ENVIRONMENTAL IMPACTS OF STONE QUARRYING AND THEIR INFLUENCE ON THE WELLBEING OF HOUSEHOLDS IN KHALALEO, MANDERA COUNTY, KENYA

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JUNE 2022

DECLARATION

I declare that this document and the research that it describes is my original work and that it has not been presented in any other university for academic work.

Abdiwahab Madker Maalim.
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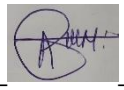
_____  _____ _____10.06.2022___

This research was conducted under our supervision and is submitted with our approval as University supervisors.

Dr. Micky Mwamuye

_____ 10.06.2022 _____

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DEDICATION

I dedicate this study work to my brother; Mohamed Madker, my spouse; Meimuna Sheikh, and workmate Engineer Abdullahi Roble who encouraged me throughout my studies and supported me emotionally and financially.

ACKNOWLEDGMENTS

I acknowledge the supremacy and the divine providence of the Almighty God for enabling me to get this far. I can confidently say that this is a blessing from God almighty. I wish to acknowledge my supervisors, Dr. Micky Mwamuye and Dr. Sharon Jones for their immense support and good guidance all the way to attain success. I do greatly appreciate my family members including my brothers, spouse, friends, workmates, and my line manager for their support during the period of my study.

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ABSTRACT

Stone quarrying along the Daua River in Khalaleo is a big economic activity for the households in the area, the activity has created environmental impacts, which affect the subjective wellbeing of the households. This study sought to investigate the environmental impacts of stone quarrying on household wellbeing, specifically: i) to assess the influence of the impacts of plant diversity loss from stone quarrying on the wellbeing of households within the stone quarrying areas; ii) to determine the influence of pollution impacts from stone quarrying on the wellbeing of households in the stone quarrying areas; iii) to examine the influence of land degradation impacts on the wellbeing of households within the stone quarrying areas; iv) to assess the influence of the impact of water filled quarries on the wellbeing of households found in the stone quarrying areas, and v) to rank the independent variables as to their influence on the wellbeing of households within the stone quarrying areas. A descriptive research study design was adopted for this study. The target population was the households living not more than a kilometer from the stone quarries in Khalaleo. A random sample of 196 households was selected from a sampling frame of 540 households. A researcher administered structured questionnaire was used to collect information from the household heads. The data was analyzed using descriptive (means, median, mode and frequency distribution) and inferential statistics (regression analysis, ANOVA and Chi-square test) at 95 % level of confidence in a Statistical Package for the Social Sciences (IBM SPSS version 26). The wellbeing of the households in the study area was found to be of medium level with a mean of (M= 5.32, SD=3.91) on a scale of 0 to 10. Household wellbeing of the households found in the quarrying areas was negatively influenced by loss of plant diversity ((β=-.422, t=-6.48, p<.001), pollution (β= -.246, t= - 3.542, p<.001), land degradation (β= -.736, t= - 15.149, p<.001), and Water filled quarries (β= -.522, t= - 8.531, p<.001). The wellbeing of the households in the study area can be improved by making use of the water in the quarries for irrigation and other purposes, having mitigation measures for land degradation, plant diversity loss and pollution by planting trees and grass. The findings of this study will be useful in assisting the National and County governments in formulating policies applicable to environmental management of the stone quarrying projects and improvement of the well-being of the people.

DEFINITION OF TERMS

Chronic Cough: A severe cough that lasts for a long time like more than a month (Schmitt, 2018).

Logistics group: A team that transports stones from the mining site to where they are expected or needed.

Community Development Agreements: this is a benefit sharing contract between the community and the investor (O'Faircheallaigh, 2012).

Pollution means any direct or indirect alteration of the physical, thermal, chemical, biological, or radio-active properties of any part of the environment by discharging, emitting, or depositing wastes so as to affect any beneficial use adversely, to cause a condition which is hazardous or potentially (EMCA CAP 387)

Public Complaints Committee: means the Public Complaints Committee established under section 31 (EMCA CAP 387)

Quarrying: The process of extracting materials from underground (Langer, 2001).

Social Impact Assessment: is a process of research, planning and the management of social change or consequences (positive and negative, intended and unintended) arising from policies, plans, developments and projects (Vanclay, 2003).

Tragedy of the Commons: A situation where people tend to use things according to their self-interest which can lead to depletion of resources for the next generations (Hawkshaw et al., 2012).

Subjective well-being: refers to the extent to which a person believes or feels that his or her life is going well and is considered as one of the best available proxies for a broader, more canonical form of well-being (Diener et al., 2018).

ABBREVIATIONS AND ACRONYMS

CDAs Community Development Agreements.

PCC Public Complaints Committee

CDC Centers for Disease Control and Prevention

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This research focused on the assessment of environmental impacts of stone quarrying and their influence on the wellbeing of the households near the quarries along the Daua River in Khalaleo division of Mandera East sub-county, Mandera County.

The study scrutinized the level of environmental impact of stone quarrying on the wellbeing of the households. The study assessed the aspects of the following four (4) environmental impacts, which formed the independent variables, these were: loss of plant diversity, land degradation, air and water pollution and water filled quarries. The dependent variable; the wellbeing of the households was operationalized as an index that combined seven (7) domains and thirty (30) indicators, comprising: improved standard of living (provision of material needs), assistance to good health, safety, Improved Social Relations, spiritual fulfillment, control of the state of the environment, and emotions and affiliations.

This introduction provides the background of the study, statement of the problem, objectives of the research, research questions, and significance of the study, limitations of the study, delimitations of the study, theoretical framework and the conceptual framework of the study.

1.2 Background of the Study

A stone quarry is a place where a dimension stone or aggregate (sand, gravel, and crushed rock) is mined (Chalise, Kumar & Kristiansen, 2019). According to Langer (2001), stone quarrying is the process of extracting stones and other valuable minerals that can be used for construction and other purposes. The products of dimension stone quarries are prismatic blocks of rock such as marble, granite, limestone, sandstone, and

slate. After cutting and polishing, these materials are used in the primary construction of buildings and monuments and also for decorative purposes (Belay et al, 2020). Dimension stones are extracted in a highly selective manner, using time-consuming and expensive methods for freeing the blocks from the surrounding rock. According to USGS, (2006), there are two types of stone quarries, which are; building or dimensional stone quarries and the crushed stone quarries. Building or dimensional stones are used for construction and they are in the form of blocks while crushed stones are rocks that have been broken into small irregular fragments with a certain particle size. They are mostly used in cement industries and even in the construction industry (British Geological Survey, 2020).

The background context of this study has a pro-found foundation from different regions on earth. Stone quarrying is practiced in almost every country in the world. Norway, Germany, USA and UK are amongst the largest world contenders in quarrying output. In the African continent, South Africa tops as the country bearing many registered quarrying sites.

European countries have taken over as the leading giants in quarrying output and related technology. According to the Statista Research Department (2022), Norway leads as the top country with quarrying output; taken to mean, the country's economy is at large supported by quarrying output. According to Heldal and Neeb (2018) more than 5% living in the northern part of the country survive on stone quarrying. Other notable giants in this field include Poland, Germany, Netherlands, United Kingdom, Italy and Sweden (NationMaster.com, 2022).

Africa has also shown great interest in quarrying notwithstanding the effect coming along as its side effects. With the low technology enhancements, the practice of quarrying has become more dangerous in many areas of Africa. According to Lameed & Ayodele (2010). South Africa has more than 500 registered quarries all existing in different regions of the country, quarrying have impacted South Africa in many different ways. Egypt is historically the ancient miners of stones (Hessler, 2016). History bookmarks the country as one of the past miners of stones as well as enterprising in the activity. According to Musah (2009), studies in the Northern Region of Ghana and East Gonja District, show that commercial extraction of sand and gravel causes land degradation and desertification through destruction of economically important trees, mostly the indigenous ones.

Kenya is one of the largest miners in terms of quarrying output (Lameed & Ayodele, 2010). Kitui, Machakos, meru, Makueni, and Isiolo counties leads with many quarrying sites though there's nearly no county which doesn't do stone quarrying (Dianne, Patricia & Alex, 2020). Mandera East has more than fifty quarries, which has led to outsourcing of workers from other counties therefore constituting as a source of employment (Cece, 2020). The Business Daily (2018) illustrated that the stone quarry industry in Mandera East Sub County has created over five thousand (5,000) job opportunities which include the workers at the sites, logistics groups and supports hardware shops and construction industries (Ming'ate. & Mohamed, 2016). Such opportunities dictate the appearance of the mines in different regions of Mandera County.

Basically, the impact of quarrying is evident in different corners of the region. The stone quarrying procedure involves the following steps that have an impact on the environment and hence the society. (i) The process starts with selecting the site, where the rock is nearby or exposed, (ii) the site is then cleared of vegetation and the top soil in order to reach the rock, (iii) this is followed blasting of the rock to produce rock pieces that can be shaped into stones for building. When the quarry-site no longer provides stones, it is abandoned and the workers move to a new site (McCandless & Spirn, 2013). A lot of debris is left on the ground after the stones are transported. According to Sati (2015), operations in stone quarrying, whether small or large-scale, are inherently disruptive to the environment, producing enormous quantities of waste that can have deleterious impacts for decades and that the environmental deterioration caused by stone quarrying occurs mainly as a result of inappropriate and wasteful working practices and lack of rehabilitation measures. Mbandi (2017) found a high association between stone quarrying and environmental degradation in Kitengela Sub-County of Kajiado County.

The long-term effect can be massively negative basing on the “tragedy of common mantra (DiNapoli, Lipo & Hunt, 2021). The space covered can occupy a whole village in the suburbs of America. Such a massive intrusion to land is dangerous and could pose various problems to human beings and animals. It is evident that so much has been displaced to acquire the space. More important is the unhealthy and hazardous conditions displayed when such pits are left uncovered. During rainy seasons, the quarries tend to be a breeding site for mosquitoes (Chepchumba, 2020). However, according to Chepchumba, (2020), who considered research on the mitigation of malaria, the regions surrounding the mining areas in America have shown great

resilience to the fight and eradication of the disease in the region. In other cases, 3 out of 10 deaths occur in the region through quarry eruptions and drowning into the uncovered pools of pit waters (Kiplangat, 2019). As such, the wellbeing of the American people living within those areas is under threat.

It is important to note that many of the problems caused by quarrying are caused by the technical engineering activities during extraction. Noise pollution is one major drawback at the scene and its environments. According to Doetterl et al., (2020), the effect has caused geomorphology and conversion of land use with incumbent effects of and in visual scenes. It has also caused a loss of habitat for ground birds and animals, dust that causes allergic infections, erosion and many other impacts (Moeletsi & Tesfamichael, 2017). Therefore, on the global context, quarrying has immense impacts throughout. In some countries like US, the government has installed bottlenecks to cushion and control the level of quarrying in the country.

Studies have shown that stone quarrying causes environmental impacts, the specific impacts include: biodiversity loss (Lameed & Ayodele, 2010); deforestation (Haule et al., 2016); land cover loss (Akanwa et al., 2017); and environmental pollution (Salem, 2021). These environmental impacts affected the livelihoods of the communities living near the mines negatively and their lives directly (Asante et al., 2014; Chandra, 2015). The communities living around the quarries don’t have power to implement any policies concerning their social lives against the stone extraction, they even do not get job opportunities at the sites because they don’t have good energy to work there (Nyakeniga, 2009).

Mandera residents lack community development agreements (CDAs) in the mining industries, which results in mistreatment of the communities and bad use of the resources. According to O'Faircheallaigh (2012), there is need for CDAs especially in the mining industry where environmental and social costs are often borne by communities while project benefits accrue in national capitals and global financial centers, leading to conflict between local people and miners.

Stone quarrying along the Daua River in Mandera East Sub County are mainly small-scale open cast mines mostly producing building stones and stone aggregates sold locally and exported into neighboring areas. These mines have been shown to affect the environment and in turn the communities living in the area (Ming'ate. & Mohamed, 2016). This degradation specifically includes loss of plant diversity, soil erosion and soil nutrients (Belay et al., 2020). High levels of pollution have been observed and experienced along Daua River due to the quarries and they include; loss of vegetation cover, reduction of biodiversity, flooding, pollution of farms, and destruction of roads (Ming'ate. & Mohamed, 2016). Presence of uncovered quarrying pits has intensified war in the region. Al-Shabaab can use the uncovered pits as a shield and from where they could be launching their guerilla warfare (Kiplangat, 2019). This has put forth questions as to whether or not the mining activities should be continued in the area because it is slowly affecting the social lives of the community, who are afraid of such unprecedented attacks and more harming the environment as a habitat to both human beings and animals.

1.3 Statement of the Problem

Stone quarrying along the River Daua in Mandera East caused negative impacts to the environment in the form of pollution, reduction of biodiversity and land degradation.

Such quarries act as breeding sites for mosquitos especially during the rainy season. According to statistics of malaria affected zones, the area has reported merely the largest population of people especially kids suffering from the disease (Macharia, et al., 2018). Statistics from the above study reveals that more than 38 people are diagnosed with malaria in the region every month. Such data is a threat to the future of the region as quarries in the place keep increasing in number. Other health hazards reported from the area include lung problems resulted by the immense dusts and also other underground gases from the region (Macharia, et al., 2018). Such problems have raised alarms in the area as people plead to the national government for a control of mining. According to Kiplangat (2019), quarrying has impacted the environment through the loss of lives and contamination of resources to those living nearby. This has resulted in health problems arising from air pollution, water borne diseases arising from water filled quarries. Furthermore, livelihoods are affected due to the lack of animal feeds and reduced crop production. At the same time, the quarries have provided shields to the militia groups, where they can hide as they attack the villagers. Loss of lives and depreciation of value for their land, all resulted by the intensified acts of quarrying across Khalaleo area near river Daua. Data available do not show the extent to which quarrying has affected the wellbeing of the Khalaleo people. There is therefore a need to quantify these impacts based on how the communities in the area are affected. The household wellbeing index is designed to assess all aspects of the household and not only the economic ones.

1.4 Purpose of the Study

The purpose of the study was to assess the environmental impacts of stone quarrying on the wellbeing of households found in the stone quarrying areas of Khalaleo in Mandera County, Kenya.

1.5 Objectives of the Study

1.5.1 Broad Objective

The general objective of this study was to assess the environmental impacts of stone quarrying and their influence on the wellbeing of households in Khalaleo, Mandera County, Kenya

1.5.2 Specific Objectives of the Study

The specific objectives of the study are:

(i) To assess influence of the impacts of plant diversity loss from stone quarrying on the wellbeing of households within the stone quarrying areas of Khalaleo in Mandera County

(ii) To determine the influence of pollution impacts from stone quarrying on the wellbeing of households in the stone quarrying areas of Khalaleo in Mandera County

(iii) To examine the influence of land degradation impacts on the wellbeing of households within the stone quarrying areas of Khalaleo in Mandera County

(iv) To assess the influence of the impact of water filled quarries on the wellbeing of households found in the stone quarrying areas of Khalaleo in Mandera County

(v) To rank the independent variables as to their influence on the wellbeing of households within the stone quarrying areas of Khalaleo in Mandera county.

