ASSESSMENT OF THE ENVIRONMENTAL EFFECTS OF QUARRYING IN KITENGELA SUBCOUNTY OF KAJIADO IN KENYA

BY

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A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTER OF ARTS DEGREE IN ENVIRONMENTAL PLANNING AND MANAGEMENT IN THE FACULTY OF ARTS, DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES, THE UNIVERSITY OF NAIROBI

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DECLARATION

I declare that this research project report is my own work and has not been submitted before for any other degree, part of degree or examination at this or any other university.

STUDENT

ISABELLA JULIET MBANDI

Signature..... Date 09/11/2017

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

SUPERVISOR

PROF ELIAS H. O. AYIEMBA

Signature..... Date 13th November 2017

DEDICATION

To my parents, you are the reason of what I have become today. You have been committed to my wellbeing ever since.

To my husband and son, you are my soul mates, my inspiration and the reason why I labour every day.

ACKNOWLEDGEMENT

I acknowledge and thank my supervisor Prof. Elias H.O. Ayiemba for his guidance and patience through the entire process. My appreciation is also to the Administration and Management of the University of Nairobi through the Department of Geography & Environmental Studies Chairman, Dr Samuel Owuor and the entire departmental staff for their support and according me an opportunity to take this course.

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I also extend my sincere thankfulness to the administration of Kitengela Sub County for allowing me to take photographs and gather data amongst the quarrying workers and to Mr Daniel Suyianka for helping me out with data collection. I also appreciate the quarry owners, their workforce and Kitengela residents for contributing towards this research. Their input was inestimable.

A very special gratitude to my husband, son, parents and all my siblings, for their patience, endurance and support through my studies.

Above all else, thanks be to God

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ABBREVIATIONS AND ACRONYMS

CS	Crystalline Silica
GOK	Government of Kenya
IARC	International Agency for Research on Cancer
IUCN	International Union for Conservation of Nature and Natural Resources
KBS	Kenya Bureau of Statistics
KWS	Kenya Wildlife Service
NACOSTI	National Commission of Science, Technology and Innovation
NECC	National Environmental Complains Committee
NEMA	National Environmental Management Authority
NGO	Non-Governmental Organization
NIHL	Noise induced hearing loss
PAR	Photosynthetically Active Radiation
RSC	Respirable Crystalline Silica
RPM	Respirable Particulate Matter
SNHL	Sensorineural hearing loss
SSD	Short Sleep Duration
WHO	World Health Organization

ABSTRACT

Quarry locations, abandoned without any scheduled rehabilitation processes thereafter have posed environmental challenges globally, in addition to being among the most risky industry to work in due to high number of reported health hazards. In Kenya, stone mining in the past few years has been on the increase due to an increase in their demand by both commercial and residential property developers. And as such, this study aimed at evaluating some problems stemming from stone mining in Kitengela, one of the sub-counties of Kajiado County. The specific objectives that guided the study are; to gauge ecological upshots of stone mining in Kitengela, to scrutinise quarrying ramifications on health of labourers and on Kitengela populace, to detect mitigation processes that alleviate stone mining impacts on the environment and lastly make recommendations that address undesirable stone excavation effects on the environment. For this study, both quantitative and qualitative or mixed methods of research design was adopted targeting 5,278 people whose composition included quarry labourers and people residing within Kitengela. Out of the targeted population, a sample size of 642 was drawn using a cluster and simple random sampling techniques. The sampling process involved dividing the respondents into quarry workers and residents then randomly sampled from both categories. The procedure involved writing 'yes' and 'no' on small pieces of papers, folding them, shuffling and asking respondents to pick them. Those who picked paper pieces indicated 'yes' were chosen to participate. During data collection, questionnaires were chosen as main data gathering tool and the collected data analysed descriptively and inferentially. Chi-square tested hypothesis and significance levels. The findings of this study showed a significant association between quarrying and environmental degradationX^2 (3, N = 392) = 126.42, P< 0.05 and no substantial association on splitting of buildings and people's health respectively, X^2(1, N =180) =3.487, P< 0.05. In view of the acquired outcomes, the investigation reasoned that degradation of environment in Kitengela was due to unregulated stone excavations and therefore recommends that strict enforcement of existing regulatory frameworks be undertaken on non-compliant quarrying businesses.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Ukpong (2012) defines stone excavation as a process of abstracting materials which are neither fuel nor minerals in nature from the rocks. An upsurge in demand for stones related supplies such as gravel and building stones gives rise to the need of quarrying. Many stone mining companies use open cast method which involves drilling and use of explosives to extract rock materials from the earth. According to Nwibo et al.,(2012),the quarrying activities have adverse implications on workers, society and cultural heritage, natural environment and communities in close proximities. Whereas Ming'ate and Mohamed (2016) also describe explosives used in quarries as potentially dangerous to both human beings and the environment, Monjezi, et al. (2013) reports that only 20% to 30% of the energy is required to fragment the rocks and the remaining energy gets wasted in form of vibrations and fly rocks. Parise (2010) has given the extent of response by humans and the environment on the significance of such vibrations including destruction of buildings.

