they can earn more money from doing so.

Plate 7: Pumping out water from tunnels during rainy season, Nandi County

Table 4.15: Respondents' role during the mining process

Role played in mining process	County of origin		Total
	Nandi	West Pokot	
Digging	41(100.0%)	0(0.0%)	41(19.3%)
Crushing	35(100.0%)	0(0.0%)	35(16.5%)
Leaching	29(100.0%)	0(0.0%)	29(13.8%)
Panning	15(15.3%)	83(84.7%)	98(46.2%)
Smelting	9(100.0%)	0(0.0%)	9(4.2%)
Total	129(60.8%)	83(39.2%)	212(100.0%)
	Chi-Square		
Pearson χ^2	Value	Df	p-value
	159.756	4	0.000

The different mining activities and processes are shown on Table 4.15. The nature of how the mineralized ore avails itself to mining allows the use of distinct mining methods. In Nandi County the extraction method used was underground (hard rock) mining and thus the individuals were either digging, crushing, leaching, panning or smelting whereas in

West Pokot County the main process was panning that is associated with surface mining. In Nandi County the roles were digging, crushing leaching, panning and smelting and in west Pokot the only activity taking place in mining was panning. This result implies that there are more processes involving underground mining with negative impacts to the environment for instance excavations, hipping of waste rocks and tailings, use of mercury during amalgamation and community livelihoods.

The relation between mining method used and the county was significant, $\chi^2(df=2, N = 212) = 159.756$, $p < 0.01$, which indicates that the respondents in Nandi county are involved in several activities and processes associated with underground(hard rock) mining whereas those from west Pokot county are involved in panning associated with alluvial mining.

Table 4.16: Gender roles during mining process

Role played in mining process	Gender of the respondent		Total
	Male	Female	
Digging	30(73.1%)	11(22.9%)	41(19.3%)
Crushing	31(88.6%)	4(11.4%)	35(16.5%)
Leaching	21(72.4%)	8(27.6%)	29(13.8%)
Panning	54(55.1%)	44(44.9%)	98(46.2%)
Smelting	9(100.0%)	0(0.0%)	9(4.2%)
Total	144(67.9%)	68(32.1%)	212(100.0%)
	Chi-Square		
Pearson χ^2	Value	df	p-value
	18.121	4	0.001

The roles played by different gender in the mining process are shown in Table 4.16, indicating that majority of males were participating in arduous and laborious tasks such as digging, crushing, leaching. On the other hand, female compatriots participated in less demanding jobs of panning and less taxing jobs. The result implies that the role of smelting was exclusive task reserved for men and the other role which women were fairly involved was panning. It is widely seen that the participation of women in ASM is viewed as beneficial to the welfare of poor rural households (Yakovleva, 2007). Some of the drivers for the increase female employment are household income and employment opportunities

Chi-square results in Table 4.16 reported significant relationship between tasks and gender χ^2 (df=2, N = 212) = 18.12, $p < 0.01$), indicating that men would more likely partake in laborious task than women. These results are in harmony with those reported by Tschakert & Singha (2007), where women were reported to typically work as panners, carriers, and processors which is in addition to jewellery makers, cooks, and other service providers in and around mining sites. Women's roles and responsibilities within gold mining communities vary greatly, women may dig and carry ore, and they are more commonly involved in the processing stage, which includes crushing, grinding, sieving, washing, panning, and amalgamation with mercury (Hinton *et al.*, 2003).

Table 4.17: Gold sales

Gold sales	County of origin		Total
	Nandi	West Pokot	
Middlemen	121(59.6%)	82(40.4%)	203(95.7%)
Cooperative	4(80.0%)	1(20.0%)	5(2.4%)
Others (city market, company)	4(100.0%)	0(0.0%)	4(1.9%)
Total	129(62.6%)	83(37.4%)	212(100.0%)

Gold sales produced by artisanal miners are shown in Table 4.17. Findings indicated that sales in both counties were made to middlemen (95.7%), cooperatives (2.4%) city markets (1.9%). The result implies that there are no formal marketing channels for artisanal gold mining products and the bulk of gold by artisanal miners in Nandi and west Pokot is sold to middlemen who offer low prices. Occasionally some miners take their gold to the city markets in Kisumu, Kapenguria and Kitale where dealers buy the gold at a slightly higher price that often have direct links to Nairobi, where most of the gold is further processed and eventually exported.

The easily accessible selling points offering cash on the spot are much suited to the panning communities and thus middlemen offering quick cash exploit the panners by take advantage of lack of knowledge among miners (Maponga & Ngorima, 2003). Impoverished miners in developing countries receive low payments for the gold produced which is coupled with hazardous and unsanitary conditions (Hilson, 2008).It is inferred that low prices miners received are as a result of fewer market options and insufficient buying centres and agents (Amankwah & Anim-Sackey, 2003).

Table 4.18: Earnings from mining activities

Earnings from mining activities	County of origin		Total
	Nandi	West Pokot	
Below Kshs. 1,000	13(20.6%)	50(80.4%)	63(29.7%)
Kshs. 1,001 to Kshs. 2,000	16(69.6%)	7(30.1%)	23(10.8%)
Kshs. 2,001 to Kshs. 3,000	15(57.7%)	11(42.3%)	26(12.3%)
Kshs. 3,001 to Kshs. 4,000	7(100.0%)	0(0.0%)	7(3.3%)
Above Kshs. 4,001	78(83.9%)	15(16.1%)	93(43.9%)
Total	129(60.8%)	83(39.2%)	212 (100.0%)
	Chi-Square		
Pearson χ^2	Value	df	p-value

Earnings from mining as per county are shown in Table 4.18. Results indicate that 80.4 % of respondents in West Pokot County were earning KShs. 1,000 and below, 8 % were earning between Kshs. 1,001 and Kshs. 2,000, 30.1 % were earning between Kshs. 2,001 and Kshs. 3,000 (42.3 %) earning and Kshs. 4,001 and above (16.1%). In Nandi County, 83.9 % of respondents were earning KShs. 4,001 and above, 100% were earning between Kshs. 3,001 and Kshs. 4,000, 57.7% were earning between Kshs. 2,001 and Kshs. 3,000-4,000 and those earning between Kshs. 1,001 and Kshs. 2,000 (69.6%), while 20.6 % earning below Kshs. 1,000. This result implies that respondents from Nandi County were earning more from their gold due to more accessibility to the market. West pokot is more marginalised in terms of the market to the point where middlemen are fewer than in Nandi County.

The earnings would translate to a minimum of about USD 10.00to USD 40.00 per week, significant amounts to those who are unemployed, while in Tanzania, individuals involved in mining activities, mining earn about 66% or USD 361.50/year of the total household income with agriculture contributing 16% or USD 88.30 with other activities contributing 18% or USD 96.40 (Kitula, 2006). In Ghana, women are paid various daily rates for their work at different camps— the rates are estimated to range between 15,000 and 30,000 cedis (approximately USD 1.66–3.33).

The relationship between earnings distribution and the county was significant, χ^2(df= 4; N = 212; $p < 0.01$).This finding indicates that inhabitants from Nandi County were having a higher income than those of West Pokot County. This could be attributed to closeness to the markets and the robustness of the economic activities prevailing in the locality.

Table 4.19: Differences in mining earnings according to county

Gender	Observations	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
Nandi	127	7.732283	1.650747	18.60297	4.465504	10.99906
West Pokot	83	2.072289	.1695122	1.54433	1.735075	2.409503
Combined	210	5.495238	1.017152	14.73993	3.490046	7.50043
Difference		5.659994	2.048219		1.622064	9.697925

diff = mean(Nandi) - mean(West Pokot)	t = 2.7634	
Ho: diff = 0	Satterthwaite's degrees of freedom = 208	
Ha: diff < 0	Ha: diff != 0	Ha: diff > 0
Pr(T < t) = 0.9969	Pr(T > t) = 0.0062	Pr(T > t) = 0.0031

The results in Table 4.19 shows that Nandi county had statistically significantly higher earnings than their West Pokot counterparts (p = 0.0031). The differences are attributable to the type of mining used, that is underground mining as opposed to surface mining, production technologies used which results in higher productivity and locational economies of scale, the fact that those in Nandi county are located closer to improved infrastructure thus access to markets

Table 4.20 Differences in mining earnings according to gender

County	Observations	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
Male	142	6.950704	1.487279	17.72298	4.010455	9.890953
Female	66	2.5	.2085023	1.69388	2.083592	2.916408
combined	208	5.538462	1.026494	14.80431	3.514738	7.562185
difference		4.450704	2.188974		.1350393	8.766369

diff = mean(Male) - mean(Female)	t = 2.0332	
Ho: diff = 0	Satterthwaite's degrees of freedom = 206	
Ha: diff < 0	Ha: diff != 0	Ha: diff > 0
Pr(T < t) = 0.9783	Pr(T > t) = 0.0433	Pr(T > t) = 0.0217

The results in Table 4.20 shows that males had statistically significantly higher earnings than their female counterparts, t (206) = 2.0332, p = 0.0217. The differences in earning between the genders could be attributable to a number of factors: (1) both societies are patriarchal in nature and thus there is bigger likelihood that males will be firstly considered in any endeavour and there many male respondents (142) than there were female (66).

4.2.3 Artisanal Mining Regulatory Framework

Regulation is an important part of every productive activity being undertaken in an economy. The study sought to determine whether the mining community understood the regulatory aspects of artisanal gold mining.

Table 4.21: Agencies involved in regulating mining

Agencies involved in regulating mining	County of origin		Total
	Nandi	West Pokot	
None	56(40.9%)	81(59.1%)	137(64.6%)
County government	42(95.5%)	2(4.5%)	44(20.8%)
Ministry of mining	4(100.0%)	0(0.0%)	4(1.9%)
NEMA	27(100.0%)	0(0.0%)	25(12.7%)
Total	129(60.8%)	83(39.2%)	212(100.0%)
	Chi-Square		
Pearson χ^2	Value	df	p-value
	62.979	3	0.000

Agencies involved in regulating mining are shown in Table 4.21. Majority of the respondents (64.6%) do not have any information on who the regulator, 20.8% said that it was the county government, 12.7% viewed NEMA being involved and 1.9% viewed ministry of mining was involved. This implies that awareness on the regulator of artisanal gold mining is not known. The result is an indicative of non-supervision and monitoring in artisanal gold mining at the grass root.

The relationship between the perceived agencies and the county was reported to be significant, χ^2 (df=3; N = 205; $p < 0.05$). This indicated that respondents in West Pokot counties perceived that no government entities govern mining in their area as opposed to their counterparts in Nandi who believed that there are a number of agencies involved in mining. The perceptions are attributed to the level of education between the respondents and since majority of inhabitants from West Pokot county have no formal education they would hold such a view.

Table 4.22: Regulation of the ASM mining

	N	Mean	Std. Dev
Familiarity with mining laws	212	1.8309	1.32394
Familiarity with conservation laws	212	1.8116	1.29535
Familiarity with NEMA policies	212	1.6537	1.18902
NEMA official visits	212	1.4000	.90532
County environment official visits	212	1.3512	.84804
EIA audit is conducted	212	1.2560	.66621
NEMA cautions on environmental issues	212	1.2271	.62446

Results on regulation of artisanal mining are shown in Table 4.22. Mining communities were reported to be neither familiar with the mining laws (Mean = 1.83, SD = 1.32) nor conservation laws (Mean = 1.81, SD = 1.29).This implies that Respondents were either ignorant of the laws or lack of regulatory and conservation mechanisms at the mining areas. The respondents are not familiar with NEMA policies (Mean = 1.65, SD = 1.18) which implies that ASM mining activity are not regulated at all and as such are left to self-regulate or are non-regulated. It further implies that artisanal miners often do not know where to go in order to obtain the service and/or assistance they may require. The results further reported visits by NEMA officials (1.4, SD = 0.9) and county government officials (Mean = 1.35, SD = 0.84).This implies that there is no surveillance, supervision and monitoring by government agencies on environmental management. The lack of government agencies to monitor and enforce both mining and environmental policies gives artisanal miners an opportunity to become rampant in degrading the environment. Major problems with pollution control in Kenya is the conflict or lack of coordination among the various authorities' regulation activities, lack of enforcement of existing rules and regulations due to lack of budgetary allocation, bureaucratic inertia, lack of political will and corruption (Nasong'o and Gabsa, 2000). As a result of such factors an approach to regulate and monitor the environmental degradation in the mining areas is not likely to succeed in Nandi and west Pokot, given the challenges of control and enforcement in rural areas. Authorities are often unable to control artisanal mining because they do not enforce existing regulations.

The study reported that EIA audit was conducted (1.25, SD = 0.66). This implies that institutions that are to enforce policies like EIA audit are ineffective. Most countries have developed ASM regulations as part of their mining laws; weak institutional capacity to monitor the sector has limited the effectiveness of these laws (World Bank, 2000). Mining needs to be environmentally sustainable and therefore the need to continuously carry out environmental impact assessments for artisanal gold mining projects so as to identify, prevent, mitigate or offset adverse onsite and offsite environmental and social impacts of such projects (Zimbabwe National Environmental Policy, 2009).

NEMA cautions on environmental issues (Mean = 1.22, SD = 0.62). Another aspect of regulatory mechanism is the cautions which serve to obligate the individuals to conduct their matters appropriately while taking cognition of any legal implications. The mining community has not been given environmental cautions which mean that the institution does not consider ASM as a threat to the environment.

4.12.1 Construct Validity

Table 4.23: Factor Analysis on Regulatory Aspects

	Component		h^2
	1	2	
Familiarity with mining laws	.946		.904
Familiarity with conservation laws	.947		.931
Familiarity with NEMA policies	.887		.894
NEMA official visits		.641	.773
County environment official visits		.866	.851
EIA audit is conducted		.939	.908
NEMA cautions on environmental issues		.929	.872
			Total
Sum of squares(eigenvalue)	3.057	3.077	6.124
Percentage of trace	43.952	43.674	87.626

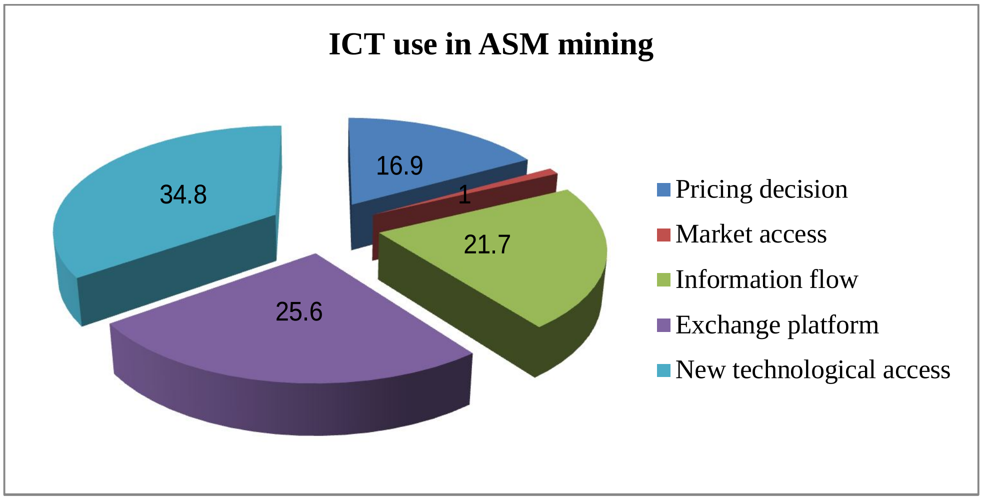
Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.787
Bartlett's Test of Sphericity	Approx. Chi-Square	1546.271
	df	21
	Sig.	.000

The Table 4.23 shows that the Kaiser-Meyer-Olkin or KMO measure of sampling adequacy for the regulatory aspects was 0.787 which exceeds the required 0.5 for factors analysis. The Bartlett's Test of sphericity, $\chi 2$ (df = 21) = 1546.271, $p < 0.05$ indicate that sufficient correlation exists among the variables to proceed.

Since the percentage of trace (the variance explained by the components) is 87.626% which indicates that it is greater than 0.5(50%) and that all the loadings estimates are greater 0.5, then construct validity can be upheld.

4.2.4 Perceived ICT Use in ASM



Source: Research data (2016)

Figure 4.1: ICT use in ASM mining

The study sought to establish the perception on the use of ICT in artisanal Gold mining. ICT can be used to mitigate structural challenges and serve many functions in ASM only if it is designed to serve them. Results shown in Figure 4.1 indicates that 34.8 % would prefer use of the ICT to get access to new technologies in artisanal mining, 25.6 % would use it for exchange platform, 21.7 % for information flow while 16.9 % would use it for pricing decision and 1 % for marketing. ICT has a variety of uses in any economic activity as it serves as an enabler to business processes. With affordable new communication techniques smart phones and improved telecommunication infrastructure in Kenya, situation in artisanal gold mining can be changed. Young people are becoming increasingly accessible to smart phones which are becoming more and more popular in rural areas and by extension those in artisanal mining. Fold *et al.*(2014) alluded that in well-connected rural centres with a number of gold buyers use of mobile phone coverage has enabled the upstream actors to keep track of world market price of gold and thus they are unable to estimate reasonable prices.

Table 4.24: ICT adoption in ASM mining

	N	Mean	Std. Dev.
ICT adoption can contribute to better prices	212	4.6368	.87361
ICT adoption can contribute to market access	212	4.5802	.83648
ICT adoption can contribute to new markets	212	4.5708	.89744
ICT adoption can contribute to market information	212	4.5498	.91085
ICT adoption can disseminate information on environmental conservation	212	4.5094	.92101
ICT adoption can disseminate information on new product technologies	212	4.5094	.92614
ICT adoption can be used in geo-mapping information	212	4.5047	.93635
ICT adoption can develop new exchange platform	212	4.5283	.92575

There are various ways through which ICT can be used as indicated in Table 4.24. For example, integration into current technologies that may be used in artisanal mining activities for example, in the area of geological mapping which is lacking in terms of new technologies in the sector. The mining community also affirmed that ICT holds key to new production technologies to be used in mining (Mean = 4.51, SD = 0.92) and used in geo – mapping systems similar to the geographical information systems (Mean = 4.50, SD = 0.93).This result implies that Artisanal gold miners do not have access to appropriate geological data therefore they are unable to locate viable deposits rather than use trial and era methods. Artisanal mining exploitations are not efficient based on luck taking long periods due to lack of geological data. Trial and era methods lead to unnecessary land destruction due to unavailable geological information to guide mining activity on the right places. Basic geological surveys will be enhanced and more accessible to the miners with the use of ICT. These would increase returns to the miners by enabling them to excavate the right areas with minerals transforming their livelihoods and avoiding degradation of land. Lack of use of new cleaner gold processing technologies is attributed to lack of information and limited access to alternative technologies.