1.6 Research Questions

(i) How do the impacts of plant diversity loss influence the wellbeing of households found in the stone quarrying areas of Khalaleo in Mandera County?

(ii) What are the influences of pollution impacts on the wellbeing of households in the stone quarrying areas of Khalaleo in Mandera County?

(iii) How does land degradation impacts influence the wellbeing of households within the stone quarrying areas of Khalaleo in Mandera County?

(iv) How do water filled quarries influence the wellbeing of households found in the stone quarrying areas of Khalaleo in Mandera County?

(v) How do the four independent variables rank in terms of their influence on the wellbeing of the households found in the stone quarrying areas of Khalaleo in Mandera County?

1.7 Significance of the Study

Research is equally important for social scientists in studying social relationships and seeking answers to various social problems (Kothari, 2004). The study is important to scholars, county and national governments, organizations and even the communities because they will gain knowledge and information on how the stone quarries affect the social lives of the communities. The study has a benefit to the communities because the creation of awareness has been enhanced and people will be conscious of the risks caused by the quarries where solutions can be brought up. There is a great threat especially to the social lives if the study is not done (Lameed & Ayodele, 2010). The communities may suffer silently till their demise comes but if the study is done, a lot will be known and a helping hand will come through to save Mandera East sub-county communities.

1.8 Scope of the Study

The research was carried out along the River Daua, Mandera East Sub County. Data was collected from and the homesteads within a kilometer radius of the stone quarries. This included regions clustered as Bella, Fiqow, Bula Haji and Bur Abor which were included in the sample as areas affected by entire quarrying process. The research

focused on individual household heads perception on environmental impacts and their subjective assessment of their wellbeing. Four independent variables were addressed in this study, they included: plant diversity, pollution, land degradation, and water filled quarries.

1.9 Delimitation of the Study

This study was basically set out to assess the social impacts brought about by stone quarrying on the lives of communities and so the researcher did not focus on those people living more than one kilometer away from the mining areas.

1.10 Limitations of the Study

The researcher required careful knowledge of the area and the community so as to attain unbiased or incorrect and sufficient data. According to Mugenda and Mugenda (2003), a limitation is an aspect of the study that the researcher knows may negatively affect the results or generalization of the results, but over which there is probably no control. The limitation of this study may revolve on insecurity issues where in any case there may be an Al-Shabaab attack or even temporary closure of the stone quarries. To handle this, the researcher consulted with the community leaders. Security in the place was paramount and the clan elder offered two community rangers who escorted us along the river and meeting the homesteads around. The most common limitation was that most of the peoples we interviewed expected an incentive. This was not in our budget but in a way, the researcher had to create a good rapport with the interviewers that aided the whole process.

1.11 Assumptions of the Study

In relation to Mugenda & Mugenda (2003), stated that an assumption is any important fact presumed to be true but not actually verified. Stating assumptions helps the

researcher to justify the study and consequently the findings. One assumption in this study was that the respondents answered the questionnaires in a transparent and truthful manner. There was also an assumption that the area will be peaceful and the target quarries will be operational.

1.12 Theoretical Framework

The study was guided by the General Systems Theory (GST) (Bertalanffy, 1962). The theory was proposed in 1936 by the biologist Ludwig von Bertalanffy, and further developed by Ross Ashby. Systems theory is the interdisciplinary study of systems, which are cohesive groups of interrelated, interdependent parts that can be natural or human-made. Every system is bounded by space and time, influenced by its environment, defined by its structure and purpose, and expressed through its functioning. A system may be more than the sum of its parts if it expresses synergy or emergent behavior (Figure 1.1) (Bertalanffy, 1968; Skyttner, 2001).

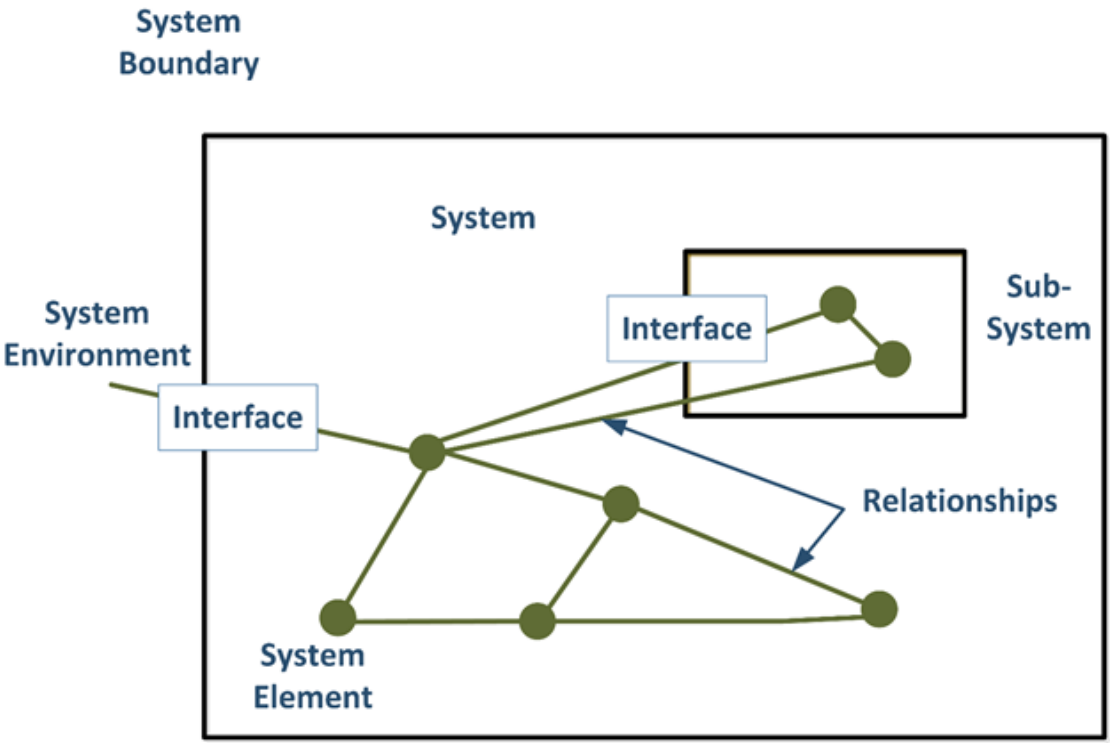

Figure 1.1: Model of a system
Source: Bertalanffy (1962)

Changing one part of a system may affect other parts or the whole system. It may be possible to predict these changes in patterns of behavior. For systems that learn and adapt, the growth and the degree of adaptation depend upon how well the system is engaged with its environment. Some systems support other systems, maintaining the other system to prevent failure. The goals of systems theory are to model a system's dynamics, constraints, conditions, and to elucidate principles (such as purpose, measure, methods, tools) that can be discerned and applied to other systems at every level of nesting, and in a wide range of fields for achieving optimized equifinality (Jørgensen, 2020).

Systems can be found in nature, in science, in society, in an economic context, and within information systems. A distinctive characteristic of systems theories is that it developed simultaneously across various disciplines and that scholars working from a systems theory perspective build on the knowledge and concepts developed within other disciplines (Mele, Pels, & Polese, 2010). Examples include natural and ecological sciences (organic aspects, homeostasis and equifinality), chemical and biological disciplines (autopoietic aspects), sociology and psychology (cognitive aspects), and information technology (cybernetic aspects). As a result, today we have several kinds of systems perspectives. There are service systems (from Service Science, Management, Engineering and Design - SSMED), viable systems (from Viable Systems Approach - VSA), smart systems (from systems thinking), reticular systems (from network theories), living systems (from natural sciences), economic systems (from economics), social systems (from sociology), institutional systems (from law), technological systems (from cybernetics), conceptual systems (from psychology), and ecosystems (from ecology) (Mele et al., 2010).

Systems ecology is an interdisciplinary field of ecology that takes a holistic approach to the study of ecological systems, especially ecosystems. Central to the systems ecology approach is the idea that an ecosystem is a complex system exhibiting emergent properties. Systems ecology focuses on interactions and transactions within and between biological and ecological systems, and is especially concerned with the way the functioning of ecosystems can be influenced by human interventions. It uses and extends concepts from thermodynamics and develops other macroscopic descriptions of complex systems (Jørgensen, 2020; Montague, 2014).

The general systems theory was found to be applicable to this study in that the environment is taken as a system with many elements in terms of resources (Evans, et al., 2013). Stone quarrying activities are processes of extracting resources that affect the environment. The interference of the environment leads to positive and negative effects. This relationship can be moderated by science and technology together with laws and regulations. All these elements work together to ensure environmental sustainability as depicted in Figure 1.2.

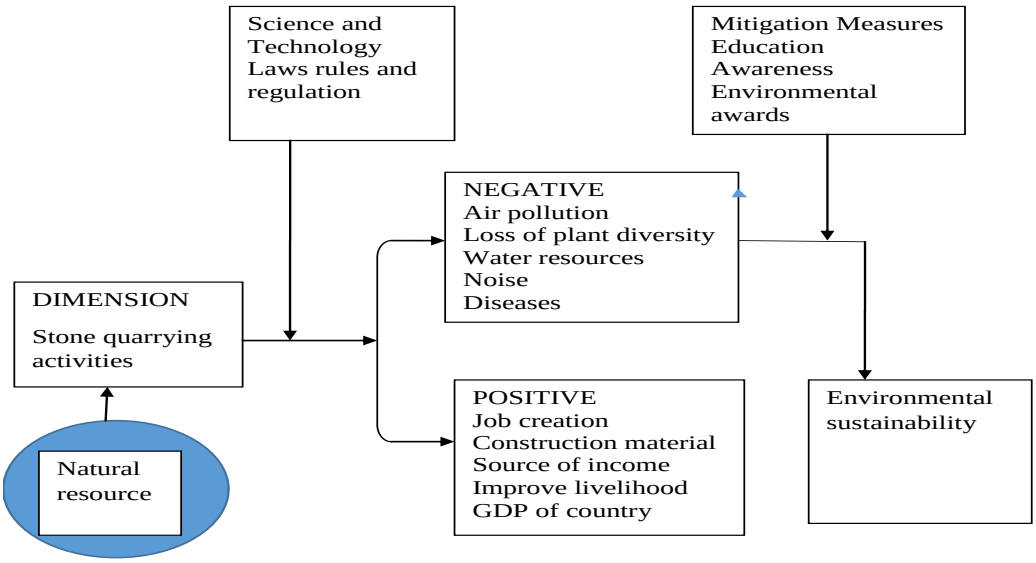

Figure 1.2: A modified General System Theory model explaining impacts of stone mining (Source; Bertalanffy, 1962)

Systems theory advanced by Bertalanffy in 1950 and which anchors this research describes nature as an intricate arrangement of society and science and that they are interdependent to attain a shared purpose which gives it a description (Hofkirchner, 2019). According to Berta.lanffy's concept, geology have a network of systems and that modification of any causes a change of the whole set. In the context of this study, environment is perceived as a complete set up made up of biophysical elements reliant on each other, both living and non-living such that alteration of any will have a trickle-down effect on any one or more subsets thus ultimately interfering with the functioning of the entire system. The physical environment such as land as in the case of this study is under immense exploitation pressure to the extent that human, animal and plant lives have been endangered (Schäffler & Swilling, 2013).

Bertalanffy, (1950) reiterated that good systems interrelate with their surroundings unreservedly and that they can subjectively gain new properties. Based on this theory, degradation is theorized as an output of stone mining which upsets the physical and

biological subsets of the whole environmental unit. Stone quarrying is a system that involves the physical and biological dimensions with both positive and negative outputs as shown in Figure 1.2. The negative outputs of this system have an effect on the biological component of the system (people and plants) which was the main focus of this study, how the quarrying affects the wellbeing of the people.

1.13 Conceptual Framework

The conceptual framework (Figure 1.3) depicts the influence of environmental impacts on the wellbeing of the households found near the stone quarries in Khalaleo Mandera County. There are four environmental impacts that have been identified for this study, they include loss of plant diversity, air and water pollution, land degradation, and water filled quarries of abandoned quarries. The dependent variable is the wellbeing of the households and the intervening variable was land use policies.