Stone mining processes irrespective of their magnitudes fundamentally have far fetching environmental repercussions due to large amounts of wastes produced during the processes especially if non-standard processes of quarrying are used and no rehabilitation measures are put in place.

According to Nartey et al. (2012) and Adeola et al (2009), four million deaths are reported annually from acute respiratory problems in developing countries owing to aggravated environmental pollution emanating from quarrying, sand blasting and emission of dangerous

chemicals. Nartey et al. (2012) highly relate respiratory dreariness with the sector since a10μm powder can be inhaled into the lungs. Rock and mineral particles of numerous sorts have too been appeared to be cancer-causing when breathed in (Derbyshire et al, 2013). The mountain ecosystem of Medvednica Mountain located North west Croatia is one example cited by Miliša, et al. (2010) who notes that the physical characteristics such as turbidity, pH and temperature of Bistra stream which originates from spring in the Medvednica Mountain had extensively been altered downstream because of quarrying uphill. Miliša, et al. (2010) further observed that prolonged disruption of the river's physiochemical parameters had affected the structures of macro invertebrates.

Prolonged and unregulated stone mining additionally has a capacity to also alter traditional land use as it is in Lebanon where according to Lad & Samant (2014), skirmishes have emerged between pastoralists and farmers because large land tracks were rendered barren by abandoned quarrying. In reference to the satellite images, Lad & Samant (2014) noticed that quarries in Lebanon had expanded to 63% between 1989 and 2005 to cover 5,267 hectors. Similarly in Ghana, the emerging desertification in the northern region was closely associated with the loss of indigenous tree species destroyed through extensive extraction of gravel and sand materials demanded by the construction industry (Musah & Barkarson, 2009).

Missanjo et al. *(*2015) established a perpetual relationship between plants and their physical, chemical and biological environments in a study of Chongoni Forest Reserve in Malawi where dust emissions affected plants' chlorophyll content. Missanjo et al. *(*2015) demonstrated this by studying chlorophyll of different plant species located close and distant from a quarry location. Plants near stone mining areas showed heavy interference of photosynthetic processes because of high intensity of dust although this reduced with distance

and differed with plant species. Interruption of photosynthesis processes was attributed to reduced plants' green surfaces and clogging of stomata thus affecting free exchange of atmospheric gases.

Kenya too have equal share of problems credited to stone mining industry especially after the recent rise in real estate business and road expansions (Anunda, 2014).There are more than thirty thousand stone mining locations in Kenya (KNBS, 2009) but those close to Nairobi have better access to markets signifying that greatest environmental impacts are also experienced in these regions as alluded in a report by the Kenya's Ministry of Environment and Mineral Resources where it is indicated that about 90% of the quarries in Kenya have no rehabilitation plans, exposing laxity of the enforcement authorities such as National Environment Management Authority(GoK, 2010).

As much as the industry has its share of challenges some highlighted in this study, its' also true that stone mining is a lucrative business that supports thousands of families. According to (Shadmon & Sam, 1999), it is estimated that the industry employs about forty thousand people and that quarter of this population are within Nairobi's environs. Despite the above positive contributions, cases of child labour and underpayments have been reported in various quarry sites, a matter that has concerned workers unions and activists. Environmentalists on the contrary have been concerned on the negative quarrying implications especially sites left without being rehabilitated pointing that abandoned pits deface landscapes and make soil structures weak.

Juja, Kitengela and Tala are the most prominent locations known for stone mining around Nairobi. Kitengela alone according to Shadmon (1999), is reported to contain stone reserves that can last a 50 years supply and this elucidates why many quarrying businesses have

proliferated. Being a region of interest as far as stone mining is concerned; this study undertook an evaluation on the effects of stone mining on environment, quarry workers and the locals in the region.