The lack of information on alternative technologies is one of the important reasons why artisanal gold miners continue to use mercury in their operations. Artisanal gold miners comprise of individuals struggling to earn a daily wage with no information on better technologies used in gold mining. Therefore, use of ICT will provide information on new improved gold mining technologies which are environmentally friendly with higher recovery rate of gold hence better income to the miners while conserving the environment.

The respondents would use ICT in improving pricing (Mean = 4.6368, SD = 0.87). This implies that miners can be informed on the prices of gold in international market and would serve to improve on the pricing offered to the mining communities. It will offer market going rates influencing local prices towards international market prices which are always higher, translating to improved earnings to miners.

Results further indicated that ICT would contribute to the dissemination of market prices(Mean = 4.55, SD = 0.91) as shown in Table 4.24. This implies that through this endeavour the mining community will be able to obtain and compare the real market prices with the prices with which they sell their gold produced to the middlemen which majority of them sale to. Findings indicated that ICT would also contribute to market access (Mean = 4.58, SD = 0.83) by providing a platform for which buyers and sellers of the gold can meet and interact. ICT would offer the participants new markets (Mean = 4.57, SD = 0.89) a market which is different from the normal physical market where individuals interact electronically and anonymously. It will serve as a trading and exchange platform for the gold and its associated products (Mean = 4.52, SD = 0.93). This finding concurs with the report by Bannock consulting ltd in 2008 that in order to make Artisanal gold miners less reliant on intermediaries for the sale of their products and to enable them to obtain better prices they need to have access to information on mineral prices and support in accessing markets directly.

As indicated in Table 4.24, ICT can be used as a reverse channel (Mean = 4.51, SD = 0.92) to disseminate environmental information and policies by government designated agencies to the mining community. Lack of appropriate interaction between artisanal gold miners and the authorities to inform of information flow contribute to environmental degradation. Mining communities can be mobilized to actively participate in environmental conservation and understanding mining policies through the use of ICT enabling mechanisms. Information flow and interaction between authorities and gold miners will contribute enormous benefits. These include increase profits for small miners; invest in cleaner equipment and the avoidance of environmental degrading practice (Clifford, 2011).

Results in Table 4.24 further indicate the use of ICT as an exchange flat form. This implies that there will be networking of miners to work together, to share information and to coordinate activities among themselves. Knowledge exchange between different groups of miners' organizations is an important strategy in generating lessons and sharing insights about organizational development, technologies, business practices, and livelihood challenges and solutions (UNEP, 2012).

Table 4.25: Factor Analysis for ICT Adoption in ASM

	Component* 1	h^2
ICT adoption can contribute to better prices	.845	.714
ICT adoption can contribute to market access	.899	.808
ICT adoption can contribute to new markets	.935	.874
ICT adoption can contribute to market information	.963	.927
ICT adoption can disseminate info on environmental conserve	.971	.942
ICT adoption can disseminate info on new product technologies	.968	.936
ICT adoption can be used in geo-mapping info	.960	.922
ICT adoption can develop new exchange platform	.968	.937
		Total
Sum of squares(eigenvalue)	7.060	7.060
Percentage of trace	88.250	88.250

Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.907
Bartlett's Test of Sphericity	Approx. Chi-Square	3344.027
	Df	28
	Sig.	.000

* Only one component was extracted, thus the solution cannot be rotated.

Table 4.25 shows that the Kaiser-Meyer-Olkin or KMO measure of sampling adequacy for the ICT adoption in ASM was 0.907 which exceeds the required 0.5 for factors analysis. The Bartlett's Test of sphericity, $\chi 2$ (df = 28) = 3344.027, $p < 0.05$ indicate that sufficient correlation exists among the variables to proceed. Since the percentage of trace (the variance explained by the components) is 88.250% which is greater than 0.5(50%) and that all the loadings estimates are greater 0.5, then construct validity can be upheld.

Table 4.26: Socio – Economic Effects of ASM

Variables	N	Mean	Std. Dev
Mining supplemented/replaced farming/agriculture	212	1.4903	1.02999
Mining provide work to individuals in the community	212	2.3333	1.21480
Mining contributes poverty reduction	212	2.4293	1.17620
Mining contributes to community dependence on gold	212	2.3065	1.17527
Mining contributes to improvement in household economy	212	3.3962	1.24816
Mining contributes to improvement in advanced needs	212	1.8066	1.12083

Socio - Economic Effects of artisanal gold mining are shown in Table 4.26. Findings mining contributes to poverty reduction (Mean = 2.42, SD = 1.17).This implies that artisanal gold Mining does not contribute to positive socio economic effects within the mining communities. This is attributable to the availability of alternative income generating activities in other communities or no alternative in those communities (like in West Pokot County). The engagement of respondents to artisanal gold mining is pegged on the short-term gains. Miserendino *et al.*(2013) conclude that artisanal gold mining is the main source of subsistence for millions of people living in developing countries and perhaps is the only livelihood alternative for those communities.

Mining contributes to community dependence on gold (Mean = 2.30, SD = 1.17).The result implies that Mining has neither contributed to or does not contribute to community dependence on gold mining as an economic activity. Some respondents are highly dependent on gold mined as an income generating activity whereas others do not. This finding resonates with empirical evidence by Fisher *et al.* (2009) which suggest that individual working in mining or related services are less likely to be poor than those with other occupations in that the income derived from mining helps reduce poverty and buffer individuals from livelihood shocks but does not confer the same individual with the capacity to progress economically.

Mining contributes to improvement in household economy (Mean = 3.39, SD = 1.24).This implies Mining as an income generating activity has improved the household economy in terms of basic necessities to the respondents. This is attributable to the income generated by the gold produced and was noted by UNECA & AUC (2011) that artisanal gold mining makes a positive contribution to African economies and more particularly, to sustaining rural. Evidence from Senegal demonstrates that ASGM has become an important source of income for many traditionally agricultural rural populations (Persaud *et al.*, 2017). Mining contributes to improvement in advanced needs (Mean = 1.80, SD = 1.12).This means mining does not contribute to elevation of the consumption power of the community, a fact that is attributable to the un sustainability of the low income generated from the ASM.

T- test Statistics on Community Livelihoods

The researcher tested differences in employment at county level and are shown in Table 4.27 below.

Table 4.27: Differences in employment effect according to county

county	Observations	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
Nandi	122	2.1311	.0930819	1.028124	1.946867	2.315428
West Pokot	83	1.5602	.0643679	.5864194	1.432193	1.688289
combined	205	1.9	.0641689	.9187588	1.773481	2.026519
difference		.57091	.1131701		.347731	.7940822

diff = mean(Nandi) - mean(West Pokot)		t = 5.0447
Ho: diff = 0		Satterthwaite's degrees of freedom = 206
Ha: diff < 0	Ha: diff != 0	Ha: diff > 0
Pr(T < t) = 1.0000	Pr(T > t) = 0.0000	Pr(T > t) = 0.0000

The results in Table 4.27 shows that Nandi county had statistically significantly higher number of individuals engaged in the mining activity than their West Pokot counterparts, t(206) = 5.0447, p = 0.0000. The mining community in Nandi affirmed that ASM has either neither replaced nor supplemented farming or agriculture in anyway whatsoever (Mean = 1.49, SD = 1.03).

Table 4.28: Factor analysis on Socio-Economic Effects

	Component		h^2
	1	2	
Earnings from mining activities		.826	.713
Mining supplemented/replaced farming/agriculture		.608	.475
Mining provide work to individuals in the community	.557		.389
Mining contributes poverty reduction	.773		.622
Mining contributes to community dependence on gold	.666		.584
Mining improves the household wealth	.742		.605
Mining contributes to improvement in advanced needs		.563	.334
			Total
Sum of squares(eigenvalue)	2.158	1.564	3.722
Percentage of trace	30.835	22.364	53.181

Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.695
Bartlett's Test of Sphericity	Approx. Chi-Square	218.773
	df	21
	Sig.	.000

Table 4.28 shows results for the Kaiser-Meyer-Olkin or KMO measure of sampling adequacy for the socio-economic effects being 0.695 which exceeds the required 0.5 for factors analysis. The Bartlett's Test of sphericity, $\chi2$ (df = 21) = 218.773, $p < 0.05$ indicate that sufficient correlation exists among the variables to proceed. Since the percentage of trace (the variance explained by the components) is 53.181% which indicates that it is greater than 0.5(50%) and that all the loadings estimates are greater 0.5, then construct validity can be upheld.

4.2.5 Effects on Community Health

The perception on health effects on the mining communities are shown in Figure 4.3. Results reported low incidence rates in health ailments affecting them in terms of skin, respiratory, eye and ear ailments; however, the occurrence of physical injuries was frequent. There was a chance that one out of five ASM participants occasionally suffers from an ailment that could be attributed to ASM mining. However, one in two ASM participant's frequency gets physical injuries due to the nature of the mining processes which were poor.

There are many risks that are associated with ASM, which Tschakert & Singha (2007) identified a total of 25 risks and hazards to miners. The most serious hazard being collapsing sediments, pits, or shafts, with other life-threatening risks dynamite rock blasting and underground heat(high temperature and reduced oxygen in shafts up to 45 feet in depth), slipping and falling into pits and conflicts among the miners. Other significant risks were eye problems resulting from muddy water on the alluvial site and rock particles and smoke from crushing and grinding at the hard rock site, fractures and respiratory tract infections (Yakovleva, 2007).

Interviews from Eastern Ghana indicate there is widespread lack of knowledge on health hazards associated with mercury and an overall absence of environmentally safe technologies and methods for recovering gold (Yakovleva, 2007).An observation from the field reported no use of protective wares such as the helmet, gloves and gumboots for safety. Those who carried out the washing entered the ponds without any protective gear such as gumboots or cloves. This implies that lack of equipment and no use of protective wares contributed to frequent physical injuries as indicated in figure 4.3. Most of the studies have shown that the elemental safety wear (gloves, helmets, goggles, and boots) were non-existent and only a few miners could afford them are. Although protective measurements are taken, such as using props for shafts and reducing the distance between pits to avoid collapsing sediments, the environment remains highly risk-prone (Tschakert & Singha, 2007).

Artisanal gold mining activities were characterized by low standards of health and safety with miner's engaging in mining activities under dangerous conditions. And as indicated by a survey in geita District, Tanzania accidents due to ASM range from minor to major injuries and are severest during rainy seasons. This is further amplified by the fact that most miners lack occupational health and safety awareness with not access to protective gear (Kitula, 2006).

It is widely acknowledged that the labour – intensiveness in artisanal mines increases the risk of illness, injury and stress due to enhanced levels of dust and noise pollution as well as extreme exertion (Hinton *et al.,* 2004) while exposure to mercury vapours results in chronic poisoning. Symptoms include gingivitis, tremors and personality changes, kidney injury, and increase in blood and urine above normal levels (Tschakert & Singha, 2007)

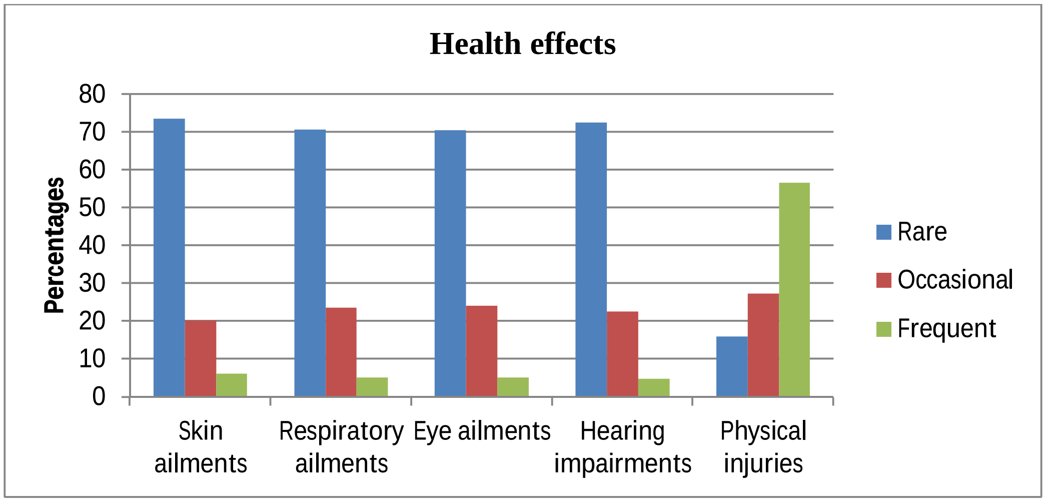


Figure 4.2: Health Effects Occurrence Rates
Source: Research data (2016)

4.3 Findings for Objective, Research Questions / Hypothesis

4.3.1 Impacts of Capital Assets Accessibility on Community Livelihoods and Environment

The study determined access level to capital assets in artisanal gold mining and its impacts to community livelihoods and their environment. Capital assets in artisanal gold mining included physical, human, financial and social capital. Access to these assets was important variables to community livelihood. Production of livelihoods involves several critical elements specifically; capital assets, social relations and organisations, institutions and access are identified as important variables to most livelihoods (Ellis, 2000).

There are generally five main categories of capital assets identified as ingredients to Livelihood production. As noted by Ellis (2000) natural capital is the stocks of the natural resource base (land, water, biological resources) while physical capital (also referred to as human-made capital) is the assets created by economic production activities such as infrastructure, tools and agricultural technologies. Human capital is the education level and health status of individuals and populations, and financial capital refers to stocks of cash or credit. Finally, social capital is understood as the social networks and trust operating between individuals and communities. Capital assets access is important component to livelihood systems that intersect to provide constraints and opportunities for individual's households and communities.

This objective gave the insights on how livelihoods are interlinked with the processes determined by level of access to capital assets in producing artisanal gold. In order to accomplish this, the study examined the diversified capital assets individuals and households combine to explore gold to generate livelihoods. Particular attention was directed towards the levels households accessed a host of assets to make a livelihood through artisanal mining.

Table 4.29: Capital Asset Accessibility

Levels of access	**Land and mining rights**		**Equipment and machinery**		**Expertise and knowhow**		**Labour and manpower**		**Finance and credit facilities**		**Group and cooperative services**	
	F	%	F	%	F	%	F	%	F	%	F	%
Low	28	13.0	50	23.8	126	59.4	136	64.3	182	85.7	185	87.3
Moderate	29	13.8	37	17.5	78	36.6	44	20.6	30	14.3	27	12.7
High	155	73.2	125	58.7	8	4	62	15.1	0	0	0	0
Total	212	100	212	100	212	100	212	100	212	100	212	100

Access to capital assets by respondents in Nandi and west Pokot counties is shown in Table 4.29. Approximately 73.2 % of the respondents had high access levels to land and mining rights, 58.7 % reported high access levels to rudimentary tools and equipment, 59.4 % showed low access levels to the technologies, 64.3 % low access levels to skilled manpower, 85.7 % low access levels to finance and credit facilities while 87.3 % had low levels access to group or cooperative services. Respondent's accessed high levels on two capital assets namely land right to mine and rudimentary equipment used in mining. In contrast, they had low access levels on expertise and knowhow, skilled labour, finance and credit facilities and cooperative services or groups which are social capital.

Plate 8: Fabricated Crushing machine in mining site, Nandi County

The result implies that artisanal gold miners in Nandi and West Pokot have a challenge of accessing capital assets which are necessary to carry out mining which make positive impacts to their livelihoods and as such they remain in a vicious cycle of poverty. Ham and Chirwa (2012) argue that resilience of such communities is increased when secure access to resources needed to generate livelihoods is reinforced. Mineral exploitation should also reduce vulnerability and enhance resilience through creating new stocks of capital by enhancing the physical, financial, and human and information resources (Isaacs & Gervasio 2010). The result further implies that low access to capital asset such as financial credit is critical in promotion of poor mining practices by using rudimentary tools with low production and recovery of gold, contributing to low income for miners leading to poverty. Low access to finance and credit facilities means miners cannot invest in modern technologies which are efficient with high recovery rate of gold translating to higher income.Word bank (1995) noted that low recovery due to inappropriate new technology results in low revenues and the inability to accumulate funds for investment.

Plate 9: Sluice bed in mining site, Nandi County

Without sufficient finances or funding to invest in prospecting equipment, artisanal miners relied on individual experiences to find right veins to mine which will take them several days to dig without any returns translating to losses. Also they will be confined more in gathering superficial ore which have less enrichment of gold than those dip underground with more gold thus fewer earnings. More so without prospecting equipment due to finance constrains they cannot quantify ore reserves in their mining fields which could have enabled them develop credible business plan which any financial institution can accept therefore it further makes them unable to get credit facilities.

Low accesses to financial assets imply that miners get their financial obligations from the middle men who eventually buy their gold. Artisanal miners are forced to bargain from a disadvantage point at the time of sale of their gold by being paid low prices preventing them from getting sufficient capital to meet their obligations and invest. This creates a cycle of poverty which makes it difficult for them to bring change in mining technologies and practices which have high recovery rate. One of the reasons for lack of access to financial capital is attributed to the reluctance of banks and other financial agencies to provide loans and other financial assistance to an unregulated ASM sub-sector. Financial capital is difficult to obtain from the financial system, which perceives small-scale mining as a risky activity (Chaparro, 2003).

Low access levels to funding implies further that artisanal miners resort to cheap methods of and easily fabricated technologies such as crushers. These crushing or mills and washing are not efficient leading to some precious metals not being recovered. The owners of the crushing machines take advantage of their fellow miners by taking Gold which were not fully recovered and remained in the washing ponds as sediments for further recovery adding more misery to the already disadvantaged artisanal miners. The rule within the mining sites was that the remains in the washing ponds as sediments belong to the owner of the crusher. The owners of crushers obtain more gold than what is obtained by the miner impoverishing them further hence keep on struggling within the poverty levels. Residuals from artisanal mining allegedly still hold 50% of the original gold content in some situations (Gervasio 2010). Inability to access new technology has consequence of low productivity making their income remains at low level hindering re-capitalization and upgrading of mining activities keeping artisanal miners in a vicious cycle of poverty.

Low access to Group and cooperative (capital asset) by artisanal miners as indicated in Table 4.29 implies that artisanal miners were unable to get services and focus artisanal mining as a business. One of the services of cooperative is to enhance finances by making it possible to increase the capacity to mobilize financial capital Miners in associations can easily access bank loans than an individual since banks prefer dealing with cooperatives than individuals when offering loans. The cooperative model is an important example of how miners have mobilized to create an organizational structure that allows the acquisition of credit (UNEP, 2012). Their mining activities are therefore constrained by the inability to improve their production restraining them from engaging in an economic activity which can transform their livelihoods.

