EFFECTS OF SOAPSTONE QUARRYING ON GEOMORPHIC AND SOCIO-ECONOMIC ACTIVITIES IN TABAKA REGION, KISII COUNTY- KENYA

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REG: C50/20115/2012

A thesis submitted in partial fulfilment of the requirement for the award of Master of Arts Degree in Geography in the School of Humanities and Social Sciences of Kenyatta University.

NOVEMBER, 2018
DECLARATION

This thesis is my original work and has not been presented for a degree in any other university. Am solely responsible for the content of this thesis including all omissions and commissions arising herein.

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DEDICATION

Tomy late father Elijah Tilji who immensely valued education and always provided us with an enabling environment to meet our goals.
ACKNOWLEDGEMENT

I sincerely wish to acknowledge with utmost gratitude my supervisors; Professor Joy Obando and Dr. Shadrack Kiana Murimi for their unwavering guidance and invaluable comments during the entire process of writing this thesis.

This thesis would not have been a reality without the contribution of my lecturers including Dr. Calvine Kayi and Dr. George Makokha at the Department of Geography who provided me with intellectual insights over pertinent issues in geographical research and analysis. I will forever remain genuinely indebted to all of them for such selfless effort.

To all my classmates, Emma Kabiru and Racheal Cherono whose engagement greatly enriched my intellectual capacity. I have lavishly embraced whatever I gained from them. I can’t forget to appreciate my field assistant Mr. Maurice Olal for his tireless effort in data collection and entry and being able to access all the sites within the prescribe time.

I acknowledge with utmost sincerity all respondents and officials who participated or assisted towards the success of this study. Clearly, this work would not have been done without their participation. I would have wished to mention all of them by name but the number is so large to fit in this space.

I wish to thank the Ministry of Education through the national commission for science, technology and innovation (NACOSTI), area chiefs and village elders for granting me permission to conduct the study. Finally, I recognise that whereas it is possible for somebody else could have made a different product out of this, it is important that I carried out the study at this time.
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## ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>GOK:</td>
<td>Government of Kenya</td>
</tr>
<tr>
<td>NACOSTI:</td>
<td>National Commission for Science Technology and Innovation</td>
</tr>
<tr>
<td>NDADLRM:</td>
<td>National Department of Agriculture Directorate, Land and Resources Management</td>
</tr>
<tr>
<td>NEMA:</td>
<td>National Environmental Management Authority</td>
</tr>
<tr>
<td>PIDS:</td>
<td>Philippines Institute for Development Studies</td>
</tr>
<tr>
<td>SMEs</td>
<td>Small and Medium Enterprises</td>
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<tr>
<td>UNECA:</td>
<td>United Nations Economic Commission for Africa</td>
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ABSTRACT

Soapstone quarrying activities have immense effects on the physical and human environments. However, it is not clear how individual soapstone quarrying activities influence the occurrence of a specific geomorphic event. The effects of resultant soapstone residues on farming and whether soapstone rocks can regenerate from such debris require deeper investigations. It is on these constructs that this study seeks to probe the influence of soapstone quarrying activities on geomorphic processes and farming activities within Tabaka region in Kisii County, Kenya. The study, therefore, seeks to determine the association of soapstone quarrying activities with the occurrence of geomorphic processes; examine how such activities affect farming and suggest a concrete policy framework for sustained soapstone quarrying activities in Tabaka region. The study used a multi-point descriptive and qualitative survey technique. It analysed four (4) out of twenty-four (24) quarries in the region and used interviews, observation, photography, measurements, questionnaires, and group discussions to collect information. The study used Excel and SPSS programmes to analyse data on different aspects of the study objectives. The hypotheses were tested using Pearson Rank Correlation to test the relationship between variables. It was determined that soapstone quarrying activities accelerate the rate of weathering, soil erosion and mass movement in the area under investigation. In addition, it was observed that soapstone quarrying activities take up to 22% of the total farmland. At the policy level, the study found out that there are sufficient policy provisions including the: Constitution of Kenya 2010, Mining Act, 2014, the Environment Act, 2012 and the Mining Policy 2011. These policies are not effectively being implemented, and most of those interviewed (68%) are not aware of their provisions. The study concluded that soapstone quarrying activities influence the occurrence and the rate of mass movement, soil erosion and weathering processes. Soapstone quarrying activities have reduced the available land for farming thus curtailing agricultural production in Tabaka region. The study recommends that the local county government in conjunction with the Ministry of Environment and Mining should ensure that residents engaged in soapstone quarrying activities adhere to the provision of regulatory policies in force. Further, soapstone quarries should be owned by the national government for proper control and management.
## OPERATIONAL TERMS AND CONCEPTS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tr>
<td><strong>Socio-Economic Environment:</strong></td>
<td>Totality of economic factors such as employment, income, productivity and wealth present in the aerial differentiation in a place (Bell, 2006).</td>
</tr>
<tr>
<td><strong>Overburden:</strong></td>
<td>Waste materials such as soil, rock or ecosystem lying above a mineral ore being exploited (World Bank, 2006).</td>
</tr>
<tr>
<td><strong>Residue:</strong></td>
<td>The remains of something after parts have been used, removed or disposed of (GoK, 2000).</td>
</tr>
<tr>
<td><strong>Slope Process:</strong></td>
<td>A set of activities that act on or below the surface of a slope and affecting the regolith and bedrock (Clark and Small, 2006).</td>
</tr>
<tr>
<td><strong>Geomorphologic Process:</strong></td>
<td>A set of sculpturing mechanisms (weathering, erosion and deposition) operating at or near the earth’s surface that develop or mould landforms (Gerilles, 1999).</td>
</tr>
<tr>
<td><strong>Mass Movement:</strong></td>
<td>Down slope movement of rock and soil materials due to influence of gravity (Bryant, 1993)</td>
</tr>
<tr>
<td><strong>Slope failure:</strong></td>
<td>Distortions of the slope as a result of influence of factors including slope gradient, geotechnical properties of materials, cohesion and the presence of discontinuities (Landowe &amp; Hammler, 2008).</td>
</tr>
<tr>
<td><strong>Weathering:</strong></td>
<td>A process by which rocks are decomposed or disintegrated through the actions of water, biological organisms and extreme temperatures (Ferrai and Guiseppi, 2011).</td>
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CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Soapstone is one of the most remarkable mineral rocks that has been excavated by man for several centuries (Storemyr, 2004). According to Landowe And Hammler (2008), soapstone is very workable rock as a result of its high content of talc, the softest known mineral in existence, is also durable, heat-resistant and has a high heat storage capacity. While the extraction of minerals would obviously bring economic opportunities, it portends several environmental challenges to the regions where they take place (Banez and Ajon, 2010).

Mining involves the extraction of mineral resources from the ground for various economic reasons (Windalund and Ohlander, 2014). The sector is a major contributor to the economic development, accounting for an average of 20% of the total world Gross Domestic Product (GDP). Besides being a source of significant income, the sector provides employment to many people and is a catalyst for industrial development (World Bank, 2006). In contrast to the above, the sector plays a big role in the destruction to the environment, thereby threatening the ecological balance of a place (Otoyin and Agyemang, 2014).

A study by Storemyr (2004) noted that soapstone was the main material used in Norwegian medieval stone architecture. The stone was used in items such as cooking pots, laying of kitchen chop boards, ornaments and cutlery (Ibid, 2012).

In Scandinavia, the usage of soapstone during the Stone Age period, was mainly used in making fireplaces and cooking pots. Soapstone fire-resistant property makes it an essential element in kitchens and industrial workshops where it is used for casting metal objects such as knife blades and spearheads (UNCEA, 2004).
Besides, soapstone is also a versatile mineral which makes it more preferable for exploitation than other rocks (Sassaman 2006). He observes that over the years, soapstone has not only changed the economic lives of people, but has also contributed to the physical alteration of the nature of land leaving most places desiccated, derelict and creating heaps of residues (Ibid, 2006). Like with other mining activities, soapstone exploitation accelerates the occurrence of various geomorphic processes.

Soapstone is a metamorphic rock with dense, long lasting and fire resistance qualities. (Storemyr, 2004). It is formed when great heat and pressure, in the presence of inflexed fluid act on buried peridotites which metamorphosed into talc (Strahler and Strahler, 2004). Soapstone is largely composed of the mineral talc and is thus rich in magnesium. Its composition varies depending on the parent rock mineral and the pressure/temperature conditions of the metamorphic environment (Rodrigues and Lima, 2012).

Kenya is averagely well-endowed with mineral resources, some of which are already being exploited while others are yet to be prospected and exploited. According to Ministry of Mining, the main minerals found in Kenya include: soda ash, fluorite, diatomite, carbon dioxide, gold, iron ore, lead, titanium, silica sands, gemstones, precious minerals, gypsum, limestone and soapstone (GoK, 2016).

The exploitation of soapstone is done using light machines, anequitemnt and tools. These processes, according to Clark and Small (2006), disturbs the soil and bedrock thereby accelerating the occurrence of geomorphic processes. In addition, soapstone quarrying is likely to bring changes in the physical outlook of the landscape including reduction in the slope angle, derelict lands, siltation of rivers, massive landslides during the rainy season and reduced soil productivity (Sassaman 2006).
A number of scholars have examined the impact of soapstone quarrying on human activities and noted its adverse effects on agriculture and settlement (Rodrigues and Lima, 2012). For instance, the scooped soil and soapstone fragments are dumped near the carving sites thus creating moulds of debris on a landscape. These heaps cumulatively occupy large surface areas that could otherwise be used for agriculture. The heap is easily eroded because it is unconsolidated and the steep nature of its slope accelerate the rate of the aforementioned processes besides changing the original appearance of the landscape.

According to Rodrigues and Lima (2012) the new land formations such as moulds of debris undergo geomorphological processes including rock regeneration (rock cycle) and denudation thus affecting the physical outlook and human activities in the area. As slope processes like erosion takes, the land is left bare leading to increased weathering and mass wasting activities.

Tabaka region is characterized by low lying bedrock of soapstone mineral which has been worked ever since 1885 (GoK, 2001). According to the Geological department in Kenya, the stone spread across 25 kilometres and runs up 265 metres deep. Up to 20% of it has been exploited with the possibility that the rock regenerates from the debris left behind during quarrying processes (Buyeke and Njoroge, 2015). The Tabaka / Kisii soapstone is carved into different artefacts which are then sold to a thriving tourist market to the local people for home decorations.

1.2 Statement of the Research Problem

The influence of soapstone quarrying activities on geomorphologic processes attract interesting geomorphic questions. According to Lorant (2008), soapstone quarrying activities entail removal of overburden soil, excavating of rock boulders, transport of boulders and carving
activies. These activities produce tones of softstone residues and volumes of rock pebbles which are dumped arounds quarry pits and carving areas.

In their study, Bell and Donnelly (2006) analysed how soapstone quarrying affected soil erosion and determined that the activities accelerate the process. On the other hand, Ritter, (2012) examined the relationship between soapstone residues and weathering. He noted that dumped residues cover the underlying rock and hence tend to slow down weathering activities in the areas where they occur. He noted no immediate. From theses studies it is not certain how individual soapstone quarrying activites are associated with other geomorphic processes.

Not only will open cast mining method acceleraterate the rate of geormorhic process, there are circumstances when the processes may actually be decelerated. This is supported by Azcuen (1999) who contend that in ceratin circumstances fragment of exploaited stones will pile up and through the activities such as lithification, sedimentation, environmental factors, geormophic agents contribute towards rock regeneration(Gupta, 2004). What is not certain is which aspect of soapstone mining activities largely influence theinfluence the occurance or rate of individual geormorphic process.

There is a growing concern that mining of mineral and development activities have the potential to influence the occurrence of geomorphic processes that cause alteration of the physical outlook of the landscape (UNEP, 2010).The National Environmental Management Authority (NEMA, 2010) indicates that the Kenya government has put in place a wide range of strategies, programmes and legislative framework to address the major causes of environmental degradation. An assessment of the impact of soapstone mining on the adjacent agricultural land in Tabaka regions reveals high load of soapstone particles in areas around the quarries (Kinyua et al., 2011).The Philippines Institute for Development Studies (PIDS,
2012) establishes that mining has a number of effects on the economic and social wellbeing of the people.

These include better living standards through increased income earnings; improved communication infrastructure and attraction of other industries. It also points out that mining may on the other hand displace human settlement and totally change the original land use pattern. These activities may also create significant visual effect on landscape by creating mould of residue and degeneration problem because of soil depletion and deep alteration of the original topography. The created mould of residue from soapstone quarrying and its impact on the economic and human activities in the area needs to be established.

The government of Kenya has put in place a set of legislations such as the Mining Policy 2011, The Mining Act 2009 and the Environmental Policy 2010 to regulate the mining sector in the country and expects players to strictly adhere to them. These legislations draw their foundation from Article 69 (1) (h) of constitution of Kenya 2010 (GoK, 2010) which provides that it is the obligation of the government to ensure that natural resources are utilised for the benefit of the people of Kenya.

The local exploiters of minerals do not quite fully implement stipulated environmental laws (NEMA, 2010). For instance, it is required in Part II Article 6 (2) of the Mining Act 2014 that the national government shall have control and ownership of mining areas and in Article 610, any one engaged in mining must dispose of refuse, effluent and residues in a manner that does not harm the environment. Evidently, these regulations are not being adhered in soapstone mining areas raising questions on the effectiveness of the implementing agencies.
1.3 Objectives of the Study

1.3.1 General Objective

The broad objective of the study is to establish the effects of soapstone quarrying activities on the geomorphic processes and farming in Tabaka region.

1.3.2 Specific Objectives

1. To determine the types of slope processes associated with soapstone quarrying on the relief of Tabaka region.
2. To examine the relationship between soapstone quarrying activities and farming within Tabaka region.
3. To establish the alternative uses of soapstone residues over the conventional methods.
4. To analyse the policy framework for sustained soapstone quarrying activities.

1.4 Research Questions

The research was guided by the following research questions:

1. Which type of slope processes is associated with soapstone mining in Tabaka area?
2. What are the relationships between soapstone mining and farming activities?
3. How else can soapstone residues be used besides the conventional methods?
4. Which policy framework should be adopted for sustained soapstone quarrying activities in Tabaka region?

1.5 Research Hypotheses

1. $H_0$. Soapstone quarrying has no significant effects on slope processes in the area.
2. $H_0$. There is no relationship between soapstone quarrying and farming.
3. $H_0$. There are no variable uses of soapstone residues over the conventional methods.
4. There is no appropriate policy option that exists for sustained soapstone quarrying in the region.

1.6 Justification of the Study

There are two main areas that justifies the need for a study of this nature. These are policy and academic considerations. The exploitation of mineral resources is normally characterised by physical alteration of the landscape and distortions of the original economic lifeline of the region (Nanor, 2011). Unplanned quarrying activities is likely to destroy the environment which leads to serious health concerns and physical destruction of the place. This study seeks to inform good quarrying practices that should be implemented to prevent environmental and social impacts from wastes for which no immediate beneficial uses exist.

Quarry waste tips must be designed, constructed, operated and maintained to avoid instability or movement that might give rise to health and safety risks. The UNECA (2004) indicates that the relationship between mineral dependence and broader economic wellbeing must be managed through sound policies that curtail the potential problem accompanying mineral dependence. (GoK, 2010).

Soapstone quarrying in Tabaka attracts little attention from the local administration and the government especially on its sustainable mining. This is because of the perception that it is a small-scale venture and all the rules governing mineral exploitation and environmental management have nothing much to do with the industry. It is for this reason that a host of mining regulation are never fully implemented leading to hazardous consequences to the environment.

The centrality and importance of geomorphology especially in its relationship with human activities such as quarry has not been fully analysed because the geomorphological
intellectual core is not easily identified with human efforts (Nanor, 2011). Their scientific foundations are more related to land forms, their distructions and triggering agents such as as climate and timespan. It is however essential to appreciate that human activities may influence of not accelerate the occurrence of geomorphic processes (Gupta, 2004). This study will therefore presents the intellectual roots of geography, geology, and geomorphology in the man in which they are related.

The study appreciates the existence of a wealth of literature on mining activities in Kenya. For instance, Oduor (2008) analysed the Socio-Economic Aspects and Geomorphic Effects of Quarrying, Kinyua et al. (2011) on the radiation exposure levels within soapstone mining area of Tabaka; GoK (2003) on Key Consideration for Good Mineral Policy, and UNECA (2004) on the Problem of Mineral Dependence in Africa. None of these academic pieces have ever conceptualized soapstone quarrying and its influence on the occurrence of geomorphic process and land use patterns. This study will therefore add value and new dimension on the already existing wealth of knowledge.

Tabaka is unique in the sense that the oldest African basement rock has been exposed to the surface after erosion episodes Mathu and Davies, (1996). It is the only region in Kenya where soapstone is found and its location is characterised by a sloppy landscape, annual rainfall amount of over 1500mm and high density of population. An assessment of the relationship between these physical factors and the occurrence of geomorphic processes in areas where soapstone activities take place will provide knowledge on how we can conduct mining activities in more sustainable manner without destruction to the environment.

The finding of the study will assist environmental and mining policy makers to establish short falls of the existing Mining Act and implement new effective option for sustainable soapstone
quarrying. The study finding will help in sensitizing the miners and quarry owners on the effects of quarrying activities and on their responsibilities in reclaiming disused quarries.

The community as a whole will also benefit from the study findings since the study will create awareness on the effects of soapstone quarrying activities on farming and which option between the two industries best suit their economic requirements.

1.6 Scope of the Study

This study was limited to the locational aspects of soapstone quarrying areas within Tabaka region. It considered the effect of quarrying activities such as mining, carving and disposal of waste (residues) on geomorphic processes and farming activities in the area. The study also considered how best the waste products can be disposed and putting them into viable economic usage.

Further, the study explored whether the existing Mining Act 2014 and other relevant environmental regulatory laws are fully being followed in respect to soapstone mining in Tabaka region and what alternative policy options could be adopted for efficient mining and management of the immediate environment.

1.7 Limitation of the Study

There were a number of limitations that the researcher experienced during the conduct of the study. A study of this nature requires a long period to observe the effect of the occurrence of geomorphic processes some of which are difficult to note within a limited span of time. The researcher however relied on past and current Land sat photographs to observe changes on the landscapes around soapstone mining sites.

Despite the existence of a wealth of literature on mining activities in Kenya, there is limited information on how soapstone quarrying activities influence the existence of geomorphic
processes and its effect on mining. Wherever such information existed, they lacked sufficient researched approach and merely dealt with economic uses of soapstone. The researcher compared parallel information from other countries such as the United State of America where soapstone mining is taking place to draw conclusions.

Since the research involved site visits and interviewing a host of respondents; it required enough amount of financial outlay. The researcher had financial challenges in the initial stages. However, additional funds were raised from well-wishers to ensure the study was successful. The sampled soapstone quarries are located far apart and within difficult hilly terrain which are not accessible by motorized transport. Not with standing this difficulty, each quarry had to be visited at least three times for information to be gathered.