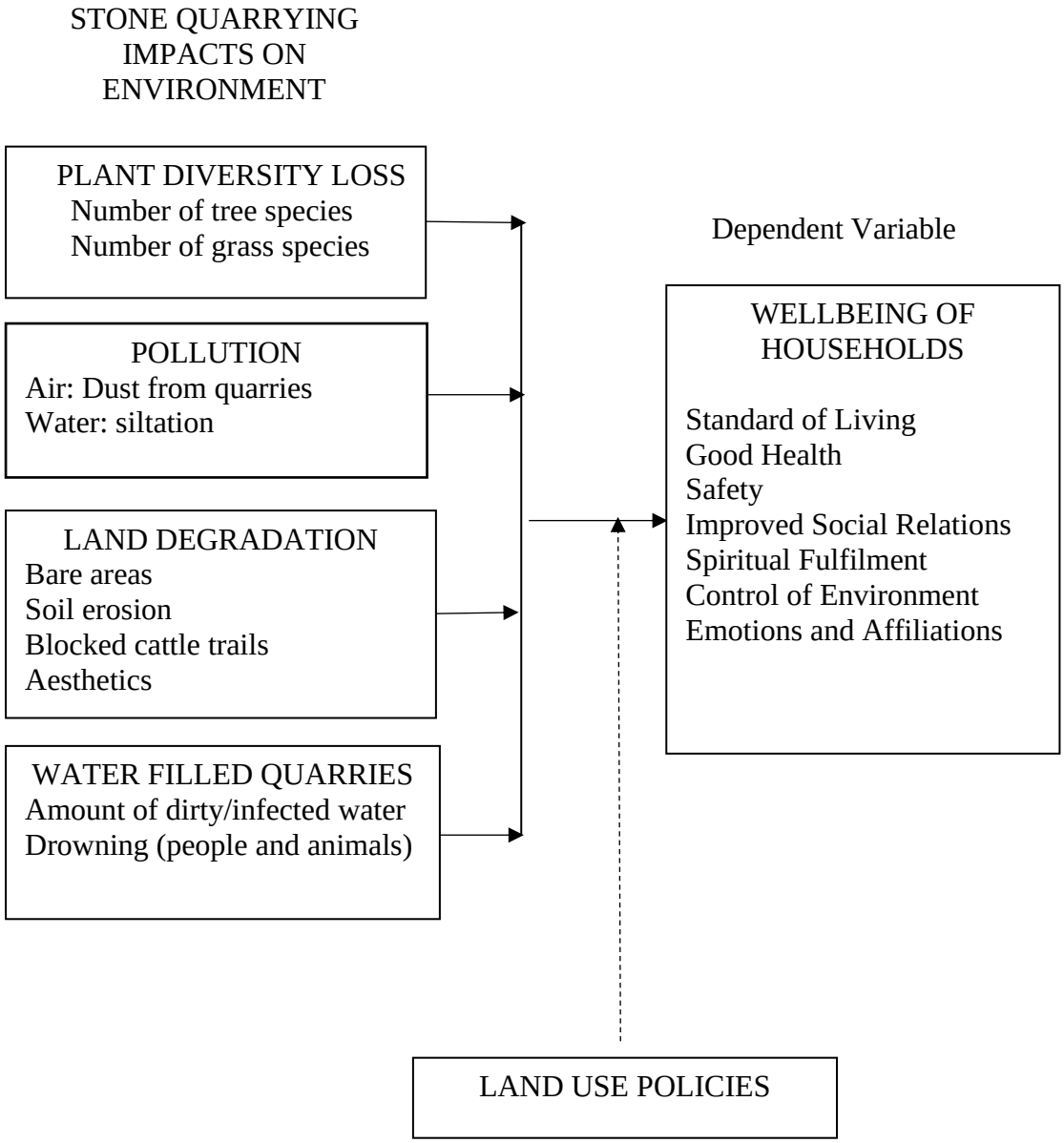

Figure 1.3: Conceptual framework showing the influence of environmental impacts of stone quarrying on the wellbeing of the households in Khalaleo, Mandera County. (Source researcher, 2022)

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter lays out the independent and dependent variables, knowledge gap and the summary. It shows the extent of literature on this research captures the uniqueness of the study under consideration. The purpose of this study was to drive the specific issue that would influence the phenomenon under research and hence establish the basis upon which the research would be initiated. The chapter consists of reviews which were reviewed for the purpose of the influence of stone quarries on social lives living along river Daua in Mandera East, Kenya.

2.2 Social Impact Assessment

This is a process that determines the effects experienced by the communities regarding their welfare. In connection to the well-being of Mandera East communities, it is the high time to assess and evaluate what they experience and go through. According to Sincovich *et al.* (2018), mining industries form good economic pillars to countries but recently, it's the time when social impacts have started receiving attention therefore, the excavation industries are required to consider how they affect local communities and implement strategies to minimize negative impacts they may be causing. Akanwa *et al*. (2016), illustrated that quarry activities are well known to cause land loss, pollution and are a threat to surface water which directly impair environmental quality and ecosystem. When water is affected due to quarrying, the effects are contagious and spread to the animals that are dependent on the same water. Fish and domestic animals are destabilized causing cause death to these animals too (Nyakeniga, 2009). At the same time, the amount of water in the rivers is not only reduced, and are more silted the livelihood of the people around such places is also affected.

Consequently, crop production and animal's dependent on the same water will be affected. Such effects are voluminous and may cause a discomfort to the people, who are directly dependent to the respective animals (Kalu & Ogbonna, 2021). Therefore, the dirt and chemicals from the quarries are exposed to the land where farming is practiced and along the river Daua which in-turn affects the wellbeing of the Khalaleo people.

2.2.1 Safety

There are many safety issues that are associated with quarry activities. Physical injury is a common ailment and a health hazard posed in quarrying areas. An overview of accident statistics in Finland, Norway and Sweden placed 300 cases yearly from which over half have led to 0-3 day's absence from work amoung people miners or people who live around mining areas (Reiman. N.d.). The statistics further indicated most these accidents were related to movement around or during manual work as safety becomes more challenging(Qudah *et al.* ,2014) .

Whereas Adams, (2013) reported 10%-20% injury cases among mine workers in India, Wormald et al. *(*2015) demonstrated in a separate study using repeat slit lamp examination that eye injuries of study group reduced by 6% thereby giving an emphasis on the prominence of utilizing protective apparels. Whereas this might be common knowledge, cases have been cited where mining staff deliberately ignore this safety measure.

There have been cases of insecurity and injuries from people falling into the deep quarry pits. Chepchumba, (2020) fears that quarry workers are at a risk of at only falling into the pits but also inhaling emitted dust which is injurious to their health and can cause

severe health problems including respiratory and pulmonary problems, while dust deposition causes skin and eye problems. Chepchumba, (2020), articulates that there are the tiny solid or liquid particles that are suspended in air during quarrying and which are usually invisible to the naked eyes and they may include; smoke, ash from fuel, dust, soot and smoke. These particulates can cause eye problems and can cause serious skin damage.

2.2.2 Water Borne Diseases

Still waters from quarry hole are breeding areas for waterborne diseases; malaria, bilharzia, dysentery, cholera and hepatitis are amongst the diseases that will attack people in areas with patches of stagnant (Hatami, 2013). Women and children are highly vulnerable to most of water-borne diseases which may be fatal if unchecked and treated early enough. This has put the communities in fear especially during rainy seasons (Cissé, 2019).

According to Imbahale *et al.* (2011), Colombia's gold mining sites have become mosquito breeding zones whereby there is a great diversity of Anopheles mosquitoes, several of which are either confirmed or suspected malaria vectors. The condition has led to a surge in waterborne related disease symptoms by the people living around.

The pool of water formed from quarry sites is a challenge in the control of water bone diseases and malaria. CDC (2018), reported that *Anopheles* mosquito breeds in numerous small pools of water that form due to rainfall. The larvae develop within a few days, escaping their aquatic environment before it dries out. It is difficult, if not impossible, to predict when and where the breeding sites will form and how to treat

them before the adults emerge. In relation to that, owing to lack of good health facilities, prevention measures, ignorance, workers migration from traditionally malaria prone area is related to the new type of malaria in traditionally none malaria areas.

2.2.3 Other Health Effects from Stone Quarries

Nartey *et al.* (2012) made an assessment of some communities who had raised alarm over the quarry dust menace, and using non affected as a control, the affected community exhibited signs of respiratory, ear infections, eye infections and malaria, thought to be as a result of pits providing conducive habits for breeding of mosquitoes.

While it is difficult to measure the extent to which quarry activities may affect livelihoods and overall wellbeing of people who live around such places, the effect are known. Wangela, (2019), agreed that it is difficult to medically prove the association of certain mine induced illnesses and diseases as the unorganized sector of laborers keep shifting from one quarry to another and therefore, they are rarely unavailable for long term studies. However, Henry, et al. (2017), noted that mine related diseases are common especially to the new entrants of the job. They will experience major tissue damage that will be painful for a short time or persist depending on the level of work/activity.

While Ilyas *et al*. (2010) established that dust related problems were exacerbated by cases of owners of the crushing stone unit not providing appropriate measures to protect the workers and residents, the challenges associated with dust from quarry cannot be over-emphasized. Sebaiwa, (2016) also established that a very high degree of respiratory morbidity is associated with the stone mining industry whereby fine rocks and mineral dust of many kinds are cancer-causing when inhaled which is a great threat

to the well-being of people. The statement might be true because there are some cases of lung cancer in the study area which might have risen due to the quarrying impacts.

2.3 Land Degradation

Aheebwa, (2020), states that land is very vital to all human beings as it is used for production and wealth. From the Holy book, God instructed man to cultivate the ground and make plenty of food which can be done for commercial purposes (Ziggler, 2020). When the land or soil gets polluted, it means that what man will harvest, will be intoxicated which will not only be unhealthy to the body but also will be less productive (Bakamwesiga, et al., 2021). The land along Daua River in Mandera is degraded due to stone harvesting, this has been caused by leaving open quarries which makes the land ugly hence losing its aesthetic value. Lorries which are used for logistics destroy the roads and lead to soil erosion, (Chalise, Kumar, & Kristiansen, 2019).

A study by Ming'ate, & Mohamed, (2016), states that Mandera County is slowly losing its biodiversity to stone quarries whereby hills have been destroyed and trees are cut down to give space for the quarries. Biodiversity defines all species in a certain ecosystem and they all depend on one another in one way or another. An example is when bees are destroyed, it would mean that there will be food insecurity to both humans and animals which will lead to death.

In most cases, land degradation and pollution are influenced by human activities. Loss of biodiversity from human disturbances tends to be more severe and long-lasting (John, 2019). When human activities are experienced, the same people find it hard to do rehabilitation as the cost of doing so is not borne by them, this is a classic example

of the tragedy of the commons. Tragedy of the commons is a situation explained by Garret Hardin in 1968 in his thesis the tragedy of the unmanaged commons, where resources owned jointly or in a group (the commons) are misused as the people look to exploit the resources for themselves without caring for the consequences of their action on the condition of the resources (Hawkshaw et al., 2012). Hardin, used the grazing areas that were owned communally or the commons where he showed that there was a tendency of the people to increase the number of their herds at the expense of the pastures as the animals were owned by individually, while the land on which the pastures grew were owned communally leading to overgrazing of the commons. Tragedy of the commons makes the state of losing biodiversity and the ecological value to be severe because of the need and want to grow economically.

Mbandi, (2017), argues that by cutting down of trees and destruction of wildlife habitat, the change of climate has started to be experienced in Mandera County as in some other parts of the North Eastern of Kenya. This has degraded the land as it is also losing its aesthetic value. Climate change is also characterized by reduced quantity of rains and increasingly dry seasons. Such weather conditions do not support agriculture and may contribute to prolonged droughts. Drought and scorching sun are a blow to the wellbeing of human beings as they try to look for means for survival.

Pollution has been noticed especially from the farms along River Daua where people aren’t harvesting their products such as sorghum as they used to do in the olden days when stone mining was not in the area. The clear waters of the river are now gone and the color is different, brown in color which means that sanitation is poor and there are risks. John (2019), noted that pollution is the addition of any substance or any form of

energy to the environment at a faster rate than it can be dispersed, diluted, decomposed, recycled or stored in some harmless form which leads to biodiversity loss by creating health problems in exposed organisms.

In their study, Sayara et al. (2016), noted that during excavation period, dust is produced which moves and settles on plants, land and even on water surface thus causing negative impacts to the ecosystem. Stone slates which are chopped when shaping the harvested stones flow into river tributaries or the main river which leads to corruption of the whole water. This can also lead to blockage of the tributaries or the river if they are of high quantity therefore leading to massive flooding.

Mining of stone and other quarry activities sometimes alter not only the landscape but also, the lives of the people who live in these areas permanently. The communities living next to natural resources end up not benefitting from the use of the natural resource directly and end up living miserable lives. This is the situation among the community living within the quarry areas, they end up experiencing the negative impacts of quarrying, while the County, the owners of the quarries and National governments end up receiving all the income from this operation (Bondo, 2006). This is also the case in other areas, such as in the oil mining in Turkana (Nyamai, 2019).

2.3.1 Landscape Rehabilitation

Land rehabilitation, includes physical restoration of the altered land and reversal of the damages done to the environment. These activities for restoring land back to its natural state after it has been degraded or damaged for future use making it safe for humans, livestock, wildlife and even flora to survive well include: enhance soil vitality, enhance

soil depth, enhance rainwater infiltration and percolation, enhance soil and plant moisture, minimizes water loss through evaporation, improves the soil as a footing medium and lastly, it eliminates the impacts of toxicity, salinity and sodic (Kenton, 2018).

In Mandera East Sub County, the land that was initially used for grazing land which is currently being forgotten as people have gone into excavation and apart from landscape alterations, the land has also become dry which means it's hard for the livestock to get their fodder easily. Because of these physical alterations of the landscape, many livestock have drowned in the quarry zones especially during rainy seasons while others have died of starvation especially in the harsh seasons (Elmustafa and Mujtaba, 2019).

2.4 Human Health Effects from Stone Quarries

The health of people is very vital and it counts a lot in boosting the economy of a country. According to World Health Organization (WHO, 2005), "human health is strongly linked to the health of the ecosystems, which meet many of our most critical needs." Plants are harvested and used for medicinal purposes but if they are all destroyed, lives will always be in danger of extinction. Both workers and neighbors to stone quarries are at risk of being unhealthy which at long term, may lead to poverty since there is insufficient manpower to generate income at family and community level. This also leads to over dependence of the possible incomes which are generated therefore causing scarcity of resources. Amongst the health hazards manifested under such quarrying conditioned environment are; physical injuries, respiratory illnesses and diseases, and waterborne diseases (WHO, 2005).

In a study by Ilyas et al. (2010), they established that dust related problems were exacerbated by cases of owners of the crushing stone unit not providing appropriate measures to protect the workers. This case is similar to what is happening in Mandera in that the quarry workers are not provided with health insurance by their employers

People around Daua River and those working in the quarries have always had illnesses and complications (Ming'ate & Mohamed, 2016). However, as Wangela, (2019) observes, it is difficult to medically prove the association of certain mine induced illnesses and diseases as the unorganized sector of laborers keep shifting from one quarry to another and therefore, they are rarely unavailable for long term studies. The industry owners always hide the true health conditions of their workers and attribute their diseases to addiction to smoking and alcoholism (Ming'ate & Mohamed, 2016).

Social lives of people around Daua River and those working in the quarries have always had illnesses and complications (Barnes, 2014). Generally, they always cough due to the stone dust. It is well known that dust related diseases which can be observed include; asthma, chest pains, common cold, headache, pneumonia and even eye infection. The dust is as a result of the drilling, crushing, cutting, crushing and transportation on the roads. According to Chepchumba, (2020), quarry workers are at a risk of inhaling emitted dust which is injurious to their health and can cause severe health problems including respiratory and pulmonary problems, while dust deposition causes skin and eye problems. This researcher, articulates that there are the tiny solid or liquid particles that are suspended in air during quarrying and which are usually invisible to the naked eyes and they may include; smoke, ash from fuel, dust, soot and smoke. These particulates are can cause eye problems and can affect the skin badly.

The prevalence of quarrying associated ailments have been noticed in many places. A review by Ugbogu, *et al.* (2019), studied the occurrence of respiratory and skin problems among manual stone workers and found out that up to 85% of the workers had respiratory symptoms while 77% had skin infection. The study also observed that although there was a high level of awareness of the effect of dust on their health, use of protective clothing and gear was not popular. Likewise, in Mandera East Sub County stone quarries where there is always suspicion of respiratory diseases only that the infected workers get weak and never return back to share their results. Skin problems have been observed where the skin looks to be pale though not painful to the victims, Ugbogu, et al. (2019).

