

**ASSESSING HEALTH AND ENVIRONMENTAL IMPACTS OF QUARRYING IN
EMBU COUNTY, KENYA.**

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**A RESEARCH PROJECT REPORT SUBMITTED FOR THE AWARD OF DEGREE
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DECLARATION

I, Kinyua Maureen Muthoni, declare that this research project is entirely original and hasnot been previously submitted for the award of a degree.

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Date.....

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Supervisor

This project report has been submitted for examination with our approval as the university supervisor.

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DEDICATION

This work is a dedication to my husband Wilfred Murungi, sons Max Ryan and RoyAustin, parents and siblings for their support during my study.

ACKNOWLEDGEMENT

I credit the success of this research to the efforts of numerous individuals who provided invaluable assistance at various stages. First, I would like to express my appreciation to my supervisors, Dr. Joseph Kurauka of the Department of Environmental Studies and Community Development and Dr. Gladys Gathuru of the Department of Environmental Science and Education, for their support and guidance throughout this research.

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ABSTRACT

Quarrying has been studied extensively throughout the world and has been shown to have an effect on the natural environment and human health. Positively, stone extraction has led to job creation and development of areas. On the negative side, quarrying leads to land degradation, noise pollution, production of dust and formation of cracks in nearby buildings due to vibration during the quarrying process. The situation is not different in Kenya since there's increase in stone use as a result of growth of construction industry and the industry is faced with challenges of poor working conditions, poverty, inadequate occupational safety knowledge, and the absence of laws. The study sought a deeper understanding of these issues and used qualitative and quantitative data descriptive research design. Questionnaires were utilized to collect information from members of the local community, site management, and quarry employees. The impacts of quarrying on the environment, including the landscape, have been studied and documented. It was decided to employ stratified random sample to gather data from the area citizens, while purposive sampling was used to gather data from quarry laborers. It was necessary to evaluate the information acquired with the assistance of statistical package for the social sciences SPSS, which was used for cross tabulation, as well as for the creation of frequencies and statistical graphs for the purpose of data interpretation. It was decided whether there is a link between quarrying activities and the well-being of both quarry workers and residents of the immediate neighborhood using the Chi-square test. In this study, a sample size of 100 respondents was used, and findings were obtained from 92 percent of those who responded. Findings from the study agree with other studies done that quarrying activities cause harm to the environment and human health and that multiple approaches should be used to deal with the menace.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The exploitation of quarries has expanded as a result of the rapid economic development that has occurred throughout the world. Stone quarrying, according to (Ukpong, 2012), is defined as the process of extracting materials from rocks that are neither fuel nor minerals. The open cast method of quarrying is the most widely used way of extracting rock materials, and it is characterized by drilling and the use of explosives to do so. According to (Nwibo et al., 2012), quarrying operations have negative consequences for employees, community, and cultural identity, as well as the global ecosystems and communities in the immediate vicinity. Most countries have relied on quarries to provide building materials, hence the growth of the building and construction industry.

Using explosives during quarrying is described as conceivably hazardous to both humans and the environment by (Ming'ate & Mohammed, 2016), while (Monjezi *et al.*, 2013) indicate that only 20 percent to 30 percent of the energy needed to shatter rocks is required, with the remaining energy being wasted as vibrations and fly rocks. Nartey *et al.*, (2012) ; Adeola *et al.*, (2009), observe that four million death incidences are reported annually in developing nations as a result of steadily increasing environmental pollution from quarrying, sand harvesting, and the emission of toxic materials. Environmental pollution is a major contributor to respiratory disorders. Rock and mineral particles inhalation have also been seen as causes of cancer (Derbyshire *et al.*, 2013).

Quarrying, however, is faced with challenges of illnesses and injuries among its workers, making it a source of work-related accidents (HSE, 2002). Poor workplace standards that don't adhere to the occupational health standards and quarrying activities lead to increased injuries and work-related deaths (Michelo *et al.*, 2013). There's a range of negative impacts of quarrying activities leading to air and noise and are dependent on rock properties, quarrying technique used, and location of quarry sites (Nwibo *et al.*, 2012).

Lack of legislations and long-term stone mining have also altered classical land use patterns, as has been observed in Lebanon, where, as per (Lad & Samant, 2014), a conflict has erupted between farmers and herders as a result of vast tracts of land becoming

unproductive as a result of abandoned quarrying.

A research conducted by (Missanjo *et al.*, 2015) in Malawi on chlorophyll content of distinct vegetation species that were situated near to and far away from a quarry site and discovered that plants near quarries had significant interference with photosynthesis process owing to increasing dust levels, as opposed to plants in faraway areas. Low photosynthesis was as a result of reduced green surfaces and blockage of stomata hence affecting free exchange of atmospheric gases.

In Africa, quarrying activities are done manually, increasing fatalities and health issues (Chigonda, 2010). In Nigeria and Ghana, breathing complications are the most common illness among quarry workers (Nwibo *et al.*, 2012). This can be associated with a lack of personal protective equipment, cigarette smoking, and long working hours.

In Kenya, quarrying largely depends on urban and rural setups as a source of livelihood despite the industry's negative impacts (Wells, 2013). Kenya has also faced more problems from quarrying especially due to recent rise in real estate industry and road expansions (Anunda, 2014). However, the sector is faced with the challenge of lack of legislation, poor working conditions, inadequate safety education, and environmental destruction (NEMA, 2010). There have been several complaints of negative quarrying outcomes like unrestrained noise from blasting, dust emission, and open pits within quarry areas. Additionally, in most areas where quarrying is done, unwarranted activities like drug abuse, local brews, and HIV/AIDs are found (Bosire, 2012).

Solanki *et al.*, (2014) Poor working environments and unavailability of personal protective equipment lead to occupational accidents and cause threat to lives of workers. These injuries are a major health problem that all developed, developing and underdeveloped countries are currently facing.

1.2 Statement and Justification of the Problem

The rise in the real estate industry in Embu County has escalated rock extraction resulting in expansion of infrastructure, employment opportunities, and development of towns and diverse industries since it's the primary source of building materials. This has led to land-use changes, increased dust and noise pollution, increased respiratory diseases among the area residents, and weakened building walls from impacts of vibration. However, according

to (Naik & Vyawahare, 2013), development projects are generally identified and undertaken for the economic and social benefits of the company with no concern of the people directly affected in the neighboring communities, not to mention the impact on the immediate environment. The dust emitted during gridding and stone transportation is more prevalent during the dry periods, and it becomes a nuisance for a large number of other individuals in the surrounding area (Kilonzo, 2014). Having all these factors at hand, this study investigated how quarrying has impacted on natural environment and health of nearby neighborhoods and its findings will provide recommendations to address the negative effects.

1.3 Research Questions

- i. How does quarrying affect the natural environment in Embu County?
- ii. How do quarrying activities affect health of quarry workers and area residents in Embu County?
- iii. Which mitigation measures are used in quarry sites within Embu County?

1.4 Research Objectives

- i. To determine environmental impacts of quarrying on health.
- ii. To establish health implications of quarrying to area residents and workers.
- iii. To assess mitigation measures used in quarry sites.

1.5 Research Hypotheses

Following hypotheses were tested in the research:

H₀₁: Quarrying activities have a major negative influence on the natural environment
H₀₂: Quarrying activities have a considerable negative impact on the safety and health of quarry workers and the surrounding community.

H₀₃: Mitigation strategies to lessen the health and safety risks associated with quarrying activities have proven ineffectual.

1.6 Significance of the Study

Laws and regulation guiding activities of quarries are in place but aren't followed. The Kenyan constitution (2010) gives Kenyans right to clean environment, while EMCA 1999 Article 14, section(2) protects Kenyans against noise pollution but lack of execution of this regulation have led to licensing of factories and industries close to residential areas. Challenges facing quarrying in Kenya need to be addressed (Ilyas & Rashid, 2010). Lack of protective gear to most workers exposes them to great danger (Koffuor *et al.*, 2012). Responses from this study shows how quarrying affects the human and physical

environment, quarry workforces, and surrounding community and can be used by relevant stakeholders like policy makers and governmental agencies like NEMA who are mandated to provide clean environment to its people and regulate quarrying environments in Kenya.

1.7 Conceptual Framework

The latest increase in real estate development has placed property developers as the primary beneficiaries, with their activities impacting the environment and humans. Negative impacts include loss of vegetation, soil erosion, air pollution, noise pollution, respiratory problems, and deaths and injuries to human beings. The positive effects of quarrying activities are that it leads to better housing and job creation.