1.2 Problem statement

Abundance and easy access of building stones has made Kitengela an ideal source to many developers in the rapidly developing areas of Machakos, Kajiado and Ngong which are considered recipient areas of the Nairobi's exploding population seeking housing, majority of whom are the middle income earners. The consequential effects of the increased quarrying activities in Kitengela to meet such rising demands have witnessed changes in landforms, increased pollution of dust and noise, development of cracks in buildings due to vibrations impacts and commonness of respiratory maladies among the quarry labourers.

In an article contained in the Kenya's Daily Nation newspaper dated June 25th 2014, residents of Chuna, Yukos, and Milimani estates in Kitengela voiced their suffering over dust, noise and tremors caused by blasts where they were particularly apprehensive of their weakened structures and noise pollution generated by blast alerting sirens, transportation trucks and rocks blasting processes which were reported to continue even during the nights causing interference to the proximate residents who wish to sleep. Kilonzo (2014) added that dust produced during grinding and transportation of stones are predominant throughout the dry seasons and that it becomes a nuisance to many other people carrying out their businesses within the locality.

In consideration of the above, the study therefore investigated how quarrying in Kitengela had affected the environment and people's health of the studied location with an aim of using

the study outcome to provide counteractive recommendations that will redress the observed negative effects.

1.3 Research questions

The research looked at exploring the following research questions.

1. What were the environmental ramifications of quarrying in Kitengela?
2. What were the medical issues pervasive among quarry labourers and persons in Kitengela Sub County?
3. What mitigation measures were undertaken to ease quarrying on the environment?
4. What moderation processes were attempted to ease quarrying ramifications?

1.4 Study objectives

This study's principal objective was to assess resultant effects of stone mining in Kitengela in Kajiado, Kenya.

Specific objectives

1. To determine implications of stone mining on vegetation and scenery of Kitengela, Kajiado County.
2. To inspect medical issues pervasive among quarry labourers and individuals in Kitengela sub-county.
3. To detect steps taken to moderate ecological aftermaths caused by stone mining.

1.5 Research hypothesis

H_0: There are no significant repercussions of stone mining on flora and scenery of Kitengela Sub County.

H_1: There are significant repercussions of stone mining on flora and scenery of Kitengela Sub County.

H_0: Quarry blasts are not the genesis of infrastructure cracks in Kitengela Sub County.

H_1: Quarry blasts are the genesis of infrastructure cracks in Kitengela Sub County.

H_0: There's no colossal connection between stone mining and pervasiveness of illnesses among quarry laborers and persons in Kitengela Sub County.

H_1: There's colossal connection between stone mining and pervasiveness of illnesses among quarry labourers and persons in Kitengela Sub County.

1.6 Justification and significance of the study

Whereas EMCA 1999 Article 14, Section (2) protects Kenyan people against noise pollution, slackness in execution of this regulation have occasioned licensing of factories and industries close to designated residential areas. An example of such is Kaputiei quarry in Kitengela whose perimeter wall is hardly one hundred metres from a residential area. Such similar incidences prompted the National Environmental Complains Committee (NECC) to undertake stakeholders' consultative forum involving NEMA and KWS among others to deliberate remedial measures to the undesirable outcomes of stone mining along Kitengela-Namanga road on the immediate premises. It was however unfortunate that later on, insignificant headways were reported on the stakeholders' proposed corrective measures and it is thought that hesitance of authorities in settling concerns raised by inhabitants are because of absence of information to substantiate such cases. The appropriate responses from this investigation therefore targets at providing some statistical evidences on the above identified objectives which will be the foundational basis of future references of similar incidences.

Additionally, the outcome of this document contributes supplementary information to the existing body of academia in the confines of the researched topic and objectives especially on the studied location of Kitengela Sub County. The findings can correspondingly be of value to policy makers and the government environmental agencies like NEMA whose mandate includes a clean and habitable environment for its people. Economic significance of the industry can similarly be pointer in providing opportunities to the jobless. The attained evidences on the conservational obliterations will moreover be key to NEMA in strategizing relief and restoration measures.

This document can as well be adopted by the environmental advocacy groups when designing awareness campaigns on the adverse ramifications of stone excavation particularly on environment and people while equally providing insights on rehabilitative measures on the already degraded sections. Correspondingly, it is expected that excavation companies and artisans will equally incorporate in their operations procedures that are environmentally acceptable.

1.7 Scope and limitations

This research geographically confined itself to Kitengela and data collected from quarry workers only present during the day of the field visit, populaces within 1km from quarry sites and identified key informants. Regarding environmental valuation, only parameters such as air or noise nuisance, ecological termination and change in scenery were considered.