Another worry is the water in quarries, especially during rainy seasons which leads to a breeding zone for mosquitoes causing the spread of Malaria. Women and children are highly vulnerable to the disease and they easily develop other complications (Vlassoff, 2007). This has put the communities in fear especially when it is almost the rainy season and unfortunately, there is no good hospital nearby where one can be admitted and treated in the best manner. Rendering to Imbahale et al. (2011), Colombia's gold mining sites have become mosquito breeding zones whereby there is a great diversity of Anopheles mosquitoes, several of which are either confirmed or suspected malaria vectors. This helps the calculation of malaria disease as the mosquitoes breed in a great variety of different conditions and adapt to local environmental characteristics such as altitude, climate, rainfall intensity (which influences larval abundance) and land use which may create temporary or permanent man-made habitats in open sky quarries.

Centers for Disease Control and Prevention (2018), reported that Anopheles mosquito breeds in numerous small pools of water that form due to rainfall. The larvae develop within a few days, escaping their aquatic environment before it dries out. It is difficult, if not impossible, to predict when and where the breeding sites will form and how to treat them before the adults emerge. In relation to that, owing lack of good health facilities, prevention measures and ignorance, workers migrate and make movements to other locations, which causes a higher spread of the malaria disease in other regions.

Sebaiwa, (2016), proved that a very high degree of respiratory morbidity is associated with the stone mining industry whereby fine rocks and mineral dust of many kinds are cancer-causing when inhaled which is a great threat to the well-being of people. The statement might be true because there are some cases of cancer in the study area which might have risen due to the quarrying impacts.

2.4.1 Stone Excavation and its Implications on Health

Crystalline silica is considered an abundant mineral forming a significant proportion of the earth's extracted materials and it is associated with respiratory disease called silicosis (Hoy & Chambers, 2020). Horwell et al. (2012) reports that Reparable Crystalline Silica (RCS) jeopardizes state of the human wellbeing, a fact reiterated by National Institute for Occupational Health (Esswein, et aI., 2013). In 1987, International Agency for Research on Cancer (IARC) branded Silicon dioxide as a plausible cancer-causing agent (Borm et al., 2011) but until 1997 that Silicon dioxide was termed Group 1 cancer-causing agent (Borm et al., 2011). Powders of iron, zinc, cadmium ions, and barium ions, among other minerals, cause pneumoconiosis and skin dermatoses in Nigeria through inhalation of dust. Additionally, Physical injuries have been similarly reported by Aliyu & Shehu, (2007) whose study testified 68.9% cases of

stone injuries and cuts also in Nigeria. To reduce such incidences, Adams *et al.* (2013) recommends education on safety and wearing safety clothing.

An overview of accident statistics in Finland, Norway and Sweden placed 300 cases yearly from which over half have led to 0-3 days absence from work (Reiman. n.d.). The statistics further indicated most accidents were related to movement and manual work, and as Qudah, *et al.*(2014) confirms, accidents happen because of safety, ignorance or negligence in work places. Ersoy, (2013) in a study on 10 marble quarries in Turkey also established an inverse relationship between safety indexes and hazards reported in stone mining sites.

Whereas Adams, (2013) reported 10%-20% injury cases among mine workers in India, Wormald *et aI.(*2015) demonstrated in a separate study using repeat slit lamp examination that eye injuries of study group reduced by 6% thereby giving an emphasis on the prominence of utilizing protective apparels. Whereas this might be common knowledge, cases have been cited where employees deliberately ignore this safety measure. Nartey *et al.* (2012) made an assessment of some communities who had raised alarm over the quarry dust menace, and using non affected as a control, the affected community exhibited signs of respiratory, ear infections, eye infections and malaria, thought to be as a result of pits providing conducive habits for breeding of mosquitoes.

2.5 Environmental Rehabilitation

Most of the time, environmental rehabilitation is done to rectify man-made processes and problems which may include; construction, mining, drilling, farming, deforestation, pollution and on the other hand to rectify natural disasters like fires, flooding, earthquakes and others, (Coratza et all., 2018). It is evident that after stone harvesting from the quarries, the sites are abandoned while still open which is risky for the wildlife, livestock and humans (Ming'ate, & Mohamed, 2016). When doing excavation from the hills and land, fertile soils are dislocated and interrupted, then after excavation the pits are left unfilled which leaves the land hollow and ugly which is never impressive. This lowers the aesthetic value of the land and its fertility, thus productivity of the land goes down hindering agricultural activities from taking place, (Elmustafa and Mujtaba, 2019).

Rehabilitation of the land is done to enhance soil vitality, enhance soil depth, enhance rainwater infiltration and percolation, enhance soil and plant moisture, minimizes water loss through evaporation, improves the soil as a footing medium and lastly, it eliminates the impacts of toxicity, salinity and sodic (Ming'ate & Mohamed, 2016). According to (Will Kenton, 2018), land rehabilitation can be explained as the process of restoring land back to its natural state after it has been degraded or damaged which in future makes it safe for humans, livestock, wildlife and even flora to survive well.

It is evident that, for mining to take place, trees and vegetation cover are cleared and burned down to give space for excavation which is termed as an economical income facility by the government and interested parties. Most of the land in Mandera East Sub County has been lost to mining which does not earn an equal share or income to the

community members but it brings negative impacts to the social lives (Chepkenen, 2020). It would be good to assume that the residents or government will steer the idea for backfilling and rehabilitating the location as others will be reclaiming lost land, Redondo-Vega, (2017).

Rehabilitation of mining site is expensive because the depth of the quarry has to be backfilled with materials that cannot submerge easily and now that the rocks are already harvested, it would mean looking for other alternatives or materials to backfill (Chepkenen, 2020). These materials will be transported to the site and the process is done using heavy machines like tractors to ensure the land is compatible and can be used on a natural basis. Some of the practices done here may include; removal of man-made structures, toxins and other dangerous substances from the site, improving soil conditions and doing re-afforestation or adding new flora to the land (Ming'ate, and Mohamed, 2016)

2.6 Loss of Plant Diversity

Loss of biodiversity from human disturbances tends to be more severe and long-lasting (John, 2019). When human activities are experienced, the same people find it hard to do rehabilitation as the cost of doing so is not borne by them, this is a classic example of the tragedy of the commons.

Mbandi, (2017), argues that by cutting down of trees and destruction of wildlife habitat, change of climate has started to be experienced in Mandera County as in some other parts of the North Eastern of Kenya. This has degraded the land as it is also losing its aesthetic value. Climate change is also characterized by reduced quantity of rains and increasingly dry seasons. Such weather conditions do not support agriculture and may

contribute to prolonged droughts (Ogalleh, et al., 2012). Drought and scorching sun are a blow to the wellbeing of human beings as they try to look for means for survival.

It is evident that, for mining and activities such as quarry to take place, trees and vegetation cover are cleared and burned down to give space for excavation which is termed as an economical income facility by the government and interested parties. Most of the land in Mandera has been lost to mining which does not earn an equal share or income to the community members but it brings negative impacts to the social lives. It would be good to assume that the residents or government will steer the idea for backfilling and rehabilitating the location as others will be reclaiming lost land (Redondo-Vega, 2017).

2.7 Air and Water Pollution

Quarrying remnants are fine sand, chemicals used in bursting stones and dust. Such unwanted pollutants may be swept to the nearest river, which is a source of water for the people. The pollutants are hazardous to human being and animals that are dependent on the river or flawing waters. With such contaminations, the risk of spreading contagious diseases such as cholera, dysentery and typhoid is high (Asante, et al. 2014).

The pollution that is increasingly spreading across the Khalaleo and Mandera in general is not only limited to human health but a big threat to the wellbeing of the people as it affects the crop production too (Ali, 2021). Dust coupled with scorching sun is a big threat to crop production. At the same time, it causes ailments to both crops and human beings. Pneumoconiosis is one disease related to Asthma and caused by dust (Schenker, 2010). Such conditions are not good for farming and may cause crop reduction. Moreso, the clear waters of river Daua has turned out to be black and seemingly fungal infested. John (2019), noted that pollution is the addition of any substance or any form of energy

to the environment at a faster rate than it can be dispersed, diluted, decomposed, recycled or stored in some harmless form which leads to biodiversity loss by creating health problems in exposed organisms.

In their study, Sayara, Hamdan, and Basheer-Salimia (2016), note that, during the excavation period, dust is produced which moves and settles on plants, land and even on water surface thus causing negative impacts to the ecosystem. Stone slates which are chopped when shaping the harvested stones flow into river tributaries or the main river which leads to corruption of the whole water (Abate, 2016). This can also lead to blockage of the tributaries or the river if they are of high quantity therefore leading to massive flooding (Ali, 2021).

2.8 Knowledge Gap

The studies undertaken to assess the impacts of stone quarrying in this country have majored on looking at the impacts at the environment level, that is the physical and biological aspects and the economic conditions of the quarrying industry (Akanwa et al., 2017; Haule et al., 2016; Lameed & Ayodele, 2010; Salem, 2021). However, these environmental impacts also have an effect on the people and their livelihoods (Asante et al., 2014; Chandra, 2015). Few studies have looked at how the environmental impacts affect the wellbeing of the people, especially in the proposed study area. The wellbeing concept looks at the totality of the households, by including variables such as standard of living, environmental, health, spiritual, emotions and affiliations. This concept will provide a much deeper understanding of the problem as it affects the households. The research gap addressed in this study relates to location and objectives. These have not been undertaken in this area, which places this research as unique, Al-Otaibi, (2018).

2.9 Summary

The literature review shows that impacts of stone quarrying on the environment are well known and documented both locally and internationally. These environmental impacts have a negative effect on the society at the household and community levels. The quantification of these impacts have been done on specific aspects of the community such as: effects: on livelihoods, incomes, provision of work and health. But the problem of stone quarrying goes beyond these few aspects as it affects the totality of the households having impacts on animals, people and their economies. The communities living in Khalaleo, Mandera County may be aware of the problem but the government may not be aware of the magnitude of the problem at the household level. This study provides the missing information and enhance the knowledge on how the impacts can be mitigated both at the household and government levels.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter unfolds through eight sections. The next section describes the research design and the justification for the chosen research design. The description of the research site precedes the target population, which is followed by the study sample. Data collection appears in the sixth section while the seventh section outlines data processing and analysis. The final section provides the legal and ethical considerations of the research.

3.2 Research Design

The study adopted a descriptive research design (Mishra & Alok, 2017). Descriptive studies result in the formulation of important principles of knowledge and solutions to significant problems. The descriptive survey design uses both quantitative and qualitative research design to portray any conceivable conduct, dispositions, qualities and attributes.

Quantitative method that involves collecting data from various sizable proportions by use of questionnaires and interviews that helps in achieving the results of the set objectives of the study was used. Kombo and Tromp (2006) define a research design as the structure of the research. It is the ‘glue’ that holds all of the elements in a research project together. A design was used to structure the research, to show how all of the major parts of the research study work together and try to address the research questions. Questionnaires were administered to the interviewees majorly in Fiqow, Bur Abor, Bulla Haji and Bela villages which have an ongoing and recent quarrying.

3.3 Research Site

The study was conducted in households found near the stone quarries located along the Daua River in Khalaleo division. The division is located in Mandera East sub-county, which is one of the nine (9) sub counties in Mandera County in the North Eastern tip of Kenya (Figure 3.1). The sub counties are: Mandera West, Mandera South, Mandera North, Mandera East, Kutulo, Kiliwihiri, Arabia, Banisa, and Lafey.

The County is characterized by low lying rocky hills located on the plains that rise gradually from 400 meters above sea level in the south at Elwak to 970 meters above sea level on the border with Ethiopia (Lameed & Ayodele, 2010). The rest of topography is low lying, characterized by sparse vegetation with thorny shrubs of savannah type. This is especially found along foots of isolated hills, where it is characterized by bushes, shrubs, boulders and occasionally the invasive bush *Prosopis juliflora* locally known as ‘Mathenge’(Aburo, 2017). The flat plains make drainage to be very poor, causing floods during heavy rains. There are no lakes, swamps or dams but earth pans are a common feature in the county.

River Daua covers a distance of approximately 150 Km along the Kenya border with Ethiopia and is a major source of water used in irrigated agriculture. The river has its source in the Ethiopian highlands and flows eastwards along the border through Malkamari, Rhamu Dimtu, Rhamu, Liberia, Khalaleo and Township wards into Somalia at Border Point One (BP1). The research study site was Khalaleo division, along River Daua in Mandera East constituency (Figure 3.1).

Figure 3.1: Mandera County Khalaleo Divison Aerial View. The location of Khalaleo division; Fiqow, Bella, Bur Abor and Bulla Haji.
Source; Google Map (2022)

Figure 3.2: Location of Mandera County in Kenya

Source; (KNBS, 2019).