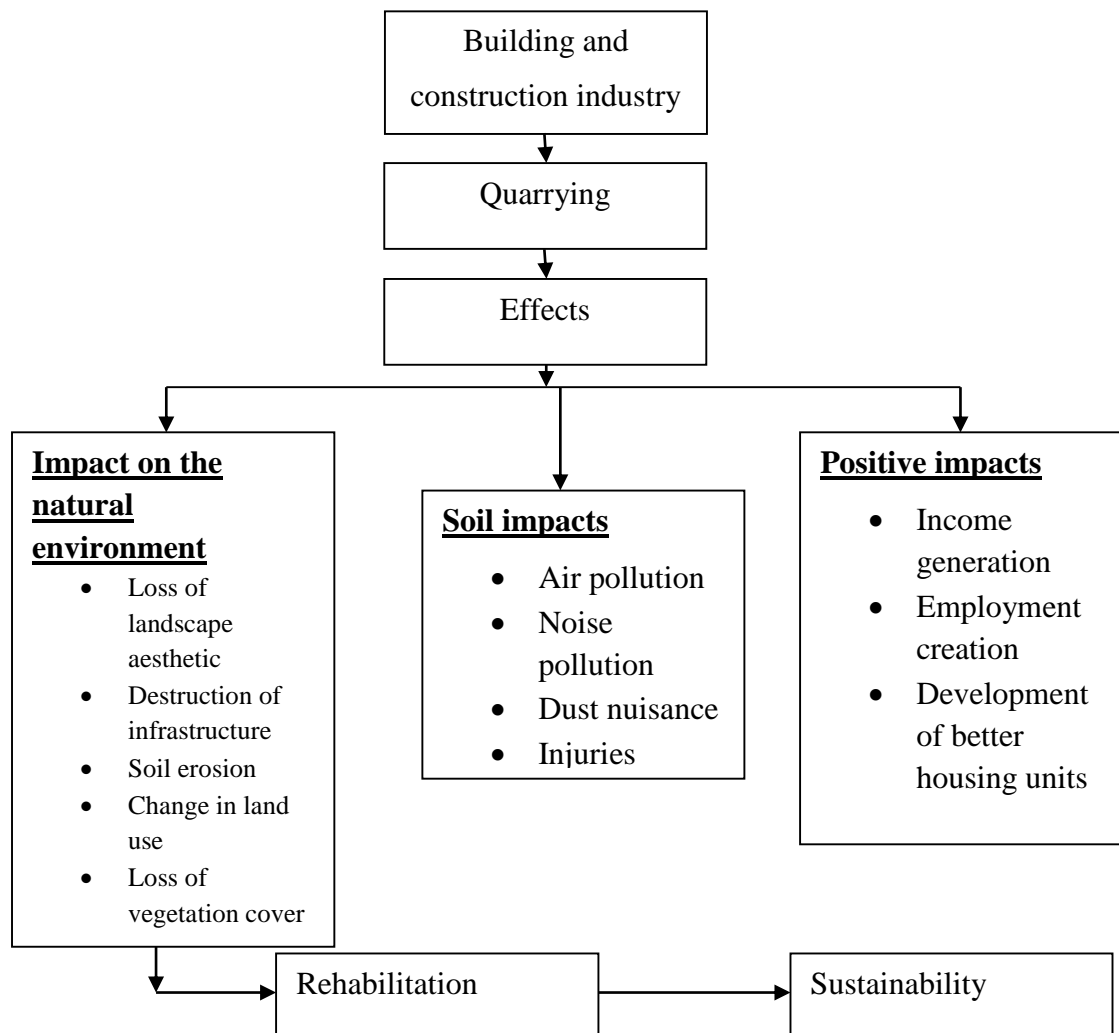


Figure 1.1: A Conceptual Framework

Source: A modification of Crocker (2010)

1.8 Definition of Terms

Dust: a fine powder made up of exceedingly fine particles of a specific material.

Environmental Impacts: These are the consequences of mining and quarrying that are unintended. They may have a positive or negative impact on the environment.

Noise: is defined as any obnoxious sound that can be harmful to people

Pollution: is defined as the introduction of potentially hazardous and toxic

Silicosis: is a lung illness caused by the inhaling crystalline silica.

A quarry: is an open-pit used to extract aggregate.

Quarry Worker: A person paid to undertake quarrying activities.

1.9 Scope and Limitations

The study area is Embu County, and views were taken from respondents who were reached during the field visit. Environmental concerns were measured only on parameters like air or noise pollution, loss of aesthetic value, and redundant crop production. A financial limitation was also a challenge despite prior planning of activities slowing the pace of research. Another challenge experienced was the unavailability of all gender in the visited homes since most were out of their homes.

CHAPTER TWO: LITERATURE REVIEW

2.1 Overview of Stone Quarrying

Excavation of stones from natural rock beds, depending on composition, chemical and physical components of rocks which are used mostly for the construction and improvement of infrastructure is referred to as stone quarrying (Punmia, Jain & Jain *et al.*, 2013). Quarrying and mining differ in that mining is done underneath the earth's surface and quarrying is done on the surface (Punmia, Jain & Jain, 2013). A quarry is a vast deposit of rocks that is mined for its valuable materials or an open pit mine where sand and construction materials are extracted for the aim of supplying materials and sand to the construction industry (Eshiwani, 2014). Quarrying methods vary from channeling to use of equipment but the commonly used method is excavation (Kumar, 2014).

Since time immemorial, stone has been the significant construction material being used. In the old days, the use of stone had a negligible long-lasting impact on the surroundings. Gradually, more stone use in construction increased shooting demand for quarrying (Asante *et al.*, 2014). The extraction of rocks is a risky job, and many workers suffer from related health problems (Lesley, 2011).

As reported by the Natural Environment Research Council, quarrying has contributed to economic development through the provision of construction materials, tax money for the government as a result of taxing, and employment opportunities, particularly for the rural population. (NERC, 2017). Increase in population worldwide and increased demand for construction need has also led to increased stone use and emergence of stone quarrying sites (Lad & Samant, 2014). However, the methods used in quarrying are poor making it unsustainable venture and there's need for equilibrium between ecosystem conservation, project planning and implementation of quarrying process (Nene, 2011).

Stone quarrying affects that environment and peoples' wellbeing both positively and negatively (Endalew *et al.*, 2019). Economic gains lead to rock extraction at the expense of environmental and social facets and if not cautiously operated, its effects may affect future generations. Increase in demand of stone use has increased with population growth and need for housing and transport infrastructure (Adimo, Njoroge & Waweru *et al.*,

2018).

According to (Bewiadzi, Awubomu & Glover-Meni, 2018), stone quarrying is depended on for survival through direct and indirect job creation for residents in Daglama municipality Ghana. Analysis on lifestyle of people reveals that employment is one of the visible advantages of quarrying in an area (Euronomis, 2016).

A trail of negative effects accompanies quarrying activities ranging from change in land reforms, loss of biodiversity, reduced agricultural lands, habitat loss, air pollution and aesthetic value loss (Endalew *et al.*, 2019). Respiratory problems, deaths and chest pains also accompany stone quarrying activities (Lad & Samant, 2014).

In addition to the economic advantages of a quarry, populations dwelling in close proximity to the quarries face social concerns such as relocation, uneasiness, fear, escalating tensions, and a rise in the number of foreigners living in the area, among other things (Adimo, Njoroge & Waweru, 2018; Lad & Samant, 2014).

Child labor is on the rise, particularly in uncontrolled quarries, according to a 2013 report by the International Labor Organization (ILO) in Ghana on child labor, which revealed that 10,500 children were involved in quarrying and mining activities (ILO, 2013).

Area residents are also affected by quarrying activities like Pali Village in India (Azad & Ashish, 2006). A lack of personal protective gear to the personnel led to allegations that people were buried alive during the quarry operation. The most vulnerable group to the silica contact among the workers and area residents are women, children, and the elderly (Asante *et al.*, 2014). The unrestrained increase in quarrying in Senegal led to environmental degradation and diseases for the quarry employees and nearby residents, forcing the day's government to stop quarrying licenses (Chigonda, 2010).

Regionally, quarrying has been depended by many as a source of livelihood for families. In Kenya, (Malashi, 2007) did a study in the Barut location in Nakuru Municipality on the impact of sand harvesting and established that it had an adverse effect on the environment.

2.2 Global and local perspective of stone quarrying

While quarrying can be executed in a sustainable manner, many countries have quarries that are unauthorized, poorly regulated, and quickly expanding, as is the case in Lebanon. These factors have resulted in environmental problems due to the destruction of forests and trees, which has had a negative impact on the country's climatic changes. Years of unrestricted quarrying have left a legacy of deserted quarries all over Lebanon's natural landscape (Khater, 2010). Despite the fact that Lebanon has huge arid and desert areas that are suitable for quarrying activities, it places a strain on the country's limited water and soil resources, causing soil erosion and the degradation of agricultural lands to increase (Dharwesh, 2004). This can be attributed to ignorance despite existence of governing regulations with legal frameworks for quarry exploitation and management.

A study done in Ebonyi state in Nigeria shows that open cast quarrying system causes massive destruction of vegetation and land cover. It is a threat to vegetation cover if stone extraction continues at its current high rate without strong implementation of government rules, directives, and surveillance (Osibajo, 2003). Open pit is the commonly used quarrying method in the area and caused damage to the environment contrary to the goal of sustainable development. However, there's a need for intervention to reduce negative effects to the environment by looking at geology of the area, proper planning, quality choice of equipments and safety through constant monitoring and improvement (CEMAC, 2007).

Quarrying has affected several individuals in India. According to (Azad & Ashish, 2006), quarrying is an extremely dangerous work whereby workers who are mainly migrants suffer from many health issues. The most common health issue is silicosis from exposure to silica dust which causes lung disease. Other health issues include excessive noise, strenuous manual labor, minor and serious accidents at work, and long working durations, among others. The absence of clean, safe water, shelter, and sanitary facilities adds to the list of factors contributing to a negative working environment (Azad & Ashish, 2006).