The study also acknowledges that despite prior detailed planning of the activities, some financial limitations remained a challenge because the researcher had a modest budget. The other impediment was that stone miners were overwhelmingly male and their reaction along these lines couldn't be described to equally converse for females.

1.8 Operational definitions and concepts

Aggregates: Rocks, sand or gravel used in construction.

Blasting: Use of explosives to fragment large underground rocks.

Buffer zone: A barricade of plants, trees or constructed wall between the quarry and the adjoining community.

Conveyor belt: A stretchy belt that moves around crushed rocks to desired locations.

Crushers: Machines that fracture stones into reduced sizes.

Crushed stone: Stones that come out of the crushers.

Drilling: Boring of hole underground for the purpose of placing rock explosives

Dust suppression: Technique espoused to minimize dust emission

Explosives: Detonated materials that explode to loosen rocks from the earth surface.

Geologist: Experts of nature and earth.

Landform: Earth's surface forming terrains

Mining: Removal of underground rocks.

Screening: **S**eparation of rocks of different sizes and pilling together those of similar dimensions.

Vibrations: Movement caused by blasting.

1.9 Outline of chapters

The second chapter of this document entails current works of other scholars globally on the topic of research. The review process encompassed where possible relating, appraising and scrutinizing methodologies used, study participants involved, findings and conclusions of the identified scholarly works. Towards the end, literature gaps are identified in respect to reviewed works and an outline given on how the research fills the predominant knowledge blanks. Applied and hypothetical systems supporting this examination are additionally found in this part.

Methodology adopted by the study is in detail described in the third chapter. Information given entail a description of Kitengela which is the study location, research design chosen, target population, sample size, and the procedure used to sample, research instruments used, data collection procedures, data analysis, ethical contemplations.

Analysis of collected data, presentation and interpretation in this document are found on the fourth chapter. Discussion of results is also found herein. Chapter five is the final section and it recapitulates study findings while bringing afore author's conclusions and recommendations grounded on the obtained outcomes. Addendums found at the back of this document consist of list of references, sample of questionnaires used, University's authorization letter, and research permit from National Commission for Science, Technology and Innovation.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter examines works presented by previous scholars on the thematic areas of this study which includes effects of stone excavations on environment, health and presentation of relevant proven mitigation measures.

2.2 Implications of stone excavation on the environment

Most undesirable environmental outcomes such as soil erosion and loss of rich biodiversity, is largely attributed to active and abandoned mines (Mwangi, 2014). Such problems escalate due to lack of environmental awareness while operating the mines (Langer, 2009). The reason behind existence of the high number of abandoned quarry pits universally is because of the low reserves of the excavated materials compelling mining corporations to relocate from time to time leaving behind a trail of environmental menace (Phillips, 2012).

The most obvious engineering effect of quarrying is on the environment. Quarrying distorts nature by disturbing unique habitats, significant alteration of topography and unchecked disruption of basic ecological relations (Walker & Del Moral, 2003; Sharma & Roy, 1997).

Land is a critical resource for people dependent on farming. Today, about two 2 million hectares of agricultural lands are lost every year due to anthropogenic influences which affect the ecosystem and cause severe land degradation, (Walker & Del Moral, 2003). Open cast quarrying activities represents a major perturbation to the natural landscape, creating significant effects on habitat loss, (Menta, 2012). Quarrying and mining activities are destructive enterprises. Quarrying activities have altered vegetation cover worldwide such as

Appalachian Mountains, Netherlands, Ghana, Germany and Nigeria (Townsend et al. 2008, Ata-Era, 2016, Tischew et al. 2014, Akanwa et al. 2016). Undergrowth clearance is perhaps the prime cause of environmental dilapidation and exhaustion of natural communities worldwide, (Akanwa et al. 2016).

Ukpong (2012) pronounces excavation sceneries as visually dramatic. The sentiments were nearly comparable to Dávid's, (2007) who termed open quarry pits in Hungary as “scars in the landscape”. The mentioned state of the topography according to Ukpong (2012) is a creation of the unwarranted excavation of the earth surface and disregard of the natural sceneries. The magnitude of the environmental obliteration however can be said to correspond to the scope, number and locations of the undertaken operations.

Ukpong (2012), made an observation in Akamkpa, Nigeria, that bounteous smaller excavations upset the environment to a greater degree as opposed to one large excavation, meaning that environmentally conscious artisanal miners have an opportunity of amalgamating their operations and capitalize on deep excavations rather than scattering so as to minimize ecological upsets including the earth’s geomorphology. A manifestation of such occurrences was recounted by Nawaz et al. (2004) who used remote sensing technique to demonstrate how Margalla hills in Pakistan were at the brink of being vanished by stone miners at the western side.