The researcher had difficulties accessing research materials such as topographical maps and Landsat images from established libraries. The researcher was able to consult with the Kenya Institute of Survey who availed the material.
CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter provides a critical analysis of literature on the concept, theory and practice of soapstone quarrying activities in the context of their effects on the geomorphic processes and farming activities in Tabaka region. Material for reference were drawn from several sources which are closely related to theme and objectives of the study.

Soapstone quarrying is one of the open cast mining methods widely used to extract rock boulders which exist on or below the land surface (Banez et al, 2010). Unlike adit and deep sharft mining methods, quarryingpits rarely reach depthsof more than than 18 metres (Adams, 2003).

Soapstone quarrying activities involve the removal of deposit of rocks which run close to the earth surface using light excavation equipment. The main activities include: removal of top soil, channelling and wedging, cutting of rocks, crushing, conveyance or transfer of rock boulders to carving sites. These activities form part of the human forces that disturb and affect the immediate landscape and are sensitive to other forms of human activities (Langer, 2004).

It is imperative to map what constitute geomorphic processes and their occurrences so as to clearly understand how they relate to soapstone quarrying activities.In general sense geomorphic processes refer to the transfer of material or disturbance of biota without regard to development of landforms or the time scale in which they occur.

Geomorphology is defined as the scientific study of the earth’s surface features involving interpretive description of landforms, their origins, development, nature and mechanisms of geomorphic processes which evolve the landform (Gouldie, 2004).Geomorphology is
essentially an explanatory subject emphasizing the interpretation of the upper surface of landscape areas in relation to the different causes which have shaped it. The process continually shape the earth's surface and generate sediments that circulate in the rock cycle (Gupta, 2004). The process can be slow or sudden. Slow process include weathering, erosion, transportation and deposition. These can occur naturally but can be triggered or accelerated by farming, quarrying and other human activities (Banez et al., 2010).

He further argue that quarrying process creates a potential negative impact on the environment (ibid). Similarly, Walker et al 2003 also noted that quarrying activities distort the physical landscape by disturbing unique habitat, significant alteration of topography and unchecked disruption of basic ecological relations. Environmental disturbance created by quarrying trigger geomorphic processes like erosion, weathering, mass movement, besides it changes and conversion of land use with the associated change in visual scene (Gale et al 2001).

The magnitude of the occurrence of geomorphic process is influenced by different interacting factors like climate, relief, soil, vegetation, human perturbation, tectonic instability and volcanic activity (Clark and Small, 2006). Subsequently, areas where soapstone quarrying activities take place could also experience accelerated, erosional, mass movement and weathering activities.

Clearance of vegetation prior to quarrying is the prime course of environmental dilapidation and exhaustion of natural communities (Akanwa et al 2016). The major effect is accompanied by loss of habitat damage of biodiversity, dust, erosion, sedimentation and dereliction of the quarrying sites. The loss is likely to be irreversible (Banez et al 2010).

The original landform is permanently altered and the original vegetation cover destroyed. The visual impact of the quarry extend over large areas as noticeable scars of high colour
contrast reducing the aesthetic appeal of the landscape and deteriorating the scenic quality of
the area (Mouflis et al 2008). Ukpong 2012 noted that the excavation sceneries as an ‘eye
sore’. The sentiments were nearly comparable to Davids 2007 who termed open quarry pits in
Hungary as ‘scars’ in the landscape. Run-off from the quarry site or piles of residue cause
erosion and contaminate local water sources. Suspended solid sediments may harm fresh
water ecosystem and impact on other water sources (Banez et al 2010).

Land is a critical resource for people depending on farming. About 2 million hectares of
agricultural land are lost every year due to human activities (quarrying) which affect the
ecosystem and cause severe land degradation (Walker et al 2003). Arable land are destroyed
with residue occupying space that could have otherwise been used for farming.

The overburden, unavoidable by product of quarrying activity has no market value (Banez et
al 2010). The higher the proportion of residue, the greater the environmental and social impact,
storage of the material is difficult to handle and is more prone to mobilization under action
of gravity, wind, and water. Disposal area are elevated more than the original ground level
further exacerbating geomorphological processes. According to Banez (2010) quarry waste can
often be put to beneficial use around the site.

Most of the effects can be mitigated, kept at tolerable levels and restricted to the immediate
vicinity by employing responsible operational practices that are recommended by
NEMA. Langer, 2009 asserts that problems associated with quarrying escalate due to lack of
environmental awareness while operating the mines. Disused quarries should be revegetated
to create a stable final landform and integration with the surrounding landscape.
2.2 Theoretical Framework

The mining sector, while being a major contributor to the economy of any region, may also pose a serious threat to the environment of the place (Chauhan, Andrew and Bryan, 2012). Bryant (1993) alludes to this claim and argues that the consequences of human activities on the environment are not only confined to mineral exploitation, they are also experienced while engaging in other actions such as farming, fishing and construction.

According to Lins and Horwitz (2007), such threats include alteration of the ecosystem, pollution and various forms of land degradation. Subsequently, this study assumed that mining activities are likely to accelerate the occurrence of geomorphic processes which may induce the modification of the original landforms (Bell and Donnelly, 2006). It is assumed that individual would choose to engagement in those economic activities which maximizes their income and other economic rewards. Lipsey (2014) explain that certain economic activities are preferred because they are able to earn maximum returns on investment compared to alternative sources. To understand the details of these assumptions, the study used Mining Impact Theory (Mathu and Davies, 1996) and the Economic Land Use Theory (Greenberg, 1999) to explain why an individual will either opt to engage in an activity such as soapstone quarrying instead of farming or vice versa.

2.2.1 The Mining Impact Theory

Mining Impact Theory was first advanced in the early 19th century as a social impact assessment to manage the intended and unintended social consequence which are brought by mining activities (Mathu and Davies, 1996). It states that mining activity can be sustainable only if it does not alter the character of a region, and development if it is carried out in the overall interest of society. The theory covered aspects of economic gains and/or losses. It only alludes to physical consequences, perhaps land dereliction and leaves out its influence
on geomorphic processes which may be witnessed within the mining zones (Landowe and Hammler, 2008).

In their work on the physical impact of mining on landforms, Rutland and O’Hagan (2007) and Rodriguez et al (2006) have developed the Mining Impact Theory to explain the relationship of mining activities and occurrences of geomorphic processes. According to them, mining activities including quarrying directly influence or accelerate the occurrence of geomorphic processes such as erosion, weathering and various forms of mass movement.

This theory makes the following assumptions: that geomorphic processes occur everywhere on the earth’s surface usually in situ and human activities only act to accelerate the rate at which they happen; that while the resultant impact of geomorphic processes is realized within a geological time scale, the involvement of human activities is likely to hasten the output. Mining becomes sustainable if it does not alter the character of a region, and contributes towards development when it is carried out in the overall interest of society.

2.2.1 Economic Land Use Theory

The effects of soapstone quarrying activities on farming can be explained through economic land use theory. This theory is associated with David Ricardo (1772 – 1823). According to Ricardo, the intensity and choice of land use is based on the input of labour per individual. The higher this ratio is on land, the higher the quality of it (Greenberg, 1999).

Economic Land Use theory states that the available land space is likely to be applied (used) in a manner that brings about the highest return to the owner. Land use practices will return different level of benefits. It is upon the owner to decide, based on the possible return, on what activity to apply the land (Simmonds, 2007). Similarly, Langer (2009) asserts that land owners are likely to be driven by the benefits and social cost that a given activity have.
This theory assumes that land owners are rational and will not compelled by the dominant practice in their neighbourhood when opting to engage in select land use activities. It is however important to ask whether such rationalities exist among land owners? This technically is explained by Rodrigues, et al., (2006) who suggests that the option lies on trade-off between competing interest and substantial conflicts about the desired use of land among stakeholders.

In most areas where soapstone occurs and are exploited, there are other activities which take place alongside (Rutland and O’Hagan, 2007). Often, land owners in those circumstances will apportion the land into several competing activities. It is likely therefore, that land owners in Tabaka region in Kisii County will trade off their lands between farming, soapstone activities and settlement.

2.3 Theoretical Literature

This review of literature builds a context for indepth discussion on the current issues concerning soapstone quarrying activities and how they relate to farming and geomorphic processes. Specifically, the review focuses on discussing the roles of individual soapstone quarrying activities on key geomorphic processes such as erosion, weathering and mass movement. It also delve in looking at the legal framework and its role in planning, executing and managing soapstone quarrying activities.

2.3.1 Slope processes associated with soapstone quarrying

A number of geomorphologist such as Storemyr (2004) and Ritter (2012) describes soapstone as a metamorphic rock which consist mainly of mineral talc, also known as stalactite. The stone is very soft and is found between 0 and 50 metres below the earth surface. The mineral occurs as brown, grey or dark brown stone (Mathu and Davies, 1996). Bell and
Donnelly (2006), explains that the soft nature of the stone and its resistance to humidity makes it easier to be carved into various shapes of ornaments and other artefacts.

It is not quite clear when commercial use of soapstone was made. What is certain none the less is the fact that soapstone usage started about 3000 years ago in China where it was used to make stabs, dishes, cooking pots and fireplaces (Dobinski, 2011). In America however, commercial usage of soapstone begun in Vermont around 1825 and later spread to Grafton, Vermont, Franconia and New Hampshire (Haghi, 2009). At that time the stone was used to make water pipes, chimney and kitchen counters (Sort and Alcantz (1996).

It is estimated that soapstone occurs in isolated pockets in African countries such as Angola, Egypt, Tunisia and Kenya. Soapstone mining in Kisii started in 1885 when artisans in Gucha South District begum to carve the stone into various shapes (Pulfrey, 1948). The soft nature of soapstone and its resistance to fire has made it one of the most valuable minerals in making cooking surfaces. Soapstone normally occurs on sloppy grounds where talc is subjected to great pressure and heat occasioned by huge heap of overburden on the surface (Strahler and Strahler, 2006). Such great pressure changes the mineral talc into Pyrophyllite which occurs as soapstone (Landowe and Hammler, 2008). According to a study by Wahome (2013) the exploitation of soapstone loosens the top soil cover and even weakens soil colloids making those areas susceptible to erosive processes. This then results in erosion which is understood to be the removal of top soil or break up of rocks either by water, wind or ice.

The PIDS (2012) identified four types of erosion largely witnessed in areas where open cast mining activities take place. They include gulley, rill, tunnel and terrace erosions. These types of erosion have marked differences in their physical characteristics. Gulley erosion is the advanced form of rill and sheet erosions. They are common in sloppy areas and exhibit steep sided scarps with flat funnel bottoms.
According to a study by Gathuru (2012) the process of quarrying follows some steps. For instance, before soapstone quarrying is commenced, substantial vegetation is cleared from the land to allow access to the mineral. This enhances the effects of surface runoff on soil. Sheet erosion occurs gradually in large expanse of surface land. Rill erosion on the other hand consists of long narrow trenches on land surfaces often occasioned by foot paths and rapid surface runoffs (Strahler and Strahler, 2006).

Gathuru (2012) notes that apart from erosion, there are other slope processes that may occur as a result of quarrying processes in a place. For instance, weathering and mass movement has been common around mining sites. Veldkampa et al (2012) explain that under normal circumstances, weathering is a natural phenomenon that leads to the disintegration or decomposition of rocks into fine particles by agents such as water, biotic factors and heat.

According to Veldkampa, et al (2012) weathering forms the basic component in the denudation of landscape. Human activities such as quarrying loosens rock particles and expose them to agents such as heat and rain which may hasten weathering processes (Bryant, 1993). Veldkampa, et al (2012) notes that the loosened rocks particles and remnants of mineral ores left as residues around mining sites may rapidly move down slope as mass movement when there are saturated by rain water.

Studies conducted by Ferrai and Guiseppi (2011), revealed that quarrying has potentially significant negative environmental impacts. Slope quarrying result in the scraping of the upland topsoil and destruction of the vegetation. The sub soil that has been moved from the upper position to the lower position can bury the productive top soil in the lower slope areas.

According to Bryant (1993), the severity of soil erosion depends on a number of factors such as rainfall, land use, slope, soil texture, permeability, shear strength and most importantly soil aggregate stability. Kinyua et al (2011) note that these properties affect how the soil responds
to the impact of rainfall and how this water moves through the soil. Evidently, these adverse implications are attributable to quarrying.

Landowe (2008) analysed the slope processes that result from soapstone mining. He identified mass movement, increased erosion, and weathering as those processes which are associated with soapstone mining sites around New Hampshire. The occurrence of these processes has brought physical changes in the land outcrop particularly the formation of soapstone ridges. Obwori, et al (2012) describes these as rugged, dissected, oval shaped features around areas where soapstone is quarried.

Bryan and Azid (2005) also argue that the surrounding aquatic environment, and biological communities face habitat alteration or loss as fine sediments smother the bottom of the streams and river channels. This position is supported by Mathu and Davies (1996) who contend that the quality of water is degraded by the addition of excess sediments, nutrients, and compounds such as heavy metals which may be associated with the eroded particles from the deposited residue particles.

When quarrying takes place, the angle of the slope is altered by heaps of residues deposited and excavation resulting into either a steeper or gentle slope. According to a study by Obwori, et al (2012) where the slope is steeper, the movement of soil down slope through gravity is more rapid. This may result into massive landslides if the area receives high amount of rainfall. Low amount of rainfall on the other hand leads to slower movement of materials down slope.

It is posited by Haghi (2009), that bare surfaces normally experience rapid mass movement than areas where vegetation is present. Similarly, GoK (2001) also explains that where quarrying involves clearing of the vegetation and in areas which are wet and sloppy, rapid mass movement is likely to be experienced.
Quarries in the long run may have detrimental effects in form of dereliction when exhausted pits are abandoned. Derelict lands and heaps of residues left behind interfere with farming by reducing the size of farmlands and soil fertility. Soapstone activities also distort the aesthetic value of the slope and transform the landscape into steep or vertical rock face thus destroying the previously existing ecosystems. The soil, air and water properties are degenerated beyond short term repair (Buyeke and Njoroge, 2015).

The Kisii County is dominated by hilly environment. Soapstone activities take place along these slopes (Onura, 2012). There are unconsolidated residues which are found deposited around the place. It is likely that this deposition could attract a number of slope processes and their associated effects. Given the steep nature of the new slope created, the residue is easily swept down slope in case of rainfall. Obwori, et al (2012) notes that this explains the severity of river pollution and deposition of sediments.

Soil erosion is one of the most devastating environmental degradation and happens nearly continuously in many places across the earth surface. There are both human and natural factors that affect the occurrence of soil erosion (Haghi, 2009). In their analysis of the causes of soil erosion in the upland regions of Ruhr, Ferrai and Guiseppi (2011) identified a combination of factors including the slope angle, bare grounds, mining activities and population increase as some of the causes of soil erosion. To them, soil erosion is more likely to happen in exposed areas and in regions where the slopes are steep.

Wessels, et al. (2007) assert that in most parts of South Africa, soil erosion is caused by overstocking, overgrazing, lack of crop rotation, slope angle, soil texture and quarrying. Areas such as Kimberley where diamond and gold are mined release tonnes of top soil into the neighbouring environment.
Soapstone quarrying is done through open cast method. According to Wessels, et al. (2007) open cast method exposes the mineral sites to several slope processes including erosion, weathering, and mass wasting. Since quarrying of soapstone uses light tools and is concentrated on the slopes, the grounds are often shaken causing some materials to move down slopeen-masse.

According to Gerilles (2001), mining of any mineral resource contributes significantly to the economic growth of a country and the residents of such places. However, quarrying affects, the stability of the surface material which may result in direct movement of material while others create favourable conditions for other geomorphic factors to exert their influence (FerraiandGuiseppi, 2011).

2.3.2 The relationship between soapstone quarrying activities and farming

According to a study by Gathuru (2012) mining operations including but not limited to quarrying which draws ores and other raw material from the earth has a direct impact on the economic and social aspects of the area. The nature and degree of impact however vary widely depending on the location and types of operation (Bryan andAzid, 2005). According to them, mining is a great source of income for those directly engaged in it. Respective governments also draw in revenue in terms of taxes and loyalties.

The process of soapstone quarrying causes substantial effects on the physical and socio-economic activities in the areas where they occur (Walker et al, 2003) . Quarrying creates a host of slope processes through loosening of soil colloids (Gale et al 2001). According to Gathuru (2012), soapstone activities also result into moulds of residue deposits some of which have very fine grains. This makes the areas more vulnerable to soil erosion, weathering and mass movements(Benaz et al, 2010). The UNECA (2004) argue that where quarrying is situated in sloppy areas, erosion activities are much more accelerated.
Soapstone quarrying may impact negatively on human activities in the area where it occurs. In their study on quarries, land degradation and rehabilitation, Obwori, *et al* (2012) established that mining residues and moulds of overburden have displaced a sizeable population from their original home. Where mining activities occur in areas which had hither been practising agriculture, there are sudden changes in land use patterns.

These phenomena not only affect the economic life of the people but also their social wellbeing. This argument is supported by Oduor (2008), in a study on effects of quarrying in Nairobi and its environment. The study concludes that quarrying has enhanced pollution and displaced settlement. The residues take up space which would have been used for farming and other activities.

Soapstone quarrying also influences economic activities in the area by creating employment thereby increasing the standards of living. It also pulls workers into the area creating new settlement. With the new settlements and increased demand for services and utilities, other industries sprout up in the region further creating new sources of income (Oduor, 2008). However, soapstone quarrying could also bring negative impacts on human activities. The process may result into dislocation of the populations, deforestation, reduction of agricultural land, and opening dangerous zones of dereliction which enhances disease infestation (GoK, 2001).

Additionally, mining and sculpturing of soapstone produces dust effluents which have profound effect on the quality of lives of local residents (Haghi, 2009). Erosion and sedimentation also have a variety of on-site and off-site impact on both the terrestrial and aquatic environment. Gathuru (2012) avers that within the surrounding aquatic environment, biological communities face habitat alteration or loss as fine sediments at the bottom of the
streams and river channels continue to accumulate. The water quality is degraded by the erosion and sedimentation, particularly from the deposits of residue.

2.3.3 Alternative utilization of soapstone residues

When soapstone is mined, fragments of particles are left behind as fine or strips of solid rocks. Banez (2010) asserts that the quarrying waste can often be put to beneficial use around the quarrying site. This material is deposited as residues within the mines and carving factories. According to Storemyr (2004) soapstone fragments are so impervious to heat and make it to be used as lining in oven interiors, pizza pans and chimney linings.

Storemyr (2004) indicates that soapstone surfaces do not allow for the existence of germs. Its residues could then be ground and used in making the inner coating of packaging. The remnants of soapstone can be used as materials in building for painting and smearing walls. Rodrigues, and Lima (2012) notes that soapstone residues are also very useful in the making of paintings, paper filling material, and in the production process in the plastic and ceramic industries.