The unregulated proliferation of quarries in Senegal, as per Irin Africa 2003, has resulted in coastline erosion and a decline in arable lands, in addition to skin and respiratory issues for quarry workers and the surrounding environment, forcing the government to stop issuing quarrying permits within the area.

According to (Aigbedion, 2005) cement factories in Nigeria emit large amounts of dust to the air daily. Similarly, a significant amount of airborne particulate matter originates from numerous crushing companies throughout Nigeria (Aigbedion, 2005; Mtoka & Ngongolo, 2013). People's health is harmed by the inhalation of dust and airborne particles (Ngongolo & Mtoka, 2013). A study in Thika municipality in Kenya revealed reduction in size of arable land and possible conflict between agriculture and extractive quarrying industry (Okoko & Kamewelle, 2015). Conflict between the two government /regulatory agencies, i.e. National Environmental Management Agency and County authority on management of quarries was also noted when NEMA withdrew quarrying license and stopped operations leading to protest by the county authority.

(Musyoka, 1997) conducted a study in Kangundo on impacts of quarrying to the environment and land use and found out that quarries on slopes led to soil erosion due to surface run offs. The study is similar to one done by (Okoko & Kamwele, 2015) in that it's hard to enforce quarrying regulations since they are both done in private lands.

On establishing attempts taken to rehabilitate quarry site, Waweru and Mukundi, (2015) carried a study in Ndarugu river in Kiambu County and established that backfilling with dump soil was the only attempt taken towards quarry restoration. It was also noted that arable land was decreasing with time and that unused quarry sites had been transformed into man-made dams causing threat to the neighborhood.

(Mogambi & Mohammed, 2016) did a study in Mandera County on economic and environmental impacts of stone quarrying and established that quarrying had both positive and negative effects. Positively, it was source of employment to the area residence as well as negatively reducing the vegetation cover hence soil erosion. Lack of measures towards quarried land reclamation also led to land degradation.

A study done in Kangundo observed that loss of aesthetic value of land was rampant in the area due to lack of quarry rehabilitation (Mathu, Nyamai & Ngecu, *et al* 2003). The study also noted heaps of unused rock fragments, open and unfenced quarries making the areas dangerous for animals and humans they are prone to falling in the pits.

The corporation in charge of building of the Thika Super Highway has launched many quarries around Eastern bypass, as they produce a lot of air pollutants. The corporation is interested with its project and does not regard the well-being of those who live near the quarries. People who live near quarries are also disturbed by the operations that take place there. Human welfare is not taken into mind in Pali Village, India, as per (Azad & Ashish, 2006). Employees are not provided with personal protection gears, such as headgear, safety belts, masks, or safety footwear.

Cement factories in Kenya are also major contributors of degraders of environment. Bamburi and Athi river Portland cement in Mombasa have left a trail of environmental and health effects but with time efforts have been taken to rehabilitate the unused quarry sites leading to creation of Haller park an eco-tourism sight and a success example of quarry site reclamation.

2.3 Quarrying process

The quarrying procedure starts with a precise three-dimensional assessment of the quarry face (Ramcharan, 2008), which help specialists to precisely drill shot openings where blasting can be executed securely and quickly. Based on whether the quarry face is protruding or hollow, explosives are expertly calculated to produce the required disintegration of rocks. A bulge is more expensive than normal since it requires more explosives to ensure that rocks are fully fragmented. Ground leveling comes following the face profiling study and physical drilling. Drilling is carried out with an air-powered drilling rig, at the designated areas that connect to the whole location on the blast layout and at the angle and depths needed for decided material extraction. Drilling is performed with two drillers confronting each other, turning the chirage clockwise and anticlockwise in constant movement. This is followed by the pouring of water to dissolve the stone dust that has accumulated throughout the drilling operation, and the pole is removed. After

that, the drilled openings are checked to ensure that they are compatible with the blast design before being filled with explosives. If you're blasting, you'll place a detonation rope in each hole before filling the holes with powerful explosives until they're just a few metres below the surface of the water (Dey, 2008).

Afterward, quarry dust or fine aggregate is used to fill up the remaining space, which serves as an explosive cover. A siren is activated or a red flag is raised to inform the surrounding community. As soon as all of the explosive devices have been linked to the power supply, the firer can begin to set off the explosives, releasing some energy into the atmosphere and generating air pollution in noise form and dust pollution form. Poor design of the detonators may cause flying rocks far from the projected area and may lead to accidents to quarry workers or neighbourhood. Following the blast, the faceplate and shot pile are checked to confirm that all explosives have been detonated and that all holes have been properly filled.

Foremost, secondary, intermediate, and in some quarry sites, quaternary stage smashing are involved. Conveyor belts or down chutes are used to carry coarse aggregate along the processing line. The basic crusher is fed via a vibrating and chute distribution system with a steel bar base that performs the initial screening operational processes. The blast's fine substance and dust, as well as any residual subsoil or worn down rock on the open-pit face, fall through the bars and onto a completely separate belt conveyor and stockpile.

Basic crushing is typically accomplished with a jaw crusher, which comprises of an intensely stacked metal plate that moves back and forward against a settled plate and is propelled forward and backward by a large flywheel. The rock is discharged from the quarry front into the beat of the crusher, which is broader than the bottom, and the remaining material falls from the bottom of the jaws. The gap between the gaps determines the ultimate size of the crushed product, which is then heaped and fed into the secondary crusher. The main crusher's output is aimed directly to the primary stockpile, from which the secondary crusher receives its feed. A screen house is located immediately after the secondary crusher and is responsible for separating small coarse

aggregate and dust into blinding stockpiles. While the larger stones are being nourished through various screens and cone crushers, the smaller stones are being provided through a single cone crusher and screen. Using continuous vibration caused by the mounted motor or diesel-powered equipment, the final cone crusher's output is sent to a screen house, where larger and more diversified deck screens classify the coarse aggregate into the needed aggregate sizes. Each time that the mantle rotates within the concave, the crevice between it and the marginally bended at any one point closes and expands, causing the desired crushing action to take place. It is fed with stone from the top of the cone, and it is filled with crushed material from the bottom of the cone (Northstone materials). It is possible to elevate or lower the mantle staging within the concave, considerably varying the available space and, as a result, the size of the crushed stone, while also ensuring that each phase of crushing produces stones that are increasingly smaller in size. Furthermore, screening is carried out at several points throughout the crushing process (Northstone materials). Springs or robust rubber mountings are used to attach the screening chamber to the supporting framework. The screens vibrate as a result of the rotation of the transverse shaft. Vibratory movement is imparted to the aggregate through the use of a shaft that has been machined to be unbalanced and coupled to an electric motor through v-belts (China South mining machinery co ltd). Screen decks are tilted in such a way that the aggregate crushes them as they pass through them. Following the supply of aggregate onto the top deck's upper end, the vibration causes the aggregate to jiggle down the screen until it falls through a mesh aperture or off the finish of a deck, depending on the application (Northstone materials). The material is then grouped or 'screened' according to the mesh sizes that have been installed, starting with the greatest aperture mesh and ending with the smallest aperture mesh, in that order (small apertures sizes are of woven wire mesh larger sizes of perforated plate). It is determined by the nature of the aggregate to be crushed (cubical, flaky, elongate, or any combination of these) and by the functional properties of the screen, such as efficiency, throughput, and whether the screen is over, under, or properly loaded, that the mesh size of the screen is determined (Northstone materials). As a result, the dust is transformed into a sand substitute product for use. Courser granules are available in sizes ranging from 10mm to 50mm and are utilized in

the casting of building blocks, whilst larger granules are used to strengthen steel in construction and to provide a firm foundation for railroad tracks.

2.4 Environmental guidelines, regulations and policies

2.4.1 Occupation Health and Safety Act No.5 of 2003

This legislation provides for the health and safety of the workforce in industries and other establishments of employment; and for the security of people other than workers against threats to their health and safety deriving from or in association with the operations of workers. The proposed road repair and upgrade activities will employ both skilled and non - skilled employees, as required by this Act. Occupational safety and health are critical components of the business. During the construction phase, the construction company will provide and administer first aid and suitable safety equipment for employees. Quarry owners must comply with the Occupation Act No.5 of 2003 by ensuring that all of the Act's criteria are met (URT, 2003).

2.4.2 The Environmental Management and Coordination Act

In Kenya, (EMCA) addresses environmental issues pertaining to appropriate mineral exploitation and exploration by enacting legislation that regulates environmental issues that arise during the exploration and mining activity in the country. The Act defines national environmental guidelines in order to offer guidance and uniformity to effective environmentally friendly practices across the country.

The Act also contains measures that address issues that affect all spheres of the environment, and it imposes an obligation on the government to conserve the environment and encourage environmental sustainability (EMCA, 1999).

2.4.3 The Mining Act 2016

Kenya has passed the Mining Act 2016, which governs mine exploration, prospecting, mining and processing as well as trading. The Mining Act 2016 came into effect in 2016. Kenya Geology, Minerals, and Mining Authority and the minerals and mining board were established by the Act, and it aims to address issues such as the award of mining licenses

and the conclusion of mining contracts, the requirements for the grant of exploitation and exploration permit holders, the establishment and operation of the Kenya Geology, Minerals, and Mining Authority and the minerals and mining board, as well as the penalties that may be imposed in the event of a violator of the Act. The Act also contains provisions pertaining to the Act's implementation (Mining Act, 2016).