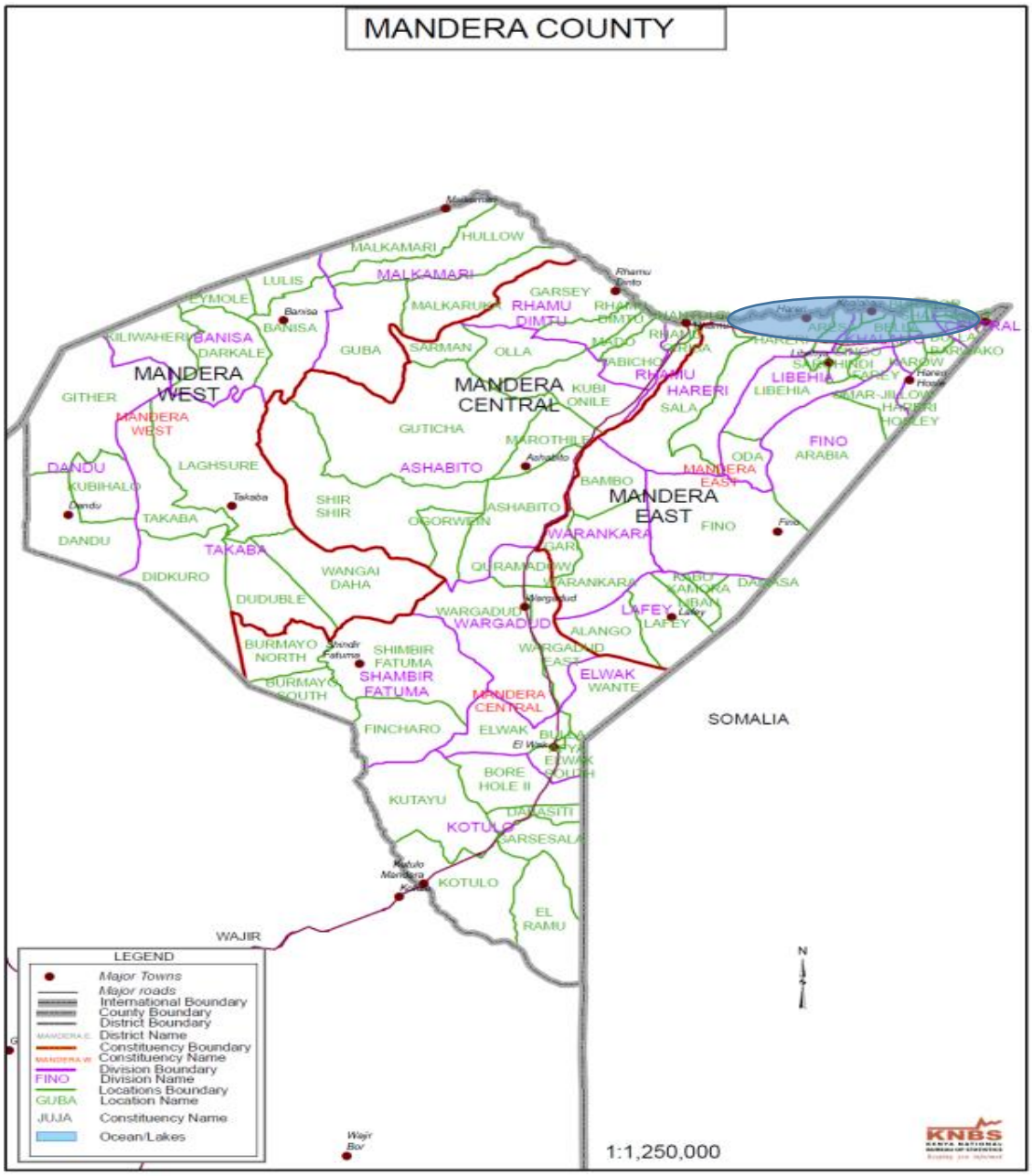

Figure 3.3**:** Mandera County Map. The location of Khalaleo division is indicated by the area covered by the blue circle.

Source; (KNBS, 2019).

3.4 Target Population

The target population for this study was the households in Khalaleo division of Mandera East sub-county, which has an area of 499.9 Km2 with a population of 17,737 people and 2,674 households. The population density is 35 persons per square km. The

households in Khalaleo location found near stone quarries along the Daua River formed the sampling frame and are estimated to be 540 households (KNBS, 2019).

3.5 Study Sample

A sample is a selected set of participants from a population, which adequately represents the population from which it was drawn and therefore true inferences about the population can be made from the results obtained (Mukherjee, 2019).

3.5.1 Study Sample Size

The households found near the stone quarries along the Daua River formed the sampling frame. The sampling frame was composed of 540 households. The following formula by Nassiuma (2000) was used to come up with appropriate sample size for the study:

$$n = \frac{NC^2}{C^2 + (N-1)e^2}$$

Where:

n= the required sample size

N= the population within the study area (540)

C= Coefficient of Variation (0.21)

e= Standard error (0.02)

In most surveys or experiments, a coefficient of variation is in the range of 21%≤ C ≤ 30% and a standard error in the range of 2% ≤ e ≤ 5% is usually acceptable (Nassiuma, 2000). Therefore, a coefficient of variation of 21% and a standard error of 2% was preferred for this study. The lower limit for coefficient of variation and standard error were selected so as to ensure low variability in the sample and minimize the degree of error.

$$n = \frac{540 * (0.21)^2}{(0.21)^2 + (540 - 1)(0.02)^2}$$

For this study *n* = 196.

Based on the population of the area and the formula the required sample size was 196 households. The households in the clusters below were proportionally distributed (Table 3.1) according to the households in the clusters, where active quarrying was ongoing.

Table 3.1: Households Study Sample Size

Cluster	Number of Households	Calculations	Sample size
Fiqow	133	(133/780)*196	33
Bur Abor	440	(440/780)*196	111
Bulla Haji	54	(54/780)*196	14
Bela	153	153/780*196	38
Total	**780**		**196**

Source; (KNBS, 2019).

3.5.2 Sampling Procedure

A Simple random sampling procedure was used to select the households sampled for this study. The households located near the stone quarries (not more than 1,000 meters from the quarries) along the Daua River formed the sampling frame. The households in the sampling frame, were listed and given numbers. The numbers were used to select the households at random using a table of random numbers. The table was used to select the numbers of the houses to be interviewed and the numbers were then matched with the houses.

3.6 Data Collection

This section explains the process that was used to collect data from the household heads. This is a systematic process of gathering observations or measurements on the qualitative and quantitative information of the study variables. During the process care was taken as described by Tan (2018) to collect good, clean, consistent and reliable data that enable the evaluation of the outcome (Tan, 2018).

3.6.1 Data Collection Instruments

A researcher-administered structured questionnaire was used to collect information from the household heads within the study area. The questionnaire (Appendix B) is divided into six (6) sections: section one (i) has questions related to the characteristics of the respondents; section two (ii) has questions on the dependent variable, wellbeing of the households, the third (iii) section has questions related to the first independent variable, Plant diversity, the fourth (iv) section has questions on pollution, the fifth (v) section has questions on land degradation, the sixth (vi) section has questions on water filled quarries. The well-being of the households was operationalized as an index, which combined the subjective rating by the household heads on the wellbeing variables. The household heads assessed this index using a 10-point rating scale, where I indicated extremely low levels of wellbeing and 10=extremely high level of wellbeing.

3.6.2 Pilot Testing of Research Instruments

Pilot-testing involves trying out a questionnaire on a small group of individuals to get an idea of how they react to it before the final version is created (Creswell, 2014). A pilot-test was conducted on 19 households in the study area but the data was not used in the final analysis but were used by the researcher to fine-tune the questionnaire for objectivity and efficiency of the process.

3.6.3 Instrument Reliability

Instrument Reliability is defined as the extent to which an instrument consistently measures what it is supposed to measure. Reliability concerns the degree to which the scores are free from random measurement errors. Cronbach's alpha was used to estimate the internal consistency of multi-item indicators by determining how items of the instrument are related to each other and to the entire instrument. A Cronbach's alpha of 0.7 was taken to be enough to confirm whether the variables were reliable (Sekaran & Bougie, 2009). Field (2009) argues that a Cronbach's alpha value equal or greater than 0.5 is regarded to be an indication of reliability. Therefore, the study considered coefficient alpha greater than 0.6 to indicate the reliability of the research instrument.

3.6.4 Instrument Validity

The content validity was established during wide reading, discussions and deliberations with peers, and colleagues in the University. The experts were consulted to provide guidance on the content of the instruments; to ensure that all the research objectives were addressed by the questions or information sought in the instruments. The manner of construction of the instrument was checked to ensure that the questions were not misinterpreted and only relevant information was obtained. The findings from the pre-test study was used to improve on the instrument, thus enhancing their validity. This approach is supported by Mugenda and Mugenda (2003).

3.6.5 Data Collection Procedure

The study employed the use of questionnaires as the main tool for data collection, the researcher then recruited enumerators who were then trained on ethics and procedures prior to being assigned to the households they were to interview. The enumerators were

then trained and given questionnaires to interview the household heads, who went into each of the households.

3.7 Data Analysis

Quantitative data collected was cleaned then entered, verified and coded for analysis. Statistical Package for Social Sciences (SPSS) v.26 was employed during the analysis of data. The data was analyzed using descriptive and inferential statistics. Descriptive statistics was used to establish the extent to which variables influenced each other while inferential statistics was used to establish the relationship between the variables under study. Specifically, frequencies, percentages, mean, and standard deviation was used as the descriptive statistics while ANOVA and regression analysis was used as the inferential statistics. Regression analysis was used to determine any existing relationships between dependent and independent variables, the associations were considered significant at a significance level of $p < 0.05$ (Mugenda & Mugenda, 1999).

The multiple regression model used was the following;

$$Y_1 = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + e$$

$$HW = \beta_0 + \beta_1 LA_1 + \beta_2 DPD_2 + \beta_3 LD_3 + \beta_4 AWC_4 + \acute{\varepsilon}$$

Where: HW = Household Wellbeing in Khalaleo, Mandera East Sub-County

LA, DPD, LD and AWC = Independent Variables

LA= Landscape Alteration

DPD = Destruction of Plant Biodiversity

LD = Land Degradation

AWC = Air and Water Contamination

$\acute{\varepsilon}$.= Error Term

$B_1 \ldots B_4$= Regression co-efficient of four variables

3.8 Legal and Ethical Considerations

Considering laws and ethics of people, participants of the research were respected and gave information in a voluntary manner. Gatara (2010) defined ethical issues in research to mean the “moral principles” or behavioral codes regarding the respect of the rights of the research participants by the researcher. The researcher avoided making up other data than those obtained from the field activities. All works cited in the study were given appropriate credit and referenced. The researcher acquired all legal documentation needed to carry out research in Kenya and submitted the same where necessary. The researcher maintained objectivity in all the phases of the study in order to get accurate and reliable data. Finally, upon completion of the study, the researcher shared the research findings with the relevant users who may be interested in utilizing the research findings.

A letter of approval of the research was obtained from Africa Nazarene University (ANU). A research permit was obtained from the National Commission for Science, Technology and Innovation (NACOSTI) to conduct the research. The researcher informed the members of the Nyumba Kumi initiative in the field for permission to visit the households.

Table 3.2: Summary of Data Analysis and Statistical Tools

Objectives	Variables	Method of Data Analysis
(i) To assess influence of the impacts of plant diversity loss from stone quarrying on the wellbeing of households within the stone quarrying areas of Khalaleo in Mandera County	Independent variable: impact of plant diversity loss Dependent: wellbeing of households	Descriptive statistics Regression, ANOVA
(ii) To determine the influence of pollution impacts from stone quarrying on the wellbeing of households in the stone quarrying areas of Khalaleo in Mandera County,	Independent variable: pollution impacts Dependent: wellbeing of households in stone quarrying areas	Descriptive statistics Regression, ANOVA
(iii)To examine the influence of land degradation impacts on the wellbeing of households within the stone quarrying areas of Khalaleo in Mandera County	Independent variable: land degradation Dependent: wellbeing households in stone quarrying areas	Descriptive statistics Regression, ANOVA
(iv)To assess the influence of the impact of water filled quarries on the wellbeing of households found in the stone quarrying areas of Khalaleo in Mandera County	Independent variable: water filled quarries Dependent variable: wellbeing of households	Descriptive statistics Regression, ANOVA
(v) To rank the independent variables as to their influence on the wellbeing of households within the stone quarrying areas of Khalaleo in Mandera county.	4 independent variables Wellbeing of the households	Descriptive statistics Regression, ANOVA

CHAPTER FOUR

RESULTS AND FINDINGS

4.1 Introduction

This chapter presents the results of the data analysis of the study. The chapter is divided into the following sections: (i) characteristics of the participants, (ii) wellbeing of the households in the stone quarrying areas, (iii) influence of the impacts of plant diversity loss on the wellbeing of households, (iv) influence of pollution impacts on the wellbeing of households, (v) influence of land degradation on the wellbeing of the households, (vi) influence of water filled quarries on the wellbeing of the households, (vii) ranking of independent variables in terms of their influence on the dependent variable.

4.2 Participants Socioeconomic Characteristics

The socioeconomic characteristics of the participants for this study are presented in the following sections: sex of participants, age distribution of participants, marital status, formal education, household number, household source of livelihoods, and Number of years living in the study area.

4.2.1 Sex of the Participants

The participants' sex was noted and the frequency distribution was calculated and presented in Table 4.1.

Table 4.1: Sex Distribution of the Participants

Sex of Participants	Frequency	Percent
Male	156	79.6
Female	40	20.4
Total	**196**	**100.0**

The male participants formed the largest portion of the sample (79.6 %).

4.2.2 Age Distribution of the Participants

The participants were asked to state their ages and the information was considered into five categories and is presented in Table 4.2.

Table 4.2: Age Distribution of the Participants

Age Categories	Frequency	Percent
Below 30 years	12	6.1
Between 31-40 years	14	7.1
Between 41-50 years	107	54.6
Between 51-60 years	37	18.9
Above 61 years	26	13.3
Total	**196**	**100.0**

The participants below the age of 40 years formed 13.2 %, while those above 61years were 13.3 % and the highest category was the group between 41 and 50 years (54.6 %).

4.2.3 Marital Status of the Participants

The participants were asked to state their marital status and the data was analyzed and presented in Table 4.3.

Table 4.3: Marital Status

Marital Status	Frequency	Percent
Single	40	20.4
Married	81	41.3
Divorced	47	24.0
Widowed	28	14.3
Total	**196**	**100.0**

The married participants formed the largest group (41.3 %) followed by the divorced group (24 %), single (20.4 %) and finally the widowed (14.3 %).

4.2.4 Level of Formal Education

The highest level of formal education attained by the participants was analyzed and the frequency distribution is presented in Table 4.4.

Table 4.4: Level of Formal Education Attained by the Participants

Level of Formal Education	Frequency	Percent
Illiterate	98	50.0
Primary-Level	46	23.5
Secondary - Level	24	12.2
Middle Level College	21	10.7
Bachelors Level	6	3.1
Post Graduate Level	1	0.5
Total	**196**	**100.0**

Six levels of formal education were identified among the participants. The highest category was the illiterate group (50.0 %) followed by those that had attained the primary level of formal education (23.5 %), secondary level (12.2 %), middle-level College 10.7 %, bachelors level (3.1 %) and finally the post graduate level (0.5 %).

4.2.5 Household Number

The participants were asked to state the number of people living in their households and the information was analyzed in terms of the frequency distribution and descriptive statistics and presented in Table 4.5.

Table 4.5: Number of People Living in the House

Categories	**Frequency**	**Percent**
2-4	18	9.1
5-7	38	19.4
8-10	40	20.4
Above 11	100	50.5
Total	**196**	**100.0**

Mean 8, Median 10, Mode 10, Std. Dev 2, Minimum 2, and Maximum 12

The mean number of people living in the household was found to be (M=8, SD=2) and the maximum number was found to be 12. The majority (50.5 %) of the households were found to have household numbers of above 11.

4.2.6 Household Source of Livelihood

The participants were asked to state their main source of livelihood. The data was analyzed and the frequency distribution is presented in Table 4.6.

Table 4.6: Sources of Livelihood of the Participants

Livelihood Source	**Frequency**	**Percent**
Pastoralism	65	33.2
Agro-pastoralism	46	23.5
Crop farming	31	15.8
Quarry worker	24	12.2
Formal employment	16	8.2
Business	14	7.1
Total	**196**	**100.0**

Six different sources of livelihoods undertaken by the participants were identified. Pastoralism was highly (33.2 %) selected in the stone quarrying areas, followed by

agro-pastoralism (23.5 %), crop farming (15.8 %), working in stone quarrying (12.2 %), formal employment (8.2 %), and finally business (7.1 %).