2.3.4 Policy framework for sustainable soapstone quarrying activities

A policy is conceptualised as a broad government statement which outlines how it intends to deal with a specific social, environmental, economic or resource based issue (Mbai, 1997). Birkland (2001) on the other hand, defines policy as a set of legislation, action plans or strategies developed by authorities to influence or determine the direction of any development. According to O’Toole (2000), the basis of having a policy is to resolve inherent risks arising from a given event or flow of activities. A policy process is completed by taking actions which include execution, monitoring and evaluation to attain the desired objectives (Birkland 2001).
Mining policies like with other public policies are normally to respond to either social pressure, national interest, environmental concerns, health issues, economic considerations or a policy legacy that has been practiced overtime (Birkland, 2001). In their analysis of policy Baehr and Wittrock (1981) explain that making of policies is a unique system that responds to the operation of an industry and evolves from various practical and theoretical concerns. A well-conceived policy will effectively address these concerns with positive outcomes (Birkland 2001 and Sultana 2008).

Despite the inherent social advantages associated with well-crafted policies, most of their targets are never fully achieved (Carl, 1992). A number of scholars including Carl 1992; Birkland 2001 and Sultana 2008 have interrogated what factors militates against full attainment of policy targets. They concur that the attainment of public policy targets are most likely to fail in situations where there are weak or lack of involvement of various stakeholders. This opinion is similar to that of Allen and Carletti (2010) who argue that proper management of players and stakeholders are quite crucial in achieving public policy targets. Where this is lacking, there are high chances that the policy will not attain its goals.

The element of sustainable mining or quarrying activities is today one of the most concerns for every government. A mine must minimize the environmental and physical risks throughout the mining life cycle from exploration, through construction and extraction to closure and reclamation. This is achieved by adapting the effective environmental management plan which includes the following elements: Collection of Baseline environmental data for Environmental Impact Assessment (EIA) and preparation of Environment Management Plan (EMP) during mine planning (or pre-feasibility/feasibility stage), Biodiversity management including mitigating the effects on flora and fauna and preventing pollution of rivers, streams and creeks, Pollution control in respect of airborne contaminants, noise and vibration, Management of hazardous substances including process
Soapstone quarrying activities present substantial concerns to the environment, economic, health and social wellbeing of the local population. According to geological surveys there is approximately 22 billion tons of soapstone in the Tabaka Hills (Kenya Geological Survey, 2008). It is estimated that close to 30 tons are exploited daily. Indicatively therefore, soapstone quarrying activities has a long term future in the area and given that its activities produce very large volumes of waste, have pits which are expanded rapidly, employs several people and earns a lot of money, decisions must be made on how to dispose of the waste, sharing of the resource, trade, land use pattern and reclamation of disused quarries.

Soapstone quarrying activities can become more environmental friendly and sustainable when actions are taken to adopt and integrate the social, environmental and economic developments that will minimise negative environmental impact. These include measures to minimize land disruption and waste production, preventing air, water and soil pollution at quarrying sites, and conducting successful pit closure, reclamation and rehabilitation activities (Kumar, 2014).

Individual governments all over the world are responsible for sustainable exploitation of minerals in their jurisdiction and will put up measures for their exploitation. These measures result from the fact that mining activities will always bring about lasting conflict in land use patterns, adversely affect the physical and geomorphic environments and distort human activities (Langer, 2004).

In the US for instance, mining industry is regulated through the Mining Law Administration of 1872. The General Mining Act of 1872 is a United States federal law that authorizes and
governs prospecting and mining for economic minerals, such as gold, platinum, soapstone, and silver, on federal public lands. These laws make it mandatory for all those involved in mining to take precautionary measures to protect the environment. What is envisaged in these measures are sound soil conservation, human health and protection of wetlands (Mall, 1980).

Similarly, in United Kingdom also, the Mining and Quarrying Safety and Health Act of 1999 provides for the planning, responsibilities, exploitation and permission requirements for any mining activity in the country. The Act has provision environmental management such as limitations on total quantities that can be extracted and limitations on numbers of vehicle movements around mining areas. A key environmental consent relating to mining operations is a mining waste permit to control extractive waste as required pursuant to the EU Mining Waste Directive (Directive 2006/21/EC), implemented in England and Wales under the Environmental Permitting (England and Wales) Regulations 2010 (UK Government, 2017).

The Regulations also dictate other operational aspects of onshore mining and quarrying such as, discharges to water, emissions to air, quarrying and mineral crushing processes. Other environmental legislation will apply, for example there may be a need to obtain a licence where mining activities will disturb species or habitats protected by conservation legislation (UK Government, 2017).

In dealing with the current policy framework for soapstone quarrying in Kenya, five documents are paramount. These include:- the Constitution of Kenya 2010, the Mining Act 2016, Mining Policy 2016, the Environmental Policy 2009 and the Environment Act 2007. In all these policy framework, the government seeks to attain balance and sustainable mineral exploitation by paying attention to the environmental concerns (GoK, 2001).

Article 62 (1) (f) of the Kenya Constitution describes minerals as *land which is held collectively by the people of Kenya and provide for their protection*. This is qualified in
Article 22 which indicates that such protection should be done in such a way as to ‘establish a durable and sustainable system of development’. These provisions are corroborated in Article 69 of the constitution which provides detailed requirements and underlying procedures for the exploitation and protection of the environment including that the state shall - (a) ensure sustainable exploitation, utilisation, management and conservation of the environment and natural resources, and ensure the equitable sharing of the accruing benefits; (b) work to achieve and maintain a tree cover of at least ten per cent of the land area of Kenya; (c) protect and enhance intellectual property in, and indigenous knowledge of, biodiversity and the genetic resources of the communities; (d) encourage public participation in the management, protection and conservation of the environment; (e) protect genetic resources and biological diversity; (f) establish systems of environmental impact assessment, environmental audit and monitoring of the environment; (g) eliminate processes and activities that are likely to endanger the environment; and (h) utilise the environment and natural resources for the benefit of the people of Kenya (GoK 2010).

Subsequently, anybody involved in mining must ensure that zones of dereliction are rehabilitated through planting of trees, filling up of quarries and protecting nearby rivers from pollution (GoK, 2000 and GoK, 2009a).

The Environmental Act 2007 and the Mining Act 2016 lay out stringent measures to actualise the provision within the constitution. Articles 176 of the Mining Act provides as follows:

that, (1) A mineral right or other license or permit Environmental granted under this Act shall not exempt a person from laws to prevail. complying with any law concerning the protection of the environment. (2) A mining licence shall not be granted to a person under this Act unless the person has obtained an environmental impact assessment licence, social heritage assessment and the environmental management plan has been approved. This places
the responsibility of environmental protection on the mining persons for any damage that they may bring upon the environment.

Similarly, the Kenya Vision 2030 calls for infrastructural development to facilitate the investment in the relevant infrastructure for the purposes of facilitating sound exploitation of mineral resources which including stone quarrying (GoK, 2016; GoK, 2003 and GoK, 2011). From these policies, it is expected that quarrying activities will be carried out as per the rules which shall ensure minimal erosion, controlled soil and air pollution and rehabilitation of disused quarries.

There are several measures which can be adapted to control slope erosion and other geomorphic processes. These include instituting stringent legislations against wanton exploitation of mineral resources, sound soil conservation measures, appropriate afforestation and re-afforestation programmes (Dobinski, 2011). Other measures that could be employed include; control mining activity to take care of other land use, rehabilitation of derelict soil, and preservation of the environment through re-afforestation of former quarries, government legislation against deviant behaviour and putting quarrying and mining under local governments (ibid). The miners could also be assisted to find alternative use of heaps of residues materials.

Section 176 of the Mining Act states that, (1) A mineral right or other licence or permit Environmental granted under this Act shall not exempt a person from laws to prevail. complying with any law concerning the protection of the environment. (2) A mining licence shall not be granted to a person under this Act unless the person has obtained an environmental impact assessment licence, social heritage assessment and the environmental management plan has been approved.
It has been argued by a number of scholars for example Ukpong (2012); Nwibo et. al., (2012), and Swanson et al., (2007) that in most developing countries, these apparently good measures are never implemented leading to wanton destruction of the environment and occurrence of catastrophic geomorphic processes.

2.4 Research Gap

It is evidenced from the above information that soapstone quarrying activities may enhance, trigger or give rise to geomorphic processes such as erosion, weathering and mass movement as contrasted by Storemyr (2004). In as far as these processes still occur naturally even without human interference, Buyeke, and Njoroge (2015) contends that there are human aspects that trigger off these processes on environment where quarrying is taking place.

The two sets of opinions are correct since slope processes may take place without human involvement on one hand and at times with the instigation of man on the other. This is in support of what Bryan, et al. (2005) concluded in their study on soil erosion on hill slopes in Britain’s quarrying sites.

There are quite a number of studies which have been carried out in different aspects of soapstone mining in the Tabaka area in Kisii. These studies do not explicitly explain how soapstone activities affect slope processes and the impact they have on farming. For instance, Kinyua et al. (2011), carried out a study on the Activity Concentrations of $^{40}$K, $^{232}$Th, $^{226}$Ra and Radiation Exposure Levels in the Tabaka Soapstone Quarries in Kisii Region. They noticed that in all soapstone quarries there are general activity of $^{226}$Ra, $^{232}$Th and $^{40}$K and concluded that the soapstone quarrying activities produces radioactive elements which pollute the area.
Despite these realizations law enforcement agencies appear to be ignorant and soapstone quarry workers have no anti-radiation protective gears. The study did not consider water and land pollution by the soapstone sediments. Ombongo (2007) carried out a study on the same area on factors affecting the performance of indigenous enterprise in the soapstone carving industry in Gucha District. The objective of the study was to determine whether management, financial, government policies, strategy, and entrepreneur characteristics affect the performance of indigenous enterprise and to establish other major factors that influence performance of soapstone carving industry. The study was business oriented and sought not to address environmental issues associated with soapstone mining.

None of these studies touches on the effect of soapstone activities on slope processes and how such processes impact on the socio-economic aspects of the area. More specifically, the effects of deposited residue on farming have not been analysed by these studies.

These are some of gaps that are presently available with dire need for research. For purposes of this study the gaps can be summarised as shown in Table 2.1
Table 2.1: Summary of Findings and Gaps

<table>
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<tr>
<th>Author</th>
<th>Objectives</th>
<th>Finding</th>
<th>Knowledge Gap</th>
</tr>
</thead>
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<tr>
<td>Kinyua (2011)</td>
<td>Slope process associated with soapstone activities</td>
<td>Eroded materials carry heavy metal which interferes with water quality downstream. Sediment also pollutes water.</td>
<td>Mining not only affects water quality but also accelerates slope processes</td>
</tr>
<tr>
<td>Onura (2012)</td>
<td>Effects of soapstone activities on farming</td>
<td>Soapstone activities destroy art sites</td>
<td>Soapstone activities could also have effects on farming and settlement.</td>
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<tr>
<td>Storemyr, 2004</td>
<td>Alternative uses of soapstone residues</td>
<td>Soapstone is used in carvings</td>
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<tr>
<td>Ombongo, 2007</td>
<td>Appropriate policy options for sustainable soapstone exploitation.</td>
<td>Mining activities are influenced by economic needs and government policies.</td>
<td>Soapstone mining is business oriented and rarely take cognisance of environmental impact</td>
</tr>
<tr>
<td>Obwori, et al</td>
<td>Effects of funding constraints on the growth of small-scale enterprises in soapstone industry in Kenya</td>
<td>Soapstone industry is a major source of income for small scale enterprises and foreign exchange earner.</td>
<td>Assessment of the impact of soapstone industry on the immediate environment.</td>
</tr>
</tbody>
</table>

2.5 Conceptual Framework

Soapstone occur a few metres just below the crust as a soft solid mineral. Soapstone quarrying activities entail the clearance of vegetation, the removal of top soil and eventual excavation of the underlying mineral (Sort and Alcantz, 1996). According to Ritter (2012), land surfaces which are cleared of vegetation are highly vulnerable to the actions of the elements of weather such as wind, alternating atmospheric temperatures and rainfall. The alternating temperatures and action of water result into weakened rock joins and loose soil
colloid thereby permitting the occurrence of geomorphic processes such as erosion, weathering, and mass wasting (Storemyr, 2004).

Siting of mining pits and quarries is usually a trade-off between competing land uses. As reported by Haghi (2009), soapstone quarry sites in the US occupies relatively large amount of land which could otherwise be put into other economic uses such as agriculture, settlement or industries. Soapstone quarrying activities results into waste deposits (Sort and Alcantz, 1996).

The residue comprises of remnants of rock particles and soil deposits, some of which have very fine grains. These residues are disposed in areas adjacent to the quarries and places where carving is done (UNECA, 2004). These residues according to Onura (2012) are fast occupying those areas which were hitherto used for farming.

Soapstone quarrying activities are likely to bring negative impacts both to human and physical environment. For instance, the government of Kenya reports that in several places where mining and quarrying are taking place in the country, there has been cases of massive dislocation of the populations, deforestation, reduction of agricultural land, and opening dangerous zones of dereliction which enhances disease infestation (GoK, 2001). Consequently, there is need for clear regulatory mechanisms to ensure sustainable soapstone quarrying within Tabaka region.
Intervening variables

Independent Variables

Outcomes

Quarrying activities
- Removal of overburden soil
- Excavating and splitting rock boulders
- Curving
- Deposits of soapstone residues

Influence on geomorphic processes
- Accelerated weathering,
- Enhanced mass movement,
- Soil erosion,
- Deposition

Effect of soapstone mining activities on geomorphic and farming activities

Outcomes

Figure 2.1: Conceptual Framework

Source: Author
CHAPTER THREE: MATERIAL AND METHODS

3.1 Introduction

This chapter describes how the research study was conducted and suggests ways through which the desired information was gathered. It also outlines the research design, target population, sample size and sampling procedure, data collection instruments and techniques of data analysis.

3.2 Research Design

This study employed a multi-point descriptive and quantitative survey involving both cross-sectional and longitudinal analysis. A longitudinal research design involves repeated observations of the same variable over a period of time (Bryman & Bell, 2007). The design is able to bring out the contribution of individual item (process) over the outcome of some specific events. For instance, a given soapstone quarrying activity like removal of overburden will be assessed on how it may influence the occurrence of weathering process (Kothari, 2004).

Descriptive cross-sectional design entails an assessment of the of several different problems at the same period of time in order to collect qualitative or quantitative data related to two or more variables in order to determine the association between the them (Bryam and Bell, 2007). Kothari (2004) also argue that descriptive cross-sectional design is usually considered the best method for collecting information in order to test hypotheses the study was investigating. Descriptive research design allows for the use of research instruments such as questionnaire, observation sheets to collect data from a purposively sampled individuals and quarrying pits (Kothari, 2004).

The design was suitable because it enhanced the use of a questionnaire and carrying out of interviews to gather information (Orodho, 2003). Similarly, it was also suitable because it was not only restricted to fact finding but led to the formulation of knowledge and establishing how soapstone activities affect agriculture and influence occurrence of geomorphic processes in Tabaka region. It also gave information on the state of affairs existed on the ground.

A descriptive research design is also useful in capturing unbiased representation of perceptions and experiences of respondents (Cooper & Schindler, 2011). In view of the current study, a descriptive cross-sectional design enabled the researcher to fully describe the
role of soapstone quarry owners in relation to the structures that governs mineral exploitation in Kenya.

A survey approach is a research design that studies only a smaller number and draws conclusions based on the universal population of the study area (Kothari, 2004). The study assessed selected quarrying pits for analysis. It will also sample a small number of soapstone quarrying workers and owners for interviews.

Kerlinger (2005) confirms this view when he states that survey is a method that studies large population (universe) by selecting and studying the samples from the population to discover the relative incidence, distribution and interrelations of sociological and psychological variables.

3.3 Piloting of Research Instruments

Kombo and Tromp (2006) noted that the reliability of an instrument is a measure of how consistent the results of a test are. In this study reliability was carried out by pilot test and computing Cronbach’s Alpha. Sekaran and Bougie, (2008) point out that pilot test is necessary for testing the reliability of instruments where the feedback of the pilot study is used to refine the questionnaire to make it reliable during the study.

Cronbach’s alpha was used to test the reliability of the measures of the instruments (Cronbach, 1994). Bryman (2011) suggests that where Cronbach Alpha is used for reliability test, a rule of thumb is also used that states that the Cronbach values of the items in the study should not be lower than 0.7. To increase the reliability of the questionnaire, this study used Cronbach’s Alpha for separate domains of the questionnaire rather than the entire questionnaire.

The Cronbach values will be computed as follows:

\[ \alpha = \frac{K}{K - 1} \left[ 1 - \frac{\sum \sigma_k^2}{\sigma_{total}^2} \right] \]  

\[ \alpha = \frac{K}{K - 1} \left[ 1 - \frac{\sum \sigma_k^2}{\sigma_{total}^2} \right] \]  

Equation (1) (Ritter, 2010)

Where;

K is the number of items;

\( \sum \sigma_k^2 \) is the sum of the k item score variances, and
Σ total 2 is the variance of scores on the total measurement (Cronbach, 1994).

The questionnaire was tested on five (5) respondents while the interview guide was tried on two mining experts and a geologists based in the region. The pilot study results were subjected to correlation test using Cronbach Alpha which gave a correlation score of 0.78 which concurred with Julie (2003) that a correlation of 0.7 and above was an acceptable threshold for reliable instruments.

The pilot study results indicated that the instruments were reliable. However, some corrections such as the order of questions and the wording were done to enhance clarity and the achievement of anticipated data.

3.4 Validity of Instruments

The validity of data collection tools which included observation record sheet, questionnaires, interview guide and measuring equipment were tried during the reconnaissance period and were established to be reliable. Their reliability was emphasized by ensuring that the objectives of the study were clear in order to yield the anticipated results. The instruments were selected by considering what the research seek to investigate and the quality of respondents. For example, the questionnaire was used to collect data from quarry workers and owners, soapstone carvers, soapstone traders while an interview guide was used to get information from experts in environmentalists, mineralogists and geomorphologist.

3.5 Description of the study area

The study was carried out within Tabaka region, located in the South-Western part of Kenya. The region lies within Gucha District of Kisii County in Nyamarambe division. Nyamarambe is the only geographical areas in Kenya where soapstone mineral is currently found. The region lies between Latitude 0045’S to 0046.7’S and longitude 3403.6’E to 3404.0’E (Buyeke and Njoroge, 2015). See Figure 3.2:
Figure 3.1: The Location of Tabaka soapstone Quarry in the Inset map of Kenya.

(Sources: Philip 2002 and GoK, 2011)
3.5.1 The climate

The climate of Kisii County in western Kenya is captured in the description of the general climate of Kenya (GoK, 2010). The climate in the region is highland equatorial type which is characterized by high amount of rainfall averaging to about 1500mm annually. Rainfall experienced rainfall in double maxima; with the short rains occurring in September and November while the long rains are received between March and June. January and July are generally dry months, only experiencing pockets of isolated rains. The Relative Humidity (RH) of the area averages to about 70% (Ojwang and Situma, 2010).

The region is generally warm with maximum temperature ranging between 21°C and 30°C Celsius while the minimum temperature varies between 15°C and 20°C Celsius. The warmest month is April with an average temperature of 27°C while August has the lowest temperature of the year at 18°C (GoK, 2010). The relative humidity of the area averages to about 70% throughout the year. The climatic factors of the area are as a result of its location within the equatorial zone, close proximity to Lake Victoria, high altitude and heavily foliaged within the region (Buyeke and Njoroge, 2015).