In Ethiopia, Zelalem, (2016) found that although stone mining was a lucrative business in semi urban zones of Addis Ababa, it concerned environmentalists that it irreversibly exhausted natural resources, a fact resounded by Haule et al. (2016) whose study in Mbeya region of Tanzania revealed that limestone mining caused extensive losses of soil and vegetation covers.

In Kenya, Ming'ate & Mohamed (2016) using quantitative and qualitative methods of research reverberated that despite stone mining being the chief economic contributor to majority of the households in the County of Mandera, it had on the other hand degenerated the environment in equal measure. Waweru & Mukundi (2016), similarly in a different study in Kiambu county of Kenya found stone mining to have social and economic distresses.

2.2.1 Noise pollution

Noise is an unwanted sound-produced by a source causing vibrations in the medium around it (Agunwamba, 2001). According to LI & Tian, (2012), it is excessive noise that can even cause hearing loss after prolonged exposure. Kirchner et al. (2012) in an experiment discovered that 10 dB average at 2000Hz, 3000Hz and 4000 Hz can hypothetically induce hearing loss of human beings. WHO (2015) reiterates that approximately 1.1 million people universally are at the risk of losing their hearing abilities due to persistent exposures to precarious sound levels especially those working in a noisy environments.

Neghab et al. (2009) in a study identified Noise Induced Hearing Loss (NIHL) as rampant occupational hazard among the industrial workforce. The study involved 140 coordinated sound unexposed individuals from a similar industry. As per the discoveries, hearing of 38.5% and 7.8% among the exposed and the unexposed got debilitated respectively giving resounding difference between the groups (Neghab et al., 2009).

Ismail et.al. (2013) demonstrated NIH conditions in six stone mining locations in Malaysia involving 97 respondents between the ages of 18 and 50 years with at least 6-monthsin a quarry and without family history of ear diseases. The outcome showed commonness of NIHL at 95%. Out of this, 84% was mild and 62% had both ears affected. These findings were comparable to Ali et al. (2012) whose study on labourers from a cement plant in

Nigeria, a west African country showed that most of the studied workers (67.1%) were conclusively determined to suffer from mild Sensor neural Hearing Loss (SNHL). The findings were in concurrence with Ali et al. (2012) when 67.1% of labourers in a cement manufacturing plant in Nigeria endured gentle Sensorineural Hearing misfortune.

Omubo-Pepple et al. (2009) studied the effect of NIHL in Nigeria and established that the noise from Port Harcourt International Airport had undesirable environmental influences and that if shielding measures were not taken immediately, then it will result to induced hearing loss and other psychological and pathological effects. These findings upheld the concept that persistent exposures to high pitch sounds induce shearing impairment.

The most shared problem associated with noise pollution among many people particularly during the nights is their inability to sleep well. Uninterrupted sleep is a requirement for good physiological and mental functioning in fit persons. Luxton et al. (2011) established relationship between interrupted sleeps among the United States soldiers in Iraqi mission and symptoms of depression. Those who had no satisfactory sleep showed signs of post-traumatic stress and behaviours including increased abuse of drugs.

NIHL is not a concern at low levels and it's only a potentially hazardous above noise levels of 80 dB and where exposure is prolonged, children being more vulnerable (Savale, 2014). The potential risk to workers is dealt with by the Health and Safety Executives and at times by Local Authorities (Sliwinska-Kowalska & Davis, 2012).People are said to get disturbed by noise if it distracts their concentrations e.g. from hearing spoken conversation, listening to the radio or sleeping. The sensation of discontentment instigated by noise is annoyance (Sung et al 2017).

2.2.2 Dust

Chukwuemeka (2001) characterized dust as powder scattered in a vaporous form because of mechanical deterioration. As per Ukpong (2012), dust is considered the largely observable, invasive and having potentially irritating effects associated with quarrying. Its visibility often raises concerns that are not proportionate to its impact on humans and the environment. Dust is generated from excavation, haul roads, blasting, crushing and screening (Langer, 2009). Dust can effectively affect vegetation but fundamentally at great loadings. Doley (2010), affirms dust settlement above $7gm^{-2}$ on canopies impede plants development.