4.2.7 Number of Years in the Study Area

The number of years the participants had lived in the stone quarrying area was analyzed and the frequency distribution and descriptive statistics are presented in Table 4.7.

Table 4.7: Number of Years Living in Study Area

Categories (Years)	Frequency	Percent
1-4	45	22.9
5-8	50	25.6
9-12	58	29.6
13-16	28	14.4
Above 17	15	7.5
Total	**196**	**100.0**

Mean 8.87±.412, Median 9. Mode 11, Std. Dev 5.77, Minimum 2, Maximum 34

The mean number of years the participants had lived in the stone quarrying areas was (M=8.87, SD=5.77) years. The minimum time period lived was 2 years and the maximum was 34 years.

4.3 Wellbeing of Households Affected by Stone Quarrying

The dependent variable for this study, wellbeing of households influenced by stone quarrying was developed as an index based on 30 variable items categorized into seven domains as follows: standard of living, good health, safety, improved social relations, spiritual fulfilment, controlling the state of environment, emotions and affiliations. The participants were requested to rate the variables on a scale of 0-10 (0=very low and 10 extremely high). The ratings for each household were then added together and averaged to form the wellbeing index. The descriptive statistics of all the variables are shown in

Appendix C, while the descriptive statistics for the seven domains are shown in Table 4.8.

Table 4.8: Descriptive Statistics for the Wellbeing Domains and Index

Domains of Wellbeing	Mean	SD	Minimum	Maximum	Alpha
Standard of living	5.03	.475	3.88	5.00	.910
Good Health	5.32	.685	4.17	7.00	.692
Safety	5.10	.759	3.50	6.25	.942
Improved Relations	4.88	.627	4.00	6.00	.792
Spiritual Fulfilment	4.75	.780	3.67	7.00	.847
State of Environment	4.91	.458	4.33	6.11	.826
Emotions and Affiliations	4.92	.317	4.17	6.00	.725
Wellbeing Index	**5.31**	**.814**	**3.91**	**8.85**	**.821**

The wellbeing index was then categorized into ten (10) categories and the domain with the highest mean was good health (M=5.32, SD= .685). The Chi-square test for the equality of the means was performed on the distribution of the index categories and the results are presented in Table 4.9.

Table 4.9: Chi-square Test for the Equality of Categories of the Wellbeing Index

Index Categories	Observed N	Expected N	Residual	Statistics
3.01-4 (Low)	139	65.3	73.7	χ^2=147.74
4.01-5 (Medium)	56	65.3	-9.3	*df*=2
5.01-6 (High)	1	65.3	-64.3	*p*=,001
Total	196			

The chi-square test indicates that the majority of the participants' household wellbeing scores were in the category of low level (score of 3.01-4), which had the highest residual

value. The chi-square test returned a statistically significant value (χ^2 147.74, *df* 2, *p* .001) meaning that the differences within the categories were true differences and did not occur by chance.

4.4 Influence of Impact of Plant Diversity Loss on the Wellbeing of Households

The first objective of this study was to determine the influence of the impact of plant diversity loss on the wellbeing of the households found in the stone quarrying areas of Khalaleo in Madera County.

4.4.1 Impact of Plant Diversity Loss

The independent variable impact of plant diversity loss was determined as an index involving the number of tree and grass species existing in the quarrying areas of Khalaleo. The participants were asked to rate the variable based on the indicators of loss of plant diversity in the area due to stone quarrying. The rating was based on a scale of 0-10 (0 being no impact and 10 the highest impact). The descriptive statistics for the indicator are shown in Table 4.10.

Table 4.10: Descriptive Statistics for the Indicators of Plant Diversity Loss

No	Rating of Indicators for Plant Diversity Loss	Mean	SD
1	Rating on the loss of grass species due to stone quarry mining	7.3	1.16
2	Rating on the loss of tree species due to stone quarry mining	6.2	1.03
3	Rating on the increase in bare areas in the area	7.5	1.15

The scores for the three indicators were added and averaged for each of the households and the frequency distribution and descriptive statistics are presented in Table 4.11.

Table 4.11: Frequency Distribution and Descriptive Statistics of the Index of Plant Diversity Loss

Index Categories	Frequency	Percent
4.01-5	7	3.6
5.01-6	8	4.1
6.01-7	89	45.4
7.01-8	80	40.8
9.01-10	12	6.1
Total	**196**	**100.0**

Mean 7.1±.06, median 7, Mode 6.3, Std. Dev .869, Minimum 5, Maximum 10

The impact of plant diversity loss was found to be (M=7.1, SD= .86) on a scale of 1-10. The households that scored highly (above 6) the impact of plant loss were found to be the majority (92.3 %).

A chi-square test for the equality of the categories for the impact of plant diversity loss was performed and the results are presented in Table 4.12.

Table 4.12: Chi-square Test for the Equality of Categories for the Impact of Plant Diversity Loss

Index Categories	Observed N	Expected N	Residual	Statistics
4.01-5	7	32.7	-25.7	χ^2=249.04
5.01-6	8	32.7	-24.7	*df*=5
6.01-7	89	32.7	56.3	*p*=.001
7.01-8	80	32.7	47.3	
9.01-10	10	32.7	-22.7	
10.00	2	32.7	-30.7	
Total	196			

The Chi-square test revealed a statistical ($p<.001$) significant differences among the different categories of the Plant diversity impact. The category between 6.01 and 7 was

significantly (χ^2= 249.04, *df* = 5, *p*< .001) higher than the other categories, indicating that the majority of the households found plant diversity impacts to be high.

4.4.2 Influence of Plant Diversity Loss on the Wellbeing of Households

The first research question for this study, sought to answer the question how the impacts of plant diversity loss influenced the wellbeing of households in the quarrying areas of Khalaleo in Mandera County. This question was answered by testing the relationship between the impact of plant diversity loss (independent variable) and the wellbeing of the households (dependent variable) using bivariate linear regression analysis. The results of the regression model are shown in Table 4.13.

Table 4.13: Regression Model Summary for Plant Diversity Impact and Wellbeing of Households in Quarrying Areas

R	R Square	Adjusted R Square	Std. Error of the Estimate
.422[a]	.178	.174	.74013

The regression model indicates an adjusted R^2 value of 0.174, meaning that the independent variable, plant diversity impact explained approximately 17.4 % of the variation in the dependent variable wellbeing of households in the quarrying areas. The *F* test for the fit of the regression model is shown in the ANOVA Table 4.14.

Table 4.14: ANOVA Table for the Regression Testing the Fit of the Model

	Sum of Squares	df	Mean Square	*F*	*p.*
Regression	23.049	1	23.049	42.077	.001
Residual	106.271	194	.548		
Total	129.320	195			

The fit of the overall regression model was found to be significant (F (1, 194) =42.07, p <. 001). The regression coefficients of the model showing the *beta,* and *t* statistics are shown in Table 4.15.

Table 4.15: Regression Coefficients for Impact of Plant Diversity Loss and Wellbeing of Households

	Unstandardized Coefficients		Standardized Coefficients		
	B	**Std. Error**	**Beta**	***t***	***p***
(Constant)	8.130	.437		18.593	.001
Plant Diversity	-.395	.061	-.422	-6.487	.001

The regression analysis (Table 4.15) shows that the impacts of plant diversity loss significantly influenced (β=-.422, t=-6.48, p<.001) negatively the wellbeing of the households in the quarrying areas of Khalaleo. This indicates that as the impact of plant diversity loss increased, the wellbeing of the households decreased.

4.5 Influence of Pollution Impacts on the Wellbeing of Households in Stone Quarrying Areas

The second objective of this study was to determine the influence of increased pollution due to quarrying on the wellbeing of the households found in Khalaleo in Madera County.

4.5.1 Impacts of Increased Pollution due to Stone Quarrying

The independent variable pollution was based on the participants rating of the pollution caused by stone quarrying on the land and water resources in the study area. The participants were asked to rate the variable based on the indicators of increased pollution in the area due to stone quarrying. The rating was based on a scale of 0-10 (0

being no impact and 10 the highest impact). The descriptive statistics for the indicator are shown in Table 4.16.

Table 4.16: Descriptive Statics of the Rating of Pollution by the Participants

No	Rating of Indicators for Pollution	Mean	SD
1	Increase in dust due to quarries	7.0	1.21
2	Increase in dust all over the area and houses	7.5	133
3	Dust on vegetation (grass)	7.3	1.15
4	Dust on vegetation (woody plants)	6.9	1.00
5	Increase in noise pollution due to quarrying	7.4	1.21
6	Increase in soil erosion	7.0	1.18
7	Irrigation canal silting and blockage	7.4	1.11

The scores for each indicator by a household were added and then averaged to form the impact of pollution on the land and water resources. The frequency distribution of the index and descriptive statistics are shown in Table 4.17.

Table 4.17: Frequency Distribution and Descriptive Statistics of the Index of Pollution Impacts

Index Categories	Frequency	Percent
6.01-7	33	16.8
7.01-8	110	56.1
9.01-10	53	27.0
Total	**196**	**100.0**

Mean 7.7±.05, Median 7.6, Mode 9, Std. Dev.756, Minimum 6.5, Maximum 9.

The impact of pollution from stone quarrying was found to be (M=7.7, SD= .75) on a scale of 1-10. The households that scored very highly (above 7) the impact of pollution were found to be the majority (83.1 %).

A chi-square test for the equality of the categories for the impact of pollution was performed and the results are presented in Table 4.18.

Table 4.18: Chi-square Test for the Equality of Categories for the Impact of Pollution from Stone Quarrying

Index Categories	Observed N	Expected N	Residual	Statistics
6.01-7	33	65.3	-32.3	χ^2= 48.86
7.01-8	110	65.3	44.7	*df*=2
9.01-10	53	65.3	-12.3	*p*=.001
Total	196			

The Chi-square test (Table 4.18) revealed a statistical (p<.001) significant differences among the different categories of the pollution impact. The category between 7.01 and 8 was significantly (χ^2= 48.86, df = 2, p< .001) higher than the other categories, indicating that the majority of the households found pollution impacts to be very high.

4.5.2 Influence of Pollution Impacts on the Wellbeing of the Households

The second research question for this study, sought to answer the question how the impacts of pollution from stone quarrying influenced the wellbeing of households in the quarrying areas of Khalaleo in Mandera County. This question was answered by testing the relationship between the impact of pollution (independent variable) and the wellbeing of the households (dependent variable) using the simple linear regression analysis. The results of the regression model are shown in Table 4.19.

Table 4.19: Regression Model Summary for Pollution Impact and Wellbeing of Households in Quarrying Areas

R	R Square	Adjusted R Square	Std. Error of the Estimate
.246[a]	.161	.156	.79126

The regression model indicates an adjusted R^2 value of 0.156, meaning that the independent variable, pollution impact explained approximately 15.6 % of the variation in the dependent variable wellbeing of households in the quarrying areas. The *F* test for the fit of the regression model is shown in the ANOVA Table 4.20.

Table 4.20: ANOVA Table for the Regression Testing the Fit of the Model

	Sum of Squares	*df*	Mean Square	*F*	*p.*
Regression	7.857	1	7.857	12.549	.001
Residual	121.463	194	.626		
Total	129.320	195			

The fit of the overall regression model (Table 4.20) was found to be significant (*F* (1, 7.857) =12.54, *p* <. 001). The regression coefficients of the model showing the *beta,* and *t* statistics are shown in Table 4.21.

Table 4.21: Regression Coefficients for Impact of Pollution and Wellbeing of Households in Stone Quarrying Areas

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	*t*	*p*
(Constant)	7.366	.582		12.657	.001
Pollution	-.265	.075	-.246	-3.542	.001

The regression analysis (Table 4.21) shows that the impacts of pollution significantly influenced (β= -.246, *t*= - 3.542, *p*<.001) negatively the wellbeing of the households in

the quarrying areas of Khalaleo. This indicates that as the impact of pollution increased, the wellbeing of the households was affected negatively or reduced.

4.7 Influence of Land Degradation Impacts on the Wellbeing of the Households in Stone Quarrying Areas

The third objective of this study was to assess the influence of land degradation impacts from stone quarrying on the wellbeing of households in Khalaleo, Mandera County.

4.7.1 Land Degradation Impacts from Stone Quarrying

The independent variable land degradation was based on the participants rating of the degradation caused by stone quarrying on the natural resources in the study area. The participants were asked to rate the variable based on the indicators of increased land degradation in the area due to stone quarrying. The rating was based on a scale of 0-10 (0 being no impact and 10 being the highest impact). The descriptive statistics for the indicator are shown in Table 4.22.

Table 4.22: Descriptive Statistics of the Rating for Land Degradation Indicators

No	Rating of Indicators for Land Degradation	Mean	SD
1	Change due to increased quarry pits	8.1	1.55
2	Changes due to increased large stones	7.7	1.20
3	Change due to increased small stones	7.5	1.43
4	Change due to erosion features on the landscape	7.9	1.56
5	Aesthetics: change into desert conditions	8.2	1.55

The scores for each household were added and then averaged to form the impact of land degradation of the natural resources. The frequency distribution of the index and descriptive statistics are shown in Table 4.23.

Table 4.23: Frequency Distribution and Descriptive Statistics of the Index of Land Degradation Impact

Index Categories	Frequency	Percent
3.01-4	1	.5
4.01-5	8	4.1
5.01-6	5	2.6
6.01-7	20	10.2
7.01-8	91	46.4
9.01-10	52	26.5
10.00	19	9.7
Total	196	100.0

Mean 7.7± .07, Median 7.9, Mode 7.2, Std. Dev 1.03, Minimum 4, Maximum 10

The impact of land degradation from stone quarrying was found to be (M=7.7, SD= .07) on a scale of 1-10. The households that scored very highly (above 7) the impact of land degradation were found to be the majority (82.6 %).

A chi-square test for the equality of the categories for the impact of land degradation was performed and the results are presented in Table 4.24.

Table 4.24: Chi-square Test for the Equality of Categories for the Impact of Land Degradation from Stone Quarrying

Index Categories	Observed N	Expected N	Residual	Statistics
3.01-4	1	28.0	-27.0	χ^2=226.71
4.01-5	8	28.0	-20.0	*df*=6
5.01-6	5	28.0	-23.0	*p*<.001
6.01-7	20	28.0	-8.0	
7.01-8	91	28.0	63.0	
9.01-10	52	28.0	24.0	
10.00	19	28.0	-9.0	
Total	196			

The Chi-square test (Table 4.24) revealed a statistical (p<.001) significant differences among the different categories of the land degradation impact. The category between 7.01 and 8 was significantly (χ^2= 226.7, df = 6, p< .001) higher than the other categories, indicating that the majority of the households found land degradation impacts to be very high.