2.4.4 Legal framework for quarrying in Kenya

According to the Mining Act 2016, the Artisanal Mining Permit controls quarrying in Kenya and further describes the person who will be awarded the license, as well as the location where the quarrying will take place.

2.4.5 Institutional framework for quarrying in Kenya

In Kenya, the Mines and Geology Department, which was formerly under the Ministry of Environment and Forestry but is now under the Ministry of Mining, is the primary organization in charge of mining regulation and oversight. Under the Mining Act, Cap 306, it is authorized to conduct earth science surveys and studies of geo-scientific databases and data; administration of legislation pertaining to mineral resources development; mineral and extraction program planning; advising the administration on issues pertaining to mineral and mineral extraction plan; monitoring the safety of quarry and mine operations; and security of commercial explosive materials.

Following the recommendations of Kenya's mining statute, the government has identified three of the most essential institutions to be established: the Minerals and Mining Authority, the Kenya Mining Corporation, and the Mining Disputes Resolution Tribunal. According to the Mineral Resources Management and Policy Implementation Tribunal, these institutions improve the effectiveness and efficiency with which mineral resource policies and management are carried out and implemented. The Minerals and Mining

Board has the jurisdiction to offer recommendations to the government on whether or not to issue a mining license to a particular company.

2.4.6 Social Effects of Stone Quarrying

Rock extraction has increased with time and with it comes social issues such as domestic violence, moral decadence, increase in visitors, displacement and increased cases of insecurity. (Adimo, Njoroge & Waweru, *et al* 2018).quarrying also leads to interference to traditional shrines and loss of cultural heritage.

Lad & Samant (2014) established increase in cases of disharmony between area communities and quarry owners. Mancini & Sala's, (2018) findings show that unequal distribution of resources from the quarrying activities fuel disputes and social disorder between landowners and miners mostly due to political influence. As a way of protecting esources and territories, chaos erupt between community and developer as a way of defence (Terminski, 2012). Terminski, (2012) while researching on development and security found out that increase in quarries directly affect local community causing conflict-induced displacements due to lack of compensation to the displaced families especially in small-scale quarries.

As the quarrying industry is growing, nearby community is faced with other challenges like buying clean and safe water and treating health related illnesses (Melodi, 2017). Lack of peace, comfort and fear is common to people in quarrying areas (Lad & Samant, 2014). Saraya, (2016) agrees with (Lad & Samant, 2016) in that quarrying causes ground vibration causing fear and discomfort to people living near quarries mostly due to presence of cracks on floors and walls of their houses. Most of quarries engage minors in their operations. Study by (ILO, 2013) in Ghana, showed that illegal quarries had engaged young children from local community in their sites a scenario also noted in Madagascar where children drop out of school to engage in quarrying activities. Mancini & Sala, (2018) in their findings noted a concern on forced and compulsory child labour hence concurring with study by ILO.

As a way of survival, more women have been engaged in quarrying activities mostly due to gender discrimination, reduced yields of arable lands, drought, reduced employment chances and high inflation rates (Priyadarshi & Lahiri-Dutt, 2014). Gender parity in quarrying sector is evident and women become disadvantaged when it comes to decision making, resource control and hands on work (GoK, 2016). Quarries are a substantial economic activity in the building and construction industry, according to (Ng'ang'a, 1997), who presented quarrying as a report following an artisanal workshop. Quarries provide a source of income for a wide range of people including landowners, quarry owners, concession holders, quarry workers, and people working in the transport industry.

2.4.7 Effects of Quarrying on Human Health

Health issues arising from quarrying activities depend on the size of the quarry and its location. Dust produced from quarries enters the human body through the mouth causing various complications (Kim *et al.*, 2015). Lengthy exposure to fine dust alongside tobacco or cigarettes increases breathing problems (Nwibo *et al.*, 2012). Dust-related health problems increase since quarry owners provide no suitable measures to control dust (Ilyas *et al.*, 2010). According to (Urom *et al.*, 2014), respiratory problems include chest pains, catarrh, non-productive cough, and dyspnea, are common to quarry personnel. As a result of the continuous movement of heavy lorries to and from mines, residents nearby develop asthma, stunted lung development, and other respiratory problems (Arthur, 2006). To reduce cases of dust inhalation in quarry sites, (Adams *et al.*, (2013) recommends education on safety and wearing personal protective equipment.

Analysis of work related accidents in Finland, Norway and Sweden shows that in a year around 300 cases are reported. In addition, the statistics reveal that the majority of accidents are related to manual labor and mobility, and as (Qudah *et al.* 2014) have confirmed, accidents occur as a result of workers' lack of safety procedures or negligence in their work environments. Most quarries have indicated that physical injuries are a big problem, and (Adams *et al.*, 2013) urge that employees be educated on the need of wearing protective apparel to help alleviate these difficulties.

The Abate report (2016) also states that quarry workers confront a number of health concerns including physical injuries and respiratory troubles as well as fatal accidents, among others.

In a study of stone quarry site in Ho Municipality of the Volta Region at Daglama 2018, it was observed that dust-related diseases were prevalent. Coughing and blood spitting were also observed among the quarry workers, as were chest pains, waist aches, and pneumonia. Dry cough and blood spitting were also reported among the quarry workers. Additional ailments have been recognized, including headaches, cuts, cold, dislocations, insomnia, and eye infections.

The Foundation for Middle East Peace published a report in Palestine in 1998 that found that people who lived near quarries had higher rates of asthma and acute bronchitis infections than the general population. Inability to sleep well is the commonly shared problem associated with noise pollution among quarry workers. Uninterrupted sleep is essential for good physiological and mental functioning of human being. Luxton *et al.*, (2011), established relationship between interrupted sleep among United State soldiers on a mission to Iraq and symptoms of depression and established that those who didn't get enough sleep majority depicted signs of depression, drug abuse and stress.

Noise Hearing Loss (NIHL) is not harmful when is at low levels but it causes harm especially to children when they are exposed for long period to noise levels above 80 dB (Savale, 2014). Sung *et al.* (2017) noted that the sensation of discontentment caused by noise is annoyance and noise disturbs people if it affects their concentration to sleep or conversations.

In Nigeria studies done on NIHL showed that noise from Port Harcourt International Airport had negative impacts and lack of immediate intervention would lead to hearing problems and other psychological effects to those being exposed to the noise (Omuobo-Pepple *et al.*, 2009). This finding agreed with fact that persistent exposure to loud sounds causes hearing problems

2.4.8 Effects of Quarrying on the Environment

Among the environmental consequences of quarrying include ecological damage, the formation of landslides, the destruction of natural habitat, and the presence of undesired substances in the soil, groundwater, and surface water as a result of chemicals used in quarrying activities.

The trail of harmful quarrying activities lasts for a long time, even after the quarry's closure, making most nations of the world apply regulations designed to moderate negative quarrying effects. Change of original land use has led to habitat loss, noise, dust, vibrations, chemical spills, erosion, and sedimentation. Quarrying and mining are destructive ventures causing worldwide vegetation changes, examples being Ghana, Appalachian Mountains, Nigeria, Germany, and Netherlands (Townsend *et al.* 2008 ;Ata-Era; 2016, Tischew *et al.* 2014; Akanwa *et al.* 2016).

In Ghana, presence of desertification in the northern region was closely linked with loss of original tree species which were destroyed through sand and gravel harvesting due to increased demand of the material from upsurge in construction industry (Musah & Barkarson, 2009).

Air pollution in the form of dust is the most noticeable environmental pollution from quarrying activities from excavation, blasting, drilling, crushing, and roads used in transportation. The impact of dust is dependent on various factors like the size of the quarry, prevailing winds, rock properties, and proximity to living suburbs.

Prasad *et al.* (2013) and Nanos *et al.* (2015) agree that when crop leaves are covered with dust, it negatively affects photosynthetic processes leading to stunted growth of plants and reducing yields. This is caused by dust covering leaves causing stomatal blockage and other effects on leaf cells like transpiration rates and water use efficiency. Doley (2010) shows that vegetation and plant development can be affected by dust settlement above 7gm^{-2} .

Paoli *et al.* (2015) did a study on how dust originating from cement factory affected growth of lichen plant species. The length of exposure differed and came about

uncovered that there was a relationship between length of growth and exposure .Dust presence on the leaves also led to variations in the leaf size and texture.

Noise pollution in quarry sites is a significant challenge which is as a result of close proximity of homes and quarry sites where processing equipment and earth moving equipment situation are, and according to (WHO, 2015), approximately 1.1 million people worldwide are experiencing hearing problems due to loud sound levels exposure.

According to (LI & Tian, 2012), a person can develop hearing problems or loss due to prolonged exposure to excessive noise. Neghab *et al*, (2009), in a study, identified Noise Hearing Loss (NIHL) as a common health problem in quarrying work.