Prasad et al. (2013) and Nanos et al. (2015)validated that dust negatively affect plants. Both scholars showed that plants' photosynthetic processes get stalled by accumulated dust on the leaves due to dwindled stomatal conductance, photosynthetic and transpiration rates, and water use efficiency possibly due to stomatal blockage and other effects on leaf cells.

Paoli et al. (2015) similarly investigated the how dust originating from cement plants affected the physiological processes of lichen plant species. The plants were exposed for 30 days, 90 days and 180 days to dust sites in Slovakia. Paoli et al. (2015) established a linear relationship between duration of exposure and vitality of the mycobiont of lichens. Dust deposition furthermore led to variations which included increment in lipid beads, puffiness of cell segments and thylakoid degeneration giving cells matured appearance.

Among humans, dust is connected to a torrent of genuine respiratory ailments (Nwibo et al., 2012). Nwibo et al (2012) additionally included that respiratory complications is leading cause of indisposition worldwide. Particulates enter breathing canals and prompt respiratory infections (Kim et al., 2015). The conclusion certified with results amongst 4,265 workers in

Europe exposed to cement dust that affirmed the narrative suggesting obstruction of airways is synonymous to dust exposure.

Breathing in micro-particles cause grave respiratory ailments (Nwibo et al., 2012). Nwibo et al. (2012) adds that breathing complications is among medical perils to dust-exposed labourers causing indisposition worldwide. Dust infiltrate breathing canals to induce complications (Kim et.al., 2015). This was upheld by a cohort investigation amongst 4,265 labourers in Europe where findings sustained the narrative suggesting obstruction of airways is synonymous to dust exposure.

2.3 Implications of stone excavation 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. Horwell et al. (2012) reports that Respirable Crystalline Silica (RCS) jeopardizes state of the human wellbeing, a fact reiterated by National Institute for Occupational Health (Esswein, et al. 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).

Ohakwe et al. (2009) demonstrated powders of iron, zinc, cadmium ions, and barium ions, among other minerals to 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 Anatolia 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 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 a common knowledge, cases have been cited where employees deliberately ignore this safety measure. Ugbogu et al. (2009). 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.

2.4 Possible mitigation measures

A good mitigation approach adopts multiple approaches in alleviating quarry wastes and must be technically and economically feasible as well as incorporate inputs from all stakeholders (Banez et al., 2010).

2.4.1 Directorate bodies

Seeking the views and ideas of the affected populations and those in charge of environmental conservations can fashion viable environmental plans (Banez et al., 2010). Admasu, (2015)

gives a case in Ethiopia where conservatory measures of the environment are barely observed because the experts are hardly available to give guidance.