Findings from the present study showed 64.3% low access levels to skilled (Table 4.29). Skilled manpower is expertise acquired from people’s exposure to education and training. The result implies that respondents are unable to identify, evaluate and exploit opportunities for commercialization. Furthermore, it suggests that respondents are unable to have knowledge of efficient mining technologies, knowledge about gold mining sector and markets in particular which would affect the pricing of their processed gold, minimizing the earnings. Respondents are unable to increase their productivity as a result of skills that is embedded in individuals influencing business development.

Artisanal gold mining in Nandi and West Pokot are faced with problems of sustainability due to inability to access capital assets as a result of being neglect by county governments and national government development agenda. They do not feature in national government and county government poverty alleviation strategies due to the negative perceptions of Artisanal gold mining which tend to outweigh its positive impacts.

Artisanal miners lack access to appropriate and affordable technology at 59.4% as indicate in Table 4.29. This is as a result of prohibitive cost of plant and machinery and lack of suitable small-processing technologies. The result implies that miners use rudimentary technologies, poor excavation methods, poor processing methods and inappropriate waste disposal methods which are damaging to the environment. The poor method implies mining operations which modify the surrounding landscape by exposing previously undisturbed earthen materials. Erosion of exposed soils, extracted mineral ores, tailings, and fine material in waste rock piles result in substantial sediment loading to surface waters and drainage ways.

Miners in Nandi County engaged in underground type of mining where shafts are used to access gold ore deposited underground. With low access to technologies which is a capital asset, excavation process was done manually with the use of basic tools to get Ore from underground gold reefs. Artisanal miners used basic tools like wooden ladders, bullies and tunnelling to access underground ores contributing to environmental problems. Use of wood to fabricate tools to be used in underground artisanal mining contributed to deforestation which is a negative environmental effect.

Plate 10: Use of wood in underground mining Nandi County

Poor mining methods are associated with poor safety, health and environmental practices. In underground artisanal gold mining, weak rock formations are poorly supported, leading to frequent cave-ins and injuries or loss of life. This reflects labour-intensive exploitation techniques without sufficient capital to invest in mine productivity (Midende, 2010).

Techniques used to treat the gold ores include hammering, crushing, washing the minerals in pits filled with water and use of mercury in Nandi County were reported to be inappropriate. Poor mining methods are associated with poor environmental practices and reflect labour-intensive exploitation techniques without sufficient capital to invest in mine productivity (Midende, 2010).

Field observation indicate that ASM gold is extracted from ore through amalgamation (Hg^{o}– Au^{o}/amalgam) Mercury was used by mining communities for amalgamation in Nandi County as indicated in Table 4.11 due to inexpensiveness, non-requirement of skilled labour to handle but end up being discharged along the tailings. As stated by Shields (Woolford, 2010), the primary issue that arises with the replacement of mercury in mining is that of cost and finance. Artisanal gold miners used the cheapest and easy method which is mercury amalgamation to get the highest benefits for themselves. This is attributed to lack of access to credit to implement cleaner technologies therefore mercury amalgamation of gold was the best technology available for many artisanal gold miners. This agrees with (Telmer and Veiga 2009) that mercury was widely used because it is ‘cheap, simple, fast, independent and reliable’. This result implies further that Mercury leakage and improper disposal of mine wastes is dangerous to humans and can pollute ground water, soils for farming which contribute to the livelihood of the majority respondents. During these underground mining processes, a significant amount of mercury is released into the environment, affecting miners and their communities (Balistreri *et al.,* 2009).

Low access levels to modern technologies which are part of capital assets such as exploration equipment impact negatively to the environment. The underground ores brought to the earth surface come with a lot of waste materials which do not contain any precious metals. The waste earth materials quantities increase due to case work on the right veins to mine due to lack of exploration equipment. Use of inadequate processing techniques leads to low recovery of valuable minerals further increasing quantities of waste material being disposed into the environment. These wastes inform of stockpiles of excavated materials destroyed both agricultural and grazing land as observed in mining sites. The depositions of underground waste materials alter the aesthetics of the environment and get exposed to erosion. This implies that exposed soils and fine material in waste rock piles can result in sediment loading to surface waters and drainage. The waste materials and tailings contained heavy metals which get exposed to the environment when brought to the earth surface and disposed poorly (refer laboratory results).

Due to poor technologies heavy metals, lead, cadmium zinc (refer to laboratory results in Figure 4.2) which were found in the tailing were disposed in ways which are not appropriate. The disposal of tailings containing heavy metals can be the source of leached elements leading to destruction of the environment. Lovitz (2006) also found that tailings and mine wastes containing heavy metals negatively impact the environment. The tailings and wastes containing heavy metals interact with water to generate contaminants to soils.

During ore processing at the washing ponds, sediment remains and gets accumulated within the ponds and thereafter are scooped out and pilled outside the pond, this are referred as tailings. Due to poor technologies these tailings contain unrecovered Mercury, lead, Cadmium, Zinc (refer to laboratory results in Figure 4.2) leading to destruction of the environment. According to the laboratory analysis the Tailings contained harmful quantities of toxic substances, including lead, cadmium, and chromium. The very possible environmental impacts of these tailings include contamination of surface and groundwater during periods of heavy rain due to leaching.

During heavy rains more water may enter washing bonds which are small with no enough capacity to contain any extra water. This will necessitate the release of washing impoundment effluent because they will over flow the impoundments. Since this effluent contain toxic heavy metals, the release of this effluent will seriously degrade water quality of surrounding rivers and streams since this the effluent are not treated. Another environmental concern is the exposed materials and tailings from mining operations containing heavy metals will pollute the soils. Socio-economic barriers linked to poverty and informality, and the lack of access to information and credit lines to implement cleaner technologies, means that mercury amalgamation of gold is the best technology available for many artisanal and small-scale gold miners. It is widely used because it is ‘cheap, simple, fast, independent and reliable (Telmer & Veiga 2009).

Lovitz (2006) reported that tailings and mine wastes containing heavy metals negatively impact the environment. The tailings and wastes containing heavy metals interact with water to generate contaminants to soils. ELAW (2010) noted that perhaps the most significant impact of a mining project is its effects on water quality. Mercury leakage and improper disposal of mine wastes is dangerous to humans and can poison ground water, farming land which the livelihood of the majority. During these processes a significant amount of mercury is released into the environment, affecting miners and their communities (Hilson, 2005; Balistreri & Worley, 2009).This demonstrates that there where negative environmental practices taking place and there could also be further implicit risks through leaching to water bodies, soils and food chain.

Rudimentary tools which were accessed by artisanal miners especially in Nandi county implied limited efficiency in penetration to hard rock down the tunnels necessitating the use of explosives making it risk to the miners and causing environmental degradation. It further implies artisanal miners engaged in underground mining required access to explosives so that they are able to break through hard rock to reach gold ores. Cumulative vibrations significantly affect surrounding community such as cracking of stone walled houses, dust and noise due to of drilling blasting, crushing and grinding in mining. Fabricated crushers are the other rudimentary equipment used in Nandi County which have no standards, producing dust and noise which effect the environment negatively. In west Pokot environmental impacts along river Murruny were artisanal gold mining activities take place were cutting of trees leading to deforestation, digging the river beds loosening soils leading to erosion and subsequent destruction of aquatic life habitat. Poor mining methods along river Murruny in West Pokot was due to low accessibility of technology leading to destruction of vegetation along the river in places where alluvial gold panning was carried out.

Mining operations were abandoned once the easy ore is extracted and as the tunnels become dipper while the rocks are harder leaving behind long-term environmental damage. It was observed in the study area that old shafts which are no longer in use were left uncovered, soil heaps and tailings were left above the ground. The result implied that artisanal miners moved to new sites because technologies used or equipment such as chisels, hummers and hoes cannot manage hard rock and dip tunnels. This was mention by Midende (2010) that extraction is often carried out with rudimentary techniques and tools, such as pickaxes, hammers, chisels, shovels and pans. This left behind a much degraded environment within the mine sites while abandon shafts are a hazard to both humans and their livestock. Mining activities accelerated the changes in the natural environment by modify landscapes this agrees with ELAW (2010) that there is a long-term impacts on communities and natural resources due to their physical degrading nature . Better production practices which are environmentally friendly with less environmental degradation output are possible with new technologies.

Poor mineral processing mining methods due to lack of access to new technology was the main reason behind both physical and chemical environmental degradation.

Plate 11: Deforestation along River Murruny, West Pokot

Plate 12: Destruction along the bed of River Murruny, West Pokot

Table 4.30: Factor Analysis of Scalability of Capital Assets

	Component		h^2
	1	2	
Land and mining rights		.637	.701
Equipment and machinery		.893	.822
Expertise and knowhow	.779		.607
Labour and manpower	.836		.761
Finance and credit facilities	.855		.733
Group and cooperative services	.799		.699
			Total
Sum of squares(eigenvalue)	2.994	1.329	4.323
Percentage of trace	49.906	22.144	72.051

Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.644
Bartlett's Test of Sphericity	Approx. Chi-Square	399.994
	df	15
	Sig.	.000

Table 4.30 indicates that the Kaiser-Meyer-Olkin or KMO measure of sampling adequacy for the capital assets was 0.644 which exceeds the required 0.5 for factors analysis. The Bartlett's Test of sphericity, $\chi 2$ (df = 15; $p < 0.05$), indicating significant correlations among the variables to proceed. Since the percentage of trace (the variance explained by the components) is 72.051% (greater than 50%), therefore, construct validity can be upheld.

4.3.2 Impacts of Artisanal Gold Mining Organizational Dynamics on community livelihoods

The study sought to find out organization dynamics in artisanal gold mining and the effects on community livelihoods. Artisanal gold mining is a practice and a subsistence livelihood based on whoever finds a mineral has the right to exploit. There is laxity on control and access to mining sites which are open enabling the rural poor to exploit the natural resource without formal permits or leases. The organization of the sector prevents it from realizing improvement of quality life for the mining communities and environmental conservation. Unorganized artisanal gold mining deprives the government collection of revenue in terms of taxes which is an important financial resource to the state. It brings about poor environmental, health and safety technical and trading conditions to mining communities. The organization dynamics in the artisanal gold mining sector is an obstacle to competitiveness, productivity and social development in mining areas. At its best artisanal gold sector follow organizational form of family structure where the head of the family retains and manages income generated.

Table 4.31: ASM Organizational Dynamics

	N	Mean	Std. Deviation
Low barriers of entry	212	1.6509	1.02613
Sectoral economic marginalization	212	1.6919	1.09757
Informality of the sector	212	1.6812	1.07703
Mainstay economic activity	212	2.0566	1.30497

Findings on organizational dynamics in artisanal gold mining are shown in Table 4.31. Mining communities consider ASM do have low entry barriers (Mean = 1.65, SD = 1.02). This result implies that artisanal gold mining is an activity engaged by those with low education level and no initial capital for investment. The respondents have no restrictions when joining the activity of artisanal mining to earn a livelihood. This is attributed to an activity which does not require any skills and therefore those who have low education levels or basic can enter into that sector. The initial investments such as the need for simple rudimentary tools and effort to get into gold mining activity may be considered low. The mining communities need the basic and rudimentary tools and no specialised skills required to participate when compared to other economic activities including the allure of higher returns drives individuals to artisanal gold mining.

Organizational dynamics in artisanal gold mining findings are shown in Table 4.31, where sectoral marginalization was reported (Mean = 1.96, SD = 1.09).This result implies that Marginalization of artisanal mining is attributed to political class, the policy drivers on policies to do with management and exploitation of natural resources. The miners are far from the centre due to political marginalization and at policy making level thus unable to influence policymakers. This makes the sector contribute to environmental degradation and little contribution to community livelihoods. This is attributable to government institutions and policy makers who do not consider artisanal gold mining activity as a source of income and employment. This is due to lack of advocacy for appropriate incentives and capacity for miners to carry on their mining activities in a more environmentally sensitive manner. This conforms to (Hruschka & Echavarria, 2011) who noted that geographic isolation and lack of political influence means ASM activities and their structural challenges often poorly understood are not well translated into public policy and development interventions. ASM's marginalization within the mining industry primarily stems from much government believing that large-scale mining should be prioritized whenever possible over ASM, their marginal tax revenue contributions and the obscurity of the gold trade. It means also that Artisanal Miners operate in remote areas with poor communication suffering geographical marginalization that makes them less able to access markets and technologies.

Organizational dynamics in artisanal gold mining results are shown in Table 4.31, where informality of the sector was recorded (Mean = 1.68, SD = 1.07).This result implies that artisanal gold mining is informal an indication of government failure to properly set and implement appropriate laws. It means that respondents exploited this natural resource without formal permits therefore non-committal to environmental conservation. The result further implies that artisanal mining activities are not integrated into legal, economic, and institutional framework. Formalization is one of the factors which play a role in environmental problems in artisanal mining and community livelihoods. This has been noted by (Lovitz, 2006) that the major obstacles in adopting mercury-free technologies in artisanal mining are the historical structure and lack of planning, miner's organization, government capacity, organization and corruption.

The result implies further that the government is deprived of important financial resources and prevents the sector from delivering on important social objective formal employment, improved quality of life for mining communities and environmental degradation. Informality implies that artisanal mining will not benefit Miners by being given support to invest in safer and more efficient productive mining practices which would increase community's income and less negative environmental effects. The promotion of artisanal mining as an important driver of local development require a wide range of efforts including technical support and training, facilitating access to the market access to finances and protection of the environment, linking up with other development programs (Midende, 2010. The idea of bringing artisanal miners under a legal framework that will have greater support, incentives, and resources to improve their operations, develop safer mining practices, obtain greater profits, and potentially scale up their operations to the level of small and medium-scale mining (Hruschka, 2011).

Organizational dynamics in artisanal gold mining are shown in Table 4.31 and show that the mainstay economic activity (Mean = 2.05, SD = 1.30).The result implies that artisanal gold mining is not considered to be the mainstay economic activity in Nandi County with primary economic activities such as agriculture. Miners originate from the village were mostly farmers look for additional resources to support their families (Irene, 2015). In West Pokot it is considered to be the mainstay activity due to harsh climatic conditions.

Table 4.32: Factor Analysis for ASM Organizational Dynamics

	Component		h^2
	1	2	
Buyers offer competitive prices		.857	.736
Familiarity with gold value chain		.859	.793
Familiarity with gold market procedures		.596	.702
Familiarity with final end product	.785		.823
Low barriers of entry	.905		.914
Sectoral economic marginalization	.887		.869
Informality of the sector	.904		.888
Mainstay economic activity	.707		.546
			Total
Sum of squares(eigenvalue)	3.945	2.326	6.271
Percentage of trace	49.307	29.076	78.383

Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.872
Bartlett's Test of Sphericity	Approx. Chi-Square	1468.494
	df	28
	Sig.	.000

Results in Table 4.32 shows that the Kaiser-Meyer-Olkin or KMO measure of sampling adequacy for the ASM organizational dynamics was 0.872 which exceeds the required 0.5 for factors analysis. The Bartlett's Test of sphericity, $\chi 2$ (df = 28) = 1468.494, $p < 0.05$ indicate that significant relationship among the variables to proceed. Since the percentage of trace (the variance explained by the components) is 78.383% which is greater than 0.5(50%) and that all the loadings estimates are greater 0.5, then construct validity can be upheld.

Table 4.33: Reliability Coefficients

Variables	N of cases	Average inter item correlation	No of items	Reliability Coefficient
Non-scalable assets*	212	0.3242	5	0.7057
Scalable assets	212	0.3461	6	0.7606
ASM Organizational dynamics	212	0.3009	5	0.6828
ICT use	212	0.6483	8	0.9365
Regulation	212	0.8837	7	0.9815
Socio-economic effects	212	0.3333	6	0.7500
Health effects	212	0.0955	6	0.3878

* One item reverses (Land and mining rights)

The statistics in Table 4.33 indicates that ASM organizational dynamics had a Cronbach coefficient > 0.60 which indicate that the instrument was acceptable for explanatory purposes whereas non-scalable assets, scalable assets, ICT use, regulation and socio-economic effects had a Cronbach coefficient > 0.70 which indicate that the instrument was adequate for explanatory purposes. However, the health effects had a Cronbach's coefficient of 0.3878 which was inadequate, thus it was only used to detail the specific aspects of the health of the mining communities.

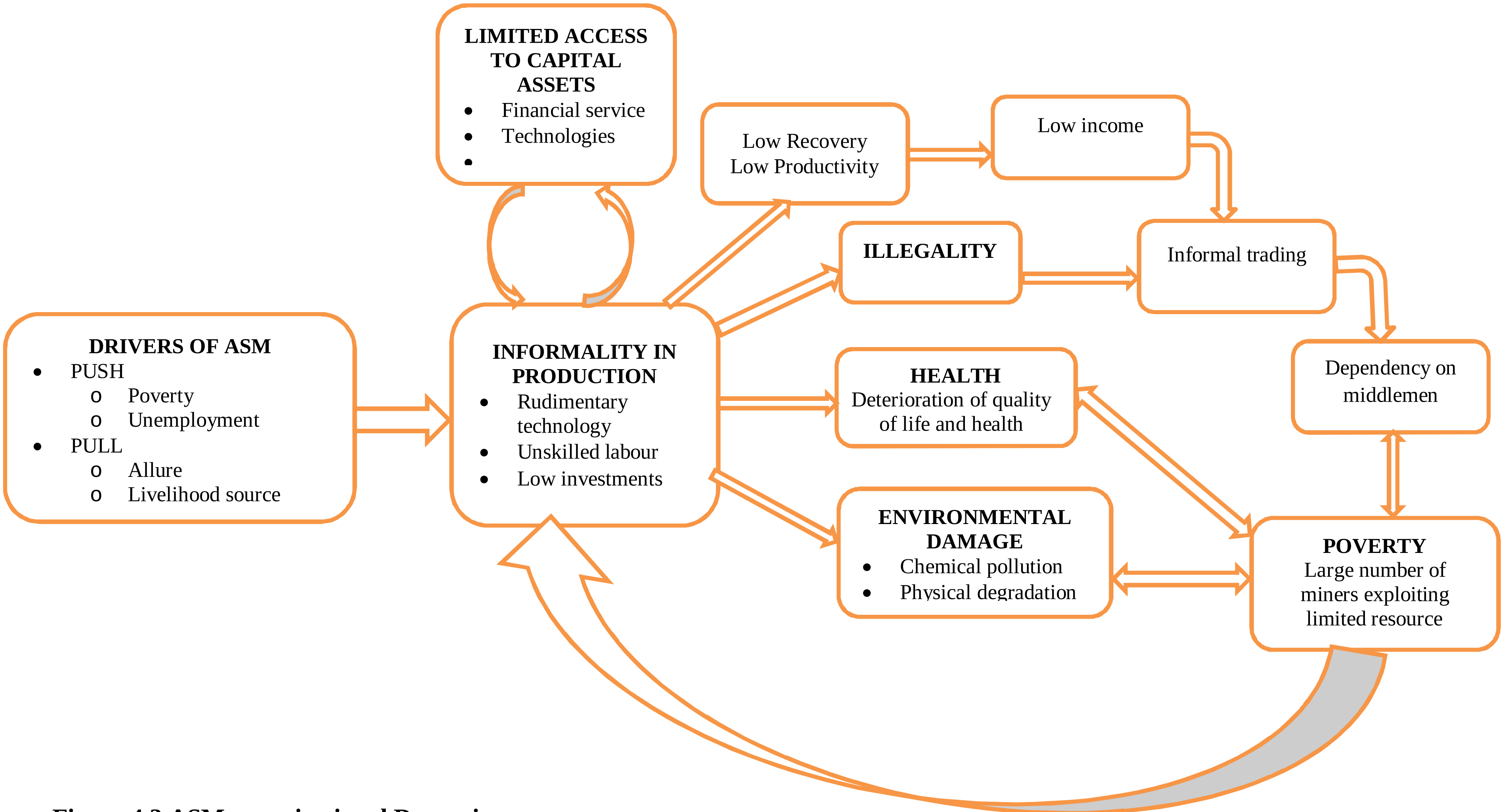


Figure 4.3 ASM organizational Dynamics
Source: Authors (2016).