3.5.2 Topography

The region is generally hilly with most areas reaching up to 1,800 metres above sea level. The most outstanding hills within the regions include Tabaka, Nyangweta, Ntamocha and Nyangebene. Most of the places are dissected by rivers flowing west into Lake Victoria for example rivers Gucha, Nyangweta, and Mogusi (Muchene and Gachere, 1988).

3.5.3 Geology and soil

The geological base of Tabaka consist of the Nyanzian Kavirondian and Bukoban rock series. These are Precambrian rocks and date back to some 2 million years ago. The Bukoban rock system which is also known as the Kisii series predominate the region. The main rock type consists mainly of lava quartzite, granite, grits, banded ironstones, sandstones and isolated pockets of talc soapstone (Muchene and Gachere, 1988).

Most areas in the region is covered by fertile volcanic soils except for a few places with stony rock outcrop. The main soil in the area include the fertile dark brown clay, the red brown friable clay and the less fertile brown soil. The less fertile brown soils have been subjected to
geological and recent accelerated erosion in the area and have completely lost their original characteristics. According to Ritter (2012), the resultant soil type in any given area is as a result of elaborate process of rock cycle in the place. This explains the existence of less fertile brown soil in Tabaka region which may explain the dwindling agricultural productivity in the region compared to other areas within the larger Kisii County (GoK, 2009c). Soapstone rocks in Tabaka area have been formed at convergence plate boundaries where broad areas of the old Nyanzian rocks were subjected to heat and pressure. Peridotites in this environment are metamorphosed into soapstone. The same is used for laying kitchen hot surfaces, casting of knife blades and carving artefacts. Below in figure 3.4 is a geological map of the area under study.
Despite the reducing soil fertility in the area, majority of the area residents still engage in farming even as others turn to soapstone mining activities. This, according to Onura (2012), explains the trade-off between soapstone quarrying activities and farming in the region. An increasing number of farmers are committing sections of their land to soapstone quarrying activities (Muchene, 1988).

3.5.4 Demographic Factors

From the Kenya Population and Household census of 2009, the average population of Tabaka region is estimated at about 102,740 people with a density of about 382 people per square kilometre (GoK, 2009b). Settlement in the area is mainly clustered and basically concentrated in the lower ridges of the slopes. It is estimated that about 51%, of the population in the area lives below poverty line and has an age dependency ratio of 100:94 (GoK, 2009b).

3.5.5 Economic Activities

The region’s economic activities are agriculture, soapstone quarrying, and small-scale commerce. Given the high population density of the region, the land has been fragmented into small portions making it difficult to practice large scale commercial agriculture. Consequently, many people have turned to the soapstone quarries to eke a living out of it. The region supports crops such as banana, coffee, tea, and pyrethrum. Subsistence crops are maize, beans, millet, sweet potatoes and a variety of vegetables. It has high potential for large agro-based industries due to its location in rich agricultural lands (Onura, 2012).

3.6 Target Population

The target population for the study is 12,742 people, an estimate from the Kenya Population and Household Census (GoK, 2009). The population comprise of farmers, quarry owners, quarry workers, government employees and professionals on mining, environment, geomorphology and geology sectors. The study shall target select number of farmers living within the neighbourhood of the soapstone quarries in the area. Neighbourhood is used here to refer to those people within a kilometre of the quarry pit.
A reconnaissance field visit conducted in 2015 reveals that there are 24 quarries in the region of which Bomware, Nyakichenche, Bokimai (Nyaroa) and Nyatike are the largest. It was also established that each quarry employs an average of fifteen workers giving a total of 360 potential respondents. Those who are directly employed in the carving are also estimated at around 200 people, while farmers in the three division comprise of about 536 households.

Since the research is technical in nature, there was a need to consult specific professionals in the Ministry of Mining (Geology Department), Ministry of Environment and Natural Resources, Ministry of Trade, and Ministry of Agriculture, which between them have up to 40 technical and semi-skilled workforces. The study therefore has an effective universal population of about 1160 respondents.

3.7 Sample Size and Sampling Techniques

The study undertook a purposive sampling technique so as to capture variables such as the length of time the person has stayed in the area. This is important as the duration is long enough to enable one to have proper knowledge of the area.

According to a preliminary field finding conducted by the researcher, there are 24 quarries in the region. To facilitate an in-depth analysis of the sites, a sample of four (4) quarries was purposively selected. These sites are spread one each within the four divisions of the target study area.

The researcher considered the spread, size and average population of people who work in an individual quarry. This sample size is about 16% of the universal population which is sufficient in addressing the research question.

The sample size was calculated by using the formula $n = \frac{z^2 \times p \times q \times N}{e^2(N-1) + z^2 \times p \times q}$ (Kothari, 2004).

Using the formula,

$$n = \frac{z^2 \times p \times q \times N}{e^2(N-1) + z^2 \times p \times q} \text{ Equation 2}$$
Where,

\( n \) = sample size  
\( N \) = Population size  
\( p \) = Sample proportion \((q = 1 - p)\)  
\( Z \) = the standard variant at a given confidence level of 90\%  
\( e \) = acceptable error  

Given that,  
\( p = 0.5 \)  
\( Z = 1.86 \)  
\( e = 0.1 \)  
\( q = 1 - p \)  
\( N = 1160 \)

By substituting the above in the formula,  
\[
\text{Where } n = 1.86^2 \times 0.5 \times 0.5 \times 1160 \\
0.1^2 \times (536 - 1) + 1.86^2 \times 0.5 \times 0.5 \\
= 3.4596 \times 0.25 \times 1160 \\
(0.01 \times 1160) + 3.4596 + 0.25 \\
= 992.5 \\
15.05 \\
= 69.28
\]

From the above, we can construe the sample size to be Sixty-Nine (69) respondents who comprise farmers, quarry owners and workers, soapstone carvers and professionals from line ministries within the mining industry. This is illustrated in table 3.1 below.
Table 3.1: Distribution of Sample Population

<table>
<thead>
<tr>
<th>Category</th>
<th>Location</th>
<th>Population</th>
<th>Sampled Size (5.7%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarry miners</td>
<td>Quarries</td>
<td>360</td>
<td>20</td>
</tr>
<tr>
<td>Quarry owners</td>
<td>Quarries</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Soapstone carvers</td>
<td>Informal and factories</td>
<td>200</td>
<td>10</td>
</tr>
<tr>
<td>Professionals</td>
<td>Government offices</td>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td>Farmers (household)</td>
<td>Area (four divisions)</td>
<td>736</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>Tabaka</td>
<td>1160</td>
<td>69</td>
</tr>
</tbody>
</table>

Source: Field data

The study sample size was 5.7% of the target population. According to Kothari (2004) a good sample size should be between 5% and 30% of the universal population to allow for a better representation of the universal population.

3.8 Data Collection Methods

The source of data for this study was both primary and secondary. They include: direct field observation (appendix 3), questionnaire (appendix 2), photography, and interview schedules (appendix 3). Interview schedule was of particular importance as the researcher to physically meet the respondents. It also allowed the researcher to modify and vary the questions so as to extract additional information that was necessary for a comprehensive study (Mugenda and Mugenda, 2004).

Secondary information was collected through desk top analysis, library information, internet access, group discussion and reference to academic journals on the study topic. This information was vital for investigating analysing the occurrence of geomorphic processes and their relationship within individual soapstone quarrying activities.

3.8.1 Observation

Performa checklist (appendix 5) was used to establish effects of geomorphologic processes resulting from soapstone quarrying. The researcher paid attention to features such as cracks
on the ground, arrangement of rock layers along the quarry slopes, tilted trees and utility poles to determine the geomorphic process that could have taken place around the quarries. The researcher then proceeded to use photography to capture further evidence of geomorphic processes. Observation record sheet was also used to compile data from the field. This was done in line with the study objective of assessing the slope processes that are associated with soapstone quarrying.

The secondary sources and observation which provide data on physical characteristics of the site as well as the quarrying process were used to prepare the assessment matrix for the analysis of the effects of geomorphic processes around soapstone quarrying areas. The primary methods of data collection included the following:

**3.8.2 Questionnaires**

Questionnaire was used to get information from farmers, quarry owners and quarry workers and soapstone carvers. This was to gain insight on the relations between soapstone quarrying activities and farming. In addition, the tool was used to gain data on the alternative uses of soapstone residues and the policy framework which would aid sustainable soapstone quarrying activities.

Data was collected by use of structured questionnaires (appendix 3) on different aspects of soapstone quarrying activities, farming and policy issues. This was to elicit primary information on aspects such as sex, age, level of education, ownership of quarries, perception on policies direct employment generation, income and wealth generation, welfare of those involved, welfare of those living nearby, support of quarrying to other social aspects and conditions of work. It also provided information on extent of quarry rehabilitation.

The tool is useful for obtaining large amount of information from individual interviewee. According to Kothari (2004), ‘questionnaires are free from the bias of the interviewer and allow answers are in respondents’ own words’ thus being useful in examining individual perception on issues that affect them.

**3.8.3 Interview Schedule**

Interview Schedules were used mainly to extract information from professionals in land survey, geomorphology, geologist, mining and environmentalists. These professionals were
accessed from the government sector working on the ground in their respective specialised area. The tool assisted to gather information on the technical aspects of geomorphic processes and how they are influenced by soapstone quarrying activities.

Interview schedules are quite ideal as they allow for additional questions to be asked. Using interview schedules also enable the researcher to vary the questions so that hidden aspect of the topic can be revealed or better explained (Kerlinger, 2005). The information which were obtained using this tool was later used to corroborate and authenticate resulting observable features of geomorphic processes.

3.8.4 Measurement of Quarry properties

A number of measurements were made in determining slope properties including elements such as the slope angle, the depths of quarries, the cross-sectional distance of the quarries and length of slope, formed through erosion. Measurements of the slope profile were made using Abney Level tool and tape measure. The information collected on disused quarries was then used in constructing slope profile for the sites (Odour 2008).

3.8.5 Soil Samples

Soil samples from various points around soapstone quarries were collected using both stratified and random sampling techniques. From each quarry, the researcher used a 30 centimetres long tube that was inserted directly into the ground such that when pulled out it collected a sample that comprised soil across the 30 centimetres into the ground. 30 centimetres depth was considered ideal since it was considered to be the soil that could be useful for agricultural purposes. Information gathered was used to examine soils aspects such as availability of soapstone fragments and soil depth. Such information was used in determining areas where deposition or erosion has occurred relative to the mining spots.

Secondary methods

3.9. Procedure for Data Analysis

Since the study was both descriptive and quantitative in nature, the researcher used qualitative and statistical techniques to analyse the information gathered. Descriptive information obtained was analysed by taking the dominant responses that cut across majority of the respondents and the most prevalent information captured in the observation recorded sheets (Yin, 2003). The data collected in this case was basically on assessing the types and extent of erosional, weathering and mass movement activities.

Quantitative data was analysed using statistical techniques such as averages, frequencies, totals, tabulations and cross tabulations (Mugenda and Mugenda, 2004). The data was then subjected to significance tests using Pearson Rank Correlation.

The Pearson rank correlation coefficient was used to determine the relationship between the slope quarrying activities and farming within Tabaka areas. The study also used excel and SPSS for calculating variables which assisted in drawing accurate conclusions. Data was presented by use of tables, charts and diagrams to present data to allow for ease of interpretation (Oduor, 2008).

Result obtained from the questionnaire were coded and analysed through the use of computer software. In this regard the Microsoft office excel (version 2007) was used to get descriptive statistics, and percentages. The statistic of interest was the mean since it enables to determine the general response of the respondents. The analysed data was then presented using tables and charts.

Soil samples were taken to a nearby school laboratory for analysis. The soil samples were analysed to determine its constituents including the presence of soapstone fragments and its fertility. This was to benchmark which of the soil characteristics affect farming decisions and establish what role if any has soapstone quarrying activities played.

A summary of the type of instrument, type of data to be collected and for which objective and type of analysis is presented in table 3.2 below.
Table 3. 2: Variables, Methods of Data Collection and Analysis

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Variables</th>
<th>Methods of data collection</th>
<th>Methods of data analysis</th>
<th>Source</th>
<th>Expected Outcome</th>
</tr>
</thead>
</table>
| Determine the types of slope processes associated with soapstone quarrying activities | - Soil erosion  
- Weathering  
- Mass movement | - Observation  
- Measurement of quarry properties  
- Field mapping | - Dominant features.  
- Measurement | Primary | Evidence gullies, tilted trees, scree and deposition sediments. |
| Examine the relationship between soapstone quarrying activities and farming | - Area occupied by quarries  
- Area occupied by overburden  
- Size of land under farming | - Measurement  
- Photography  
- Observation | - Averages  
- Mean  
- Standard deviation | Primary | Relative land division of land between farming and quarrying |
| Establish the alternative uses of soapstone residues over the conventional ones | Uses of soapstone residues. | - Questionnaire  
- Interview  
- Observation | - Dominants responses  
- Descriptive  
- Averages | Primary and secondary | Available alternative uses. |
| Analyse the policy framework for sustained soapstone quarrying activities | - Mining Act  
- Environmental policy  
- Mining policy | - Desk top analysis  
- Questionnaires  
- Interviews | - Dominant response  
- Desk top analysis | Secondary | Sound policies on soapstone quarrying |

*Source: Field Data*
CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents data which were generated from the collation of the responses on various aspects of soapstone quarrying activities and their influence on geomorphic processes. The responses were gathered through questionnaires administered to soapstone quarry owners, quarry workers and farmers within Tabaka region. Further information was gathered through interviews with experts on environment, geomorphology and mining.

The information was collected between the months of October and November 2015. The choice of these months was purposely done because the season records moderate rainfall which permits both quarrying and farming activities in the area. During the long rainy seasons in the months of April to August, most quarries are flooded with runoff water which limits extraction of stones and subsequent activities such as carving. Moreover, in the long rainy season, most of the residents are engaged in farming as the core activity.

The study targeted a population of 1160 respondents out of which, a sample of 69 was drawn. The respondents comprised of soapstone quarry workers and local farmers. In addition, there were experts in agriculture, mining and survey who provided technical information on aspects such as the number of residents engaged in farming, the geology of the area and the possible effects of quarrying on the geomorphic activities.

4.2 Response Rate of Respondents

The study used questionnaires, interview schedules, group discussions; photography and desktop analysis to collect information. Responses were received as described on table 4.1.
### Table 4.1: Response Rate

<table>
<thead>
<tr>
<th>Description of Respondents</th>
<th>Target Population</th>
<th>Sample size</th>
<th>Actual Response</th>
<th>% Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevant government specialists</td>
<td>40</td>
<td>5</td>
<td>5</td>
<td>100%</td>
</tr>
<tr>
<td>Quarry workers</td>
<td>360</td>
<td>20</td>
<td>20</td>
<td>90%</td>
</tr>
<tr>
<td>Quarry owners</td>
<td>24</td>
<td>4</td>
<td>4</td>
<td>100%</td>
</tr>
<tr>
<td>Farmers</td>
<td>736</td>
<td>40</td>
<td>27</td>
<td>68%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1160</strong></td>
<td><strong>69</strong></td>
<td><strong>56</strong></td>
<td><strong>81%</strong></td>
</tr>
</tbody>
</table>

*Source: Field Data*

In Table 4.2a total of 54 out of 69 respondents were interviewed. This constitutes eighty-one (81%) percent of the target sample size. This is an indication of a very positive attitude of the respondents who connected readily with the researcher and felt the finding of the study may help improve the overall benefit that accrue from trade in soapstone products and mining activities.

### 4.3 Demographic Information

The demographic information of quarry owners, quarry workers and farmers is a significant component in understanding the factors which influences human behaviour or responses towards a given stimulus. An analysis was therefore made on factors such as the gender, education levels, the role played and the duration one has been engaged in the soapstone activities. The main highlights of these characteristics are tabulated in table 4.1 below.
## Table 4.2: Demographic Information of quarry workers

<table>
<thead>
<tr>
<th>Demographic Characteristics</th>
<th>Frequency</th>
<th>% response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>39</td>
<td>70%</td>
</tr>
<tr>
<td>Female</td>
<td>17</td>
<td>30%</td>
</tr>
<tr>
<td><strong>Level of education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No education at all</td>
<td>9</td>
<td>16%</td>
</tr>
<tr>
<td>Primary certificate</td>
<td>31</td>
<td>55%</td>
</tr>
<tr>
<td>Secondary</td>
<td>15</td>
<td>27%</td>
</tr>
<tr>
<td>Undergraduate degree</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Masters Degree</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Role</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quarry owners</td>
<td>4</td>
<td>14%</td>
</tr>
<tr>
<td>Quarry workers</td>
<td>20</td>
<td>69%</td>
</tr>
<tr>
<td>Experts</td>
<td>5</td>
<td>17%</td>
</tr>
<tr>
<td><strong>Age of respondents (all categories)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 – 25 years</td>
<td>9</td>
<td>16%</td>
</tr>
<tr>
<td>26 – 35 years</td>
<td>24</td>
<td>42%</td>
</tr>
<tr>
<td>36 – 45 years</td>
<td>16</td>
<td>29%</td>
</tr>
<tr>
<td>46 – 55 years</td>
<td>6</td>
<td>11%</td>
</tr>
<tr>
<td>56 years and above</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Duration worked in soapstone quarry / carving (exclude experts)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 – 5 years</td>
<td>4</td>
<td>7.3%</td>
</tr>
<tr>
<td>6 – 10 years</td>
<td>14</td>
<td>25.4%</td>
</tr>
<tr>
<td>Over 10 years</td>
<td>37</td>
<td>67.3%</td>
</tr>
</tbody>
</table>

*Source: Field data*
The information in table 4.2 indicates that there are more male (about 70%) than female (30%) working in various stages in soapstone quarrying and carving activities. In most case female tend to work in light duty engagement (only assisting their male counterparts) in such as activities as the disposal of soapstone residues, polishing of carvings and selling of food.

Majority of them, about 55% had primary level of education while 27% had secondary education. Only 2% of the quarry workers interviewed had college education. This indicates that majority of the respondents have modest education background and turn to soapstone quarrying activities for their income sustenance. All the five (5) selected experts had a degree in their respective profession and do not directly work in the quarries.

It can also be deduced from the information that the majority (42%) of soapstone quarry workers are in the middle age group of between 23 and 35 years. This is the age where a number of people leave school and start fending for themselves. It is also in this age set where majority of the people are full of energy to work in those activities which require more physical labour. Those aged between 36-45 years forms about 29% of the total interviewees. Those who are above 56 years constitute only 2% of the worker in quarries.

Most of the respondents, about 67% have engaged in soapstone quarrying or carving for more than ten (10) years. Only 7.3% has worked in the quarries for less than 5 years. This indicates that those working in the quarries have wide experience and normally come from the local areas where soapstone quarrying activities is one of the main lifelong economic engagement for the people.