River pollution occurs when rivers are situated close to quarries or other drainage systems. This is due to underground infiltration of untreated lead in oil, waste metals and petroleum spills, as well as machinery used in quarry extraction and transportation. It is also possible that quarries will induce variations in the water table if the quarries are deep enough to disrupt groundwater aquifers. Construction of dams at quarry sites is additionally a standard occurrence at closed or abandoned quarry sites (Agevi & Ogero, 1990).

According to Aigbedion (2005), a substantial amount of dust is emitted into the atmosphere on a daily basis from a variety of sources, including cement manufacturing facilities and lime quarries in Nigeria. In a similar vein, increase in number of quarries across the country contribute to a substantial amount of airborne particles being released (Aigbedion, 2005; Ngongolo & Mtoka, 2013). This air pollution exposes people to danger of having health problems, according to the CDC (Ngongolo & Mtoka, 2013).

In Ogun State, pollutant tests conducted in the neighborhood of the Sagamu and Ewekoro cement works discovered that individuals suffer from eye strain and asthma problems as a result of dust pollution and proximity to the plant's location.

Active and abandoned mines are the primary cause of most undesirable environmental outcomes like biodiversity depletion and soil erosion (Mwangi, 2014). Damage to biodiversity is among the most exceedingly bad negative impacts of quarrying on the

environment (Anand, 2006). Low reserves of excavated materials compel relocation of quarrying sites from time to time, increasing abandoned quarry pits and, as a result causing environmental problems (Phillips, 2012).

Open cast quarrying method is the commonly used method of rock extraction and with it comes changes to the natural environment leading to habitat loss (Menta, 2012). David (2007), termed open quarry pits in Hungary excavation trails as “scars in the landscape”, sediments seconded by (Ukpong, 2012), who viewed the sad state of environment as harm to the environment and its magnitude depends on location and number of operations undertaken.

Ukpong (2012), in an observation in Akamkpa, Nigeria noted that smaller quarries produced greater threat to the environment in comparison to larger quarries since most of the big quarrying companies are more environmentally conscious and use skilled artisans in their operations used deep excavations unlike small quarries who use scattering quarrying sites, hence minimizing harm to the environment.

Zalalem (2016), in a study in Ethiopia discovered that there was increase in quarrying activities a profitable business in semi urban zones of Addis Ababa but stones were fast depleting due to overuse a thing that worried the environmentalists. This rhymed with findings of (Haule *et al.*, 2016) in Tanzania Mbeya region, which showed increase in soil erosion and vegetation loss as a result of limestone mining.

In Kenya, (Ming'ate & Mohamed, 2016) in their study in Mandera county found that stone mining was a major contributor to economic growth but with it came trail of environmental degradation. Waweru & Mukundi (2016), similarly in their study in Kiambu County found out that quarrying caused social and economic distress.

According to (Nartey *et al.*, 2012), stone quarrying contributes to environmental degradation. Additionally, the author asserts that stone quarrying, whether on a large or small scale is fundamentally harmful to the environment, creating huge sums of squander

that can have long-lasting negative consequences, and that the environmental degradation caused by stone quarrying is primarily the result of inappropriate and wasteful working practices as well as inadequate or ineffective rehabilitation measures.

It has been pointed out by (Gale & Groat, 2001) that part of the environmental disturbance generated by quarrying may be traced back to engineering activities carried out during aggregate extraction and processing. They assert that the most visible engineering impact of quarrying is a change in geomorphology and a shift in land use, with the resulting visual change as a result of this change.

Further, according to (Sreenivasa & Reddy, 2014), the most significant environmental repercussions of quarries include water pollution, vibrations, and landslides. According to them, this could have a direct or indirect impact on human life as well as the environment.

It has also been stated by (Maponga & Munyanduri, 1998) that quarrying has a harmful impact on the ecosystem from activities like exploration and blasting, transportation, and the disposal of waste rocks. Environmentalists categorize most significant environmental problems to include vegetation deforestation and habitat destruction, loss of animal habitats, diversion and obstruction of natural drainage systems, soil erosion and natural drainage systems, soil erosion and river siltation, noise & vibration, and dust contamination.

Quarrying has ramifications for land use policy; it is either quarrying vs. agriculture or agriculture with quarrying coexisting, which is frequently a source of debate over traditional land employments according to (Chizoro *et al.*, 1997). The removal of land to construct access roads and open up mining sites continued, disruptions of habitats for wild animals and also decreasing the amount of grazing available and reducing the availability of plant life for humans and animals. Munyadri, (1998) asserted that quarrying has a negative impact on ecological balance because it disrupts the food chain. At the end of the day, according to Stehouwer *et al* (2006), quarrying activities place a significant strain on limited soil and water resources, increasing the rate of erosion processes and resulting in the degradation of existing arable land.

2.4.9 Research Gaps and Summary

In this section, related reviewed works on similar issues are analyzed and the gaps identified

Table 2.1: Key Gaps of Study

Author	Year	Key Contribution	Finding	Gaps
Nwibo <i>et al.</i> ,	2012	Pulmonary complications among Nigerian quarry workers	Dust inhalation causing health problems	The study focused only on health problems
Ilyas <i>et al</i>	2010	Health and environmental concerns in Pakistan's stone crushing industry	Lack of dust control measures causes the most dust-related problem	The study didn't give ecological effects of dust
Akanwa <i>et al</i>	2016	Effects of open cast quarrying techniques on vegetation cover in southeastern Nigeria	The most noticeable impact of excavation is changed in the landscape	Study only dealt with environmental implications with no mention of health effects
Asante <i>et al</i>	2014	Stone quarrying and livelihood transformation	The most vulnerable group to dust-related problems are quarry workers and area residents	The study didn't focus on the role of quarry owners

CHAPTER THREE: METHODOLOGY

3.1 Study Area

Embu County is bounded by Kirinyaga in the west, south by Machakos, north by Tharaka Nithi, and east by Kitui. Certain areas of the county are dry and receive little rainfall, prompting residents to engage in non-rain-dependent activities. The presence of rocks and low literacy levels makes the majority engage in quarrying activities as a source of livelihood. This is also accelerated by the growth of the real estate industry in Embu County.

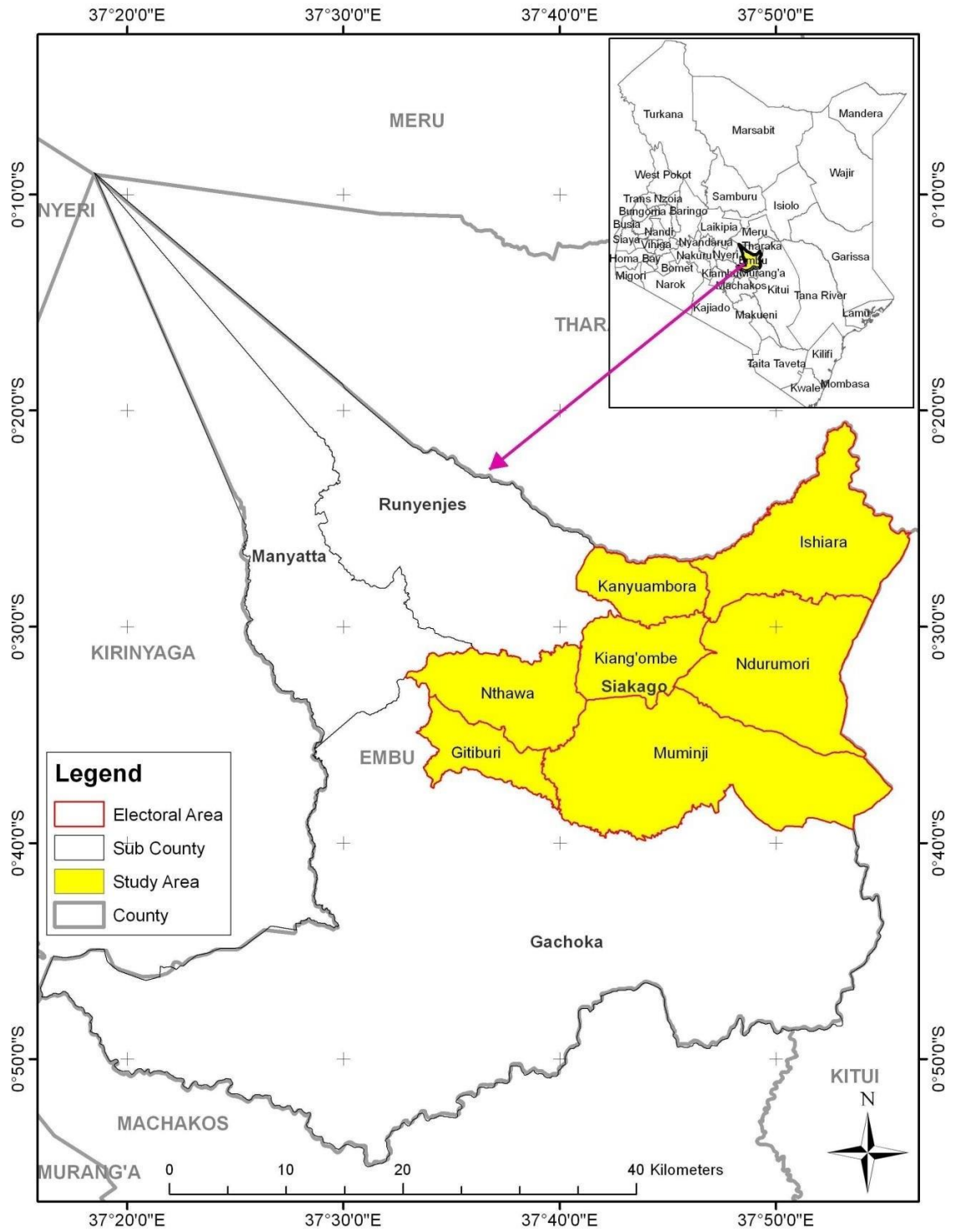


Figure 3.1: Study area: GIS Map of Embu County showing the excavation areas.