4.3.3 Impacts of Artisanal Gold Value Chain on Community livelihoods

Every economic activity has a value chain processes that signify the processes that the end product follows. The value chain of artisanal gold value chain is the linkage between the miners, markets and different actors in the chain. After extraction artisanal miners sell their gold to local buyers who sale to businessmen staying in the nearby towns. The businessmen move within the different mining sites buying up gold from artisanal miners within the locality. Local buyers are at every mining site and are members of the community leaving amongst themselves. After buying from local buyers the business men transport gold to Nairobi and sell it to brokers who eventually export to foreign countries. Gold is used in a wide range of technological and manufacturing applications because of its electrical conductivity and the largest consumers are United States followed by China and Germany.

Table 4.34: Perceived uses of gold mined

Uses of gold mined	County of origin		Total
	Nandi	West Pokot	
Don't know	37(61.7%)	23(38.3%)	60(28.3%)
Prizing ceremonies	34(100.0%)	0(0.0%)	34(16.0%)
Ornamental gifts	27(90.0%)	3(10.0%)	30(14.2%)
Prestige products	26(31.3%)	57(68.7%)	83(39.1%)
Others	5(100.0%)	0(0.0%)	5(2.4%)
Total	129(60.8%)	83(39.2%)	212(100.0%)
	Chi-Square		
Pearson χ^2	Value	df	p-value
	65.424	4	0.00

Perceived uses of the gold mined are shown in Table 4.34. About 28.3 % of the respondents do not know the use, 16.0 % perceived use for prizing ceremonies, 14.2 % knew it for ornamental gifts and 39.1% knew it for prestige products. These results suggest that respondents had varied perceptions on the uses of gold depending on the value attached to it. It further implies that respondents are unable to bargain the prices of their product without background information and knowledge of the cost of the end product of gold. For those who do not know the use of gold were unable to figure out the value of the product they were holding and bargain for a good price ending up being offered low price. The varied perceptions are attributed to the level of education in the gold mining areas.

The relation between the perceived use of gold and the county was significant, χ^2(df=4; N = 211; $p < 0.05$). This indicates that individuals from West Pokot counties perceived gold to be more valuable than their counterparts from Nandi County. There are indications that gold is valued by their affirmation that it is used in the making of prestige products.

Table 4.35: ASM Value Chain Activities

	N	Mean	Std. Dev.
Buyers offer competitive prices	212	2.2370	1.33122
Familiarity with gold value chain processes	212	2.0670	1.29545
Familiarity with gold market procedures	212	1.8246	1.21990
Familiarity with final end product	212	1.6274	1.10054

The study sought to find out whether the respondents understood the gold value chain activities and results are as shown in Table 4.35 Respondents were reported to be familiar with gold value chain processes (Mean = 2.06, SD = 1.29), gold market procedures (Mean = 1.82, SD = 1.21) and final end product (Mean = 1.62, SD = 1.10). This result implies that the value chain of artisanal gold is informal, unclear, unregulated, and subject to abusive activities. Artisanal miners are disconnected from the market and are unable to get a fair price for their products. The actors in the artisanal gold value chain operate in a complicated value chain with negative consequences on community livelihoods in terms of low earnings thus reduced benefits. In this value chain Miners are the least compensated low prices cannot help build sustainable livelihoods.

This is attributed to marginalization by the policy makers and government in terms of marketing policy which works towards betterment of the miners. This force the respondents to sell through channels of middlemen on site who offer low prices than international market prices therefore having very limited impact to their livelihoods. It means no fair trade and therefore cannot serve as a major incentive to improve their lives. Sustainable value chains have increasingly become one of the cornerstones of multi-pronged strategies in other contexts around the world to effectively professionalize, manage, regulate and increase benefits from ASM and work toward ecologically and socioeconomically responsive ASM (Levin, 2008).

The result further implies that respondents are at a weak position in the market when not Familiar with gold value chain processes and gold market procedures therefore dependent on middlemen. When linkages are made between artisanal gold miners and formal markets it creates positive outcomes, such as improved livelihoods, and individual, family and community development (Levin, 2008). One approach used successfully in both Ghana and Ethiopia was for the government to act as a licensed buyer of gold. In 1989, Ghana enacted the Precious Minerals Marketing Corporation, PMMC, a parastatal that buy gold from licensed miners and brokers at prices determined weekly by international markets. The PMMC also licenses and finances local agents to buy gold in remote areas, asserting control over the agents to assure that they do not seek an unreasonable economic windfall.

In Ethiopia, the National Bank guarantees international market prices for artisanal-mined gold and mandates that artisanal miners conduct transactions with the Bank. This requirement increased the amount of gold purchased by the National Bank from artisanal miners twenty-fold between 2008-09 and 2011-2016.This brought transparency into a value chain transparent supply chain while encouraging value addition within the production chain which provides a means of enabling small-scale miners to generate additional income and create jobs for the local community through cutting; polishing and transforming gold into jewellery.

With regard to the competitive pricing of the gold produced, the respondents were divided on the prices offered (Mean = 2.23, SD = 1.33). This indicated that the mining communities either do not understand the pricing mechanisms or lack the necessary market pricing information. This result implies that artisanal gold miners received low prices for their products due to unfair supply chains which are unregulated. Artisanal miners are often more dependent on the prices fixed by local buyers and intermediaries than global market prices. Artisanal gold mining account for 10% of the global gold supply, but the profit is made higher up in the value chain (Smith, 2012). Those working further along the chain, traders, intermediaries, and manufacturers tend to benefit from the profits. This imbalance tends to be greatest when the miners are working illegally without any formal protection from the state, and are effectively selling black market goods and being exploited by intermediaries or traders, rarely getting fair prices (Dreschler, 2002).

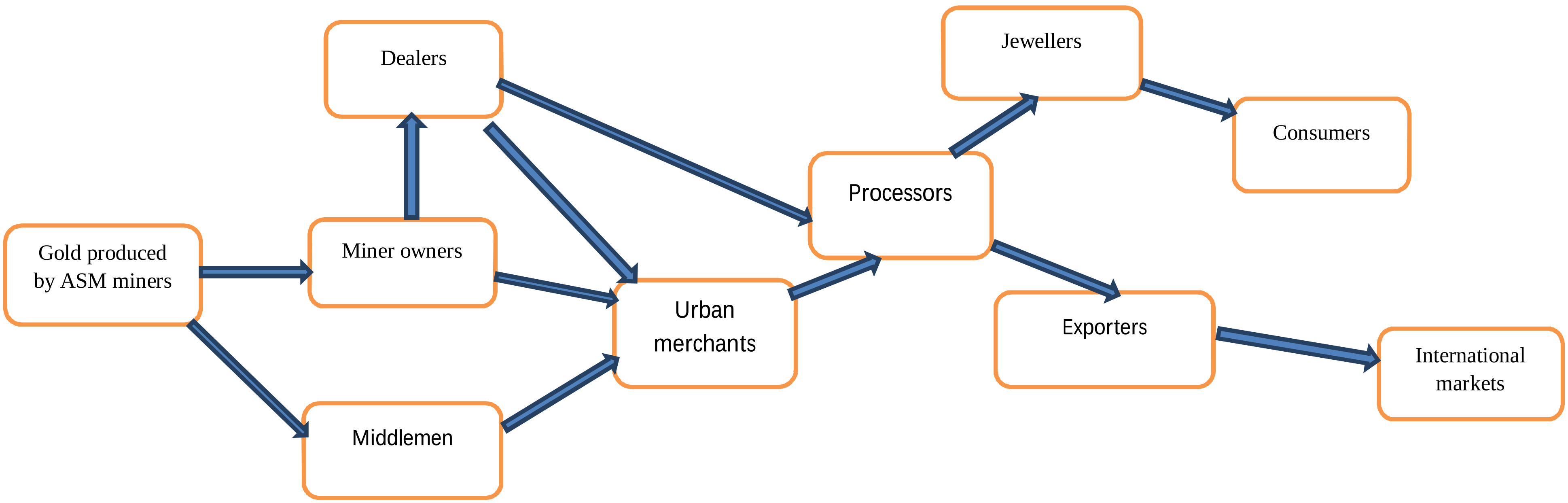


Figure 4.4 ASM gold value Chain
Source: Authors (2016)

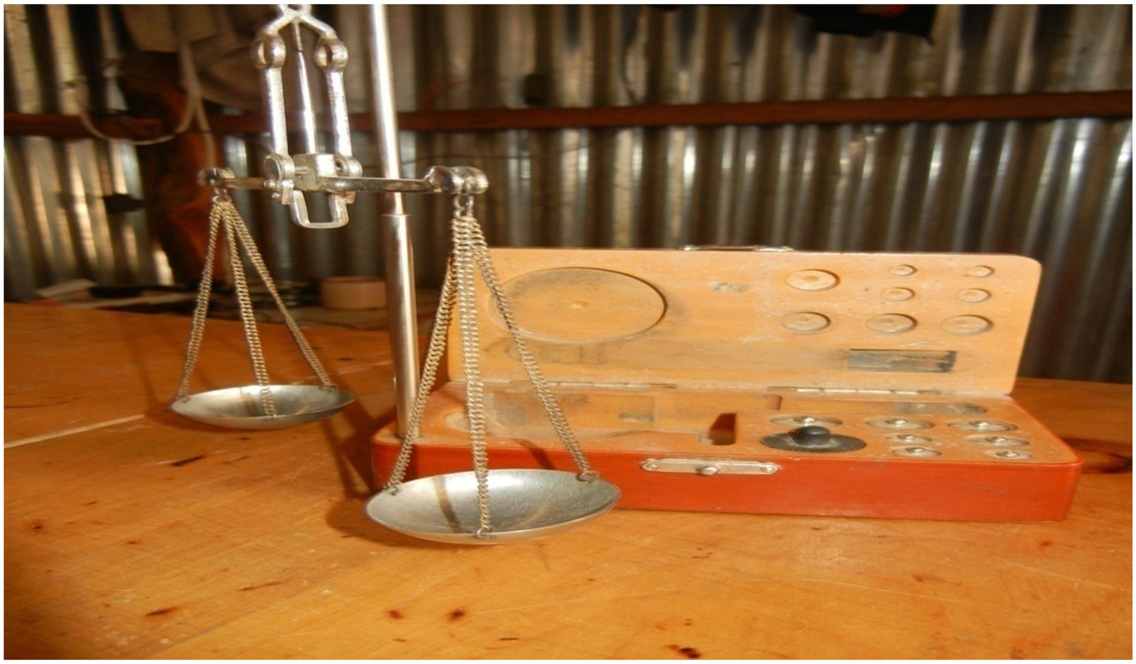


Plate 13: Gold weighing scale in use at Nandi County

Figure 4.3 illustrates how the ASM is organized structurally. At the onset, individuals are either pulled into ASM activities to the allure of riches or as alternative source of livelihood or pushed into the activities by poverty and unemployment. Because of ease entry, miners are informally producing gold using rudimentary tools, unskilled labour and low investments. Due to the informality of the production systems, miners are not able to access required capital assets to upskill scalable capital assets such as financial services and production technologies.

Use of rudimentary technologies and lack of investment leads to low recovery of gold accompanied by environmental damage with consequent deterioration of quality of life and health. Further, informality signifies illegality of the whole activity and consequently leading to informality in trading. Low productivity leads to low income which perpetuates informal trading of gold and because of the informality in trading, miners increasingly become dependent on middlemen who offer low prices while exploiting the miners. Consequently, exploitation and low prices leads to impoverishment of the miners. As the number of impoverished miners increase and mining resource diminish, more artisanal gold mining activities leads to environmental degradation and deterioration of health. The cycle of poverty reverts back to the informality in production because of the surge in the number of miners participating in artisanal gold mining activities.

The mining communities need basic and rudimentary tools for participation when compared to other economic activities and the allure of higher returns drives individuals towards ASM.

Correlation statistics

Table 4.36: Correlation statistics

	Income effect	Indirect effect	Non-scalable assets	Scalable assets	ASM Value chain	Organizational dynamics	ICT usage	Regulatory aspects	Enforcement aspects
Income effect	1								
Indirect effect	.496**	1							
Non-scalable assets	-.090	.043	1						
Scalable assets	.218**	.072	-.223**	1					
ASM Value chain	.313**	.046	-.151*	.312**	1				
Organizational dynamics	.293**	.140*	-.072	.112	.485**	1			
ICT usage	.031	.005	-.019	.017	.051	-.003	1		
Regulatory aspects	.310**	.092	-.248**	.141	.278**	.257**	-.052	1	
Enforcement aspects	.129	.094	-.106	-.058	.084	.283**	-.120	.549**	1

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

The correlation statistics in Table 4.36 recorded significant relationship between the variables. The statistics show income earned by the miners significantly correlate with scalable assets($r = 0.218$, $p<0.01$), ASM gold value chain ($r = 0.313$, $p<0.01$), ASM organizational dynamics ($r = 0.293$, $p<0.01$) and regulatory aspects ($r = 0.310$, $p<0.01$).

The results show that a number of the variables including scalable assets, ASM gold value chain and organizational dynamics associate with the income effects such that a significant increase in these factors would have a corresponding increase in income earned by the miners.

Hypotheses testing

H_{01}: Accessibility to capital assets in artisanal gold mining has no significant impacts to community livelihoods.

Results in Table 4.39, the coefficient for non-scalable resources, -0.031 ($t = 0.44$, $p> 0.05$) and scalable resources, 0.0509($t = 0.70$, $p> 0.05$) are statistically not significant, it indicates that accessibility to capital assets does not determine the income earned by the artisanal gold mining communities.

The researcher did not reject the null hypothesis that accessibility to capital assets in artisanal gold mining has no impacts on community livelihoods. Accessibility to capital assets has no impacts on income of the ASM communities.

H_{02}: ASM organizational dynamics no significant impacts on community livelihoods

The table 4.36 shows the coefficient for ASM organizational dynamics, 0.191($t = 2.50$, $p< 0.05$) is statistically significant, it indicates that ASM organizational dynamics determines the income earned by the ASM community.

ASM organizational dynamics reported a significant impact on the community livelihoods. ASM organizational dynamics have impacts on community livelihoods. This indicates that ASM organizational dynamics significantly impacts the community livelihoods by increasing their sources of income. Further organizational dynamics positively correlates with economic income ($r = 0.2941$, $p < 0.05$) and with mining earnings($r = 0.2674$, $p < 0.05$).The researcher rejected the null hypothesis that ASM organizational dynamics have no significant impacts on the community livelihoods and concludes that ASM organizational dynamics impacts community livelihoods by increasing earnings. The alternative hypothesis that artisanal gold mining organizational dynamics has significant impact on the community livelihood would hold.

H_{03}: The artisanal gold mining Value chain has no significant impacts on the community livelihoods.

Results in Table 4.36 reported significant effect of ASM gold value chain ($r=0.191$; $t=2.38$; $p< 0.05$) on income earned by the ASM community. This indicates that value chain activities have a significant impact on the community livelihoods by increasing their earnings. Further, value chain activities positively correlate with mining earnings ($r = 0.3948$; $p < 0.05$) and with employment ($r = 0.2823$; $p < 0.05$). The researcher rejects the null hypothesis that Value chain activities have no significant impacts on the community livelihoods and concludes that value chain activities impacts on community livelihoods by increasing earnings and providing employment. The alternative hypothesis that value chain activities have significant impacts on community livelihoods would stand.

Regression analysis

Diagnostic tests

Table 4.37: Shapiro-Wilk test for Normality

Variable	Obs	W	z	Prob>z
Non-scalable resources	196	0.96464	3.782	0.00008
Scalable resources	196	0.92551	5.494	0.00000
AMS value chain	212	0.92593	5.661	0.00000
Organizational dynamics	212	0.92335	5.740	0.00000

The statistics in Table 4.37 shows that the probabilities that all the variables were below 0.05, therefore, they violated the assumption of normal distribution. However, the graphical analysis of the normality indicates that the data variables closely follow the straight diagonal line which represents normal distribution (Hair *et al.*, 2010) as indicated in the figures.