It is assumed that the duties within the quarries will follow the traditional practice where the period one has worked will determine the probability that they will have been exposed to real situation affecting soapstone mining in the area. This is important gauging in the authenticity of the responses given.
4.4 The Study Sites

The study took place in Tabaka region in Kisii County. The region is under laid with vast amount of soapstone rock mineral. It hastwenty- four (24) main soapstone quarries out of which four were selected for the study. Besides there are numerous carving areas within individual homesteads and outpost locations spread in the entire region. However, there is one major factory engaged in carving of various types of artefacts. The study accessed four main quarries which is 16% of the total number of quarries in the area. All the soapstone mining areas exhibits similar characteristics in terms of the mode of mining, the type of equipment being used, the physical surrounding and type of labour used.

4.5 Division of roles among soapstone workers

The exploitation of soapstone is normally carried out through clear cut division of labour. The role of individual quarry workers was examined. The finding is summarized in table 4.3 below.

**Table 4.2: Division of Roles among Soapstone Quarry Workers**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Mining Activities</th>
<th>Number</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>• Bush clearing</td>
<td>40</td>
<td>80%</td>
</tr>
<tr>
<td></td>
<td>• Removal of top soil</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Extraction of soapstone</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Cutting and dressing of soapstone</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Carving of stones into artefacts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>• Polishing and washing of carvings</td>
<td>16</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>• Collection and deposition of mining residues</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>56</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Source: Field Data*
From table 4.2, it is evident that there are more male (about 80%) than female (20%) working in soapstone mining activities. The study also reveals that female take up lighter jobs compared to their male counterparts. However, the distribution of female respondents is below one-third implying that affirmative action can be adopted to promote the roles and involvement of women in the quarries.

4.6 Factors influencing the choice to work in soapstone quarries

Individuals may be influenced to engage an economic activity as a result of either one or a combination of the following factors: - income consideration, lack of viable alternative source of employment and skill orientation/education background. Respondents were asked to indicate the main reason that influenced their decision to work in the quarries. The findings are tabulated in the table 4.4.

Table 4.4 Reason for working in the Soapstone Mines

<table>
<thead>
<tr>
<th>Driving Reason</th>
<th>Respondent</th>
<th>% Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>For economic gains (employment and source of income)</td>
<td>34</td>
<td>61%</td>
</tr>
<tr>
<td>No alternative source of engagement</td>
<td>8</td>
<td>14%</td>
</tr>
<tr>
<td>Lack of farm lands for agricultural engagement</td>
<td>7</td>
<td>13%</td>
</tr>
<tr>
<td>Socio-economic factors (family business)</td>
<td>4</td>
<td>7%</td>
</tr>
<tr>
<td>Source of house decoration</td>
<td>3</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>56</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Source: Field Data
The results above support the findings of Simmonds (2007) who established that residents of Scotlands will opt to commit their parcel of lands to those activities that give highest level of returns in terms of income earnings. Similarly Rodriguez (2006), found out that the choice of activities is not only dependent on the economic returns, is also a factor of time and ecosystem services. Such services inform how a farmer, for instance would opt to share their land between soapstone quarrying activities and farming during which time of the year.

![Figure 3. 3: Reasons for working in the quarries](image)

**Source:** Field Data

Majority of the farmers, quarry workers and quarry owners, about 61%, are engaged in soapstone mining activities because of the expected economic gains (source of income). Whereas the area has high potential for agricultural activities, the land sizes have since reduced due to increased population. As such, 14% of the quarry workers do so because they lack alternative source of engagement. It was also established that a small percentage of 5% collects soapstone residues for free to use in decorating their houses. In doing so, they assist in clearing the residue to allow for further exploitation of the stones underground.
Plate 4.1: Collecting data from soapstone carvers

Plate 4.1 is a close up photograph taken in one of the soapstone carving centres. It is noted that only men are engaged in carving in this particular centre. Respondent indicated that the work is hard and not preferred by women. Women will instead come in later to polish and paint the carved artefacts. Individual soapstone boulders of about half a metres square are bought at around Kshs 650/=.

The carvers also pay for transportation cost from the quarries to the carving zones. When carving work is completed, waste material are left behind in piles of fragments. The accumulated residues grow in size overtime, thereby driving away farming activities from the spots.
Plate 4.2 indicates the powdery substance in the bucket which is a heap of soapstone residues obtained after polishing of artefacts. It has been collected by the woman without payment to be used in smearing and decoration of house walls.

4.7 Methods of Soapstone Quarrying

The occurrence and characteristics of mineral largely inform the kind of mining method and the type of equipment to be used in its extraction. For those minerals which occur deep into the crust, deep shaft mining method which employs heavy machinery is used. On the other
hand, where soft solid minerals occurring at shallow ends of the ground, an open cast method may be employed and simple hand-held tools such as mattock and hoes used. Since soapstone mineral occurs just few metres under the ground it was necessary to examine which tools are used and whether such tools are most ideal for the extraction of soapstone within Tabaka area. The information is necessary in understanding the effect of mining on the environment. Heavy tools and machinery profoundly desiccate.

**Table 4.3: Tools and equipment used in quarries**

<table>
<thead>
<tr>
<th>Name of quarry</th>
<th>Season</th>
<th>Tools used</th>
<th>Tool used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry</td>
<td>Machete, hand hoes, handsaw, pick axes, shovels</td>
<td>Generator to drain water.</td>
</tr>
<tr>
<td>Bomware</td>
<td>Wet</td>
<td>Saws, hand hoes, handsaw, pick axes, shovels</td>
<td>Bucket to drain water</td>
</tr>
<tr>
<td>Nyakichenche</td>
<td></td>
<td>Machete, hand hoes, handsaw, pick axes, shovels</td>
<td>Generator to drain pool of water</td>
</tr>
<tr>
<td>Bokimai (Nyaroa)</td>
<td></td>
<td>Earth movers, hand hoes, handsaw, pick axes, shovels</td>
<td>Generator to drain water</td>
</tr>
<tr>
<td>Nyatike</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: Field Data*

From table 4.3 it is evident that simple hand-held equipment and tools are used in the extraction and processing of soapstone mineral. These tools include: machete for bush clearing, shovels, mattock and pick axes for splitting and scooping of soapstone rocks. These tools are ideal given that soapstone rocks are soft and the mining is done at a relatively small-scale basis.
Use of light equipment and tools has the advantage of use since they are basic in nature. The miners on the other hand have the assumption that simple implements are less destructive but the opposite is true. As a result, the land is less rugged than it would have been if heavy machinery was used. Work in the quarries mainly takes place during dry season.

The respondents indicated that this is so because of the following reasons: - the soapstone is quite fragile and when exposed to water it becomes brittle and easily breakable; dry season provide good environment for extraction of soapstone since the quarries are dry and not dammed by water; it is easier to transport soapstone rock cuttings to the carving workshops and sites during dry seasons, and during rainy season most of the quarry workers are engaged in farming activities.

4.8 Factors Affecting Soapstone Quarrying and Processing Activities

Soapstone quarrying activities include aspects such as removal of top soil, splitting of soapstone rocks into smaller blocks, transportation of rock fragment, carving, and deposition of soapstone residues. A number of factors may affect the rate and successful completion of these activities. The respondents were asked to rank the factors that affect their efforts in soapstone mining activities. Their responses were captured using a Likert Scale as indicated in table 4.5.
Table 4.4: Factors Affecting Soapstone Quarrying and Processing Activities

**Key:** 5 = Highly Affected (HA), 4 = Mostly Affected (MA), 3 = Affected (A), 2 = Least Affected (LA) and 1 = Not Affected (NA). The total number of those interviewed were 56 respondents.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Rank/Rating</th>
<th>(HA)</th>
<th>(MA)</th>
<th>(A)</th>
<th>(LA)</th>
<th>(NA)</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainy season</td>
<td></td>
<td>14</td>
<td>19</td>
<td>10</td>
<td>11</td>
<td>2</td>
<td>3.06</td>
<td>1.439</td>
</tr>
<tr>
<td>Dry season</td>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>50</td>
<td>3.78</td>
<td>1.217</td>
</tr>
<tr>
<td>Type of equipment used</td>
<td></td>
<td>3</td>
<td>5</td>
<td>8</td>
<td>14</td>
<td>26</td>
<td>3.84</td>
<td>0.966</td>
</tr>
<tr>
<td>Government Regulations</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>55</td>
<td>4.03</td>
<td>1.03</td>
</tr>
<tr>
<td>Farming/ economic activities</td>
<td></td>
<td>3</td>
<td>5</td>
<td>40</td>
<td>6</td>
<td>2</td>
<td>4.09</td>
<td>1.088</td>
</tr>
<tr>
<td>Availability of market</td>
<td></td>
<td>25</td>
<td>20</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>4.05</td>
<td>1.345</td>
</tr>
<tr>
<td>Cost of quarrying equipment</td>
<td></td>
<td>31</td>
<td>10</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td>4.03</td>
<td>1.03</td>
</tr>
<tr>
<td>Declining Mining sites</td>
<td></td>
<td>17</td>
<td>16</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>3.72</td>
<td>1.02</td>
</tr>
</tbody>
</table>

*Source: Author's own compilation*

The choice to engage in any mining activities is usually affected by a number of socio-economic and environmental factors such as the economic value of the mineral, the quantity
available for exploitation, the competing economic activities and the government regulatory regime. Equally, when the mining activities have commenced, several other factors such as weather changes, prevailing political climate, and global market factors may either hamper or enhance the mining activities.

According to the ranking, 25% of respondents said that the rainy season highly affected their soapstone mining activities, 33.9% felt that the rainy season mostly affected their soapstone quarrying activities. Not only is the rainy season characterized by increased farming activities which take up the labour that would have been used in the quarries, it also results into some quarries being filled by runoff water which render certain soapstone pits inaccessible. Presence of stagnant in disused quarries can accelerate the rate of chemical weathering.

On the contrary, 89% of the respondents with a mean of 3.06 and a standard deviation of 1.4 indicated that the dry season did not affect their soapstone mining activities at all. This could be explained by the factor that during dry season, majority of the residents are relatively free and hence can get time to engage in quarrying.

It is curious to note that an overwhelming majority (89%) of soapstone miners and carvers do not perceive government regulation to be affecting in either way their activities. This could indicate that various laws and government regulations are not effectively implemented in respect to soapstone mining activities in the area. There were validating evidence where disused soapstone quarry pits are left without any reclamation measures thereby going against the national environment and mining Acts.

It was established the mean and standards deviation were 3.84 and 0.966 respectively. This indicates that the type of equipment used did not affect quarrying activities. However, the cost of quarry equipment highly affects quarrying and processing activities in Tabaka areas as indicated by a mean of 4.03 and a standard deviation of 1.03.

In addition, the respondents felt that the availability of market for their soapstone carving products has a direct influence on their engagement in soapstone quarrying activities. During
the high season when the demands for the soapstone artefacts are high, there is correspondent increase in the number of quarry workers with some working long hours to meet the demand.

4.9 Physical Characteristics of Soapstone Quarries

Physical characteristics of the place represent a salient features including aspects such as the vegetation cover; the slope angle; hill side morphology, and type of rocks in the area. These features are as a result of a combination of geomorphic processes, tectonic activities and human actions within the area witnessed over a period of time. Abney Level topographic tool was used to establish the above aspects of the slope.

By using the Abney level, the researcher was able to measure the vertical angles and the depression level of the slope. Using the vertical angles, the researcher was able to determine the height and depth of quarries under investigation. The slope distance was measured using a tape measure. The tangent of the slope angle yielded the gradient of the quarry indicating how steep the slope is.
- Depth of the quarry (D) = Slope distance (hypotenuse) × SinA
- i.e. \( D = S \times \sin A \)

The findings of the measurements are presented in table 4.6
Table 4.5: Measurements of Individual Slope within quarries

<table>
<thead>
<tr>
<th>Name of quarry</th>
<th>Slope length (metres)</th>
<th>Cross sectional distance (metres)</th>
<th>Slope gradient</th>
<th>Quarry Depth (metres)</th>
<th>Excavation depth (metres)</th>
<th>Slope depth (metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bomware</td>
<td>82.3</td>
<td>53.4</td>
<td>0.65</td>
<td>28.4</td>
<td>28.4</td>
<td>5.2</td>
</tr>
<tr>
<td>Nyakichenche</td>
<td>71.0</td>
<td>50.1</td>
<td>0.71</td>
<td>30.6</td>
<td>30.6</td>
<td>7.1</td>
</tr>
<tr>
<td>Bokimai</td>
<td>59.3</td>
<td>33.7</td>
<td>0.57</td>
<td>27.2</td>
<td>27.2</td>
<td>4.8</td>
</tr>
<tr>
<td>Nyatike</td>
<td>68.5</td>
<td>40.2</td>
<td>0.59</td>
<td>25.8</td>
<td>25.8</td>
<td>3.6</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>70.3</strong></td>
<td><strong>44.4</strong></td>
<td><strong>0.63</strong></td>
<td><strong>28.0</strong></td>
<td><strong>28.0</strong></td>
<td><strong>5.2</strong></td>
</tr>
</tbody>
</table>

*Source: Field Data*

The three slopes have an average slope length of 70.9 metres and a cross sectional distance of 45.7 metres. The average slope angle for all the three quarries is 0.64 or 64%. This indicates that soapstone mining areas occur in the slopes and together are highly to influence the occurrence of slope erosion, weathering and mass wasting.

The average depth of the quarries is about 28.7 metres and covers an area of about one (1) acre. The quarry sites depict a variety of physical features. All the studied quarries had been cleared of vegetation except for scanty creepers and lianas which grow at the edges of the pits. The sides of the quarries are characterised by very steep sided cliffs almost dropping perpendicular to the ground. However, the pit entrance and surface areas have fewer steep slopes that gently open into the mining tunnels at the floor of the quarries.

The quarry pits comprise of tinny elongation of sharp pointed rocks parched on ragged surface, floor with isolated debris and screees. On the sides of the pits are gaping crevices and loosely hanging rock boulders. Adjacent to the quarries are heaps/moulds of residues comprising of a mixture of soapstone’s off-cuts, pebbles and soil.

It should be noted that mining of soapstone normally distorts the original slope (slope wasting) by reducing the slope angle and creating completely new sceneries occasioned by heaps of residues. This is exemplified by hanging plant roots and collapsing cliff walls. In
some quarries, such as Bomware, Nyakichenche and Nyatike the floor is interspersed with gullies of varied sizes and a heap of screes at the foot of the slope.

4.10 Profiles of Sampled Soapstone Quarries

Soapstone quarry pits exhibits different physical characteristics especially in terms of size and the type of geomorphic processes that has occurred.

4.10.1 Bomware Quarry

It is one of the studied quarries and is famous for its blue brown soapstone. Up to around 100 inhabitants directly rely on this quarry for their livelihood. The quarry is located in central Tabaka area. The pit is relatively shallow reaching an average of 28.4 metres deep and about 43 metres wide.

Figure 4. 1 The Profile Bomware Quarry.

Source: Author
This is one of the oldest quarries in the region. It is located in the eastern side of Tabaka town. In the figure 4.5, the quarry has a depth averages to about 37 meters deep and up to 75 meters wide.

Figure 4. 2 :The Profile Nyakichenche Quarry
Source: Author
4.11 Effects of Soapstone Quarrying on Geomorphic Processes

The study investigated the occurrence of erosion, weathering and mass wasting within the soapstone mining pits. In examining individual geomorphic processes, the proxy of physical evidence was used.

4.11.1 Occurrence of Weathering

The occurrence of weathering was determined through physical observation and recording such elements as evidence of exfoliation, oxidization, presence of screees and rock penetration by plants roots (Ridley, 2012).

Weathering process takes place when underlying rocks are broken down into smaller particles through physical, chemical or biological means. According to Strahler and Strahler (2004), weathering processes entail rotting and physical disintegration of rocks through chemical and physical means. The product of rock weathering is normally realised as accumulated soft surface layer of regolith. When regolith grades downslope, they are gathered as unaltered bedrocks.

The study sought to establish if there are evidence of weathering at all within the sampled quarry pits. We used the proxy of physical evidence and recorded the information as follows.
Table 4.6: Occurrence of Weathering

<table>
<thead>
<tr>
<th>Quarry</th>
<th>Slope Process</th>
<th>Proxy of Physical Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bomware</td>
<td>Weathering</td>
<td>• Fragments of rocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cracks on rocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Screes</td>
</tr>
<tr>
<td>Nyakichenche</td>
<td>Weathering</td>
<td>• Fragments of rocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cracks on rocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Screes</td>
</tr>
<tr>
<td>Bokimai</td>
<td>Weathering</td>
<td>• Rocks Fragments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cracks on rocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Screes</td>
</tr>
<tr>
<td>Nyatike</td>
<td>Weathering</td>
<td>• Fragment of rocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cracks on rocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Screes</td>
</tr>
</tbody>
</table>

Source: Field Data

From the information in table 4.7 it is evidenced that weathering processes occur in and around the areas where soapstone quarrying takes place. Soapstone quarrying process involves excavation the top soils and extraction rocks that lie beneath. It therefore exposes rocks to atmospheric agents such as wind, temperature, and rainfall. When exposed bedrocks are subjected to alternating temperatures, rainfall and wind, they develop cracks and eventual disintegrate into smaller particles.

In majority of the soapstone quarrying mines, rain water is often collected as pore water. This is an indication of low water percolation and high-pour water pressure on the rocks. The presence of pore water brings about potential instability leading to disintegration of rocks. The pool of water enhances the rate of chemical weathering which reduces the shear strength of the rock and enhances the rate at which soil is formed.

The exposed rocks become unstable as a result of being weaken by soapstone quarrying, making them to cracks. The weak zones and crevices are elongated gradually triggering rock materials to slip downwards as rock slides and settle down as screes on the foot of the slopes. The consistency of weathering among the quarries used in the study implies that such weathering can be attributed to human activity in the quarries.
The findings above are quite similar with those of Oduor (2008) who found substantive evidence of accelerated weathering processes in areas adjacent to quarries around Nairobi. Similarly, Clark and Small (2006) also found evidence of increased weathering activities on sloppy topography where agents of denudation and human activities are common.

4.11.2 Mass Movements

Mass movement is the downslope movement of rock and soil materials as a result of the pull of gravity. This happens when soil colloids and layers are weakened through runoff, alternate temperatures and rainfall (Strahler and Strahler, 2006).

Mass movement are broadly categorized into two: rapid and slow mass movements. Slow mass movement include soil creep, talus creep, rock creep and solifluction. Rapid mass movement include landslides such as debris slide, rock slide, rock fall, and debris fall (Landowe and Hammler, 2008). The study sites, apart from being subjected to excavations and breaking of rocks are located along the slopes of Tabaka highlands which also experience high rainfall almost throughout the year.

Mass movements occur mostly within sloppy areas where loosened rock particle, regolith soil, loose stones and soil saturated by water are moved down slope under the influence of gravity (Banez and Ajon, 2010). In mass movement soil, loose stone, rock material falls, slides, or flows downhill. Water lubricates the material but gravity is the driving force especially when the slope is steepened by quarrying. According to Bryant (1993), slope failure will occur when gravitational force exceeds forces of resistance resulting into spontaneous movement of materials downslope. This phenomena is common in places with steep gradient, weak rocks, heavy rainfall and basal undercutting or human activities like quarrying (Haghi, 2009).