3.2 Research Design

In this study, descriptive research design was the most appropriate method since it has in-depth qualitative views of respondents using interview schedules, and quantitative data of numbers that were collected through questionnaires.

3.3 Target Population

The study sought ideas of those directly affected by quarrying activities, including the management, quarry workers and area residents. Each group had divergent views from the other, and it gave a range of effects caused by the activity in the area.

3.4 Sample Size

Sample size determination method by (Nassiuma, 2000) was used in this study. Thus,

$$n = \frac{NV^2}{(CV^2 + (N-1)^2)}$$

n= sample size

N=population

CV = covariance (0.5)

e=Tolerance of preferred confidence level, take 0.05% at 95% confidence level.

$$\begin{aligned} \text{Therefore, } & \frac{n=96837(0.5)^2}{0.5^2 + (96837)*0.05^2} \\ & =100 \end{aligned}$$

3.5 Sampling Procedure

Before sampling, research respondents were categorized as quarry workers, site managers, health workers, or area residents. Quarry workers were classified into five strata: blasters, crushers, loaders, drivers, and drillers. Stratified sampling was used to get the number of quarry workers, whereby they were grouped into five members in each group depending on the type of work they do. From the different clusters, three members were picked using simple random sampling as a representation of others.

Systematic random sampling was used on the area residents using questionnaires whereby ten homes were visited, those within a one-kilometre radius from the quarry sites. In each homestead, views were taken from a man, woman, and young person. Questionnaires were administered to two site managers in each of the two quarry sites visited and three health officers were interviewed in each area visited.

Table 3.1: Categories of respondents

Category	Quarry1	Quarry2	Totals
Quarry workers	3	3	6
Blasters	3	3	6
Crushers	3	3	6
Loaders	3	3	6
Drivers	2	2	4
Drillers	2	2	4
Area residents	30	30	60
Health officers	2	2	4
Site managers	2	2	4
			100

3.6 Validity and Reliability of the Research Instruments

Standard instruments of research establish the validity of the device. To demonstrate this, there was consultation with relevant bodies to ensure the instrument meets the standard. A pre-test was done to establish if there was any ambiguity

3.7 Data Collection Process

Views of the surrounding community, quarry workers, and site managers were collected using questionnaires. The observation checklist highlighted landscape change while interview schedules got views from health officers.

3.8 Data Analysis Techniques

This research employed Statistical Package for the Social Sciences to analyze data collected to establish how dependent and independent variables of the study relate. Results were established using tables, pie charts, and bar graphs.

3.9 Ethical Considerations

Academic approval was sought from Kenyatta University graduate school while ethical approval was obtained from Kenyatta University Ethics Review Committee (KUERC). The permit to carry out the study sought from the National Commission for Science, Technology and Innovation (NACOSTI). Informed consent was mandatory for all the respondents in the study, each respondent was briefed and data was swiftly collected. Respondents were assured of privacy since all the questionnaires were coded to prevent their identity.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

Data from the study are given in this chapter assessing health and environmental impacts of quarrying activities on the quarry workers, natural environment, and surrounding community, and mitigation measures that should be taken to make the industry viable since it is vital for development in Embu County.

4.2 Response Rate

An excellent response rate was reported, with 92 of the 100 respondents reached making 92% response rate. Table 4.1 depicts study a superb response rate for the study.

Table 4.1: Response rate

Category	Frequency	Percentage (%)
Reached	92	92.0
Unreached	8	8.0
Targeted	100	100.0

4.3 Background information

A further understanding of the effects of quarry workers, quarrying activities, area residents and quarry owners gave the necessary information.

4.3.1 Respondent's Age

Age was considered and used since it helped to know the length of experience related to quarrying effects and how long area residents have resided in the area. Figure 4.1 shows the findings

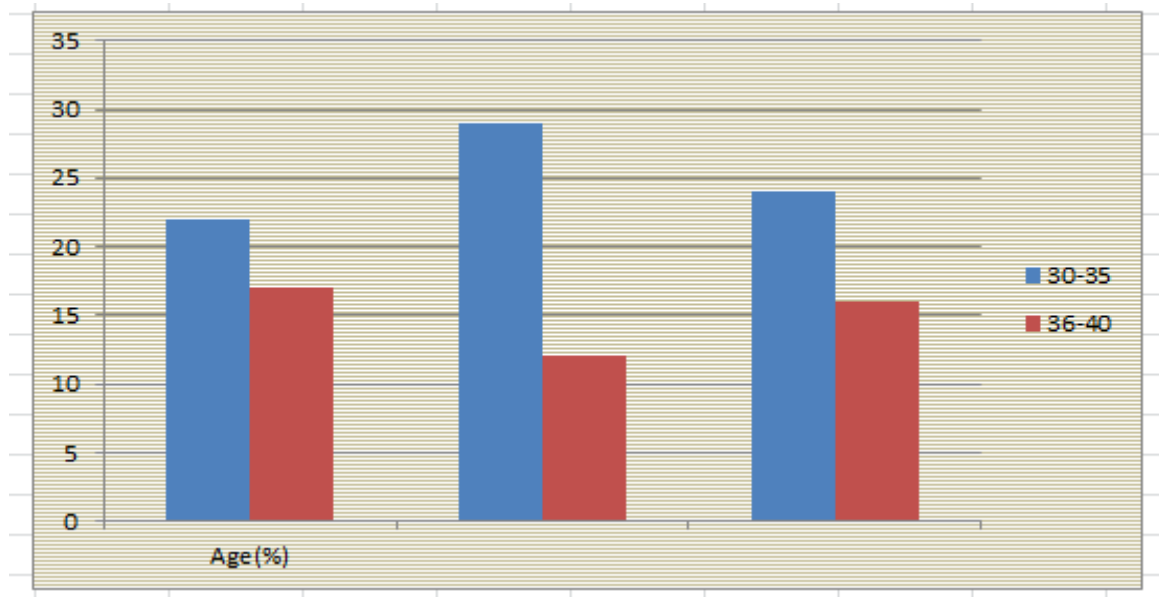


Figure 4.1: Age Distribution

From the data collected, most of the respondents aged between 31 - 40 years were 39.2% comprised of quarry workers, company respondents at 43.6%, and area residents at 29.2%.

4.3.2 Gender Distribution of Respondents

Respondents' gender was used to determine the dominant group that participated in quarrying activities as either male or female. Results are presented in figure 4.2.

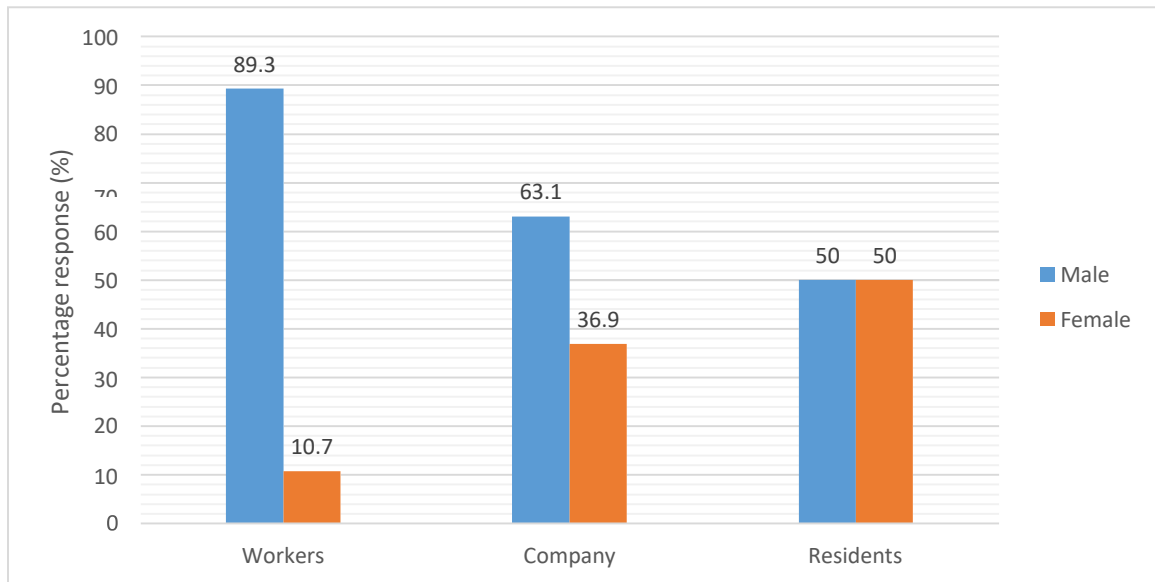


Figure 4.2: Responses by Gender

It was noted the quarry sites were male-dominated, with male workers being at 89.3%. Quarrying companies had more males than their female counterparts, standing at 63.1%, while an equal representation (50.0%) was observed among the residents. This gender difference is associated with quarrying activities being presumed relatively heavy, and few females can endure.