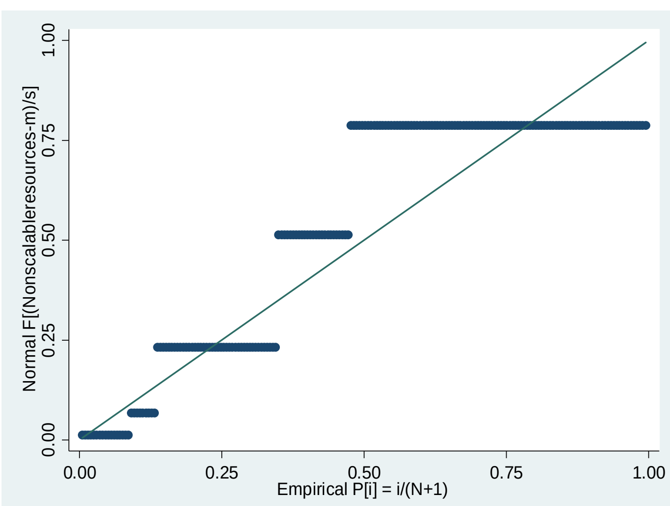


Figure 4.5a: Normality plot Non-scalable assets

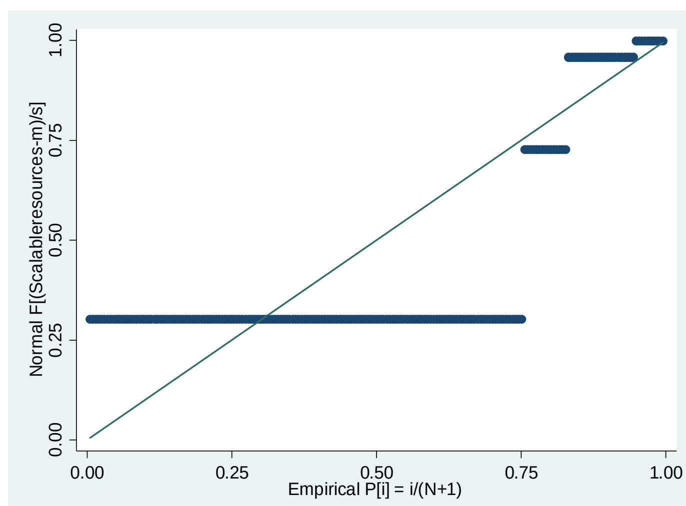


Figure 4.5b: Normality plot for Scalable assets

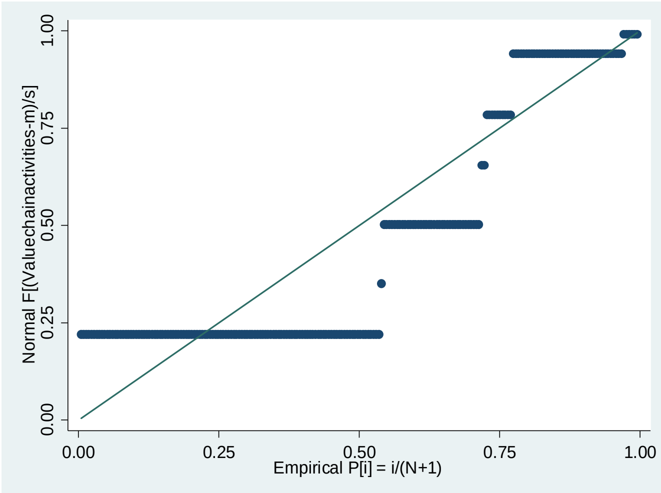


Figure 4.5c: Normality plot for ASM gold value chain

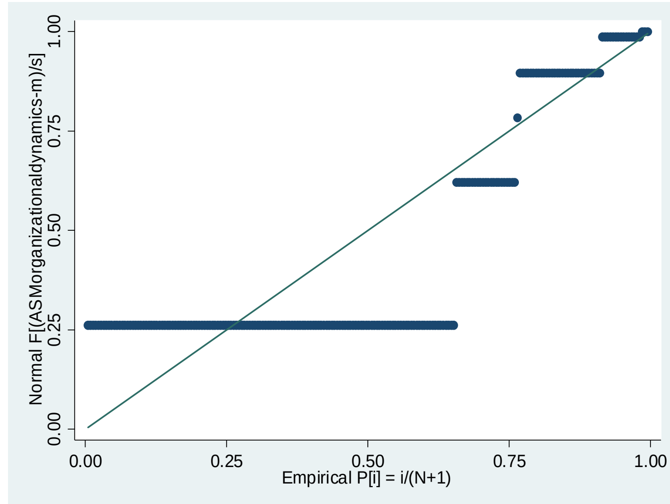


Figure 4.5d: Normality plot for ASM organizational dynamics

Figure 4.5: Graphical Normality Plots

Test for heteroscedasticity

The Breusch-Pagan / Cook-Weisberg test for heteroskedasticity indicated that $\chi^2(1)$;p = 0.0522, therefore the assumption of homoscedasticity can be upheld.

The test for collinearity for the regression residuals in the Table 4.37 below indicate that all the VIF < 10.00 indicate that multicollinearity wasn't encountered.

Table 4.38: Collinearity statistics

Variable	VIF	Tolerance
ASM gold value chain	1.35	0.743094
Organizational dynamics	1.28	0.783097
Scalable assets	1.16	0.858893
Non-scalable assets	1.12	0.896050

The regression statistics on community livelihood was conducted on the following variables: ASM gold value chain activities, organizational dynamics, scalable assets and non-scalable assets.

Table 4.39: ANOVA statistic

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	31.1098444	4	7.77746109	F(4, 191) = 6.51	0.0001
Residual	228.277911	191	1.19517231		
Total	259.387755	195	1.33019362		

R-squared = 0.1199 Adj R-squared = 0.1015 Root MSE= 1.0932

The statistic, $F(4, 191) = 6.51$, $p < 0.00$, shows that the regression model is statistically significant in predicting the dependent variable. Therefore, the listed factors in ASM explain the variations in income effect. The $R^2 = 0.1199$ indicating that 12 per cent in income effect is explained by the factors in ASM

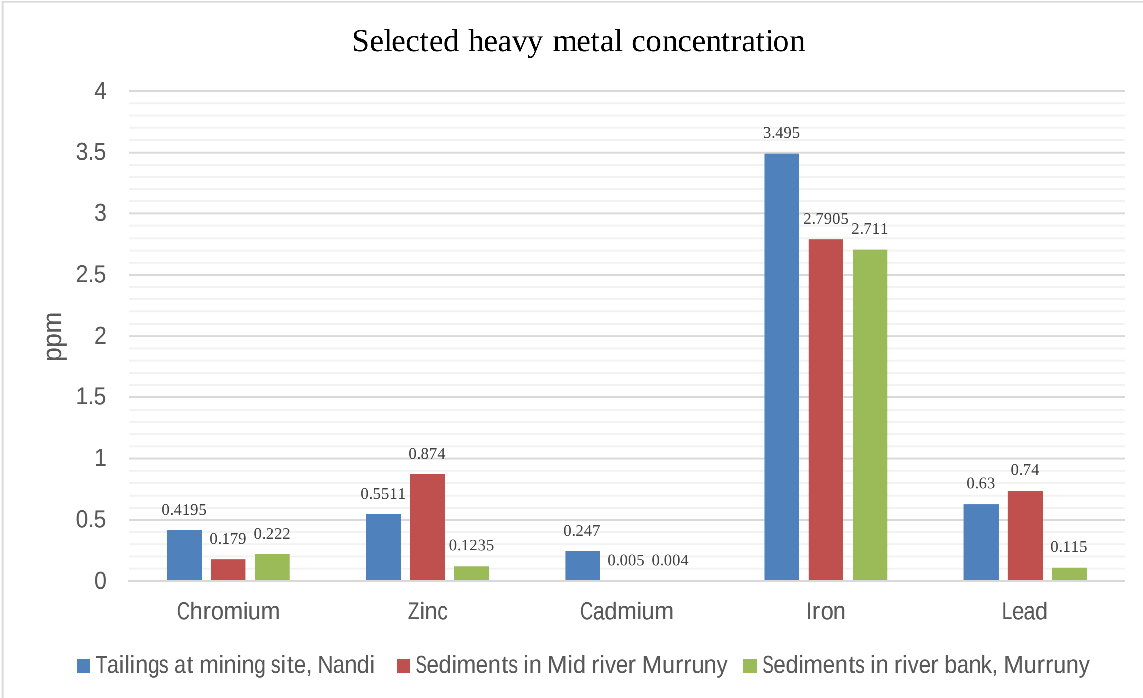
Table 4.40: Coefficient for ASM factors

Income effect	Unstd Coef.	Std. Coeff	Std. Err.	t	P>t	[95% Conf. Interval]	
Constant	1.110451		.4642762	2.39	0.018	.1946842	2.026218
Non-scalable resources	-.0561591	-.0318475	.1264499	-0.44	0.657	-.3055766	.1932585
Scalable resources	.1320519	.0509982	.1896533	0.70	0.487	-.242032	.5061358
ASM gold Value chain	.1683993	.1874459	.0707429	2.38	0.018	.0288616	.3079371
ASM organizational dynamics	.2125136	.1915276	.0851115	2.50	0.013	.0446344	.3803927

The regression equation indicates that the predicted income = 1.11 + 0.187 (ASM gold value chain) + 0.191 (ASM organizational dynamics). These indicate that a unit increase in the value chain attributes would increase the income by 0.187, while at the same time a unit increase in the ways the ASM is organized would have a significant increase in income by 0.191.

4.3.4 Concentration Levels of Selected Heavy Metals

Exposed materials from mining operations contribute to chemical pollutants which are heavy metals like Zinc, Chromium, Cadmium, Iron and Lead. The very possible environmental impacts of these metals include contamination of surface and groundwater including soils during periods of heavy rain due to leaching. The presence of these metals in soil has been reported to affect the quality of food grown, groundwater quality, micro-organisms activity and plant growth (Popescu *et al.,* 2009). The activities that generate concentration of these heavy metals in the environment and use of mercury has observed in Nandi county can have a serious effect on the health and safety of the involved communities.



Source: Research data (2016).

Figure 4.6: Mean Concentration levels of selected heavy metals

A total of five elements that were determined are presented in this study in figure 4.2.According to the laboratory analysis, result on samples from mining sites in Nandi County contained a number of trace elements which included Chromium, Zinc, Cadmium, iron and Lead. The site had the following concentration of Cr, 0.4195 ppm, Zn, 0.5511 ppm, Cd, 0.2470 ppm, Fe, 3.4950 ppm and Pb, 0.6300 ppm. All the concentrations of the selected heavy metals were well below the WHO/FAO recommended. This tallies up with results from Gravimetic analysis of soils from mining sites in Tanzania which profiled high levels of As and Hg in the upper 10cm with other heavy metals elements Cd, Cr, Pb and Zn being profiled with not so greatly varying concentrations. While stream sediments showed elevated concentrations of metals including Hg, Bi, as well as Cu and Au (Van Straaten, 2000).

On the same extent, the sediments on the river bed on river Murruny showed that the concentrations of the heavy metals were as follows: Cr, 0.1790 ppm; Zn 0.8470 ppm; Cd, 0.0050 ppm; Fe, 2.795 ppm; and Pb, 0.7400 ppm. Further, sediments on the river bank of Murruny, showed the following concentration: Cr, 0.2220 ppm; Zn 0.1235 ppm; Cd, 0.0040 ppm; Fe, 2.711 ppm; and Pb, 0.1150 ppm which are much lower concentrations than those in the river bed. The comparatively high concentration levels in Nandi County are attributable to the anthropogenic activities of underground artisanal gold mining. Most of the concentration are below the WHO/FAO recommended, and thus can be assumed to have no significant effect on the health of the miners. This is supported by a study by Van Straaten (2000) who indicated that in Zimbabwe, the Hg concentrations in rivers generally range between 0.01 – 0.02 mg/L to 0.02 to 0.65 mg/L with Tafuna mining site having 2.33mg/L, while in Mwakitolyo, Tanzania, the heavy metal concentration: Cd, Cr, Cu, Pb and Zn concentrations were, 0.1, 19-21, 15-23, 8-11, 24-35 mg/Kg, respectively.

Chromium is very toxic and carcinogenic; its compounds are known to cause cancer of the lung, nasal cavity and paranasal sinus and suspected to cause cancer of the stomach and larynx (ATSDR, 2000). According to WHO/USEPA guideline value for sediment, the concentration of 25µg/Kg, Cr is acceptable (Radojevic & Bashkin, 1999). For concentrations exceeding 25µg/Kg, a condition known as allergic dermatitis could result

(EPA, 1999). From the results of these analyses, the concentrations of chromium in the sediment samples exceeded the regulating limits, indicating severe contamination of sediments.

Zinc concentration in Nandi mining area was 0.5511ppm, in west Pokot mid river was 0.1874ppm and river bank was 0.1235ppm. The concentration of Zinc in Nandi sentiment was low than WHO/FAO recommended guideline value 0.5511ppm against 5.0 ppm. In west Pokot concentration of Zinc lower 0.222 against WHO/FAO recommended guideline value 5.0. Zinc levels in Kenya region soils have been found to be 36-290 μg/g and permissible levels of zinc in drinking water is about 50 mg/l (Ofuso *et al.,* 1999; Annex, 2000). In Nandi low concentration of Zinc is associated with underground materials which are not rich with Zinc brought to the surface during underground gold mining. The concentration in west Pokot was lower and this could be associated with naturally weathering rocks and soils containing Zinc. Zinc is required by both plants and animals in small concentrations. It is a component of enzymes which play key roles in growth, for example alkaline phosphatises and carboxy pepti-dase.Access Zinc can damage nerve receptors in nose which can cause anosmia (Prasad, 2003; Hambidge and Krebs, 2007).

Cadmium concentration in Nandi mining area was higher 0.247 against 0.005 WHO/FAO recommended guideline, in west Pokot concentration was mid river was 0.005ppm while river bank was 0.004ppm against WHO/FAO recommended guideline value of 0.005ppm. Cadmium in Kenya region soils has been found to be 0.25-2.5 μg/g (Ofuso *et* *al.,* 1999). The levels of cadmium in drinking water should not exceed 0.005 mg/g (Annex, 2000). In Nandi higher concentration of cadmium in mining area is associated to underground artisanal gold mining which exposes them to the surface while concentration in West Pokot was within the recommended values associated to natural processes. Cadmium ranks among the most toxic elements, accumulates in the duodenum, liver and kidney tissues and is dangerous even in small quantities. Its accumulation in the body can cause cardiovascular, renal and reproductive dysfunctions. The acute effects on oral intake of cadmium are; excess salivation, nausea, vomiting, abdominal pains, diarrhoea and vertigo while large doses may lead to loss of consciousness (Sodhi, 2006). Cases of high blood pressure have also been attributed to cadmium toxicity (Nordberg, 2007). Epidemiological studies indicate that workers engaged in cadmium related work are more likely to suffer from prostrate and nasopharynx cancers than their counter parts engaged in other activities (Fergusson, 1990).

Iron concentration levels in Nandi mining area was 3.4195ppm while in west Pokot was 2.7905ppm at the mid river and 2.711ppm on river bank. The higher concentration in Nandi mining area is associated with anthropogenic activities of underground artisanal gold mining but in West Pokot lower concentration can be associated with naturally weathering of rocks containing Iron.

Lead concentration in Nandi was 0.63ppm; in west Pokot mid river was 0.74ppm and 0.115ppmon the river bank. The higher concentration in Nandi mining area compared to west Pokot is associated with underground artisanal gold mining while in west Pokot lower concentration can be associated with naturally weathering of rocks and soils containing lead. Natural uncontaminated soils contain between 15-40 ppm of lead with no detrimental health effects Denise and David, 2001).Lead (Pb), at any concentration portends both immediate and long term hazards to women and children at the greatest risks of exposures. Some of the effects of lead poisoning are reduced IQ, reduced physical development and neurological disorders (CDC, 2004). An increased level of lead in the body is the leading cause of anaemia. Although there is no safe and acceptable level of lead in the blood, tolerable levels in the blood samples of young children has been set at 10 μg/dl (CDC, 2004).Exposure to milder doses of lead causes chronic nephritis, a disease characterized by scarring and shrinking of kidney tissue (Sodhi, 2006).

The result implies that there is a possible environmental impact of these tailings from Nandi County which includes contamination of surface and groundwater including soils during periods of heavy rain due to leaching of heavy metals (Pb, Zn and Cd). These heavy metals end up in water and are absorbed by plants when the water is used for irrigation (CDC, 2004).During heavy rains more water enter washing bonds with no enough capacity to contain any extra water. These will necessitate the release of washing impoundment effluent which will over flow the washing bonds. Since these effluents contain toxic heavy metals as analysed on the tailings it will degrade the environment for instance it will. degrade water quality of surrounding rivers and streams. Tailings wastes that contained heavy metals analysed which include lead, cadmium, chromium, iron and

Zinc including exposed materials are another environmental concern. Artisanal miners disposed of tailings by heaping them within the mining sites. This will result in accumulations of high concentrations of heavy metals leading to pollution of water reservoirs and soil surface.

This result further implies that during the periods of heavy rain more water will soak the tailings heap causing the release of tailings effluent. This effluent can contain heavy metals that can degrade water quality of surrounding streams and soils. Because of large quantities of earthen materials exposed at sites, erosion is a major concern at underground mining sites. Erosion may cause significant loading of sediments and any heavy metal pollutants to nearby water bodies during heavy rains.

Contaminated sediments may also lower the pH of soils to the extent that vegetation and suitable habitat are lost. As reported by Gomeson *et al.* (2013), some mining sediments can have pH levels lower than 3 which is severely acidic. When the metals are derived from anthropogenic sources they can strongly influence their bioavailability as is the case when metal contaminated water by garage waste is applied to agricultural land (Annex, 2000).

ELAW (2010) and UNECA & AUC (2011) explained that acid mine drainage is considered one of mining's most serious threats to water resources. Acid mine drainage is a concern at many metal mines, because metals such as gold, copper, silver and molybdenum, are often found in rock with sulphide minerals. When the sulphides in the rock are excavated and exposed to water and air during mining, they form sulfuric acid.

This acidic water dissolves other harmful metals in the surrounding rock. If uncontrolled, the acid mine drainage may runoff into streams or rivers or leach into groundwater.

In west Pokot County alluvial sediments was found to have lower concentrations of heavy metals analysed compared to Nandi County. This could be attributed to the fact that there were less anthropogenic activities at this study area. The enhanced concentration levels of all the metals analysed in Nandi County were due to anthropogenic activities of artisanal mining processes. The occurrence of increased concentrations of heavy metals in the tailings is an indication of human induced perturbations rather than natural enrichment through geological weathering (Davies *et al.*, 1991; Binning and Baird, 2001; Eja *et al.*, 2003).