4.7.2 Influence of Land Degradation Impacts on the Wellbeing of Households

The third research question for this study, sought to answer the question how the impacts of land degradation from stone quarrying influenced the wellbeing of households in the quarrying areas of Khalaleo in Mandera County. This question was answered by testing the relationship between the impact of land degradation (independent variable) and the wellbeing of the households (dependent variable) using the bivariate linear regression analysis. The results of the regression model summary are shown in Table 4.25.

Table 4.25: Regression Model Summary for Land Degradation Impact and the Wellbeing of Households in Quarrying Areas

R	R Square	Adjusted R Square	Std. Error of the Estimate
.736[a]	.542	.540	.55260

The regression model indicates an adjusted R^2 value of 0.540, meaning that the independent variable, land degradation impact explained approximately 54 % of the variation in the dependent variable wellbeing of households in the quarrying areas. The F test for the fit of the regression model is shown in the ANOVA Table 4.26.

Table 4.26: ANOVA Table for the Regression Testing the Fit of the Model

	Sum of Squares	*df*	Mean Square	*F*	*p*
Regression	70.079	1	70.079	229.490	.001
Residual	59.241	194	.305		
Total	129.320	195			

The fit of the overall regression model (Table 4.26) was found to be significant (F (1, 194) =229.49, p <. 001). The regression coefficients of the model showing the *beta,* and *t* statistics are shown in Table 4.27.

Table 4.27: Regression Coefficients for Impact of Land Degradation and Wellbeing of Households in Stone Quarrying Areas

	Unstandardized Coefficients		Standardized Coefficients		
	B	**Std. Error**	**Beta**	***t***	***p***
(Constant)	9.812	.300		32.758	.001
Land Degradation	-.578	.038	-.736	-15.149	.001

The regression analysis (Table 4.27) shows that the impacts of land degradation significantly influenced (β= -.736, t= - 15.149, p<.001) negatively the wellbeing of the households in the quarrying areas of Khalaleo. This indicates that as the impact of land degradation increased, the wellbeing of the households was significantly reduced.

4.8 Influence of Water Filled Quarries on the Wellbeing of the Households

The fourth objective of this study was to assess the influence of water filled quarries from stone quarrying on the wellbeing of households in Khalaleo, Mandera County.

4.8.1 Impacts of Water Filled Quarries

The independent variable water filled quarries was based on the participants rating of the impact the water filled quarries caused by stone quarrying on the wellbeing of the

households in the study area. The participants were asked to rate the variable based on the indicators of increased water filled quarries in the area due to stone quarrying. The rating was based on a scale of 0-10 (0 being no impact and 10 the highest impact). The descriptive statistics for the indicator are shown in Table 4.28.

Table 4.28 Descriptive Statistics of the Rating for Water Filled Quarries' Indicators

No	Rating of Indicators for Water Filled Quarries	Mean	SD
1	Water quarries existing in the area	8.6	1.27
2	Increase in mosquitoes due to quarries	7.6	1.34
3	Increase in bilharzia	7.5	1.43
4	Increase in smelly quarry water	7.7	1.58
5	Increase in wastewater	8.2	1.55
6	Flooding in open quarries	8.3	1.25
7	Blockage of streams leading to the river	7.5	1.39
8	Ponds, lakes and dirty water	7.9	1.51

The scores for each household were added and then averaged to form the impact of water filled quarries on the wellbeing of the households. The frequency distribution of the index and descriptive statistics are shown in Table 4.29.

Table 4.29: Frequency Distribution and Descriptive Statistics of the Index of Impact of Water filled Quarries

Categories for the Index	Frequency	Percent
5.01-6	11	5.6
6.01-7	9	4.6
7.01-8	99	50.5
9.01-10	58	29.6
10.00	19	9.7
Total	**196**	**100.0**

Mean 7.9±.06. Median 7.8, Mode 7.8, Std. Dev .822, Minimum 5, Maximum 10

The impact of water filled quarries from stone quarrying was found to be (M=7.9, SD= .822) on a scale of 1-10. The households that scored very highly (above 7) the impact of water filled quarries were found to be the majority (90.5 %).

A chi-square test for the equality of the categories for the impact of water filled quarries was performed and the results are presented in Table 4.30.

Table 4.30: Chi-square Test for the Equality of Categories for the Impact of Water filled Quarries

Index Categories	Observed N	Expected N	Residual	Statistics
5.01-6	11	39.2	-28.2	χ^2=154.20
6.01-7	9	39.2	-30.2	df=4
7.01-8	99	39.2	59.8	P<.001
9.01-10	58	39.2	18.8	
10.00	19	39.2	-20.2	
Total	196			

The Chi-square test (Table 4.30) revealed a statistical (p<.001) significant differences among the different categories of the impact of water filled quarries. The category between 7.01 and 8 was significantly (χ^2= 154.20, df = 4, p< .001) higher than the other categories, indicating that the majority of the households found impacts of water filled quarries to be very high.

4.8.2 Influence of Water filled Quarries on the Wellbeing of the Households

The fourth research question for this study, sought to answer the question how the impacts of water filled quarries impacts influenced the wellbeing of households in the quarrying areas of Khalaleo in Mandera County. This question was answered by testing

the relationship between the impact of water filled quarries (independent variable) and the wellbeing of the households (dependent variable) using the simple linear regression analysis. The results of the regression model summary are shown in Table 4.31.

Table 4.31: Regression Model Summary for Impacts of Water filled Quarries and the Wellbeing of Households in Quarrying Areas

R	R Square	Adjusted R Square	Std. Error of the Estimate
.522[a]	.273	.269	.696

The regression model indicates an adjusted R^2 value of 0.269, meaning that the independent variable, impacts of water filled quarries explained approximately 26.9 % of the variation in the dependent variable wellbeing of households in the quarrying areas. The *F* test for the fit of the regression model is shown in the ANOVA Table 4.32.

Table 4.32: ANOVA Table for the Regression Testing the Fit of the Model

	Sum of Squares	df	Mean Square	*F*	*p*
Regression	35.278	1	35.278	72.775	.001
Residual	94.042	194	.485		
Total	129.320	195			

The fit of the overall regression model (Table 4.32) was found to be significant (F (1, 194) =75.77, p <. 001). The regression coefficients of the model showing the *beta,* and *t* statistics are shown in Table 4.33.

Table 4.33: Regression Coefficients for Impact of Water filled Quarries and Wellbeing of Households in Stone Quarrying Areas

	Unstandardized Coefficients		Standardized Coefficients		
	B	**Std. Error**	**Beta**	***t***	***p***
(Constant)	9.143	.452		20.246	.001
Water filled Quarries	-.482	.057	-.522	-8.531	.001

The regression analysis (Table 4.33) shows that the impacts of water filled quarries significantly influenced (β= -.522, t= - 8.531, p<.001) negatively the wellbeing of the households in the quarrying areas of Khalaleo. This indicates that as the impact of water filled quarries increased, the wellbeing of the households was significantly reduced.

4.9 Ranking of the Independent Variables as to their Influence on the Wellbeing of Households in the Stone Quarrying Areas of Khalaleo

The fifth objective of the study was to determine the order of importance of plant species diversity loss, pollution from stone quarrying, land degradation and water filled quarries on their influence on the wellbeing of the households impacted by stone quarrying in Khalaleo of Mandera County. To answer this research question, a multiple linear regression analysis was done and the results are presented in Tables 4.34. 4.35 and 4.36.

Table 4.34: Multiple Regression Model Summary

R	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
.815[a]	.664	.657	.47680

The regression model indicates an adjusted R^2 value of 0.657, meaning that the four independent variables explained approximately 65.7 % of the variation in the dependent

variable wellbeing of households in the quarrying areas. The *F* test for the fit of the regression model is shown in the ANOVA Table 4.35.

Table 4.35: ANOVA Table for the Regression Testing the Fit of the Model

	Sum of Squares	***df***	**Mean Square**	***F***	***p***
Regression	85.898	4	21.475	94.462	.001
Residual	43.421	191	.227		
Total	129.320	195			

The statistical significance for the overall regression model was tested using the F test (Table 4.35). The regression equation was found to be statistically significant (F (4, 191) =94.46, p <. 001). The regression coefficients of the model showing the beta and the t statistics are shown in Table 4.36.

Table 4.36: Regression Coefficients for the Independent Variables

	Unstandardized Coefficients		**Standardized Coefficients**		
	B	**Std. Error**	**Beta**	***t***	***p***
(Constant)	13.464	.546		24.671	.001
Plant Diversity Loss (X_1)	-.103	.050	-.110	-2.086	.038
Pollution (X_2)	-.253	.048	-.236	-5.249	.001
Land Degradation (X_3)	-.446	.039	-.569	-11.530	.001
Water Filled Queries (X_4)	-.249	.044	-.270	-5.661	.001

The order of influence was determined by looking at the magnitude of the standardized regression coefficients (Beta statistics "β") in Table 4.36. The results indicate that land degradation had the highest negative influence (β=-.569, t= 11.53, p< .001) on the wellbeing of the households impacted by stone quarrying in Khalaleo, Mandera County. This variable was followed by water filled quarries, whose influence was (β=-.270, t= 5.66, p< .001), pollution impacts (β=-.236, t= 5.24, p< .001) and finally plant diversity loss (β=-.110, t= 2.08, p= .038).

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the study, discussion of the results, conclusions of the study and the recommendations made.

5.2 Summary of the Study

This study aimed at assessing the environmental impacts of stone quarrying and the influence these impacts have on the wellbeing of the households in Khalaleo, Mandera County. The study specifically examined four factors: plant diversity loss, pollution, land degradation and water filled quarries

In achieving these objectives, the study used primary data which was collected using a structured questionnaire that was organized according to the key thematic areas corresponding to specific objectives of the study. The study then utilized descriptive and inferential statistics to analyse the data.

The results indicated that stone quarrying had negative impacts on the wellbeing of the households found in the stone quarrying areas of Khalaleo in Mandera County.

5.3 Discussions

The study findings for this study are discussed in this section based on the specific objectives of the study as stated in section 1.5 of this thesis.

5.3.1 Participants Socioeconomic Characteristics and Stone Quarries

Socioeconomic characteristics of the households found near the quarries are normally affected both positively by the incomes arising from the quarries and negatively by the

environmental impacts arising from the quarrying process (Euromines, 2016; Mwangi, 2014).

The majority of the households in Khalaleo were headed by males, the high percentage of the males reflects the situation in the sub-county during the 2019 census, as the men were recorded to be more than the females (KNBS, 2019). Not all men work in the stone quarries as only a small portion (12.2 %) were directly engaged in the stone quarries (Table 4.6). This could be attributed to the fact that stone quarrying is a specialized art requiring hard work and some working knowledge to be able to be done (Kibii, 2020). The women are normally not engaged in stone quarrying as they tend to view it as hard work (Kibii, 2020) and also due to religious reasons of not mixing with men. Therefore males provided the information required during the interview with compassion.

The majority (67.8 %) of the respondents were young, within the age bracket of (below 40 years), this implies that HH head can able to take up the quarrying work and find mitigation measures to curb the problem e.g use of Quarry water for irrigation.

The majority of the household head were married indicating that they were living with their families (men women and children) within the quarry areas, thus increasing the risk and negative effects arising from the quarries.

The majority (50 %) of the participants were illiterate, while the group that had attended primary school was (23.5 %). These statistics vary with the census data for the county (KNBS, 2019) in that the people who had not received formal education were few (16.06 %).

The average number of people living within the households (household number) was eight (8) and fifty percent (50 %) of the households had more than 11people living in their household, this situation compares well to the one found in Ethiopia by Abate

(2016) that 87.7 % of the households in the quarries had large family members above seven (7).

The study found out a diversification in the livelihood sources undertaken by the quarry households. Seven different livelihood sources were identified, they included: pastoralism, agro-pastoralism, crop farming, formal employment, quarry worker, and business. Quarrying activities should provide room for other income generating activities such as business to supply for the needs of the workers (Abate, 2016), but this was not the case for the Khalaleo mines as business were only undertaken by only 7.1 % of the households, this could be due to the menace of Al-Shabaab raids (Kiplangat, 2019). Most of the income from the quarries does not benefit the households directly, except for the business people (7.1 %) and the quarry workers (12.2 %) but a high portion of the money goes to pay tax/rent to the County government for use of the quarries and the people who own the quarries.

The number of years the households had lived in Khalaleo was found to be more than five (5) years by majority (77.1 %) of the households. This is an indication that households surveyed understood the problem and were aware of the economies of the quarries. A lot of migrant workers of different ethnicity and who are not Muslims work in the quarries (Kiplangat, 2019), this means that a lot of the income does not benefit the households directly (Abate, 2016) and this can be a source of problem to the communities living in the mining areas (Waweru et al., 2018).

5.3.2 Influence of the Impacts of Plant Diversity Loss on the Wellbeing of Households in Stone Quarrying Areas

The loss of plant diversity due to stone quarrying was found to have a statistical significant negative impact on the wellbeing of the households in the mining areas of Khalaleo. These findings are in agreement with other authors as the quarrying activities tend to affect plants in three different ways: directly by removal of the plants to create the quarry holes, the reduction of photosynthetic ability of the plants by covering the leaves (the photosynthetic area) with dust from the quarries (Mbandi, 2017). The loss of plants tends to reduce pasture for grazing animals (Ming'ate, & Mohamed, 2016) affecting livestock feeding. Belay et al. (2020) concluded that stone mining causes adverse impacts on plant species and soil physico-chemical properties.

5.3.3 Influence of Pollution on the Wellbeing of Households in Stone Quarrying Areas

The wellbeing of households was found to be negatively influenced by the impacts of land and water pollution in the study area and the results were found to be statistically significant. These results are in agreement with those of Sayara et al. (2016, who found that pollution impacts from the stone quarrying include huge amounts of inorganic dust particles of below 10 micrometers in diameter that arises from the quarries and cover plants and houses. This was also the case with Subhasis et al (2018) who concluded that the dust particles include also other suspended particulate matter and tend to be higher closer to the mine causing pollution to the air, which is harmful to the quarry workers and people who reside near the mines especially within a kilometer to the mine. The dust particles do impact the residents nearby (Mbandi, 2017), and crops and animals (Kalu & Ogbonna, 2021). This has a direct impact on the households as they inhale the dust ending up in pulmonary infections (Bakamwesiga et al., 2021; Chepchumba, 2020) and other mine related diseases (Henry et al., 2017).