4.4 Education Levels of Respondents

The literacy level was used to know whether all those involved in the quarrying sector had formal education and to which level. It was clear that few had post-secondary education; hence, the majority relied on quarrying as their source of survival. Findings are as shown in figure 4.3.

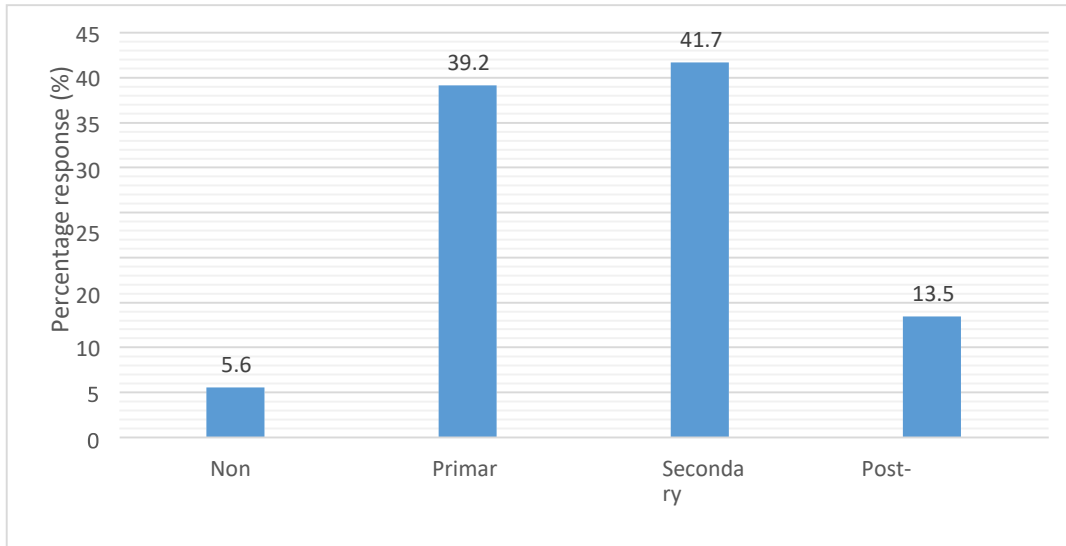


Figure 4.3: Literacy Levels

4.4.1 Duration of Service/Residence

From the data collected, it was clear that few workers had been in service for more than 15 years, primarily due to the negative health issues they acquired in their work line.

Concerning the length of residence, a majority had lived within the region for more than 15 years a long time, and they had vast knowledge of changes in the landscape due to quarrying.

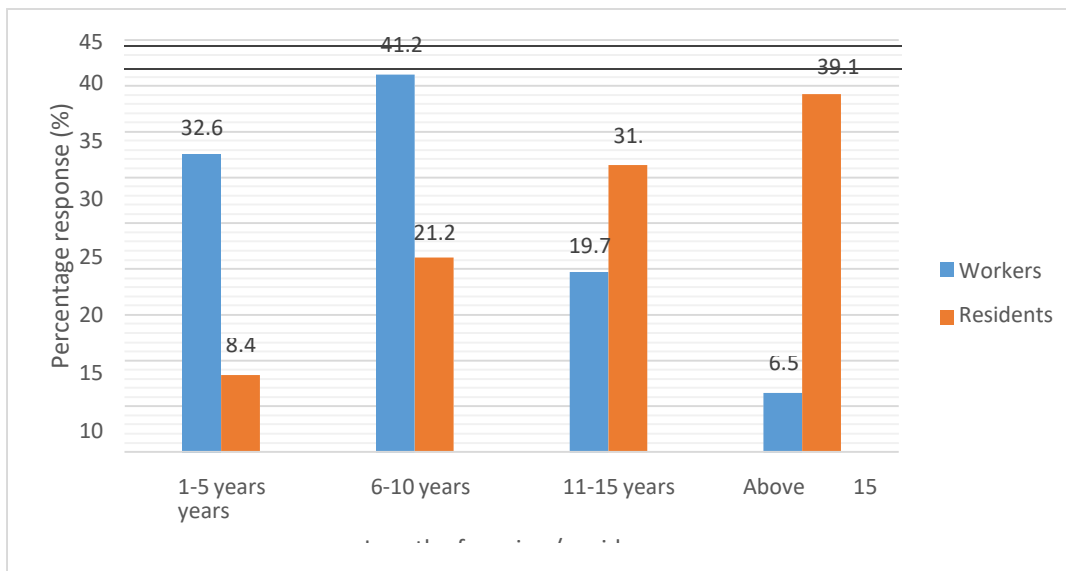


Figure 4.4 Length of service/residence

4.5 Effects of Quarrying on Health and Environment

This research aimed at examining the impacts of quarrying on the natural environment, and it was clear that quarrying had a trail of negative implications in the area. The majority of the respondents highlighted a change of topography with the increase in left open pits posing threats to the residents as people can fall into them.



Plate 4.1: Open Pits

Noise pollution was also noted, with most noise being produced during blasting and earth-moving and processing equipment. Loud sounds made during such processes caused cracks in walls of homesteads near quarry sites.



Plate 4.2: Cracked House Walls

Dust production caused many health problems, with most quarry workers and area residents suffering from breathing complications ranging from chest pains, catarrh, non-productive coughs, wheezing, and eye infections. Sources of dust were blasting and vehicles used to transport quarrying products. This concurs with (Ilyas *et al.*, 2010), who found that lack of appropriate quarrying procedures leads to mass dust production.



Plate 4.3: Dust from Trucks during Transportation

4.6 Health and Risks Control Measures

To determine the health and safety of workers, respondents were asked whether they have personal protective equipment. Majority lack some of the primary protective gear like helmets, gloves, dust masks, and boots, and also those in management positions.

There was noticeable land degradation, with many open pits being left open after use. Company supervisors quickly clarified that they had started reclaiming the land by filling the holes with soil.

To deal with colossal dust production, the company had a plan to water the roads used in transporting quarry materials. They had also reduced the carrying capacity or covering the Lorries used in transportation to avoid spillovers.

Noise pollution that affected the area residents was dealt with by alerting the community on blasting schedules and using light gear equipment that produces less noise.

4.7 Hypothesis Testing

4.7.1 H01: Quarrying activities have a major negative influence on the natural environment.

Data analyzed showed that the quarrying activities had negatively affected the natural environment. Prasad *et al.*, (2013); Nanos *et al.*, (2015) agree that when crop leaves are covered with dust, it negatively affects photosynthetic processes leading to stunted growth of plants, as observed in the study where crops in the nearby farms had poor yields.

Table 4.2: Chi-square test: Quarrying activities have significant adverse effects on the natural environment

???	Value	Asymp. Sig. (2-sided)
Pearson Chi-square	1.009E2 ^a	.000
Likelihood ratio	12.171	.016
Linear-by-linear relationship	4.001	.045
N of Valid cases	92	

4.7.2 H02: Quarrying activities have a considerable negative impact on the safety and health of quarry workers and the surrounding community.

The responses of quarry workers regarding health problems they have suffered during their service agreed with this hypothesis since the majority had suffered from breathing complications like coughs and wheezing. Other than the supervisors, other quarry workers lacked personal protective equipment during quarrying activities, and the lack of protective gear to a majority of workers exposes them to great danger (Koffuor *et al.*, 2012). Area residents also suffered from activities of the quarry, especially noise and air pollution. This concurs with the study of (Naik & Vyawahare, 2013), that development projects are generally identified and undertaken for economic and social benefits of the company with no concern of the people directly affected in the neighboring communities, not to mention the impact on the immediate environment.

Table 4.3: Quarrying activities do have significant deleterious safety and health effects on quarry workers and the area residents

	Value	Sig.(2-sided)
Pearson Chi-square	2.009E2 ^a	1.000
Likelihood ratio	2.171	.016
Linear-by-linear relationship	1.001	.045
N of Valid cases	82	0.1

4.7.3 H03: Mitigation strategies to lessen the health and safety risks associated with quarrying activities have proven ineffectual.

Results from the test conducted clearly show a lack of basic mitigation measures as observed in the study.

Table 4.4 Chi-square Test: Mitigation measures to reduce health and safety risks resulting from quarrying activities have not been ineffective

	Value	Asymp. Sig. (2-sided)
Pearson chi-square	2.418 ^a	.490
Likelihood ratio	2.469	.481
Linear-by-linear relationship	.026	.872
N of Valid cases	95	

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary of Key Findings

Quarrying is an industry that has both positive and negative impacts though the negative effects outweigh the positive ones. Quarrying activities are relied on by many people in studies since most have low literacy levels. The positive attributes of quarrying activities in the area are that it has created employment opportunities for many residents, improving livelihood. It has also contributed to the growth of the building and construction industry, leading to towns and other markets.

Negatively quarrying activities cause noise pollution from the activities involved like blasting and during transportation where vehicles produce noise-causing health issues among the workers and cracks in buildings nearby.