This aspect could be attributed to either fact, that farming is recognized as the mainstay economic activity or the consistency with which the mining community derives income from the farming as opposed to ASM. The mining community had a divided opinion on whether mining activity provides employment opportunities to individuals (Mean = 2.33, SD = 1.21). This is attributable to the perception of the community that employment is seen as a formal activity whereas mining is taken as an afterthought

CHAPTER FIVE: SUMMARY OF THE FINDINGS, CONCLUSIONSAND RECOMMENDATIONS

5.1 Introduction

This chapter presents the study findings and discussions on the Impacts of artisanal gold mining dynamics on community livelihoods and the environment. The study unravel the impacts of Artisanal gold mining on community livelihoods and the environment, a mixed research design by use of both descriptive and experimental research design were used. The presentation summary of findings, conclusions and recommendations were guided by the research objectives, hypothesis and a research of the study.

5.2 Summary

The findings showed that Male respondents were 70.2% in Nandi and 29.8% in West Pokot county while Female were 42.2 % in Nandi county and 58.8% in West Pokot county. This result implies that males dominate mining in Nandi County while in West Pokot County both genders participate in mining. Male domination in Nandi County is associated with patriarchal nature of the Nandi community in terms of resources ownership and the type of mining activity which was gender oriented demanding males than females hence not gender sensitive.

The age of respondents in Nandi County peaks at age 26 to 33 years and then drops sharply and evens out at the age of 57. In West Pokot County, respondents' age peaks at the ages of 34 to 41 years and then gradually evens out at the age of 57 years. This result implies that in Nandi County, there were younger people engaging in artisanal mining as compared to west Pokot who are more elderly.

Findings from the study showed that respondents who had no formal education were 36%, primary level 49.1%, secondary level 11.8%, technical level 1.4% and tertiary level 1.4%. These result simply that those who participated in artisanal gold mining in both counties had either no formal education or had basic education. Results further suggest that artisanal mining communities lack critical capacity and ability levels to grow their mining activities. Having low education levels, respondents lack the knowledge on environmental conservation policy requirements, occupational health and safety in mining.

The residential status of those involved in mining indicated that 98.5% were residents of the respective counties while 1.5% was non-residents. This result implies that artisanal gold mining was dominated by the local residents in both west Pokot and Nandi County, the activities of artisanal gold mining were not associated with any migration. This result further implies that there were no inter community competition related to artisanal gold mining hence local communities benefit from it.

The results showed the ASM community in Nandi County had other significant economic activities such as subsistence farming, trading, dairy and cash crop husbandry and thus artisanal gold mining was an alternative source of income which either supplement or complement their present income. However, the results in West Pokot County indicate that 5 per cent of the respondents engaged in other income activities and thus artisanal gold mining was their primary source of livelihood, since their agro-ecological zone offers those limited options of other economic activities.

Monthly earnings from other economic activities were 100% below KShs. 10,000among respondents in West Pokot County, while in Nandi County majority earned above Kshs10, 000 per month. This result implies that respondents in Nandi County were earning much more income from other economic activities than their counterparts in West Pokot County. This could be attributed to the different sources of livelihood or different income sources.

Findings on methods used in excavation and processing of gold were(10.8%) surface mining, (50.4%) underground mining and (38.8%) dredging. Respondents within Nandi County affirmed that underground mining and a few surface mining are the methods used in excavation, while dredging and a few surface mining were reported in West Pokot.

Virtually all the miners in the Nandi County affirmed that mercury is used in the amalgamation process whereas their counterparts from West Pokot County asserted that they do not use any chemicals in the process. This aspect is attributed to the nature of mining process used; such that in West Pokot County the type of mining is alluvial which does not require the use of mercury while in Nandi county it is underground mining which needs use of mercury for amalgamation. It implies that the use of chemicals dependent on the type of mining such that underground mining which involve processes like digging, crushing and amalgamation are associated with chemical use whereas surface mining or dredging is associated with panning.

Duration spent in mining activity by respondents according to the findings were that in Nandi County63.3% had been involved in mining activity for less than 1 years, 22.5 % 6 - 10 year,5%11-15 years,16-20 years 5.8% and above 21 years 2.5%. In West Pokot County those who had participated in artisanal mining for between 1-5 years' duration were 26.5 %, 6 - 10 year 26.5per cent, 11-15 years 15.7% 16-20 years 2.4%and above 21 years 28.9%. This result implies that Individuals in Nandi County participate in artisanal mining for shorter period of time because they have alternative sources of livelihood and the lure of instant riches fizzles out. It is further attributed to dangers and physical demand in underground mining, hence the older people tend to plan to exit and quit artisanal gold mining activities. In West Pokot, respondents participated in artisanal gold mining activity for longer periods of time before quitting and these was attributable to lack of alternative livelihoods particularly being a marginalized area with limited economic alternatives.

The results indicate that Preoccupation with mining activity in West Pokot County was 89.2 % all year round and only 10.8% on seasonal basis. Approximately 27% of respondents within Nandi County were preoccupied with mining all year round, 64.8 % were on a seasonal basis and 8.2 % preoccupied on a temporary basis. This result implies that those who have limited sources of livelihood participate in artisanal mining all year round or on a full time basis while those with other sources of livelihood participate on seasonal or temporary basis.

Findings from the study showed that ICT can be used to mitigate structural challenges and serve many functions in artisanal gold mining only if it is designed to serve them. ICT has a variety of applications in artisanal gold mining activities and will serve as an enabler to business processes changing the situation in artisanal gold mining. The respondents affirmed that ICT holds key to new production technologies to be used in mining such as geo – mapping systems. Unavailable geo – mapping systems makes miners to engage in Trial and era methods leading to unnecessary land destruction.
The study found out that 64.4 % of the respondents did not have any information on who was the regulator, 20.8% said that it was the county government, 25 % viewed NEMA being involved and 4% viewed ministry of mining was involved. This result implies that the level of awareness on the regulator of artisanal gold mining was low, which was indicative of non-supervision and monitoring of artisanal gold mining activities.

One of the objectives of the study was to determine the impacts of capital assets accessibility in artisanal gold mining to community livelihoods and the environment. The findings showed that respondents in both counties were able to access land right to mine and used rudimentary equipment. High access levels to rudimentary tools explain the restrain in their production making them to engage in an economic activity which cannot conserve the environment. Respondents had low access levels on new technologies, skilled manpower, finance, credit facilities and social capital/cooperative. Low access to finance facilities implies that miners cannot invest in modern technologies which are efficient with high recovery rate and output contributing to increased income for miners.

Access to capital assets is influenced by policies, organizations and relationships between individuals and organizations and authority.

The second objective of the study was to evaluate the impacts of artisanal gold mining organizational dynamics on community livelihoods. The study findings showed that artisanal gold mining activities in Nandi and west Pokot counties were informal and unorganized in nature because of the relative ease with which the activity presented itself. Respondents lacked any form of mining or prospecting licences in order to operate, thus they were operating informally. This informality prevented the sector from delivering on important social objective of improved quality of life for mining communities and environmental degradation. Informality further implied that the authorities cannot enforce effectively regulation contributing to the problems in environmental degradation.

The third objective of the study was to establish the impacts of value chain activities in artisanal gold mining to community livelihoods. The findings showed that respondents did not understand the gold value chain activities at the same time they were not familiar with the gold market procedures. The value chain of artisanal gold is informal, unclear, unregulated, and subject to exploitation by interested parties. The players in artisanal gold value chain operated in non-transparent and complicated manner which contributed to low earnings to miners' hence negative consequences on community livelihoods. The respondents in both counties attributed the massive sale of gold to middlemen to the lack of direct markets and subsequent low prices.

The fourth objective of the study was to determine the concentration levels of selected heavy metals in the mining sites. laboratory analysis, result on samples from mining sites in Nandi County contained a number of trace elements which included Chromium Cr, 0.4195 ppm, Zinc Zn, 0.5511 ppm, Cadmium Cd, 0.2470 ppm, iron Fe, 3.4950 ppm and Lead Pb, 0.6300 ppm. All the concentrations of the selected heavy metals were well below the WHO/FAO recommended. Sediments on the river bed on river Murruny showed that the concentrations of the heavy metals were as follows: Chromium Cr, 0.1790 ppm; Zinc Zn 0.8470 ppm; Cadmium, 0.0050 ppm; iron Fe, 2.795 ppm; and Lead Pb, 0.7400 ppm. Further, sediments on the river bank of Murruny, showed the following concentration: Chromium Cr, 0.2220 ppm; Zinc Zn 0.1235 ppm; Cadmium Cd, 0.0040 ppm; iron Fe, 2.711 ppm; and Lead Pb, 0.1150 ppm which were much lower concentrations than those in the river bed. The concentration levels were comparatively higher in Nandi County than in West Pokot which was attributable to the anthropogenic activities of underground artisanal gold mining.

5.3 Conclusions

The findings of the study indicated that high access levels to rudimentary tools explain the restrain in their production making them to engage in an economic activity which cannot conserve the environment.

It also showed that low access to finance facilities prohibits respondents from investing in modern technologies which are efficient with high recovery rate and output contributing to increased income for miners.

From the results there were empirical evidence that artisanal gold mining were informal and unorganized in nature because of the relative ease with which the activity presented itself thus informality and unorganized nature prevented the sector from delivering on improved quality of life for mining communities and environmental degradation.

The findings showed that respondents did not understand the gold value chain activities and not familiar with the gold market procedures.

The value chain of artisanal gold is informal, unclear, unregulated, and subject to exploitation by interested parties thus contributes to low earnings hence consequences on community livelihoods.

Finally the findings showed that the concentration levels were comparatively higher in Nandi County than in west Pokot which was attributable to the anthropogenic activities of underground artisanal gold mining.

5.4. Recommendations

5.4.1 Policy Recommendation

i) Artisanal gold miners lack financial support to purchase requisite capital equipment to increase efficiency and output. The study recommends that artisanal miners be made aware on how to get access to the already available revolving funds set aside by the government such as youth and women funds. These finances will be used to improve access to technologies in mining which will have less negative environmental impacts and improved gold recovery leading to better income and livelihoods to miners.

ii) Findings from the study showed that artisanal miners were disorganised. The study recommends that artisanal miners should be encouraged and assisted by relevant government agencies to form cooperatives in order to have a collective voice in their undertaking such as advocating for government assistance on technology and equipment, marketing and training. Miners will be able to access financial credits from the banks than being an individual and from savings and credit societies. Miners are disadvantage for they do not operate in groups or associations and it is difficult to address their concerns individually.

Environmental degradation at the mine sites is uncontrolled. The researcher recommends that the Kenya government review further the current mining policy specifically focusing on management of artisanal mining. The policy should consider EIA be carried out collectively for groups of miners or mining areas before obtaining the Artisanal Mining License. The assumption of the approach is that mining processes in the same area has similar environmental and social impacts and therefore the need for same environmental management plans. This approach will help miners afford to fulfil the environmental requirement of carrying out the EIA by pooling finances together. It will reduce financial costs which could be high if they could have conducted individual environmental assessment resulting to non-conformity of the requirement which is critical in social and environmental sustainability

iii) Results obtained in the present study reported that value chain of gold was not structured. Therefore, study recommends the government develop a gold Value chain which is structured and clear. A clear Value chain development will create linkages between artisanal gold miners and the markets through government authorities avoiding middlemen.

Artisanal gold miners lack financial support to purchase requisite capital equipment to increase efficiency and output. The study recommends that artisanal miners be made aware on how to get access to the already available revolving funds set aside by the government such as youth and women funds. These finances will be used to improve access to technologies in mining which will have less negative environmental impacts and improved gold recovery leading to better income and livelihoods to miners.

iv)The study recommends further that the government should increase funding for geo-mapping, evaluation and assessment to determine the potential of the counties for gold deposits exploitation.

5.4.2 Recommendation for further research

Further research should be carried on**:-**

i) The effects of heavy metals including mercury on human health of the surrounding communities to the mining areas in Nandi County.

ii) Climate change and artisanal gold mining trends among local communities.

iii) On how to enhance Artisanal gold mining efficiency in culturally sensitive and appropriate ways.

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APPENDICIES

Appendix I: Introductory Letter

Dear Participant, **DEC 2015**

My name is **ELIUD KIBET YEGO,** a PhD student at **Kabarak University**, with a study titled“D**ynamics in artisanal gold mining and its impacts on community livelihoods and the environment: a case of Nandi and West Pokot counties, Kenya**”

The information on the questionnaire is designed to define and explain how dynamics in artisanal gold mining impacts on community livelihoods and the environment. You are invited to participate in this research by providing your views and the information you provide will only be used strictly for academic purposes. Participation in this research is voluntary and your confidentiality will be preserved with no names or information about any individual will be published.

Thank you very much for your time and cooperation. I greatly appreciate your help in furthering this research endeavour.

Sincerely

ELIUD K YEGO

Appendix II: Consent Forms
Survey/Questionnaire Consent Form

I, ______________________________, understand that I am being asked to participate in a survey/questionnaire activity that forms part of **Eliud Yego** requirement for research thesis in the **Kabarak University**. It is my understanding that this survey/questionnaire has been designed to gather information about the following subjects or topics: Dynamics in artisanal gold mining and its impacts on community livelihoods and environment; a case of Nandi and West Pokot Counties, Kenya. I have been given some general information about the study and the types of questions I can expect to answer.

I understand that my participation in this project is completely voluntary and that I am free to decline to participate, without consequence, at any time prior to or at any point during the activity. I understand that any information I provide will be kept confidential, used only for the purposes of completing this assignment, and will not be used in any way that can identify me. All survey/questionnaire responses, notes, and records will be kept in a secured environment. I will also be provided with a copy of the student assignment at my request.

I understand that the results of this activity will be used exclusively in the below-named student's Kabarak University study and the information I provide may be use for publishing, in any form, in any journals or conference proceedings. I also understand that there are no risks involved in participating in this activity, beyond those risks experienced in everyday life.

I have read the information above. By signing below and returning this form, I am consenting to participate in this survey/questionnaire project as designed.

Participant name ____
Signature: ____
Date: ____

Please keep a copy of this consent form for your records. If you have other questions concerning your participation in this project, please contact me at:

Student name:
Eliud Kibet Yego **0726503134**

Survey/Questionnaire Consent Form

I, Vincent Boit understand that I am being asked to participate in a survey/questionnaire activity that forms part of **Eliud Yego** requirement for research thesis in the **Kabarak University**. It is my understanding that this survey/questionnaire has been designed to gather information about the following subjects or topics: Dynamics in artisanal gold mining and its impacts on community livelihoods and environment; a case of Nandi and West Pokot Counties, Kenya. I have been given some general information about the study and the types of questions I can expect to answer.

I understand that my participation in this project is completely voluntary and that I am free to decline to participate, without consequence, at any time prior to or at any point during the activity. I understand that any information I provide will be kept confidential, used only for the purposes of completing this assignment, and will not be used in any way that can identify me. All survey/questionnaire responses, notes, and records will be kept in a secured environment. I will also be provided with a copy of the student assignment at my request.

I understand that the results of this activity will be used exclusively in the below-named student's Kabarak University study and the information I provide may be use for publishing, in any form, in any journals or conference proceedings. I also understand that there are no risks involved in participating in this activity, beyond those risks experienced in everyday life.

I have read the information above. By signing below and returning this form, I am consenting to participate in this survey/questionnaire project as designed

Participant name: Vincent Boit

Signature: [signature]

Date: 14/05/2015

Please keep a copy of this consent form for your records. If you have other questions concerning your participation in this project, please contact me at:

Student name:
Eliud Kibet Yego **0726503134**

Survey/Questionnaire Consent Form

I, Malakwen Kirop, understand that I am being asked to participate in a survey/questionnaire activity that forms part of **Eliud Yego** requirement for research thesis in the **Kabarak University**. It is my understanding that this survey/questionnaire has been designed to gather information about the following subjects or topics: Dynamics in artisanal gold mining and its impacts on community livelihoods and environment; a case of Nandi and West Pokot Counties, Kenya. I have been given some general information about the study and the types of questions I can expect to answer.

I understand that my participation in this project is completely voluntary and that I am free to decline to participate, without consequence, at any time prior to or at any point during the activity. I understand that any information I provide will be kept confidential, used only for the purposes of completing this assignment, and will not be used in any way that can identify me. All survey/questionnaire responses, notes, and records will be kept in a secured environment. I will also be provided with a copy of the student assignment at my request.

I understand that the results of this activity will be used exclusively in the below-named student's Kabarak University study and the information I provide may be use for publishing, in any form. in any journals or conference proceedings. I also understand that there are no risks involved in participating in this activity, beyond those risks experienced in everyday life.

I have read the information above. By signing below and returning this form, I am consenting to participate in this survey/questionnaire project as designed

Participant name: Malakwen Kirop

Signature: MKirop

Date: 21/May/2015

Please keep a copy of this consent form for your records. If you have other questions concerning your participation in this project, please contact me at:

Student name:
Eliud Kibet Yego **0726503134**

Appendix III: Questionnaire for Respondents

Section A. General Information

1. Sex.... Male [ ] Female [ ]

2. Indicate your age (tick as applicable) below18 [ ] 18– 25 yrs [ ] 26– 33 yrs [ ] 34– 41 yrs [ ] 42– 49 yrs [ ] 50– 57 yrs [ ] Above 58 yrs [ ]

3. Marital status? Single [ ] Married [ ] Widowed [ ] Divorced [ ]

4. County.........................Sub County.......................Which location............................

5. Level of education (tick as applicable)

No formal education [ ] Primary level [ ] High school level [ ] Technical level [ ] Tertiary level [ ]

6. Do you reside within the locality Yes [ ] No [ ]

7. If NO specify where you have come from…………………………..

8. What is the number of your dependents in your family?

1 to 3 [ ] 4 to 6 [ ] 7 to 9 [ ] Above 10 [ ]

Section B. Demographic Information

9. How long have been engaged in mining?

1 to 5 yrs [ ] 6 to 10 yrs [ ] 11 to 15 yrs [ ] 16 to 20 yrs[ ] Above 21 yrs [ ]

10. Specify your engagement in mining Fulltime [ ] Part-time [ ]

11. If part-time state the other activities you engage in

Formal employment [ ] Dairy farming [ ]Subsistence farming [ ] Cash crop farming [ ] Trading [ ] Other.............................

12. How much money do you earn from other activities apart from mining per month?

Below Kshs. 10,000 [ ] Kshs.10, 001 to Kshs. 20,000 [ ] Kshs. 20,001 to Kshs. 30,000 [ ]Kshs. 30,001 to Kshs. 40,000 [ ] Above Kshs 40,001 [ ]

13. Which role do you play in the mining process?

Mine owner [ ] Miner [ ] Middle men [ ]

14. What quantity of gold in grammes do you typically get per week?

1to5 [ ] 6 to 10 [ ] 11 to 15 [ ] 16 to 20 [ ] Above 21 [ ]

15. As a mine owner, how much are you earning per month? Below Kshs. 10,000 [ ] Kshs.10, 001 to Kshs. 20,000 [ ] Kshs. 20,001 to Kshs. 30,000 [ ]Kshs. 30,001 to Kshs. 40,000 [ ] Above Kshs 40,001 [ ]

16. Who do you sell the gold to?

Middlemen [ ] Self-help Group [ ] Cooperative [ ] others specify……………

17. In what format is the compensation pegged on?

Gold recovered [ ] Hours worked [ ] Days worked [ ] Other......................