Scholars such as Ritter (2012); Strahler and Strahler (2006) and Landowe and Hammler, (2008) have distinguished different types of mass movements which they explain is based on what moves, how it moves and how rapidly it does so ; with all of them occurring on sloppy areas. A Proxy of physical evidence was used to record the occurrence of mass wasting within the quarry sites. The resulted were tabulated in table 4.8
Table 4.7 Occurrence of mass wasting

<table>
<thead>
<tr>
<th>Quarry</th>
<th>Slope Process</th>
<th>Proxy of Physical Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bomware</td>
<td>Mass Wasting</td>
<td>Rock Fragments down slope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tilted Trees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mixed Soils</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accumulation of mud down slope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exposed plant roots</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loose rocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loose soil colloids</td>
</tr>
<tr>
<td>Nyakichenche</td>
<td>Mass Wasting</td>
<td>Rock Fragments down slope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tilted Trees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mixed Soils</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accumulation of mud down slope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exposed plant roots</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loose rocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loose soil colloids</td>
</tr>
<tr>
<td>Bokimai</td>
<td>Mass Wasting</td>
<td>Rock Fragments down slope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tilted Trees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mixed Soils</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accumulation of mud down slope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exposed plant roots</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loose rocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loose soil colloids</td>
</tr>
<tr>
<td>Nyatike</td>
<td>Mass Wasting</td>
<td>Rock Fragments down slope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tilted Trees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mixed Soils</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accumulation of mud down slope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exposed plant roots</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loose rocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loose soil colloids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rock Fragments down slope</td>
</tr>
</tbody>
</table>

*Source: Field Data*

From the information in table 4.8, it is evidenced that mass wasting is occurring in all the quarries which were studied. The main evidence for the occurrence of mass movements are:
tilted trees, exposed plant roots, presence of screes and mixed soils. See pictorial evidence in plate 4.5

Plate 4.5 Mass movement at Nyakichenche Quarry

Mass Movements such as rock fall and slope wastage were most common in the four sites. Rock fall is spontaneous debris movement on slopes that exceed 40°. Individual rock suddenly become detached and falls at the base of the slope. Slope disturbance by quarrying can trigger this besides tectonic movements like earthquakes. It takes place where miners expose and remove rocks for processing. The rocks and soil on slopes become weakened because of mining activities leading to slope failures and rapid rock fall. This is evidenced by loosely hanging debris and tilted trees. In some area, soil movement was evidently clear with exposed plants roots.

Soapstone mining process involves pilling up of mould of residues. This creates steep sided moulds which have loose unconsolidated materials and hence are easily carried down slope. The dumped heaps exert pressure on the surface, weakening the material beneath thereby enhancing the process of slope movements.

Overall, the areas around the quarry pits (within 500 metres) exhibits evidence of cracks. In the adjacent homes, there were evidence of cracks on walls and floors. This could be as a
result of loose soil type and loose underground rock fractures. The above findings are quite similar to the assertion of Ritter (2012).

In his research on

4.11.3 Effects of soapstone quarrying on soil erosion

Soil erosion is a gradual slope process that takes place in nearly all land surfaces. There are a number of factors that may trigger slope erosion to occur in places where mining activities take place. Whereas it is common for erosion to cause effects on land after a long duration of time, some type of erosion may be rapid with devastating impacts just within hours of the occurrence of an erosion agent. Analysis of sheet erosion was evident by presence of scattered soapstone particles from the heaps of unconsolidated residue shattered by rain drops. The study used observation methods to record evidence of slope erosion. The findings in table 4.9

Table 4.8 Occurrence of Soil Erosion

<table>
<thead>
<tr>
<th>Quarry</th>
<th>Type of erosion</th>
<th>Evidence</th>
<th>Average Width (m)</th>
<th>Average Depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bomware</td>
<td>Gully</td>
<td>U-shaped shallow hollows</td>
<td>3.35</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Rill</td>
<td>Narrow steep sided trenches</td>
<td>0.46</td>
<td>0.15</td>
</tr>
<tr>
<td>Nyakichenche</td>
<td>Gully</td>
<td>U-shaped shallow hollows</td>
<td>2.74</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Rill</td>
<td>Narrow steep sided trenches</td>
<td>0.30</td>
<td>0.20</td>
</tr>
<tr>
<td>Bokimai</td>
<td>Gully</td>
<td>U-shaped shallow hollows</td>
<td>2.13</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Rill</td>
<td>Narrow steep sided trenches</td>
<td>0.20</td>
<td>0.10</td>
</tr>
<tr>
<td>Nyatike</td>
<td>Gully</td>
<td>U-shaped shallow hollows</td>
<td>4.27</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>Rill</td>
<td>Narrow steep sided trenches</td>
<td>0.30</td>
<td>0.18</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td><strong>1.72</strong></td>
<td><strong>0.29</strong></td>
</tr>
</tbody>
</table>

Source: Field Data
From the information in table 4.9 it is clear that erosion activities have taken place in and around the four quarries that were studied. There are evidences of erosion is pronounced in the Nyatike quarry as evidenced by the size and depth of the quarries. Nyatike quarry is the largest and the oldest of the four. It has therefore been exposed to repeated actions of erosion agents.

The average width of all gullies and rills is 1.72 metres while the depth averages to about 29 m. This indicates that substantive erosion has been witnessed in those areas where soapstone quarrying takes place.

A number of factors were evidently found to have influenced the erosion in the area. For instance, since soapstone quarry activities involve bush clearance and excavations, this exposes the bedrocks to physical agents such as rain water, wind, flush floods, alternating temperatures and humidity. The action of these agents weakens and breaks the bedrocks to small lighter fragments which are then washed away down slope. Vegetation cleared before quarrying can block the natural rills and gullies that drains the landscape. Water is then forced to enter the ground through the cracks which weaken the structure and promote landslides.

4.12 Effects of Soapstone Quarrying on Physical Environment

Slopes are normally described in terms of their form, process and evolution. These characteristics of the slopes are a function of the interaction of several factors including, slope angle, time element, cumulative effects of geomorphic processes, human activities and actions of physical agents such as wind, water, plants root and atmospheric temperatures. Soapstone quarrying is seen therefore in light of its contributions on the occurrence of slope processes and its eventual evolution.

The study identified and isolated various physical features around quarries and examined how they have been affected by soapstone mining and related activities. The information was collected through observation and recording of features and how they relate to the adjacent slopes which have not been subjected to soapstone mining activities. The following are the findings.
Table 4.9 Effects of Quarrying Activities on the Physical Environment

<table>
<thead>
<tr>
<th>Physical Features</th>
<th>Quarry With No Quarrying Activities</th>
<th>Under Quarrying Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land out crop</td>
<td>• Bomware</td>
<td>• Open pits</td>
</tr>
<tr>
<td></td>
<td>• Bokimai</td>
<td>• Steep cliffs</td>
</tr>
<tr>
<td></td>
<td>• Nyatike</td>
<td>• Occurrence of slope failure</td>
</tr>
<tr>
<td></td>
<td>• Nyakichenche</td>
<td>• Open scraps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Slope retreat</td>
</tr>
<tr>
<td>Vegetation</td>
<td>• Bomware</td>
<td>• Foliage coverage.</td>
</tr>
<tr>
<td></td>
<td>• Nyakichenche</td>
<td>• Presence of crops and eucalyptus trees.</td>
</tr>
<tr>
<td></td>
<td>• Nyatike</td>
<td>• Outgrowth of grass, herbs and shrubs.</td>
</tr>
<tr>
<td></td>
<td>• Bomware</td>
<td>• Nearly all vegetation has been removed from the quarry sites.</td>
</tr>
<tr>
<td>Debris and Moulds of Soapstone Residue</td>
<td>• Bokimai</td>
<td>• Reclaimed quarries have shrubs, herbs and grass</td>
</tr>
<tr>
<td></td>
<td>• Nyakichenche</td>
<td>• Tilted trees and exposed roots</td>
</tr>
<tr>
<td></td>
<td>• Nyatike</td>
<td>• Little grass and no trees</td>
</tr>
<tr>
<td></td>
<td>• Bomware</td>
<td>• Soapstone residues are dumped on farmlands and in areas next to the carving spots.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Heaps of soapstone fragments are scattered within quarrying pits and at the foot of the slopes</td>
</tr>
</tbody>
</table>

Source: Field data
Plate 4. 6 Exposed rock face accelerate the rate of weathering and mass movement

Plate 4. 7 Dumping of residues of soapstones
4.12.1 Slopes

From the information above, the slope which is subjected to quarrying activities is also under the actions of weathering, erosion and mass movements. This encourages the pre-existing uplands and the scarps to be worn back. Consequently, a gradual slope retreat ensues leading to the extension of a gentle slope at the foot. The slope will retreat parallel to itself and the waste may accumulate at the foot of the scarp (Strahler and Strahler, 2006).

The slope becomes progressively smaller as the pediments merge to form extensive areas of gentle sloping surface (Pedi-plains). Quarrying has encouraged rock cracks which are visible on slope sides and on the adjacent rocks.

4.12.2 Vegetation

Although the Tabaka region experiences high amount of rainfall that should support lavish highland vegetation, a number of areas have little or no vegetation at all. From the information gathered by the study, the regions where soapstone quarrying takes place is fully cleared of vegetation and is a barren relict lands. However, the adjacent areas where no quarrying is taking place have crop cover, grass, herbs, scattered pines, spruces and eucalyptus trees.

Plate 4. 8 vegetation cover on deposits of soapstone residue on the side of Bokimai Quarry

The vegetation shown in the picture, plate 4.8 above is found on the slopes of Bokimai quarry. The inside slopes comprise of rock scalp with no vegetation apart from isolated lianas and
algae. This quarry is about 18 metres deep and has a huge rock reserve for further exploitation.

![Figure 4.3: The profile of Bokimai Quarry. Source: Author](image)

\[
\text{Quarry depth} = \text{Slope distance} \times \sin(\text{slope angle})
\]

\[
= 54.4 \text{m} \times \sin(30^\circ)
\]

\[
= 27.2 \text{m}
\]

![Figure 4.4: The Profile of Nyatike quarry. Source: Author](image)

\[
\text{Quarry depth} = \text{Slope distance} \times \sin(\text{slope angle})
\]

\[
= 68.5 \text{m} \times \sin(22.1^\circ)
\]

\[
= 25.8 \text{m}
\]
4.12.3 Disused Quarries

These are deep barren stony pits with some of them having accumulated pools of water. Some of them have been reclaimed. Reclamation takes place using soil, soapstone’s chips and pebbles excavated from the main quarrying pits.

In the disused quarrying little or scanty vegetation; especially herbs, grass, shrubs and reeds are visible. This is more common in those quarries where reclamation has been attempted. These areas are left fallow and take a great deal of land which could have been used for crop farming. Nonetheless, in one of such disused quarries, animals could be seen grazing indicating that such zones could easily be turned into alternative land use.

Plate 4. 9  Inside Nyakichenche quarry

1.12.4 Debris/ Moulds of Soapstone Residues
Soil mixed with soapstone’s residues and plant roots are damped at the fringes of quarry pits. Their loose nature makes them susceptible to water and wind erosion. This is evident at the foot of the slopes where these materials are deposited. This phenomenon is also witnessed at the carving sites. (Refer to plate 4:10)

Plate 4. 10 Debris deposited at the foot of the slope of Nyatike quarry

Plate 4. 11 Heaps of soapstone waste from carving activities dumped around a factory
Rivers

There was evidence of soapstone’s residues on river beds. The river water is coloured brown grey. White brown are common colours of soapstone rock. The research did not undertake chemical analysis of the river water. However, physical evidence observed from River Mosache indicates that the rivers are polluted and ageing as a result of heavy visible deposition of quarried material.

4.12 Effects of Soapstone Residues on Farming

The effects of soapstone residues on farming activities was investigated by observing whether there were crop evidence along side the residues. It was observed that the areas occupied by residues had no crops under them. Farming or cropping in the area is therefore affected by deposites of residues.

1.13.1 Ownership of Quarries

Ownership of the soapstone quarries was investigated as a basis of analysing which portion of land area owned by individuals is allocated between quarrying and other land use activities. From the information in figure 4.3, it can be deduced that out of the four quarries studied, three (75%) were owned by individuals while one was rented. It was established that eighteen of the remaining quarries are self-owned while the rest two are rented.

The study noted that nearly all quarry owners were also farmers. It is therefore the decision of the land owners to decide which portion of their land is allocated to soapstone mining activities. Within Tabaka area there are no communal or trust ownership of quarries. In reality however, mineral resources belong to the national government and one would have expected that quarries are rented out by the authorities (GoK, 2010). This is represented figure 4.3 below:-
Figure 4.3 Effects of Soapstone residues on farming.
Source: Field Data

Plate 4.12 Swath of farmland occupied by soapstone residues
4.13.2 Land Use Pattern by Different Activities

Tabaka region, apart from being very rich in soapstone mineral is also a highly potential agricultural area. Buyeke and Njoroge (2015) highlights the suitability of this land for agricultural purposes citing its high level of productivity. The area is suitable for arable and livestock framing. Given this scenario and its high population density, there is high probability of competing economic and social interests in the use of land. Analysis was done to establish what potion of land is allocated to soapstone quarrying activities. The essence was to determine the amount of land that could have been used for farming but is now under quarrying. The findings were tabulated in table 4.13.
## Table 4.10 Land use of Allocation

<table>
<thead>
<tr>
<th>Quarry</th>
<th>Area in Acres</th>
<th>Soapstone Quarries</th>
<th>Residues</th>
<th>Farming</th>
<th>Settlement</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>½ acres (23.5%)</td>
<td>1/8 acres (5.8%)</td>
<td>1 acre (47.1%)</td>
<td>½ acre (23.5%)</td>
<td>2.125 Acre (100%)</td>
</tr>
<tr>
<td>Bomware</td>
<td></td>
<td>1 ½ acres (29.3%)</td>
<td>1/8 (2.4%)</td>
<td>3 acres (58.5%)</td>
<td>½ acres (9.8%)</td>
<td>5.1 acres (100%)</td>
</tr>
<tr>
<td>Nyakichenche</td>
<td></td>
<td>1 acre (14.7%)</td>
<td>1/8 acres (1.8%)</td>
<td>4 acres (58.8%)</td>
<td>1 acre (14.7%)</td>
<td>6.8 acres (100%)</td>
</tr>
<tr>
<td>Bokimai</td>
<td></td>
<td>2 acres (24.2%)</td>
<td>¼ acres (3%)</td>
<td>5 acres (60.6%)</td>
<td>1 acre (12.1%)</td>
<td>8.25 acres (100%)</td>
</tr>
<tr>
<td>Nyatike</td>
<td></td>
<td>5 acres (22.4%)</td>
<td>0.625 acres (2.8%)</td>
<td>13 acres (58.3%)</td>
<td>3 acres (13.5%)</td>
<td>22.28 acres (100%)</td>
</tr>
<tr>
<td>Total Average</td>
<td></td>
<td>5 acres (22.4%)</td>
<td>0.625 acres (2.8%)</td>
<td>13 acres (58.3%)</td>
<td>3 acres (13.5%)</td>
<td>22.28 acres (100%)</td>
</tr>
</tbody>
</table>

*Source: Author own compilation*

It is evidence from the table 4.11 that soapstone quarries take up to about 22.4% of the total land belonging to farmers. Residues from soapstone carvings and soapstone chips take about 2.8% of the land area. Farming is still a major activity occupying about 58.3% of the total land area belonging to individual farmers.

The finding also shows that farmers apportion their land differently to competing needs. This division of land use however depend on individual farmer, the size of the land and where his priorities are. Those farmers with big lands tend to allocate larger chunk of their pieces to soapstone quarrying activities. It was also noted that bigger pieces of land were allocated in areas with laterite soils and fertility is evidently lower. Clearly therefore, soapstone quarrying and its residues occupy a substantial acreage of land amounting to about 22% that could have otherwise been used for farming. These findings are supported by plate 4.5.
Plate 4. 14 Competing farming and quarrying activities

The study established that farming activities is carried out alongside quarrying activities and other forms of agriculture. Equally there exist competition between dumping of the residues and space for crop farming and also grazing areas. This is evident by tethering of animals close to soapstone dumping areas (Field Information).

Plate 4. 15 Soapstone residues and fragment dumped on a plot replacing farming
4.13.4 Income Specification from Quarrying Activities

Quarrying activities is one of the main sources of income from those engaged in it. The respondents were asked to disclose their income from quarrying activities and their responses captured in table 4.12

Table 4.11 Income earning of the respondents

<table>
<thead>
<tr>
<th>Income per day (Kshs)</th>
<th>Response</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>100-200</td>
<td>14</td>
<td>25%</td>
</tr>
<tr>
<td>201-500</td>
<td>24</td>
<td>43%</td>
</tr>
<tr>
<td>501-800</td>
<td>10</td>
<td>18%</td>
</tr>
<tr>
<td>801-1000</td>
<td>6</td>
<td>11%</td>
</tr>
<tr>
<td>1001 and above</td>
<td>4</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td><strong>56</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Source: Field Data

Out of the sampled 56 respondents, 43% indicated that they earn between Kshs 200/= and Kshs 500/= per day. This integrates to 15, 000/= per month. The earnings depend on individual’s own effort and the market price. Those who earn Kshs 1000/= and above are
mainly the quarry owners who are paid loyalties. It was established that different works are paid differently depending on the effort and skills involved. For instance, those who excavate and split soapstone rocks are paid per piece of rock removed. A two feet squared rock goes for Kshs 500/= and it takes the effort of five labourers working two hours to deliver a piece for sale.