2.4.2 Acoustic screening

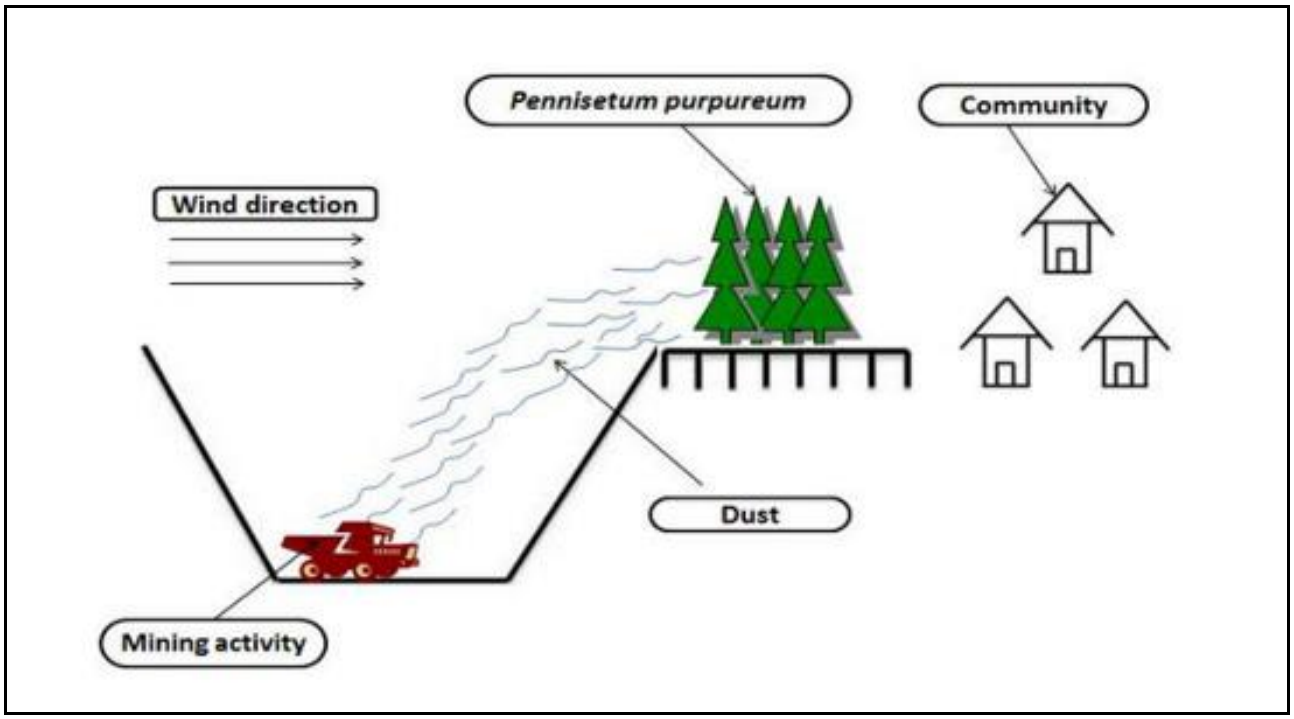
Screens in the context of stone mining are materials that assist moderate sound produce by the mining apparatuses and processes (Fahy and walker, 1998). This is a necessary intervention despite being complicated because these screens have to be shifted from time to time as machineries relocates to other fresh excavation locations or points. Walls are ideally most preferred because of costs involved and their ability to deflect sound. Kotzen & English, (2009) and Bies & Hansen (2009) demonstrated that a good absorptive barrier can conceivably decrease sound by up to 8dB although Ranjbar et al. (2012) also suggested cantilevers principally for works in commercial and residential areas. More practically in quarries, similar results can be obtained with the use of earth mounds. Although acoustical blockades are currently the most popular, deflection properties of sound have interested researchers in the hope that other more efficient sound absorbents can be discovered (Bies & Hansen, 2009).

2.4.3 Dust barriers

Control of dust ranges from a simple act of sprinkling water on the earth surfaces to setting up of suitable barricades to serve as buffer zones. At Hanson Aggregates, stone mining in San Marcos, California, the corporation created barrier walls around the excavation to eradicate dust reaching local residents. Reuben, (2014) similarly demonstrated a model how *pennisetum purpureum* plants could be used to trap dust from quarries. Figure 2.1 represents an active quarrying site whereby dust is spawned from diverse operations. And as shown in

the figure, wind carrying dust particles towards human settlements would be intercepted by *Pennisetum purpureum* along the paths.

Figure 2.1: Dust barrier model



Source: Mintah (2014)

2.4.4 Restoration

Restoration of mined areas is an essential part of mineral sand or gravel mining. To carry out good quarry restoration, a strong partnership between stakeholders, policy, ecology, research and community is important (Legwaila et al., 2015). Restoration processes that begins from designing to aftercare enables the dilapidated land revert to its original use such as agriculture or gets transformed to a recreational place (Tongway& Ludwig, 2011).

2.5 Theoretical framework

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 (Weber, 2008).According to Bertalanffy'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 trickledown effect on any one or more sub-sets 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 sub-sets of the whole environmental unit.