18. As a mine worker, how much are you earning per week? Below Kshs. 500 [ ] Kshs. 501 to Kshs. 1000 [ ] Kshs. 1,001 to Kshs. 1,500 [ ] Kshs. 1,501 to Kshs. 2,000 [ ] Above Kshs 2,001 [ ]

Section B. Processing technologies

19.What method(s) of excavation is/are used mining activities in this village?

Surface Mining [ ] Underground Mining [ ] Dredging [ ] Alluvial Mining [ ]other, specify……

20. What direct role do you play in mining process?

Digging [ ] Crushing [ ] Leaching[ ] Panning [ ] Smelting[] others specify……………….

21. Which type of chemical are you using in the extraction process

Mercury [ ] Cyanide [ ] No chemicals[ ] others specify……………….

Section B. Scalability of capital assets

22. Which types of mining resources are you able to access?

Credit facilities [ ] Production technology [ ] Skilled manpower [ ] Mine/land [ ] Group/co-operatives services [ ]other, specify……

23. Which types of mining resources are you able to secure?

Credit facilities [ ] Production technology [ ] Skilled manpower [ ] Mine/land [ ] Group/co-operatives services [ ]other, specify……

24. Which types of mining resources are you able to utilize or use?

Credit facilities [ ] Production technology [ ] Skilled manpower [ ] Mine/land [ ] Group/co-operatives services [ ]other, specify……

Section C. ASM Organizational dynamics

In the following statements/questions, tick the most appropriate choice {Once in a while - (1), Seldom - (2), occasionally – (3), frequently – (4), Very Frequent – (5)} that best represents your opinion concerning health effects.

	1	2	3	4	5
25.Gold price changes affects my earnings from ASM					
26.Low barriers of entry led me to ASM					
27.Informality of the sector led me to ASM					
28.Low legal requirements led me to ASM					
29.weak legislation and policies led me to ASM					
30.ASM is not considered as a main stay economic activity by the government/county					

Section D. Perceived ICT use

31. The adoption of ICT in artisanal mining can aid in the following activities?

Pricing decisions [ ] market access [ ] information flow [ ] exchange platform [ ] access to new technologies [ ] other, specify……

In the following statements/questions, tick the most appropriate choice {Once in a while - (1), Seldom - (2), occasionally – (3), frequently – (4), Very Frequent – (5)} that best represents your opinion concerning health effects.

	1	2	3	4	5
32.The perceived ICT use can contribute to better pricing					
33.The perceived ICT use can contribute to market access					
34.The perceived ICT use can contribute to new markets					
35.The perceived ICT use can contribute to market information					
36.The perceived ICT use can be used to disseminate information on environmental conservation					

37.The perceived ICT use can be used to disseminate information on 38.new production technologies					
39.The perceived ICT use can contribute to the use of geological mapping information					
40.The perceived ICT use can be used to develop new exchange platform					

Section E. Legal and regulatory framework

41. The following agencies hold stake in monitoring, regulating and addressing the activities of the mining sector in the country? NEMA [ ] Ministry of mining [ ] County government [ ]

In the following statements/questions, tick the most appropriate choice {Once in a while - (1), Seldom - (2), occasionally – (3), frequently – (4), Very Frequent – (5)} that best represents your opinion concerning health effects.

	1	2	3	4	5
42.I am familiar with the laws/policies governing mining					
43.I am familiar with the laws/policies governing conservation					
44.I am familiar with the county laws/policies governing conservation					
45.I am familiar with the NEMA policies on environment					
46.The government mining officials visits mining sites regularly					
47.NEMA officials visits mining sites regularly					
48.County Environmental official visits mining sites regularly					
49.Environmental Impact Assessment is conducted on the mining sites regularly					

Section F. Impacts of artisanal mining on community livelihoods

. In the following statements/questions, tick the most appropriate choice {Strongly Disagree - (1), Disagree - (2), Undecided – (3), Agree – (4), Strongly Agree – (5)} That best represents your opinion concerning the following areas.

	1	2	3	4	5
50. That mining activities has replaced the farming/agriculture as a source of livelihood					
51. That mining activities has supplemented the farming/agriculture as a source of livelihood					
52. That mining activities provides employment to the community					
53. That mining activities provides a source of income to the community					
54. That mining activities contributes to higher standard of living within the community					
55. That mining activities contributes to the improvement in the standards of educations within the community					
56.That mining activities has brought about economic exploitation within the community					

Section E: Occupation safety and health effects

. In the following statements/questions, tick the most appropriate choice {Once in a while - (1), Seldom - (2), occasionally – (3), frequently – (4), Very Frequent – (5)} that best represents your opinion concerning health effects.

	1	2	3	4	5
57.Skin diseases – rashes					
58.Acute conjunctivitis					
59.Skin warts/corns					
60.Sore throat					
61.Physical injuries					
62.Accidents					

Appendix IV: Interview Guide for Key Informants

Name of respondents: .... (Optional)

District ……………………………………….......

Division/ward……………………………………..

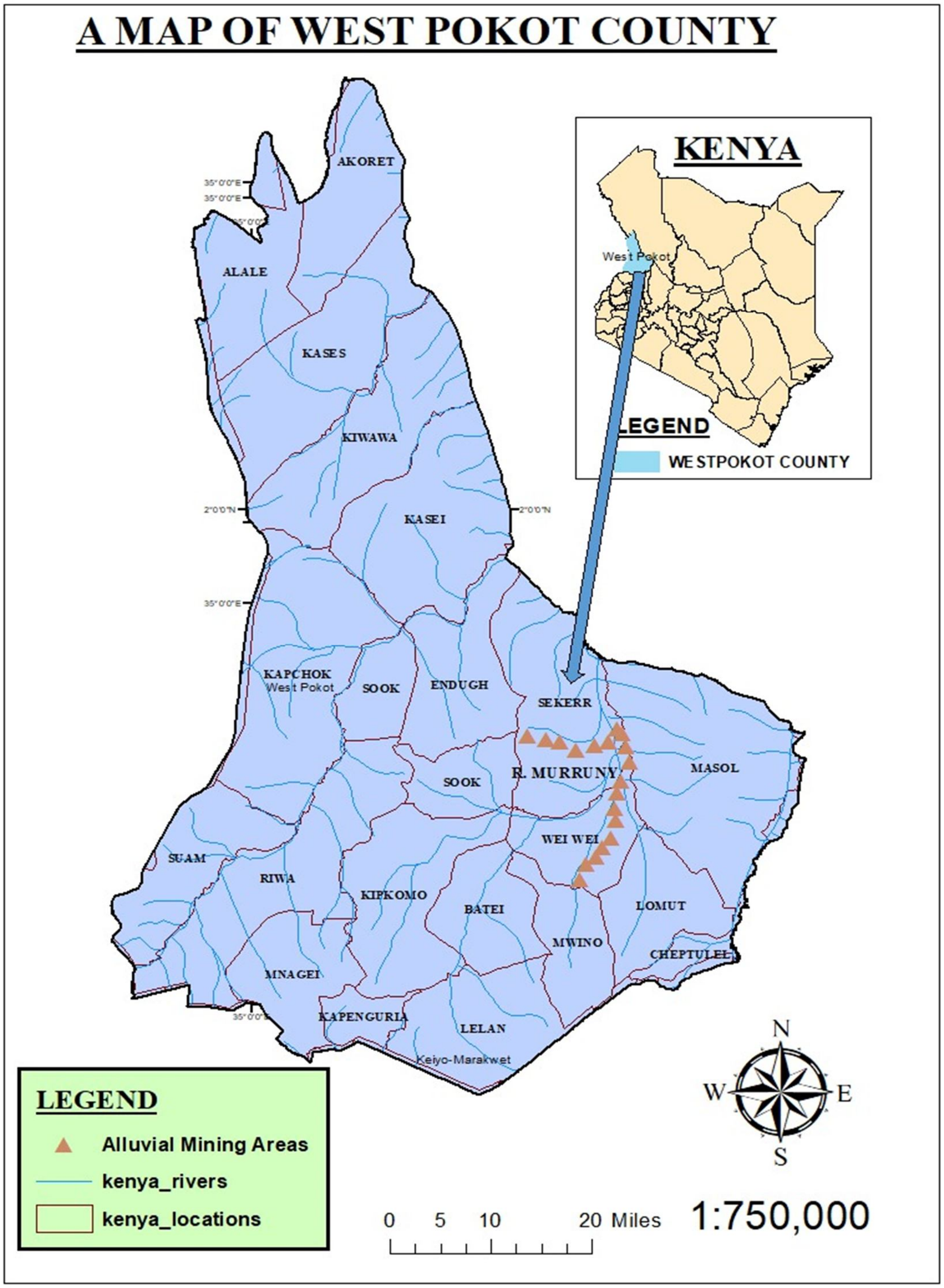
1. Sex of respondents ……………………………………..
2. Occupation:
   Interior government officials [ ] County government officials [ ]
   NEMA officials [ ] Other If other, specify:_______________
3. What are some of the impacts of artisanal gold mining on the people?
4. In your own opinion, what are the major problems faced in artisanal gold mining?
5. How do you think these problems can be resolved?
6. What do you think the government can do to solve these problems?
7. What are the environmental problems caused by the activities of artisanal gold mining?
8. In your opinion how important is environmental management in artisanal gold mining operations?
9. Are there any chemicals used by miners to extract gold from the ore?
10. Outside the ecological problems, what other effects have been encountered in the artisanal gold mining activities?
11. Which laws and policies govern artisanal mining practices?
12. What is the government policy on the ASM sector?
13. Are legislation and regulations effective in artisanal gold mining sector?
14. Are regulations being properly enforced?
15. Briefly explain how miners are organized
16. What entails a successful formalization of the artisanal mining sector?
17. What is your long-term vision for a sustainable artisanal gold mining sector?
18. Do you think the artisanal gold miners are involved in any way in the formulation of mining policies?
19. What kinds of government support can be given to artisanal gold mining sector?
20. What do you think the government can do to enhance artisanal gold mining activities?
21. Are there any land rehabilitation activities in place? non
22. Who have been leading the efforts to improve the artisanal gold mining sector?

Appendix V: Guide for Focus Group Discussion

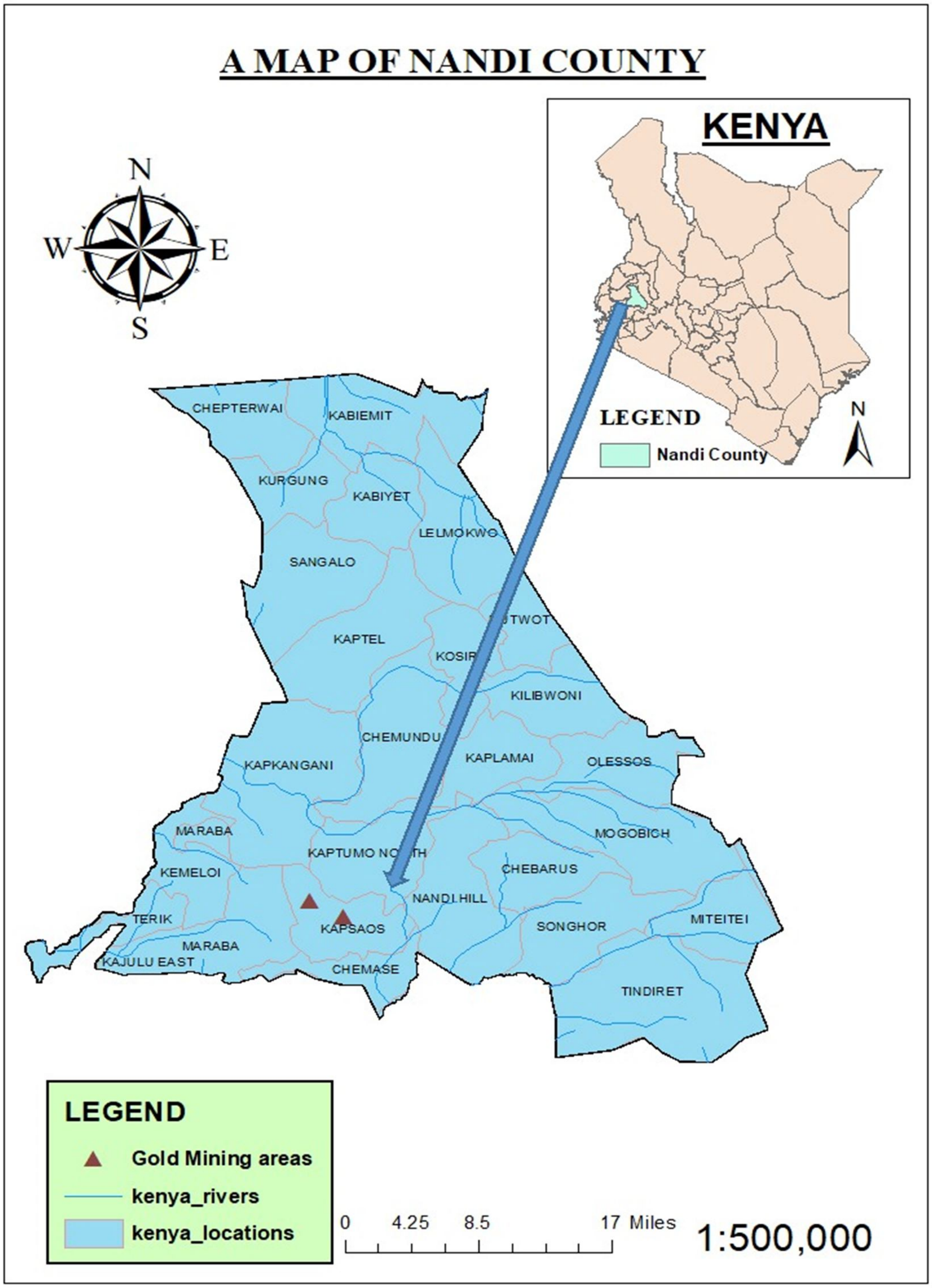
Group ……………

1) Briefly explain how miners are organized
2) What do you think the government can do to help solve these problems?
3) In your own opinion, what are the obstacles faced in artisan mining?
4) How do you think these problems can be resolved?
5) What are some positive impacts of gold mining activities in this community
6) What is your opinion about the use of the earnings from gold mining at household level?
7) In your opinion what are the possible environmental impacts of artisanal gold mining?
8) What are the alternative livelihoods for artisanal miners?

Appendix VI: MAPS OF STUDY AREA (West Pokot and Nandi Counties)



Location of mining area in West Pokot County
Source: (Author, 2017)



Location of mining area in Nandi County.
Source: (Author, 2017)

Appendix VII: Laboratory Data

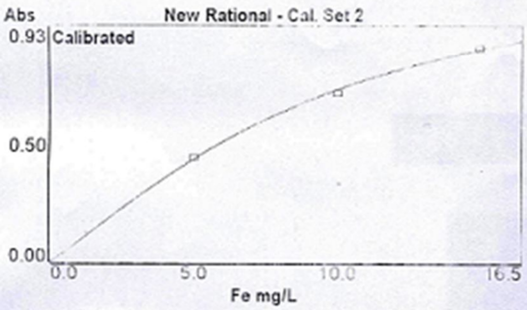
Analyst	maritim
Date Started	18 Jul 2017, 15:22
Worksheet	dr yego
Comment	
Methods	Fe,Cr,Zn,Cd,Pb

Method: Fe (Flame)

Instrument Mode:	Absorbance
Sampling Mode:	Manual
Calibration Mode:	Concentration
Measurement Mode:	Integrate
Replicates Standard:	3
Replicates Sample:	3
Expansion Factor:	1.0
Minimum Reading:	Disabled
Smoothing:	5 point
Conc. Units:	mg/L
Conc. Dec. Places:	3
Wavelength:	248.3 nm
Slit Width:	0.2 nm
EHT:	418 Volts
Lamp Current:	5.0 mA
Lamp Position:	1
Background Correction:	BC Off
STANDARD 1:	5.000 mg/L
STANDARD 2:	10.000 mg/L
STANDARD 3:	15.000 mg/L
Reslope Rate:	50
Reslope Standard No.:	2
Reslope Lower Limit:	75.0 %
Reslope Upper Limit:	125.0 %
Recalibration Rate:	100
Calibration Algorithm:	New Rational
Cal. Lower Limit:	20.0 %
Cal. Upper Limit:	150.0 %
SIPS:	Off
Measurement Time:	5.0 s
Pre-Read Delay:	10 s
Flame Type:	Air/Acetylene
Air Flow:	13.50 L/min
Acetylene Flow:	2.00 L/min
Burner Height:	13.5 mm

Sample ID	Conc mg/L	%RSD	Mean Abs	Readings		
CAL ZERO	0.000 m	90.2	-0.0009	-0.0000	-0.0011	-0.0017
STANDARD 1	5.000 m	0.2	0.4119	0.4126	0.4113	0.4117
STANDARD 2	10.000 m	0.2	0.6659	0.6672	0.6663	0.6641

Sample ID	Conc mg/L	%RSD	Mean Abs	Readings			
STANDARD 3	15.000 m	0.2	0.8423	0.8442	0.8412	0.8414	
		Curve Fit	= New Rational				
		Characteristic Conc	= 0.053 mg/L				
		r	= 1.0000				
		Calculated Conc	=	-0.011	5.087	9.691	15.269
		Residuals	=	0.011	-0.087	0.309	-0.269



Sample ID	Conc mg/L	%RSD	Mean Abs	Readings		
Sample 002	4.233 m	0.4	0.3499	0.3494	0.3488	0.3515
Sample 004	3.520 m	0.3	0.2948	0.2941	0.2946	0.2957
Sample 005	3.085 m	0.6	0.2598	0.2579	0.2606	0.2608
Sample 006	4.124 m	0.2	0.3417	0.3412	0.3423	0.3415
Sample 007	2.530 m	0.2	0.2140	0.2141	0.2145	0.2135
Sample 008	1.441 m	0.7	0.1218	0.1207	0.1223	0.1223
Sample 009	1.541 m	0.8	0.1303	0.1293	0.1303	0.1313
Sample 010	2.450 m	0.2	0.2074	0.2071	0.2071	0.2079
Sample 013	0.814 m	1.4	0.0684	0.0694	0.0678	0.0679
Sample 001	2.722 m	5.1	0.2300	0.2418	0.2295	0.2186
Sample 011	6.571 m	18.3	0.5082	0.5918	0.5250	0.4077
Sample 012	9.415 m	0.1	0.6541	0.6536	0.6543	0.6543
Sample 003	14.557 m	0.2	0.8250	0.8235	0.8258	0.8257