Plate 4. 17 Soapstone carvings
Plate 4. 18 Soapstone artefacts and carvings on display for sales

4.13.4 Socio Economic Perceptions arising from Soapstone Quarrying

Problem analysis was done to gauge the perception of respondent on what they consider to be the adverse effects of soapstone quarrying. A Likert scale was used to rank the severity of various interactions of pre-determined problems. The findings are presented on table 4.13 below:

Table 4.12 Problems from Soapstone Quarrying

<table>
<thead>
<tr>
<th>Problem</th>
<th>Ranks</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very Severe</td>
<td>Severe</td>
<td>Less Severe</td>
<td>No effects</td>
<td>Total</td>
</tr>
<tr>
<td>Respiratory infections (e.g. breathing problems)</td>
<td>37 (66%)</td>
<td>13 (24%)</td>
<td>6 (10%)</td>
<td>0 (0%)</td>
<td>56 (100%)</td>
</tr>
<tr>
<td>Takes up agricultural land</td>
<td>0 (0%)</td>
<td>2 (4%)</td>
<td>40 (71%)</td>
<td>14 (25%)</td>
<td>56 (100%)</td>
</tr>
<tr>
<td>Causes waterborne diseases (e.g. typhoid, dysentery)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>56 (100%)</td>
<td>56 (100%)</td>
</tr>
<tr>
<td>Air Pollution</td>
<td>0 (0%)</td>
<td>3 (5.3%)</td>
<td>45 (80.3%)</td>
<td>8 (14.2%)</td>
<td>56 (100%)</td>
</tr>
<tr>
<td>Family Conflicts</td>
<td>2 (3%)</td>
<td>11 (19%)</td>
<td>19 (33%)</td>
<td>24 (45%)</td>
<td>56 (100%)</td>
</tr>
<tr>
<td>Influences Acts of prostitution</td>
<td>6 (10%)</td>
<td>13 (22%)</td>
<td>35 (64%)</td>
<td>2 (3%)</td>
<td>56 (100%)</td>
</tr>
<tr>
<td>Land Conflicts</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>10 (18%)</td>
<td>46 (82%)</td>
<td>56 (100%)</td>
</tr>
<tr>
<td>Average Cumulative</td>
<td>7</td>
<td>6</td>
<td>22</td>
<td>21</td>
<td>56</td>
</tr>
<tr>
<td>% of Total</td>
<td>12%</td>
<td>10%</td>
<td>40%</td>
<td>38%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Field Data

The findings in table 4.13 show a summary of individual’s perception of what problem soapstone quarrying activities have brought to residents of Tabaka region. The findings show that respiratory infections are the major problem resulting from soapstone quarrying with
66% rating it as very severe. Water borne diseases, and land conflicts are however the least of the problems faced with 100% and 79% of residents in the area respectively.

Although majority of the respondents have modest education, they appear to grasp the consequences of soapstone quarrying activities on their health and socio-economic wellbeing. Majority of the respondents amounting to 66% felt that soapstone quarrying and carving is the major factor that causes the common respiratory diseases which are prevalent in the area. Soapstone is a very soft mineral material and during carving it produces a lot of dust into the atmosphere. The carvers and miners of the stone however do not put or have dust masks. It is therefore possible that respiratory problems affecting people in the area are either as a result of the soapstone dust or its agents.

The respondents felt that the areas currently under quarrying are of no significant effect on farming or agricultural lands. Accordingly, therefore, many of those were interviewed feel that it is possible to integrate soapstone activities alongside farming. Whereas this could be the popular perception among those who work in soapstone quarries, it is obvious that there is trade-off between soapstone activities and farming.

A sizeable piece of land that is under soapstone quarrying and carvings could easily have been put to farming. In general, up to 40% of respondent feel that soapstone quarrying and related activities do not cause them any serious problem.

4.13 Alternative Uses of Soapstone Residues

Soapstone residues consist of small fragments of rocks and powdery by-products from carvings activities. The residues are strewed all over in areas close to the mines. Heaps of these residues take up part of the agricultural land areas besides being a serious pollutant to the surface air and adjacent rivers. An assessment was done to establish how soapstone residues can be used to ensure environmental sustainability and income to the residents. Respondents were asked to list the uses they feel soapstone residues should be put to. Their responses are indicated in the figure 4.4
Figure 4.4: Alternative uses of soapstone

*Source: Field Data*

From the findings in figure 4.4 it was found out that soapstone residues can be put into a number of alternative uses. Majority of the respondents (24%) suggested that the residues should be exported to consumers who need it for making blackboard chalk. About 23% of respondent however felt that soapstone residues should be promoted as house smearing and wall decoration material.

The study also found that most of the respondents appear to appreciate the fact that the residue poses a serious environmental concern particularly as air and water pollutant and also as a health risk material. As such it should be dispose of in the best possible ways that can save the environment as well as earning income to those engaged in soapstone quarrying activities.

25/10/2015
4.14 Policy Framework for Sustainable Quarrying of Soapstone

The Mining Act 2016 (GoK 2009a) is the main legal framework for the regulation and management of all mining activities in the country. However, there are other policy documents that guide the conduct of mining activities in Kenya. These include the Constitution of Kenya, the Environmental Act 2007, Environmental Policy 2009 and the Mining Policy 2016. Other issues on the management and control of certain services that support mining activities are managed by other Acts. For instance, the provision and management of water is dealt with through the Water Act, 2014; safety and health issues are addressed through the Occupational Health and Safety Act, 2007.

The study reviewed these documents to determine how their provisions support sustainable soapstone quarrying activities. According to Deflies (2004) mining activities can become more environmentally friendly and sustainable through the adoption of an integrated social, environmental and economic factors that will minimise the environmental impact of mining or quarrying operations. These factors include less usage of water and energy consumption, minimizing land disruption and waste production, preventing air, water and soil pollution at mine sites, and conducting successful mine closure, reclamation and rehabilitation activities (Kumar, 2014).

The basis for sustainable soapstone quarrying is therefore to guarantee exploitation that ensure safe environment and better income. The Mining Policy of Kenya 2016 advocates for scientific mining activities that involve innovative mining methods, geoscientific knowledge and practices originating from a systematic approach to mine development and operation (GoK, 2016). Poor mining practices such as the extraction only of the highest-grade material in a deposit, ignoring the lower grades and avoiding environmental management responsibility for short-term gains is highly discouraged.

This study has made detailed analysis of the Mining Act 2016 to determine its application in the soapstone quarrying activities and made several observations. The Act establishes several agencies to oversee the implementation of its provision. In section 12 of the Act, it is incumbent upon the Cabinet Secretary of mining to oversee the general administration of the department. Policy issues are however implemented through various institutions which
include: the office of the Director of Mines, the National Mining Corporation, and the Mineral Right Board.

In section 6 (a) of the Act provides that minerals in Kenya are the property of the Republic and is vested in the national government in trust for the people of Kenya. It goes further to state that mining of any mineral can only be done under license from the Kenya government. Section 149 (1) makes it mandatory for all those engaged in any mining activities to protect the immediate environment and social heritage.

Section 152 of the Mining Act provides as follows: That a) those involved in the exploitation of extractive minerals must put in place measures for sustainable use of land through restoration of abandoned mines and quarries; b) while undertaking mining activities, the seepage or disposal of toxic waste into streams, rivers, lakes and wetlands is avoided and that disposal of any toxic waste is done in the approved areas only and c) upon completion of prospecting or mining, the land in question shall be restored to its original status or to an acceptable and reasonable condition as close as possible to its original state.

An analysis of the above provision was made and the finding presented in the table below.

**Table 4.14 Measures for Sustainable land use in soapstone quarrying areas**

<table>
<thead>
<tr>
<th>Activity Requirement</th>
<th>Done</th>
<th>Not Done</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restoration of abandoned quarries</td>
<td>2 (8.7%)</td>
<td>22 (91.3%)</td>
<td>24</td>
</tr>
<tr>
<td>Waste disposal to avoid seepage into streams</td>
<td>0 (0%)</td>
<td>52 (100%)</td>
<td>52</td>
</tr>
<tr>
<td>Restoration of the land</td>
<td>1 (4%)</td>
<td>24 (96%)</td>
<td>25</td>
</tr>
<tr>
<td>Cumulative</td>
<td>4%</td>
<td>96%</td>
<td></td>
</tr>
</tbody>
</table>

From the observation made in the field, there is a 4% cumulative compliance with the provision of sustainable quarrying activities. The entire provisions on the management of wastes was not being observed at all in the area. Soapstone residues were being dispose of haphazardly in all the placed visisted. This confirms the Kinyua et al (2011) findings which established that most rivers in Tabaka area were heavily polluted with toxic waste from soapstone quarrying sites. In addition, there are no observable efforts to reclaim disused quarries in the area. It can therefore be argued that either the government has little interest on protecting the environment in the region or the local have chosen to conduct their mining activities without due regards to the provision of the law.
The study investigated whether quarry owners had license to operate and whether aspects such as soapstone carving were also license as per the law. Sections 101-113 of the Mining Act make it mandatory of the quarry owners to obtain license from the Ministry of Mining. The finding of the study are tabulated in table 4.14 below:

**Table 4.13: Licensed Operations**

<table>
<thead>
<tr>
<th>Description of activity</th>
<th>Licensed</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Total interviewed</td>
</tr>
<tr>
<td>Quarry owners</td>
<td>8 (33.3%)</td>
<td>16 (66.6%)</td>
<td>24</td>
</tr>
<tr>
<td>Quarry workers</td>
<td>0 (0%)</td>
<td>50 (100%)</td>
<td>50</td>
</tr>
<tr>
<td>Soapstone carvers</td>
<td>12 (20%)</td>
<td>48 (80%)</td>
<td>60</td>
</tr>
<tr>
<td>Traders in soapstone artifacts</td>
<td>44 (73%)</td>
<td>12 (27%)</td>
<td>60</td>
</tr>
</tbody>
</table>
From the information above, it was established that majority of soapstone quarry owners (66%) do not have operating license. On whether they knew of this requirement, 57% answered to the affirmative. These means that some of the owners have chosen not to get operation license. It also brought to question the efficacy of implementation process.

Given that there are different government department which are also mandated to conserve the environment such as the Ministry of Environment, Ministry of Water and Irrigation and the National Environmental Management Unit (NEMU) it is difficult to understand why no action is being taken to promote sustainable soapstone mining in the area.

4.15 Testing of Hypothesis

The study had formulated four main hypotheses all of which were Null Hypotheses. They include H\textsubscript{01}, that soapstone quarrying has no significant effects on slope processes in the area; H\textsubscript{02}, that there is no relationship between soapstone quarrying and farming; H\textsubscript{03}, that there are no alternative uses of soapstone residues over the conventional methods and H\textsubscript{04}, that no appropriate policy option that exists for sustained soapstone quarrying in the region.

H\textsubscript{01} that ‘soapstone quarrying has no significant effects on slope processes in the area

This hypothesis was meant to establish the association and relationship between soapstone mining activities and the occurrence of geomorphic processes as shown through the proxy of physical evidence.

The study established compelling evidence such as mixed soil types, presence of scree, rock decays, tilted plants, exposed roots which suggest that soapstone quarrying activities accelerate erosion, weathering and mass movement processes. Heaps of soapstone residues created as a result of soapstone quarrying activities form steep sided layers of loosened unconsolidated materials. Such areas are likely to experience enhanced erosion process beside alteration of the original landscape. Therefore, the hypothesis that soapstone quarrying has no significant effects on slope processes in the area is rejected.

Hypothesis H\textsubscript{02}, that there is no relationship between soapstone quarrying and farming
This hypothesis analyzed the size of the land area occupied by farming against what is occupied by soapstone quarries and deposit of soapstone residues based on the land belonging for an individual quarry owner from the four quarries.

To find out whether there was linear relationship between soapstone quarrying activities and farming, Pearson Moment’s Correlation Coefficients was used as suggested by Cohen, West and Aiken, (2003). The result of the finding is presented on table 4.14. The result indicates that quarrying activities and farming had a strong positive relationship indicated by a correlation coefficient value of 0.60. This suggests that there was a linear positive relationship between the two activities which means that an increase in soapstone quarrying activities deprive farming a lot of land space and labor or still a linear increase in farmland result in a commensurate decrease in soapstone exploitation. This hypothesis is aptly rejected.

Table 4.14: Relationship between soapstone quarrying activities

<table>
<thead>
<tr>
<th>Quarry</th>
<th>Area soapstone activity</th>
<th>Rank</th>
<th>Farming</th>
<th>Rank</th>
<th>D&lt;sup&gt;1&lt;/sup&gt;</th>
<th>D&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bomware</td>
<td>0.625</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nyakichenche</td>
<td>1.625</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Bokimai</td>
<td>1.125</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>Nyatike</td>
<td>2.25</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Author

The above information is used to calculated the correlation coefficient ($r_s$) using the formula

$$r_s = 1 - \frac{6 \sum d^2}{n^3 - n}$$
Where $D^1 =$ difference in rank

$D^2 =$ Square of the difference between ranks

$n =$ Number of occurrences

$$
= 1 \frac{6 \times 4}{4^3 - 4} \\
= 1 - \frac{24}{64 - 4} \\
= 1 - \frac{24}{60} \\
= 1 - 0.4 \\
= 0.6
$$

**Hypothesis $H_{03}$: that there are no alternative uses of soapstone residues over the conventional ones.**

This hypothesis examining various uses of soapstone residues. Previously, soapstone residues were mainly used for decorating house walls and the big fragments being used for compacting earthen roads. The study established that soapstone residues can also be used in making dyes, enamel fire places, making of kitchen chop boards, smearing the inner lining of fire chimney and making of cooking pots. From these findings, the hypothesis was rejected and the alternative one accepted.

**The Hypothesis $H_{04}$, that no appropriate policy option exists for sustained soapstone quarrying in the region.**

The hypothesis sought to establish first, the existence of mining policy, mining act, and environmental policy; second, the provisions of these statutes in regulating mining activities and protection of the environment and third, determining whether the set regulation are being implemented.
Table 4.15: Testing of Hypothesis that no appropriate policy option exists for sustained soapstone quarrying in the region

<table>
<thead>
<tr>
<th>Policy Issue</th>
<th>Policy Provision</th>
<th>Expected policy outcome</th>
<th>Finding</th>
</tr>
</thead>
</table>
| Reclamation of derelict pits     | • Mining Act 2016 – Sec. 176  
• Constitution Art. 67  
• Mining Policy            | All disused quarry pits are reclaimed. Sound environment                                  | Disused quarry pits are not rehabilitated.                                                        |
| Licensing                        | Mining Act Sect 102 – 113                                                        | Every quarry is licensed                                                                  | Majority of the quarries are not licensed                                                          |
| Disposal of wastes               | Mining Act Section 152                                                           | Proper sites for disposal of wastes                                                      | Wastes are haphazardly disposed                                                                    |
| Restoration of land after mining | Environmental Act Sec.                                                          | Land is restored to its original form as far as possible                                  | No evidence of land restoration                                                                   |
| Implementation                    | Mining Act sec. 123                                                             | Strict govern follow ups. Laws adhered to                                                 | Defective implementation. Absence of govern officers on the ground.                                |

From the information above, we can make the following observations. That despite the existence of very robust laws and policies to guide the mining activities in country, the study observed that nearly all the provisions are never implemented throughout the conduct of soapstone mining. As a result, all soapstone quarries are never reclaimed. Additionally, there is no observable environmental protection mechanism currently being implemented to ensure sustainable exploitation of soapstone. It is however possible to come up with alternative policies and guarantee their implementation. In this regard, the hypothesis that no appropriate policy exist for sustainable soapstone exploitation was rejected.
CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the major findings of the study and the conclusions that have been reached from the findings. It also makes recommendations for sustainable soapstone quarrying activities within Tabaka and provides suggestions on areas for further studies.

5.2 Summary of the Findings

The study had four specific objectives that it sought to resolve. These were to: determine the types of slope processes associated with soapstone quarrying activities in Tabaka region; examine the relationship between soapstone quarrying activities and farming; establish the alternative uses of soapstone residues over the conventional methods, and analyse the policy framework for sustained soapstone quarrying activities.

The study revealed interesting interactions between soapstone quarrying activities such as excavation, dumping of soapstone residues and the occurrence of geomorphic processes including mass movement, weathering and erosion. Soapstone quarrying activities expose the bedrock under quarrying pits to agents of denudation such as the elements of weather, human and animal activities and climatic factors besides forces of diastrophism. These circumstances tend to accelerate the rate at which geomorphic processes occur.

Soapstone quarries and their surrounding are characterized by deposits of debris and heaps of residues (in carving areas), the components with smaller angles of repose lying at the foot of quarry walls. These materials are partly derived from quarry working and partly from natural processes (rockfalls). They are initially developed by accumulation but their origin is linked to excavation activities. As material is accumulating in debris cones, they may coalesce to form a continuous debris apron which eventually may result into the formation of rock regeneration (rock cycle).

Quarrying process is a crucial human activity in Tabaka. However, this region is also endowed with very rich agricultural lands and reliable rainfall that is felt throughout the year.
Residents of the area have options of either committing their plots to soapstone quarrying or crop farming.

Majority of soapstone quarry workers have modest education. Socially, well educated people tend to look for white collar jobs than work in the quarries and carving centres. This explains why majority (52%) of quarry workers have primary level of education.

Female soapstone workers engage in light duties such as removal of fine soapstone residues, dumping, polishing, painting and selling of soapstone merchandise. Although such duties have traditionally been carried out by women, it is worth noting that they are capable of engaging in male dominated activities such as carving.

Individuals are attracted to engage in soapstone quarrying activities either as a result of income consideration, lack of viable alternative source of engagement and as a traditional practice in the area. The study found out that soapstone rocks are processed into artefacts and carvings of various shapes which are sold out to various customers.

Most people who work in the quarries are also farmers. They trade off their times between the two activities and would concentrate more in either of them depending on the prevailing weather condition. During the rainy season, majority of the residents work most of their times in farming. In the dry season however, this trend shifts to soapstone mining and processing activities.

Soapstone quarrying and processing activities face challenges that include the lack of preliminary geologic investigation in the region, inadequate implementation of legislation, rules for the general planning and control of the activities. The traders registered serious concerns on the presence of middle men who exploit them thereby reducing their gains.

Inadequate and sometimes irrelevant guidelines on the extractions methods, reclamation of pits results into poor recovery of blocks and in the build-up of huge dumps of waste materials which occupies large swath of lands. This consumes available space for farming.

The study found out that soapstone rocks are processed into artefacts and carvings of various shapes which are sold out to various customers. Both mining activities and processing of soapstone produce huge amount of waste materials and residues which are deposited adjacent to quarrying pits.
Extraction of soapstone is done using simple equipment and implements. Heavy machines such as tractors and vans are used to transport soapstone to carving areas. Use of traditional technologies does not promote professionalism, deeper involvement of manpower in soapstone mining and processing activities. Consequently, soapstone exploitation is rudimentary done without care to the environment, health of the residents and future infrastructural development.

The physical environment such as landscape, vegetation cover, and slope angles; exhibit serious distortions with most areas being characterised by dissected slopes, open valleys, sharp rock scalps, elongated moulds in quarry floors and isolated water pond. Quarrying and subsequent carving of soapstone produce huge amount of residual wastes. These wastes are deposited/dump haphazardly around quarries and workshops where carving takes place making it difficult for such areas to support farming.

In the entire area, it was established that there are no specific measures being undertaken to reclaim disused quarries. However, natural regeneration was observed within some of the disused quarries where they are grown of grass and herbs (foliage coverage).
5.3 Conclusions

The study is exploratory and investigated the influence of soapstone mining activities on the occurrence of geomorphic processes. It also examined how the resultant soapstone residues and its other activities affect farming. The study also sought to understand whether soapstone workers adhere to the provisions of the regulatory laws.

It was observed that soapstone mining and processing entail activities such as bush clearance, removal of the top soil (overburden), excavation of soapstone rocks, transportation and carving activities. These activities are carried out by use of simple hand-held equipment and tools such as shovels, axe, mattock, and other implements.

The study concludes that soapstone quarrying activities have directly influenced on the occurrence of geomorphic processes. The activities accelerate the rate of soil erosion, weathering and mass movement. Quarrying activities such as excavation take significant size of agricultural land through dumping of waste materials and quarrying pits.