5.3.4 Influence of Land Degradation on the Wellbeing of the Households in Stone Quarrying Areas

The wellbeing of households in the stone quarrying areas was found to be negatively influenced by the impacts of land degradation. Land degradation was found to have the highest impact on the wellbeing of the households in the mining area (Table 4.36). These results are similar to the ones found by Sincovich et al. (2018), who concluded that degradation arising from the stone quarrying activities tends to directly affect the social aspects of the affected households. Schäffler & Swilling (2013) supported these findings and concluded that the extraction industry (such as stone quarrying) tends to affect the physical environment, which includes soil erosion features on the ground, barren areas, and denuded areas, and this tends to cause the area to look like a desert affecting the aesthetics value of the area. Stone quarrying has considerable adverse impacts on public health, the environment, and green cover (Salem, 2021).

5.3.5 Influence of Water filled Quarries on The Wellbeing of Households in the Stone Quarrying Areas

The wellbeing of households in the stone quarrying areas was found to be negatively influenced by the impacts of water filled quarries. The findings were found to be similar to those of Centers for Disease Control and Prevention (2018), who found that abandoned and active quarries tend to fill with water during the rains, the water filled quarries end up being a source of water borne diseases such as Malaria transmitted by mosquitoes (*Anopheles)* that breed in stagnant water. In other situations, water filled quarries have found to have a positive impact on the wellbeing of the households (Subhasis et al., 2018), in these situations the water from the quarries is used for crop irrigation as has been the case in West Bengal, India where farmers use this water to grow food crops, bathing and washing clothes, this contradicts the findings of this study.

5.4 Conclusions

The following conclusions were made from this study:

(i) The impact of plant diversity loss was found to be high and negatively influenced the wellbeing of the households in the stone quarrying areas of Khalaleo, Mandera County.

(ii) The impact of pollution from stone quarrying was found to be high and influenced the wellbeing of the households negatively.

(iii) The impact of land degradation was rated highly and significantly influenced the wellbeing of the households in the stone quarrying areas of Khalaleo, Mandera County.

(iv) The impacts of water filled quarries were found to be high and influenced the wellbeing of the households in Khalaleo negatively.

(v) A variation was found in the way the four independent variables influenced wellbeing of households in the stone quarrying areas. The impacts of land degradation were found to be the highest.

5.5 Recommendations

Based on the findings of the study, the following recommendations were made:

Mitigating measures should be put in place by the quarry owners in order to reduce the impacts of the stone quarrying. These include: fencing off the quarries to prevent people and animals going into the quarry, move away from the quarry sites,

There is need for technology in developing and maintaining environmental safe methods. The county government of Mandera should create multi-stakeholder networks of people and organizations related to the mining and maintenance of stone quarrying in the study area.

The need for creating awareness and knowledge on dangers of environmental issues. This will require the county government to create public-private partnerships to enhance capacity building of the households.

5.6 Recommendations for Further Research

The following are recommended to be done for further research within the stone quarrying areas of Khalaleo in Mandera County:

(a). Determine the influence of multi-stakeholder platforms in the enhancement of environmental conservation

(b). Assess the effectiveness of different mitigation measures for alleviating impacts of stone quarrying on the households

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APPENDICES

Appendix A: Participant's Letter

Dear Participant,

RE: SURVEY PARTICIPATION

I am a Masters student from the department of Environment and Natural Resource Management at Africa Nazarene University. In order to fulfill the requirements of this degree programme, I am carrying out a study entitled: Assessment of the social impacts of stone quarrying along Daua River in Mandera East, Mandera County, Kenya. I kindly seek your assistance in filling the questionnaire below to help in gathering information and data. You are assured of maximum confidentiality and anonymity; the information will only be used for academic purposes.

Thank you,

Abdiwahab M. Maalim,

Researcher.

Appendix B: Household Questionnaire

INSTRUCTION: **Please, fill in the spaces with the required responses in the spaces provided**

NB: The provided information will only be used for academic purposes

---

Section 1: Background Information

Location _____
Gender _____

Gender
Male [ ]
Female [ ]

Age	
i.	Under 18 [ ]
ii.	18 – 28 [ ]
iii.	29 – 39 [ ]
iv.	40 50 [ ]
v.	51 – 61 [ ]
vi.	62 and Above[ ]

Marital Status	
i.	Single [ ]
ii.	Married [ ]
iii.	Divorced [ ]
iv	Widowed [ ]

Education level	
i.	Illiterate [ ]
ii.	Primary-Level [ ]
iii.	Secondary – Level [ ]
iv.	Middle Level College[ ]
v.	Bachelors Level [ ]
vi.	Post Graduate Level [ ]

Household Number
i. 2-4 [ ]
ii. 5-7 [ ]
iii. 8-10 [ ]
iv. Above 11 [ ]

Household Source of Livelihood
i. Pastoralism [ ]
ii. Agro-pastoralism[ ]
iii. Crop farming[ ]
iv. Quarry worker[ ]
v. Formal employment [ ]
vi. Business[ ]

Number of Years Living in Study Area
i. 1-4
ii. 5-8
iii. 9-12
iv. 13-16
v. Above 17

Section 2: Wellbeing of the Households

Rate how the stone quarries have influenced your wellbeing. Rate the level using a scale of 0 to 10. A score of 0 will be entered in situations where the stone quarrying industry has not influenced or assisted the wellbeing of the household and 10, where the industry has highly influenced or assisted the wellbeing significantly.

Wellbeing categories and variables	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**10**
	No influence							**Highly influenced**
1. Standard of living (Material Provision)								
Food								
Shelter								
Clothing								
Capital								
Provision of Assets								
Work (paid labour, employed)								
2. Health (Good Health*)*								

Provision of health services								
Health ailments (breathing problems.								
Health ailments (Bilharzia Malaria)								
Health ailments (Malaria)								
Cost of health services								
3.Made you to feel more safer (Safety)								
Peace of mind								
Absence of constant fear								
Absence of constant worry								
4.Improved your Social Relations								
Connection with the other community members								
Good relations with family								
Good relations with community								
5. Assisted in your Spiritual Fulfillment								
Belief in God								
Attendance to Worship areas (Church, Mosque)								
6. Controlling the State of your Environment								
Ability to Control Political situations								
Ability to access government services								
Ability to Acquire Resources								
Ability to Acquire Skills								
Ability to Acquire Knowledge								
Ability to Acquire Information								
7. Emotions and affiliations								
Respected in the community								
Part of community								
Social obligations								
Listened to								
Receive help								

Section 3: Awareness and Impact rating of environmental factors:

Loss of plant Diversity

Indicate whether you are aware of loss of plant diversity and rate the impacts on a scale of 1 to 10, (1=low impact and 10 high impacts on the environment)

Environmental factors: Loss of plant diversity	Awareness	Rating of impacts (1-10)
Rate the loss of plant diversity: loss of grass species due to stone quarry mining		
Rate the loss of plant diversity: loss of tree species due to stone quarry mining		
Rate the loss of plant diversity: Increase in bare areas in the area		

Section 4: Awareness and Rating of Environmental Impacts:

Pollution (Land and Water)

Indicate whether you are aware of land pollution and rate the impacts on a scale of 1 to 10, (1=low impact and 10 high impacts on the environment)

Environmental factors: Land Pollution	Awareness	Rating of impacts (1-10)
Increase in dust due to quarries		
Increase in dust all over the area and houses		
Dust on vegetation (grass)		
Dust on vegetation (woody plants)		
Increase in noise pollution due to quarrying		
Increase in soil erosion		
Irrigation canal silting and blockage		
Increase in silt in irrigation channels		
Increase in silt in irrigation plots		
Reduced production due to silting		
Increase in soil erosion		
Blockage of drainage channels (lagga)		

Section 5: Awareness and Rating of Environmental Impacts:

Land Degradation

Indicate whether you are aware of degradation of land and water resources and rate the impacts on a scale of 1 to 10, (1=low impact and 10 high impacts on the environment)

Environmental factors: land degradation	Awareness	Rating of impacts (1-10)
Is the area changed by the presence of stone mining quarries (quarry pits)		
Is the area changed by having large stones scattered (debris) on the landscape		
Is the area changed by having small stones scattered (debris) on the landscape		
Is the area changed by having erosion (debris) on the landscape		
Aesthetics (land looking like a desert)		

Section 6: Awareness and Rating of Environmental Impacts:

Water Filled Quarries

Indicate whether you are aware of water filled quarries and rate the impacts on a scale of 1 to 10, (1=low impact and 10 high impacts on the environment)

Environmental factors: Water Filled Quarries	Awareness	Rating of impacts (1-10)
Water filled quarries exist in the area		
Increase in Mosquitoes due to quarries		
Increase in Malaria in the area		
Increase in Bilharzia due to people using contaminated quarry water		
Increase in smelly water		
Increase in waste water		
Flooding of open quarries		
Blockage of streams leading to river		
Ponds, lakes of dirty water		

Appendix C: Descriptive Statistics for the Wellbeing Index of Khalaleo Households

Wellbeing Domains and Indicators	Rating by the household heads		
	Mean	**SD**	**Range**
1. Standard of living (Material Provision)			
Food	5.18	1.29	4
Shelter	5.09	1.29	4
Clothing	5.05	1.21	4
Capital	4.98	1.47	4
Provision of Assets	5.12	1.55	4
Work (paid labour, employed)	4.72	1.20	4
Mean Standard of living	**5.03**	**.475**	**2**
2. Health (Good Health*)*			
Provision of health services	4.79	1.56	3
Health ailments (breathing problems.	5.12	1.55	4
Health ailments (Bilharzia)	4.72	1.20	4
Health ailments (Malaria)	4.75	1.43	4
Cost of health services	4.81	1.39	4
Mean for Health	***5.32***	***.685***	***2.83***
3.Made you to feel more safer (Safety)			
Peace of mind	5.40	1.31	4
Absence of constant fear	4.94	1.23	3
Absence of constant worry	4.88	1.54	4
Mean Safety	***5.10***	***.759***	***2.75***
4.Improved your Social Relations			
Connection with the other community members	4.73	1.16	4
Good relations with family	5.06	1.49	4
Good relations with community	5.12	1.58	4
Mean improved relations	***4.88***	***.627***	***2***
5. Assisted in your Spiritual Fulfillment			
Belief in God	4.68	1.11	4

Attendance to Worship areas (Church, Mosque)	4.78	1.18	4
Mean Spiritual	***4.75***	***.780***	***3.33***
6. Controlling the State of your Environment			
Ability to Control Political situations	5.08	1.43	4
Ability to access government services	4.90	1.41	4
Ability to Acquire Resources	4.92	1.41	4
Ability to Acquire Skills	5.07	1.30	4
Ability to Acquire Knowledge	4.64	1.24	4
Ability to Acquire Information	4.21	1.03	3
Mean Environment	***4.72***	***.458***	***1.78***
7. Emotions and affiliations			
Respected in the community	5.03	1.38	4
Part of community	4.70	1.02	4
Social obligations	5.08	1.47	4
Listened to	4.63	1.22	4
Receive help	4.57	1.19	4
Mean Emotions and affiliations	***4.92***	***.317***	***1.83***
Wellbeing Index for Khalaleo	**5.31**	**.814**	**4.94**

Appendix D: Photos from the Field

Photo 1: The researcher in one of the Quarry site showing the depth of the quarry.

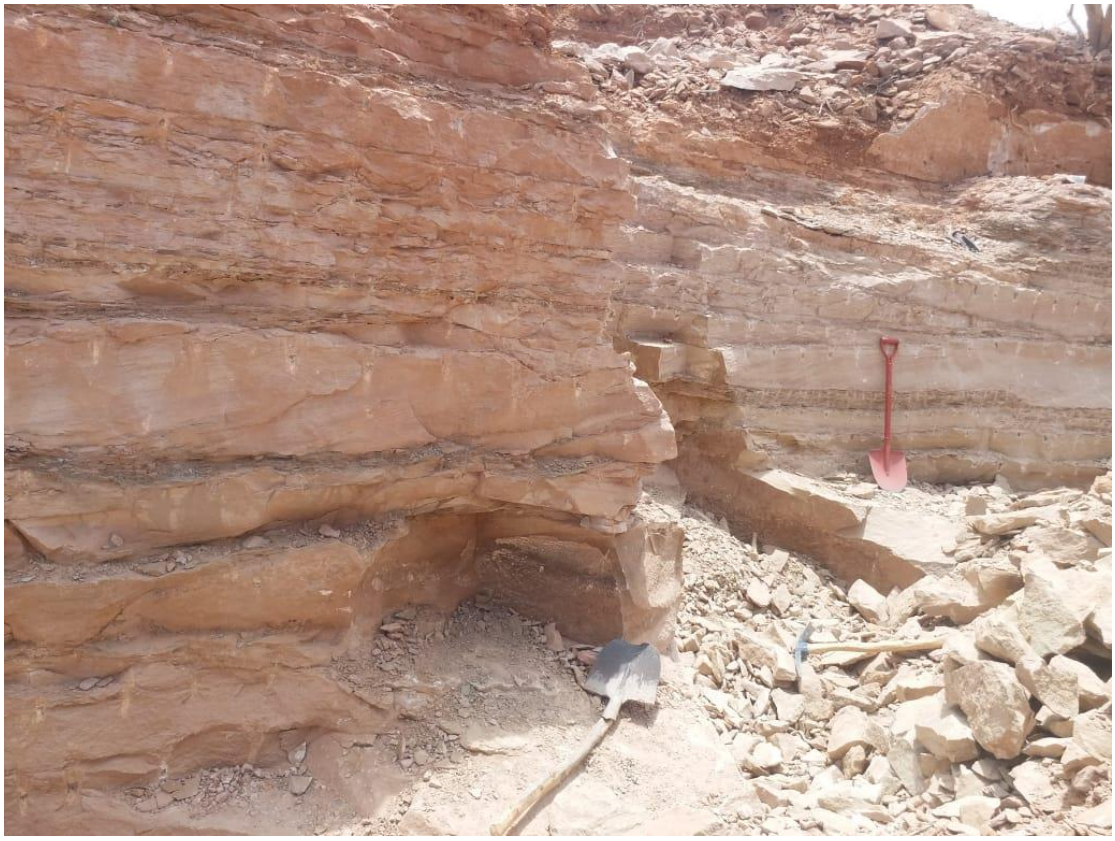

Photo 2: Digging equipment and quarry holes.

Photo 3: Stones arranged for sale and transport

Photo 3: Debris and non-dimensional stones from the quarry site

Photo 4: area cleared off vegetation to display stones at quarry site

Appendix E: NACOSTI Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **179566**

Date of Issue: **18/March/2022**

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