Method: Cr (Flame)

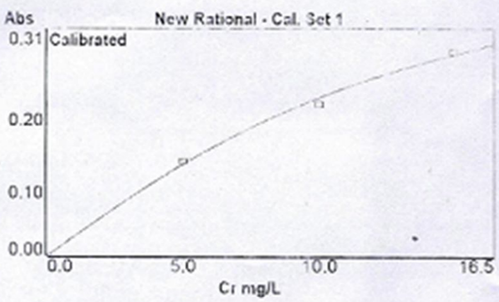
Instrument Mode:	Absorbance
Sampling Mode:	Manual
Calibration Mode:	Concentration
Measurement Mode:	Integrate
Replicates Standard:	3
Replicates Sample:	3
Expansion Factor:	1.0
Minimum Reading:	Disabled
Smoothing:	5 point
Conc. Units:	mg/L
Conc. Dec. Places:	3
Wavelength:	357.9 nm
Slit Width:	0.2 nm
EHT:	338 Volts

Lamp Current:	7.0 mA
Lamp Position:	2
Background Correction:	BC Off
STANDARD 1:	5.000 mg/L
STANDARD 2:	10.000 mg/L
STANDARD 3:	15.000 mg/L
Reslope Rate:	50
Reslope Standard No.:	2
Reslope Lower Limit:	75.0 %
Reslope Upper Limit:	125.0 %
Recalibration Rate:	100
Calibration Algorithm:	New Rational
Cal. Lower Limit:	20.0 %
Cal. Upper Limit:	150.0 %
SIPS:	Off
Measurement Time:	5.0 s
Pre-Read Delay:	5 s
Flame Type:	Air/Acetylene
Air Flow:	13.50 L/min
Acetylene Flow:	2.90 L/min
Burner Height:	13.5 mm

Sample ID	Conc mg/L	%RSD	Mean Abs	Readings		
CAL ZERO	0.000 m	33.1	-0.0006	-0.0005	-0.0009	-0.0006
STANDARD 1	5.000 m	0.4	0.1296	0.1299	0.1299	0.1289
STANDARD 2	10.000 m	0.4	0.2075	0.2083	0.2066	0.2077
STANDARD 3	15.000 m	0.9	0.2791	0.2809	0.2802	0.2761

Curve Fit = New Rational
Characteristic Conc = 0.168 mg/L
r = 1.0000

Calculated Conc	=	-0.025	5.203	9.402	15.424
Residuals	=	0.025	-0.203	0.598	-0.424



Sample ID	Conc mg/L	%RSD	Mean Abs	Readings		
Sample 001	0.443 m	3.8	0.0116	0.0112	0.0120	0.0116
Sample 002	0.414 m	3.3	0.0108	0.0105	0.0112	0.0108

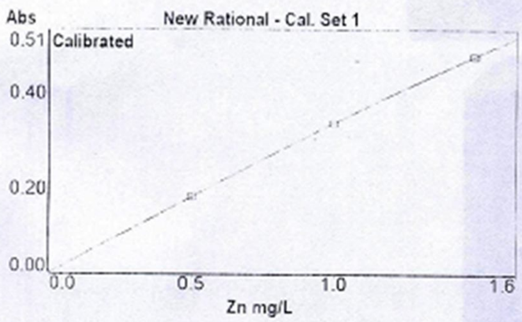
Sample ID	Conc mg/L	%RSD	Mean Abs	Readings		
Sample 003	0.336 m	5.4	0.0088	0.0093	0.0088	0.0083
Sample 004	0.284 m	3.6	0.0074	0.0077	0.0072	0.0074
Sample 005	0.259 m	6.2	0.0068	0.0066	0.0073	0.0065
Sample 006	0.275 m	7.2	0.0072	0.0073	0.0077	0.0066
Sample 007	0.027 m	10.6	0.0007	0.0006	0.0007	0.0008
Sample 008	0.036 m	55.0	0.0009	0.0015	0.0007	0.0006
Sample 009	0.033 m	41.0	0.0009	0.0005	0.0009	0.0012
Sample 010	0.055 m	15.2	0.0014	0.0012	0.0016	0.0015
Sample 011	0.122 m	2.9	0.0032	0.0033	0.0031	0.0032
Sample 012	0.206 m	5.2	0.0054	0.0057	0.0052	0.0052
Sample 013	0.088 m	9.0	0.0023	0.0024	0.0021	0.0025

Method: Zn (Flame)

Instrument Mode:	Absorbance
Sampling Mode:	Manual
Calibration Mode:	Concentration
Measurement Mode:	Integrate
Replicates Standard:	3
Replicates Sample:	3
Expansion Factor:	1.0
Minimum Reading:	Disabled
Smoothing:	5 point
Conc. Units:	mg/L
Conc. Dec. Places:	4
Wavelength:	213.9 nm
Slit Width:	1.0 nm
EHT:	358 Volts
Lamp Current:	5.0 mA
Lamp Position:	3
Background Correction:	BC Off
STANDARD 1:	0.5000 mg/L
STANDARD 2:	1.0000 mg/L
STANDARD 3:	1.5000 mg/L
Reslope Rate:	50
Reslope Standard No.:	2
Reslope Lower Limit:	75.0 %
Reslope Upper Limit:	125.0 %
Recalibration Rate:	100
Calibration Algorithm:	New Rational
Cal. Lower Limit:	20.0 %
Cal. Upper Limit:	150.0 %
SIPS:	Off
Measurement Time:	5.0 s
Pre-Read Delay:	5 s
Flame Type:	Air/Acetylene
Air Flow:	13.50 L/min
Acetylene Flow:	2.00 L/min
Burner Height:	13.5 mm

Sample ID	Conc mg/L	%RSD	Mean Abs	Readings		
CAL ZERO	0.0000 m	7.3	0.0009	0.0010	0.0010	0.0009
STANDARD 1	0.5000 m	0.6	0.1620	0.1616	0.1630	0.1613
STANDARD 2	1.0000 m	0.2	0.3147	0.3141	0.3148	0.3153
STANDARD 3	1.5000 m	0.3	0.4562	0.4552	0.4558	0.4575

Curve Fit = New Rational
Characteristic Conc = 0.0136 mg/L
r = 1.0000
Calculated Conc = 0.0029 0.5015 0.9968 1.5018
Residuals = -0.0029 -0.0015 0.0032 -0.0018



Sample ID	Conc mg/L	%RSD	Mean Abs	Readings		
Sample 001	0.9257 m	0.3	0.2935	0.2927	0.2932	0.2947
Sample 002	0.4007 m	0.7	0.1297	0.1288	0.1298	0.1305
Sample 003	0.1879 m	3.9	0.0610	0.0584	0.0614	0.0631
Sample 004	0.2834 m	0.2	0.0919	0.0921	0.0919	0.0918
Sample 005	0.3341 m	0.1	0.1083	0.1084	0.1082	0.1082
Sample 006	0.2649 m	0.2	0.0859	0.0858	0.0859	0.0861
Sample 007	0.1099 m	1.3	0.0357	0.0362	0.0353	0.0356
Sample 008	0.0406 m	0.7	0.0132	0.0131	0.0131	0.0133
Sample 009	0.0987 m	1.0	0.0320	0.0323	0.0321	0.0317
Sample 010	0.2016 m	1.0	0.0654	0.0660	0.0655	0.0648
Sample 011	0.1058 m	1.2	0.0343	0.0339	0.0348	0.0343
Sample 012	0.2560 m	0.9	0.0831	0.0828	0.0839	0.0825
Sample 013	0.1121 m	0.7	0.0364	0.0365	0.0366	0.0361

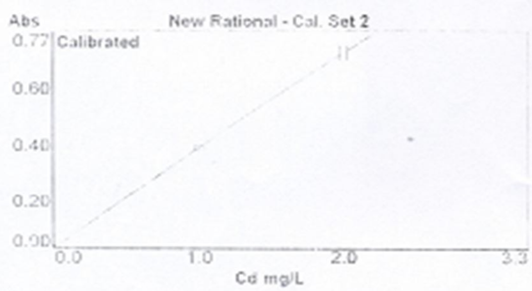
Method: Cd (Flame)

Instrument Mode:	Absorbance
Sampling Mode:	Manual
Calibration Mode:	Concentration
Measurement Mode:	Integrate
Replicates Standard:	3
Replicates Sample:	3
Expansion Factor:	1.0
Minimum Reading:	Disabled
Smoothing:	5 point
Conc. Units:	mg/L

Conc. Dec. Places:	3
Wavelength:	228.8 nm
Slit Width:	0.5 nm
EHT:	313 Volts
Lamp Current:	4.0 mA
Lamp Position:	4
Background Correction:	BC Off
STANDARD 1:	1.000 mg/L
STANDARD 2:	2.000 mg/L
STANDARD 3:	3.000 mg/L
Reslope Rate:	50
Reslope Standard No.:	2
Reslope Lower Limit:	75.0 %
Reslope Upper Limit:	125.0 %
Recalibration Rate:	100
Calibration Algorithm:	New Rational
Cal. Lower Limit:	20.0 %
Cal. Upper Limit:	150.0 %
SIPS:	Off
Measurement Time:	5.0 s
Pre-Read Delay:	5 s
Flame Type:	Air/Acetylene
Air Flow:	13.50 L/min
Acetylene Flow:	2.00 L/min
Burner Height:	13.5 mm

Sample ID	Conc mg/L	%RSD	Mean Abs	Readings		
CAL ZERO	0.000 m	13.0	-0.0005	-0.0006	-0.0005	-0.0005
STANDARD 1	1.000 m	0.3	0.3584	0.3571	0.3589	0.3591
STANDARD 2	2.000 m	3.6	0.6929	0.6645	0.7034	0.7107

Curve Fit = New Rational
Characteristic Conc = 0.012 mg/L
r = 1.0000
Calculated Conc = -0.001 1.000 2.000
Residuals = 0.001 -0.000 0.000



Sample ID	Conc mg/L	%RSD	Mean Abs	Readings		
Sample 001	0.058 m	3.0	0.0209	0.0214	0.0209	0.0202
Sample 002	0.052 m	2.0	0.0186	0.0185	0.0190	0.0183
Sample 003	0.045 m	1.3	0.0163	0.0165	0.0162	0.0161
Sample 004	0.047 m	0.3	0.0170	0.0170	0.0170	0.0171
Sample 005	0.049 m	2.2	0.0174	0.0170	0.0177	0.0176
Sample 006	0.045 m	0.7	0.0163	0.0164	0.0162	0.0162
Sample 007	-0.000 m	0.0	-0.0000	0.0001	-0.0000	-0.0002
Sample 008	-0.004 m	5.3	-0.0016	-0.0015	-0.0016	-0.0017
Sample 009	-0.005 m	7.6	-0.0019	-0.0019	-0.0017	-0.0020
Sample 010	-0.008 m	3.9	-0.0030	-0.0029	-0.0031	-0.0030
Sample 011	-0.007 m	7.5	-0.0027	-0.0024	-0.0028	-0.0027
Sample 012	-0.002 m	31.0	-0.0008	-0.0010	-0.0005	-0.0010
Sample 013	0.042 m	0.9	0.0152	0.0153	0.0152	0.0151

Method: Pb (Flame)

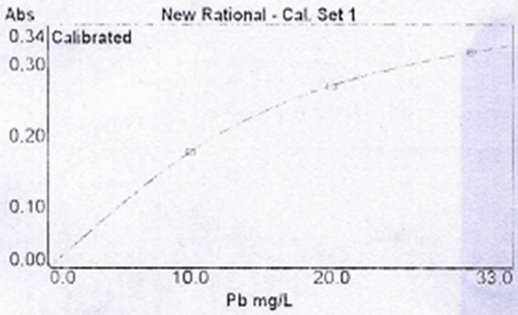
Instrument Mode:	Absorbance
Sampling Mode:	Manual
Calibration Mode:	Concentration
Measurement Mode:	Integrate
Replicates Standard:	3
Replicates Sample:	3
Expansion Factor:	1.0
Minimum Reading:	Disabled
Smoothing:	5 point
Conc. Units:	mg/L
Conc. Dec. Places:	2
Wavelength:	217.0 nm
Slit Width:	1.0 nm
EHT:	322 Volts
Lamp Current:	10.0 mA
Lamp Position:	1
Background Correction:	BC Off
STANDARD 1:	10.00 mg/L
STANDARD 2:	20.00 mg/L
STANDARD 3:	30.00 mg/L
Reslope Rate:	50
Reslope Standard No.	2
Reslope Lower Limit:	75.0 %
Reslope Upper Limit:	125.0 %
Recalibration Rate:	100
Calibration Algorithm:	New Rational
Cal. Lower Limit:	20.0 %
Cal. Upper Limit:	150.0 %
SIPS:	Off
Measurement Time:	5.0 s
Pre-Read Delay:	5 s
Flame Type:	Air/Acetylene
Air Flow:	13.50 L/min
Acetylene Flow:	2.00 L/min

Burner Height 13.5 mm

Sample ID	Conc mg/L	%RSD	Mean Abs	Readings		
CAL ZERO	0.00 m	31.4	-0.0032	-0.0034	-0.0021	-0.0040
STANDARD 1	10.00 m	0.6	0.1624	0.1629	0.1630	0.1614
STANDARD 2	20.00 m	0.5	0.2539	0.2538	0.2553	0.2526
STANDARD 3	30.00 m	0.7	0.3025	0.3040	0.3036	0.3000

Curve Fit = New Rational
Characteristic Conc = 0.27 mg/L
r = 1.0000

Calculated Conc =	-0.20	10.04	19.83	30.18
Residuals =	0.20	-0.04	0.17	-0.18



Sample ID	Conc mg/L	%RSD	Mean Abs	Readings		
Sample 001	1.83 m	4.2	0.0308	0.0305	0.0298	0.0323
Sample 002	1.21 m	12.2	0.0202	0.0229	0.0195	0.0181
Sample 003	0.73 m	5.9	0.0120	0.0125	0.0124	0.0112
Sample 004	1.28 m	10.8	0.0213	0.0236	0.0212	0.0190
Sample 005	1.72 m	3.0	0.0289	0.0279	0.0296	0.0292
Sample 006	1.54 m	19.8	0.0258	0.0244	0.0216	0.0315
Sample 007	-0.02 m	>100	-0.0004	-0.0028	0.0006	0.0011
Sample 008	-0.38 m	42.4	-0.0061	-0.0076	-0.0077	-0.0031
Sample 009	-0.33 m	29.1	-0.0053	-0.0040	-0.0049	-0.0070
Sample 010	-0.81 m	6.2	-0.0132	-0.0124	-0.0131	-0.0140
Sample 011	-0.68 m	16.9	-0.0110	-0.0128	-0.0091	-0.0112
Sample 012	-0.55 m	8.5	-0.0090	-0.0081	-0.0095	-0.0094
Sample 013	0.89 m	1.1	0.0148	0.0149	0.0146	0.0149

Appendix VIII: Kabarak University Research Authorization

INSTITUTE OF POST GRADUATE STUDIES AND RESEARCH

Private Bag - 20157
KABARAK, KENYA
E-mail: directorpostgraduate@kabarak.ac.ke

Tel: 0202656015
Fax: 254-51-343012
www.kabarak.ac.ke

24th September, 2014

Ministry of Education, Science and Technology,
National Commission for Science, Technology and Innovation,
9th Floor, Utalii House,
P.O. Box 30623 – 00100,
NAIROBI.

Dear Sir/Madam,

RE: RESEARCH BY GDE/M/1170/09/12– ELIUD KIBET YEGO

The above named is a Doctoral student at Kabarak University in the School of Science, Technology and Engineering. He is carrying out research entitled "The Impact of Artisanal Gold Mining on the Environment and Community Livelihoods: A Comparative Study of Nandi and West Pokot Counties in Kenya"

The information obtained in the course of this research will be used for academic purposes only and will be treated with utmost confidentiality.

Please provide the necessary assistance.

Thank you.

Yours faithfully,

KABARAK UNIVERSITY
24 SEP 2014
PRIVATE BAG - 20157, KABARAK

Dr. Kageni Njagi
DIRECTOR POST GRADUATE STUDIES & RESEARCH

Kabarak University Moral Code

As members of Kabarak University family, we purpose at all times and in all places, to set apart in one's heart, Jesus as Lord. (1 Peter 3:15)

Appendix IX: NACOSTI Research Authorization

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.

Date:

14th December, 2015

NACOSTI/P/15/41697/8741

Eliud Kibet Yego
Kabarak University
Private Bag - 20157
KABARAK.

<u>RE: RESEARCH AUTHORIZATION</u>

Following your application for authority to carry out research on ***"The impact of artisanal gold mining on the environment and community livelihoods: A comparative study of Nandi and West Pokot Counties in Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Nandi and West Pokot Counties** for a period ending **11th December, 2016.**

You are advised to report to **the County Commissioners and the County Directors of Education, Nandi and West Pokot Counties** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. S. K. LANGAT, OGW
FOR: DIRECTOR GENERAL/CEO

Copy to:

The County Commissioner
Nandi County.

The County Director of Education
Nandi County.

National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified

Appendix IIX: NACOSTI Research Permit

THIS IS TO CERTIFY THAT:
MR. ELIUD KIBET YEGO
of KABARAK UNIVERSITY, 0-30100
Eldoret,has been permitted to conduct research in *Nandi , Westpokot Counties*

on the topic: *THE IMPACT OF ARTISANAL GOLD MINING ON THE ENVIRONMENT AND COMMUNITY LIVELIHOODS: A COMPARATIVE STUDY OF NANDI AND WEST POKOT COUNTIES IN KENYA*

for the period ending:
11th December,2016

Applicant's Signature

Permit No : NACOSTI/P/15/41697/8741
Date Of Issue : 14th December,2015
Fee Recieved :Ksh 2,000

Director General
National Commission for Science, Technology & Innovation

CONDITIONS

1. **You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit**
2. **Government Officers will not be interviewed without prior appointment.**
3. **No questionnaire will be used unless it has been approved.**
4. **Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.**
5. **You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.**
6. **The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice**

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 7541

CONDITIONS: see back page