Farmers are increasing sections of their land to quarrying activities because of the quick economic gains. It was established that quarrying activities take up to 22% of farmlands and many farmers trade off their times between farming and quarrying activities. Interestingly also, residents of the area are more involved in soapstone activities during dry season purportedly as a result of limited farming activities. The study therefore concludes that soapstone quarrying activities directly affect farming. In essence these activities such as dumping of residues reduce agricultural productivity (amount of produce) through reduction of farm sizes under crop production and man-hour spent in farm activities.

Soapstone residues are used in many different ways that include: smearing of houses, as dyes in decoration, as a by product in making kitchen hot surfaces, laying of road surfaces, making of chalk. It is important to note that these alternative uses are crucial as means towards
effective disposal and creative utilization of soapstone residues. Furthermore, when soapstone wastes and residues are properly used, residents are likely to benefit through additional income and conservation of the fragile environment. Such measures will in the long run play a vital role in sustainable exploitation of soapstone in Tabaka region.

Having examined various policies and statutes which govern the exploitation of mineral in Kenya, the study concludes that there are adequate policy framework and sufficient laws including the Mining Act 2014. However, there is no sufficient provisions for the implementation of the laws. Secondly, the rules and regulations that govern mineral exploitation and environmental conservation are spread in so many acts and policy papers including Land Act, Mining Act, Environmental Act and respective policies leading to serious confusion and difficulties in their implementation.
5.4 Recommendations

The study makes the following recommendations:-

The locals and quarry owners should put measures to reclaim disused quarries by planting trees, reeds and filling the pits with soapstone fragments. This will reduce the rate of erosion and other geomorphic processes besides restoring the aesthetic feature of the land.

The government through the environmental and mining officers should ensure that a given quarry is fully exploited before moving on to the new sites. This will ensure prudent and sustainable use of soapstone resource and avoid disrupting other land use patterns such as settlement, farming, transport besides exposing the surface land to further denudation.

The local administrators and environmentalists should sensitize soapstone owners, quarry workers and farmers on sound soapstone exploitation. This will ensure that quarrying activities are scientifically carried out for better economic returns.

Each soapstone quarry and individual carving factories should have designated areas for disposing soapstone residues. The government should execute this by licensing only those who conform to the waste disposal measures in place. Such measures should include innovative ideas for usage of soapstone residues including processing them into industrial raw material for making hot surfaces.

The government should review the existing Mining Act 2014 and provide clear mechanism for its implementation and the authorities responsible. Further, all the rules and regulations concerning open cast mining method should be harmonized into one document for ease of implementation.

The national and county governments should regulate soapstone exploitation by restricting its activities to select areas away from the main agricultural farms especially in rocky surface and poor soil regions. Both governments should set aside grounds for dumping of soapstone...
residues and other wastes. Carving of soapstones should be in designated zones established and licensed by the government away from the current practice where small scale carvers undertake their work in informal places throughout the region.

The local government should allocate fund for establishment of soapstone processing centres where value addition can be undertaken. Since most residents are often exploited by middlemen, the county government should assist them by sourcing for markets and take action to stabilise market fluctuations.

An intensive research funded by the local government should be done on how to revamp soapstone industry as an economic pillar in the development of the region. Moreover, the research will explore further uses of soapstone residues and rocks to make it more viable resource.

**Areas for further academic research**

Our study was basically to investigate the influence of soapstone quarrying activities on the occurrence of geomorphic processes and farming activities. During the study it became obvious that there are certain areas on geomorphology and soapstone mining which needs further investigation. The following areas are recommended for further academic research:

- Scientific investigation on rate of geomorphic processes on soapstone quarrying sites
- The impact of soapstone quarrying activities on the quality of soil and water in the area.
- The influence of soapstone quarrying on geological transformation within the Tabaka region.
- Alternative uses of soapstone debris.
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104


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APPENDICES

APPENDIX 1: QUESTIONNAIRE

I am a student of Kenyatta University taking a Masters of Arts degree in Geomorphology. I am undertaking a research study on the effects of soapstone quarrying on geomorphic and human environments. I am writing to request you to assist me complete the questionnaire attached herein.

May I take this early opportunity to assure you of my utmost confidentiality and good faith with every bit of information that you shall provide. All responses will be given due merits and information obtained shall be used only for academic work and at no time will it be divulged for any reason.

Thank You.

Tabitha Tilji, C
GENERAL INFORMATION

I am requesting that tick or fill in your answers in the spaces provided. Feel free to use Kiswahili, English or local dialect in completing the questionnaire.

PERSONAL INFORMATION

1. Name of the quarry………………………………………………………………………………
2. Date……………………………………………………………………………………………
3. Age (please Tick.) 18-22 years ☐ 23-27years ☐ 28- 32 years ☐ 33 and above ☐
4. Sex: Male ☐ Female ☐
5. Marital status: Single ☐ Divorced ☐ Widow ☐ Widower ☐
6. Please tick the duration you have worked in/ owned the quarry. 1 years and below ☐
   2-5 yrs. ☐ 6-9 yrs. ☐ 10 yrs. and above ☐
7. What is your highest level of education? Primary ☐ Secondary ☐
   Tertiary/ college ☐ Undergraduate ☐

Indicate your main activity in the quarry.

Vegetation clearing ☐
Removal of top soil ☐
Extraction of the stones ☐
Cutting of stones ☐
Carving ☐
Others (specify)………………… ☐

8. What is your main reason for working in this quarry?

……………………………………………………………………………………………………………………

……………………………………………………………………………………………………………………

9. What equipment do you use in carrying out quarrying activities?

……………………………………………………………………………………………………………………

……………………………………………………………………………………………………………………

10. Do you work continuously throughout the year? Yes ☐ No ☐
11. Which season do you carry out the quarrying activity? Rainy Season ☐ Dry Season ☐
12. Please rank which factors affect your quarrying activities
<table>
<thead>
<tr>
<th>Factors</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Rainy season</td>
<td></td>
</tr>
<tr>
<td>Dry season</td>
<td></td>
</tr>
<tr>
<td>Type of equipment used</td>
<td></td>
</tr>
<tr>
<td>Government Regulations</td>
<td></td>
</tr>
<tr>
<td>Farming/ economic activities</td>
<td></td>
</tr>
<tr>
<td>Availability of market</td>
<td></td>
</tr>
<tr>
<td>Cost of quarrying equipment</td>
<td></td>
</tr>
<tr>
<td>Others specify (…………………)</td>
<td></td>
</tr>
</tbody>
</table>

Key: 4 mostly affect; 3 affect; 2 least affect; 1 does not affect
1) **EFFECTS OF SOAPSTONE MINING ACTIVITIES ON GEOMORPHIC PROCESSES**

13. Observation record sheet on geomorphic processes (*Do not answer this part*)

<table>
<thead>
<tr>
<th>Slope Process</th>
<th>Evidence</th>
<th>Presence</th>
<th>Estimated measurement</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weathering</td>
<td>Fragmented rock particles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass movement</td>
<td>Tilted trees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soapstone fragments down slope</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil erosion</td>
<td>Gullies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rills</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sheet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exposed tree roots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deposition</td>
<td>Shallow river beds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mounds of scooped soil on landscape</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Deep soils</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Physical Characteristics of soapstone quarries (do not answer this)

<table>
<thead>
<tr>
<th>Features</th>
<th>Angle</th>
<th>Depth</th>
<th>Height</th>
<th>Width</th>
<th>Cross section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quarries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gullies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 14. Figure 3: Effects of soapstone quarrying on physical environment (do not answer)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Effects</th>
<th>Quarried areas</th>
<th>Tick</th>
<th>Un-quarried areas</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Slope</td>
<td>Reduced slope angle</td>
<td></td>
<td>No quarry pits</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Steep walls of pits</td>
<td></td>
<td>Gentle and undulating slopes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cracks on slope</td>
<td></td>
<td>No cracks on slope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Vegetation</td>
<td>Absence of vegetation</td>
<td></td>
<td>Presence of grass</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Presence of shrubs in disused quarries</td>
<td></td>
<td>Presence of trees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Debris heaps/</td>
<td>Scooped soil dumped nearby creating mountain of soil.</td>
<td></td>
<td>The natural landscape has not been altered.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overburden</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Disused quarries</td>
<td>Not rehabilitated.</td>
<td></td>
<td>No gaps</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Used as dumping site and farmlands.</td>
<td></td>
<td>Land uses include agriculture and settlement.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Flooding</td>
<td>The disused quarries will accumulate water when it rains.</td>
<td></td>
<td>It is not experienced since there are no gaps in the un-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Tilted trees, utility posts,</td>
<td>Presence of tilted trees, posts and structures.</td>
<td></td>
<td>quarried areas.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and structures</td>
<td></td>
<td></td>
<td>Tilted trees, posts, structures may be observed in area</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>affected by sheet and rill erosion</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2) EFFECTS OF SOAPSTONE QUARRYING (RESIDUE) ON FARMING AND OTHER SOCIO- ECONOMIC ACTIVITIES.

17. Describe ownership of the quarry where you work

Personal ☐
Rented ☐
Employee ☐

1. If the quarry is personal, do you have any other?

Yes ☐ No ☐

2. If yes, how many?

3. How many people have you employed in total?

4. What was your previous occupation before you joined the quarry?

What factors motivated your decision?

5. Please indicate how you are paid?

Piece rate ☐
Time rate ☐
Daily rate ☐
Weekly ☐
Monthly ☐

6. What is your daily earning?
7. Do you have any other source of income? Yes □ No □

If yes, please state

..................................................................................................................................................

..................................................................................................................................................

8. What is your level of production per day?

..................................................................................................................................................

..................................................................................................................................................

9. How many units do you sell per day? (Kg, tons, wheel barrow etc.)

..................................................................................................................................................

..................................................................................................................................................

10. How much is your selling price?

..................................................................................................................................................

..................................................................................................................................................

11. Do you consider your income to be sufficient for your needs?

Yes □
No. □
12. Using the table below, please rank how you have been affected by the following problems arising from soapstone quarrying.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Respiratory infections (e.g. breathing problems)</td>
<td></td>
</tr>
<tr>
<td>Waterborne diseases (e.g. typhoid, dysentery)</td>
<td></td>
</tr>
<tr>
<td>Vector borne diseases (malaria)</td>
<td></td>
</tr>
<tr>
<td>Air Pollution</td>
<td></td>
</tr>
<tr>
<td>Noise Pollution</td>
<td></td>
</tr>
<tr>
<td>Water Pollution (coloured)</td>
<td></td>
</tr>
<tr>
<td>Accidents</td>
<td></td>
</tr>
<tr>
<td>Vibrations</td>
<td></td>
</tr>
<tr>
<td>HIV/AIDS</td>
<td></td>
</tr>
<tr>
<td>Others (state…………………………….)</td>
<td></td>
</tr>
</tbody>
</table>

Key: 4 = Very Severe, 3 Severe, 2 = Less Severe, No Effect

13. Were there any settlements on the site currently being used to extract soapstone?

   Yes ☐ No. ☐
14. Kindly tick how soapstone quarrying has affected the following aspects of people’s life.

<table>
<thead>
<tr>
<th>Aspects of Life</th>
<th>Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 3 2 1</td>
</tr>
<tr>
<td>Arable farming</td>
<td></td>
</tr>
<tr>
<td>Livestock farming</td>
<td></td>
</tr>
<tr>
<td>Agro-forestry</td>
<td></td>
</tr>
<tr>
<td>Pottery and basketry</td>
<td></td>
</tr>
<tr>
<td>Formal employment</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>Small scale trades</td>
<td></td>
</tr>
<tr>
<td>Immigrant workers</td>
<td></td>
</tr>
<tr>
<td>Others (state)</td>
<td></td>
</tr>
</tbody>
</table>

Key: 4 = Most Affected, 3 = Affected, 2 = Least Affected, 1 = No effect

32. Have you ever witnessed any cases of accident in the quarries? Yes ☐ No ☐

3. ALTERNATIVE USES OF SOAPSTONE RESIDUES

33. Kindly tick which of the following activities you are involved in.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Tick appropriately</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation of soapstone</td>
<td></td>
</tr>
<tr>
<td>Transportation of rocks</td>
<td></td>
</tr>
<tr>
<td>Carving</td>
<td></td>
</tr>
<tr>
<td>Trade in soapstone artifacts</td>
<td></td>
</tr>
<tr>
<td>Polishing</td>
<td></td>
</tr>
</tbody>
</table>
34. Does your activity involve the production of wastes

Yes ………………………….. No ………………………………

35. If yes what type of waste do you produce? Explain

………………………………………………………………………………………………
………………………………………………………………………………………………

36. Tick appropriately how you dispose of your wastes materials

<table>
<thead>
<tr>
<th>Disposal mechanism</th>
<th>Tick appropriately</th>
</tr>
</thead>
<tbody>
<tr>
<td>Next to carving sites</td>
<td></td>
</tr>
<tr>
<td>Sell to builders</td>
<td></td>
</tr>
<tr>
<td>Damp sites</td>
<td></td>
</tr>
<tr>
<td>Roads</td>
<td></td>
</tr>
<tr>
<td>Grazing fields /farms</td>
<td></td>
</tr>
<tr>
<td>Disused quarries</td>
<td></td>
</tr>
<tr>
<td>Others …………………….</td>
<td></td>
</tr>
</tbody>
</table>

37. In a scale of 5 to 1 rante how effective the following factors are in managing wastes

<table>
<thead>
<tr>
<th>Description</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Entity to manage waste through value addition</td>
<td></td>
</tr>
<tr>
<td>Quarry owners to set aside space for disposal</td>
<td></td>
</tr>
<tr>
<td>Government to start process wastes</td>
<td></td>
</tr>
</tbody>
</table>

*Key 5-Most Effective; 4-Effective; 3-Less Effective; 2-Not Effective; 1-Idont Know*

38. Suggest possible ways through which sopstone residues can be used

………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
39. At what point are the quarries abandoned? Please indicate in the table below.

<table>
<thead>
<tr>
<th>Reason for Abandoning quarries</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soapstone is depleted</td>
<td></td>
</tr>
<tr>
<td>Owners has put it to other use</td>
<td></td>
</tr>
<tr>
<td>Government stopped quarrying</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
</tr>
</tbody>
</table>

40. What alternative use are abandoned quarries put to?

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44. Which of the following ministryes or government department do you directly relate to in your soapstone quarrying activities?

<table>
<thead>
<tr>
<th>Ministry/Department</th>
<th>Tick where appropriate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of mining</td>
<td></td>
</tr>
<tr>
<td>Ministry of environment</td>
<td></td>
</tr>
<tr>
<td>Directorate of mines</td>
<td></td>
</tr>
<tr>
<td>Ministry of water</td>
<td></td>
</tr>
<tr>
<td>Mining corporation of Kenya</td>
<td></td>
</tr>
<tr>
<td>Ministry of agriculture</td>
<td></td>
</tr>
</tbody>
</table>

45. Have you ever met a government officer implementing laws and regulation

Yes ………………. No………………………………..

46. Explain your response above

……………………………………………………………………………………………………………..
…………………………………………………………………………………………………………..

47. In your own opinion, how can the government (county /national) assist in achieving sustainable quarrying activities?

…………………………………………………………………………………………………………..
…………………………………………………………………………………………………………..
…………………………………………………………………………………………………………..

48. How can soapstone workers assist in ensuring sustainable soapstone maining activities?

…………………………………………………………………………………………………………..
…………………………………………………………………………………………………………..
…………………………………………………………………………………………………………..

End
# APPENDIX 2: OBSERVATION RECORD SHEET

<table>
<thead>
<tr>
<th>Type of erosion</th>
<th>Evidence</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet</td>
<td>Tilted utility posts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accumulation silts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Change of water colours in rivers</td>
<td></td>
</tr>
<tr>
<td>Rill</td>
<td>Narrow/ small channels on the slopes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exposed roots</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bare channels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accumulation of silt</td>
<td></td>
</tr>
<tr>
<td>Gulley</td>
<td>Widen deeper troughs along slope</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Steep sided trough with and broad flat floor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accumulation of silt down slope</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 3: INTERVIEW SCHEDULED FOR PROFESSIONALS

Topic: -Effects of soapstone quarrying on geomorphic processes and farming Activities in Tabaka.

Proposed Description of Professionals

i. Agriculturalists
ii. Local surveyors
iii. Geologists
iv. Mineralogists
v. Environmentalists
vi. Trade Office
vii. Sociologist

Material/documents required

a. G.I.S. Topographical, Geological and Geomorphic maps of the area
b. Resources/ land use map
c. Geomorphic information/ map
d. County Integrated Development Plan (CIDP)
e. The mining law, the environmental law

Questions

a) What factors cause/ encourage/accelerate the geomorphic processes around soapstone mining areas.

b) Which type of slope process (s) is/are associated with soapstone mining in Tabaka area?

c) What are the relationships between soapstone mining activities and farming?

d) How has soapstone mining affected farming in the area?

e) What are the alternative uses of soapstone residues over the conventional methods?

f) Which policy framework should be adopted for sustained quarrying activities in the study area?
APPENDIX 4: INFORMATION/ DATA NEEDED

1. Mineral distribution in the area
2. Common geomorphic processes in the area and associated factors that influences their occurrences
3. Environmental effects of soapstone quarrying.
4. Legal framework for the exploitation of soapstone quarrying.
5. Specific strengths and weaknesses of the existing laws that govern the exploitation of soapstone in the area.
6. Current framework/guidelines for the disposal of soapstone residues
7. Land use pattern and trends in Tabaka by acreage
8. What are/ Are there social factors that influence the choice of economic/land use trends in the area?
9. Area in acreage under crop farming and soapstone quarrying.
10. Number of people currently engaged in soapstone quarrying activities.
11. Income trends from soapstone activities.
12. What are the main social effects of soapstone mining?
14. Which alternative usage/how else can soapstone residues be used productively and to safeguard the environment?
15. Suggestions for effective soapstone mining activities in the area.
## APPENDIX 5: PRO-FORMA CHECKLIST

<table>
<thead>
<tr>
<th>Quarry</th>
<th>Slope processes</th>
<th>Physical evidence</th>
<th>Presence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Bomware</td>
<td>Soil erosion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mass movement</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weathering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nyakichenche</td>
<td>Soil erosion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mass wasting</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weathering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nyatike</td>
<td>Soil erosion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mass movement</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weathering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bokimai</td>
<td>Soil erosion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mass movement</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weathering</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
THIS IS TO CERTIFY THAT:

MS. TABITHA TILLI CHEPCHUMBA
of KENYATTA UNIVERSITY, 29454-100
Nairobi, has been permitted to conduct
research in KISII COUNTY

on the topic: EFFECTS OF SOAPSTONE
ACTIVITIES ON GEOMORPHIC AND
SOCIO-ECONOMIC ACTIVITIES IN
TABAKA REGION, KISII COUNTY

for the period ending:
12th November, 2016

Applicant's
Signature

Permit No: RACOST/P/15/83439/039
Date Of Issue: 13th November, 2015
Fee Received: Ksh 1,000

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 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.

RESEARCH CLEARANCE
PERMIT

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CONDITIONS: see back page