Dust produced leads to breathing problems on workers depending on hours used while working, prevailing winds, and well properties of the stones used. Crop production in the area is also low due to blockage of stomata in leaves hence no photosynthesis. Mitigation measures need to be undertaken while undertaking quarrying activities to ensure sustainable development. Watering of roads used in transportation will reduce dust production and lower chest problems in the area. New pits should be filled to avoid open holes which act as disease breeding sites. Machines used in quarrying activities should also be serviced regularly to minimize noise pollution.

5.2 Conclusions

Fast economic development has led to increased demand for quarrying materials, and to deal with its impacts, a multi-sectoral approach should be used. Developers should consider the social impact of their activities other than only the economic benefits of quarrying. There is also a need to adhere to occupational health standards and ensure that workers are given the appropriate gear to work efficiently without work-related accidents. This, therefore, forms the need for more studies to be undertaken in different parts of the country and have a broader understanding of how to improve the sector since it's critical in the country's economic growth.

5.3 Recommendations

In dealing with quarry wastes, views of all parties involved should be considered and multiple approaches that are socially and economically (Banezet al., 2010). However, authorization and excavation rules should be used by company owners, quarry workers, and communities should use authorization and excavation rules to ensure that there's none or minimal ecological harm since restoration, as said by (Sahara et al., 2016), is a costly practice. Hearing screening is one way to mitigate quarrying effects through screens that assist moderate sound produced by quarrying machines and processes. However, due to relocation to new areas for fresh excavation locations, screening becomes complicated. To reduce problems during the quarrying activities, trucks that produce dust during transportation of the stones ought to use alternative routes far from the population, or frequent watering of access roads should be done to settle dust. Reuben (2014) plant (*pennisetum purpureum*) model was used to demonstrate how quarry dust could be trapped by intercepting dust particles carried by the wind towards human settlement.

Restoration is an essential part of quarrying, and for it to be successful, a multi- sectoral partnership involving research, stakeholders, policy, ecology, and community is necessary (Legwaila et al., 2015). The quarry area goes back to its initial form or gets transformed into a recreation place (Tongway & Ludwig, 2011).

5.4 Suggestions for further studies

Similar should be undertaken nationally to understand the quarrying industry's challenges and how they can be resolved.

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APPENDICES

Appendix I: Questionnaires

Questionnaire for the Quarry Workers

Dear respondents, your responses are solely for academic purposes and will be confidential INSTRUCTIONS: Tick where appropriate

1. Sex: Male Female

2. Age Bracket: 20-30 30-40 40-50 above 50

3. Literacy Standard: Primary Secondary Postsecondary

4. Years of working in quarry

1-5years 6-10years 11-15year

16-20years 20years&above

5 Tick category are work in

a) Blasting b) Crushing c) Loading d) Drilling

e) Driving

6. Do you have any of the protective gear?

a) Dust mask b) Gloves c) Helmet d) Hearing mask

e) Overall f) Boots

7. Which breathing complication do you mainly experience?

a) Coughs b) Chest pains c) Asthma d) Eye irritation

e) Back pain f) Skin irritation

8. Are you in any medical cover? Yes No

Questionnaire for the Quarry Company

Dear respondents, your responses are solely for academic purposes and will be confidential.

INSTRUCTIONS: give an appropriate answer

1. Company name

2. Sex: Male female

3. Age Bracket: 20-30 30-40 40-50 50 and above

4. Advantages of the quarry in the area?

a) Employment b) urban growth c) improved livelihoods

d) Availability of quarrying materials

5. Which are the commonly reported negative effects of the quarry?

a) Noise pollution b) Dust emission c) Vibration d) Air pollution

6. Which control measures do you use to reduce the health and environmental impacts of quarrying?

Questionnaire for the Area Resident

Dear respondents, your responses are solely for academic purposes and will be confidential.

INSTRUCTIONS: Tick where needed

1. Sex : Male female

2. Age Bracket: 20-30 30-40 40-50 above 50

3. Length of residence 1-5 yrs 6-10 yrs 11-15 yrs Over15yrs

4. How does the quarry benefit you?

a) Employment

b) Building materials

c) Better livelihoods

5. Which environmental impacts does the quarry have on you?

a) Air pollution b) vibration effects

c) Dust emission d) noise pollution

7. Which dust-related health problem have you ever experienced?

a) Coughs b) Asthma c) wheezing d) Eye problems

8. Which mitigation measures should be used to reduce these quarrying problems?

a) Dust barriers b) Watering access roads

c) Rehabilitation d) Alternative routes of trucks

9. What are some of the problems facing the environment from quarrying activities?

a) Loss of biodiversity

b) Coating of crop leaves

c) Reduction in agricultural yields

d) Cracks from vibrations

Appendix II: Authorization Letter



**KENYATTA UNIVERSITY
GRADUATE SCHOOL**

E-mail: dean-graduate@ku.ac.ke

Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 8710901 Ext. 57530

Our Ref: N50/CTY/PT/28270/2013

DATE: 28th September, 2022

Director General,
National Commission for Science, Technology
and Innovation
P.O. Box 30623-00100
NAIROBI

Dear Sir/Madam,

**RE: RESEARCH AUTHORIZATION FOR KINYUA MAUREEN MUTHONI –
REG. NO. N50/CTY/PT/28270/2013**

I write to introduce Ms. Kinyua Maureen Muthoni who is a Postgraduate Student of this University. She is registered for M.Sc degree programme in the Department of Environmental Studies and Community Development.

Ms. Kinyua intends to conduct research for an M.Sc Research Proposal entitled, "Assessing Health and Environmental Impacts of Quarrying in Embu County, Kenya".


Any assistance given will be highly appreciated.

Yours faithfully,



EK/nn

Appendix III: Approval Letter


**KENYATTA UNIVERSITY
GRADUATE SCHOOL**

E-mail: dean-graduate@ku.ac.ke P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 810901 Ext. 4150

Website: www.ku.ac.ke Internal Memo

FROM: Dean, Graduate School **DATE:** 28th September, 2022

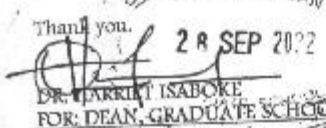
TO: Kinyua Maureen Muthoni
C/o Environmental Studies & Community
Development Department. **REF:** N50/CTY/PT/28270/2013

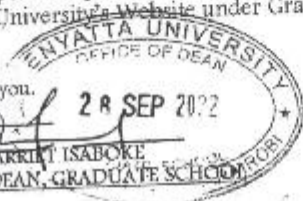
SUBJECT: APPROVAL OF RESEARCH MASTERS PROPOSAL

We acknowledge receipt of your revised Proposal as per our recommendations raised by the Graduate School Board at its meeting of 19th October, 2016, Entitled, "Assessing Health and Environmental Impacts of Quarrying in Embu County, Kenya".

You may now proceed with data collection, subject to clearance with the Director General, National Commission for Science, Technology and Innovation and Ethics Review Committee Kenyatta University.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking Forms per semester. The form has been developed to replace the Progress Report Forms. The Supervision Tracking Forms are available at the University's Website under Graduate School webpage downloads.

Thank you.

DR. PATRICK ISABOKE
FOR: DEAN, GRADUATE SCHOOL


28 SEP 2022

C.c. Chairman, Department of Environmental Studies and Community Development

Supervisors:

1. Dr. Joseph Kurauka
C/o Department of Environmental Studies
& Community Development
Kenyatta University
2. Dr. Gladys Gathuru
C/o Department of Environmental Science & Education
Kenyatta University

Appendix IV: Ethical Clearance



**KENYATTA UNIVERSITY
CENTRE FOR RESEARCH ETHICS AND SAFETY**

Fax: 8711242/8711575
Email: chairman.kuerc@ku.ac.ke
Nairobi, 00100

P. O. Box 43844,

Tel: 8710901/12

Website: www.ku.ac.ke
Our Ref: KU/ERC/APPROVAL/VOL.1

Date: 29th /09/2022

Maureen Muthoni Kinyua
P.O Box 43844, 00100
Nairobi.

Dear Ms. Kinyua,

APPLICATION NUMBER: PKU/2589/11707- ASSESSING HEALTH AND ENVIRONMENTAL IMPACTS OF QUARRYING IN EMBU COUNTY, KENYA

This is to inform you that *KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE* has reviewed and approved your above research proposal. Your application approval number is PKU/2589/11707. The approval period is 29th /09/2022 to 29th /09/2023

This approval is subject to compliance with the following requirements;

- i. Only approved documents including (informed consents, study instruments, MTA) will be used
- ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by *KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE*
- iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to *KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE* within 72 hours of notification
- iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to *KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE* within 72 hours
- v. Clearance for export of biological specimens must be obtained from relevant institutions.

- vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
- vii. Submission of an executive summary report within 90 days upon completion of the study to **KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE**

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) <https://research-portal.nacosti.go.ke> and also obtain other clearances needed.

To serve you better, researchers are kindly requested to access and complete a customer feedback form and sent it back online as you continue with research and upon completion of data collection found on the following website link; https://docs.google.com/forms/d/1viWefDwvyz5h1oz_Vln0xbxg3uGdIDzMXFWNDsMrRPQ/edit?usp=sharing

Yours sincerely



Prof. Judith Kimiywe

Director: Centre for Research Ethics and Safety