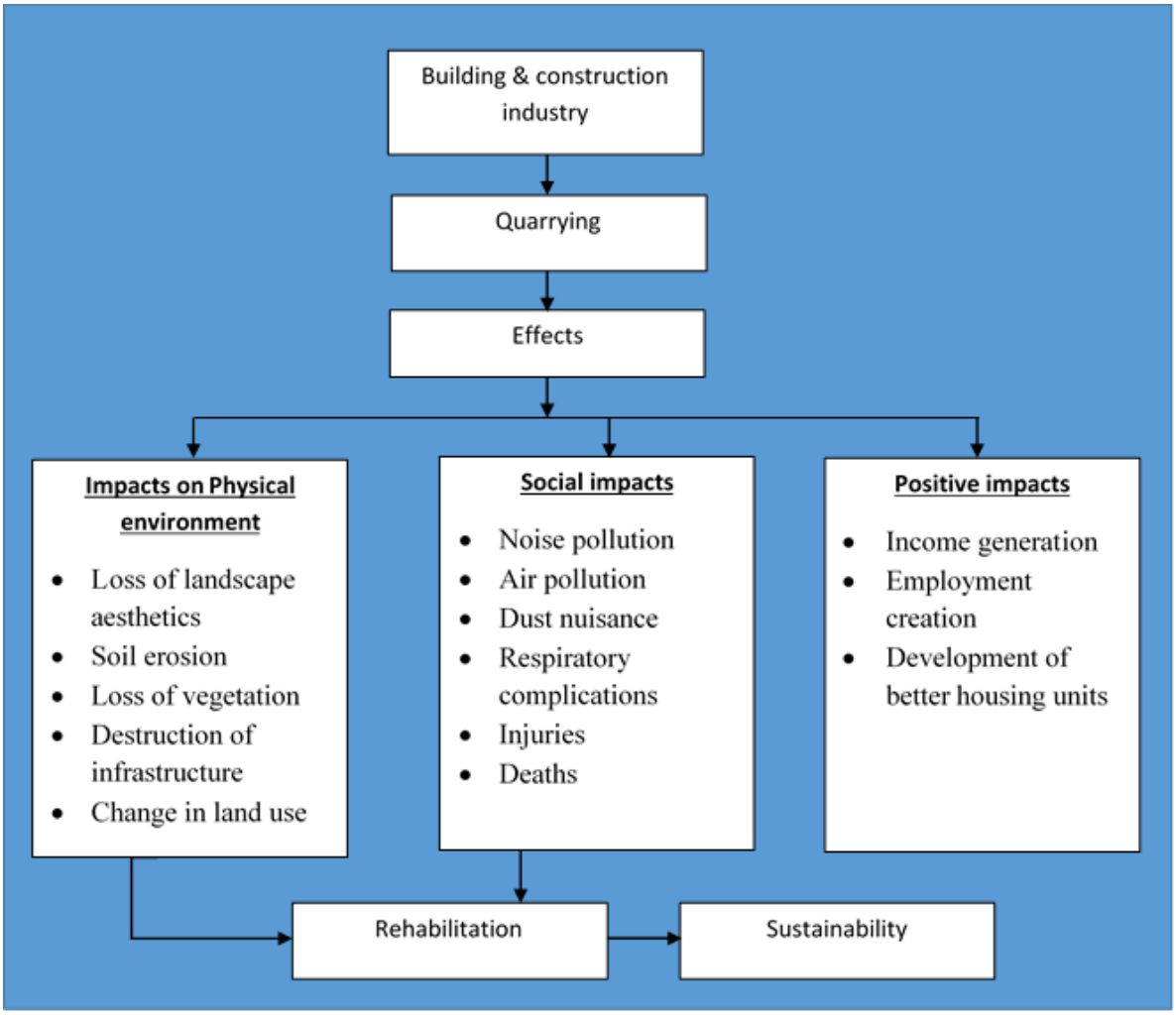
2.6 Conceptual framework

Stone extraction as an activity affects the physical part of the environment which consequently causes an adjustment of the whole or a section of an ecosystem. Human beings, being the primary sources of natures' interference equally end up being the main casualties of e.g. erosion resulting from nature's imbalances.

Figure 2.2 is researcher's conceptualized framework where property developers are regarded chief beneficiaries of extracted stones since with rise in housing demand and home ownership lately in Kenya; there has been an influx of property development dealings across the country

to meet these demands. The consequent outcome of over exploitation of these resources finally gets manifested socially and on the environment out of which some are positive while some are negative and highlighted in this study. They include; employment opportunities, modernization of houses and properties, noise pollution, air pollution and dust nuisance. The environmental drawbacks on the other hand comprises distortion of landscape's natural beauty, soil erosion attributed to clearance of vegetation, weakening of structures through developed cracks caused by vibrations and probable transformation in traditional land use.

Figure 2.2: Conceptual framework



Source: A modification of Crocker (2010)

2.7 Gaps identified in literature review

Reviewed literature mostly showed ramifications of stone excavation on flora and fauna. Langer (2009) and Phillips (2012) revealed problematic open pits are since responsible companies rarely rehabilitate excavation sites once they are through with their business, generating what Dávid, (2007) describe as “scars in the landscape”.

Though Fayaz (2004) utilized remote sensing procedures to distinguish geomorphologic alterations in stone mining zones, the methodology failed to establish far-reaching

significances on adjacent communities. Ismail et al. (2013) in a study on NIHL then again narrowed to only mineworkers and botched to offer comprehensive environmental ramifications of stone mining. The review additionally did not discover existing write up regarding the matter under scrutiny for Kitengela zone, and accordingly this investigation looked to fill this current knowledge breach.

CHAPTER THREE

RESEARCH METHODOLOGY

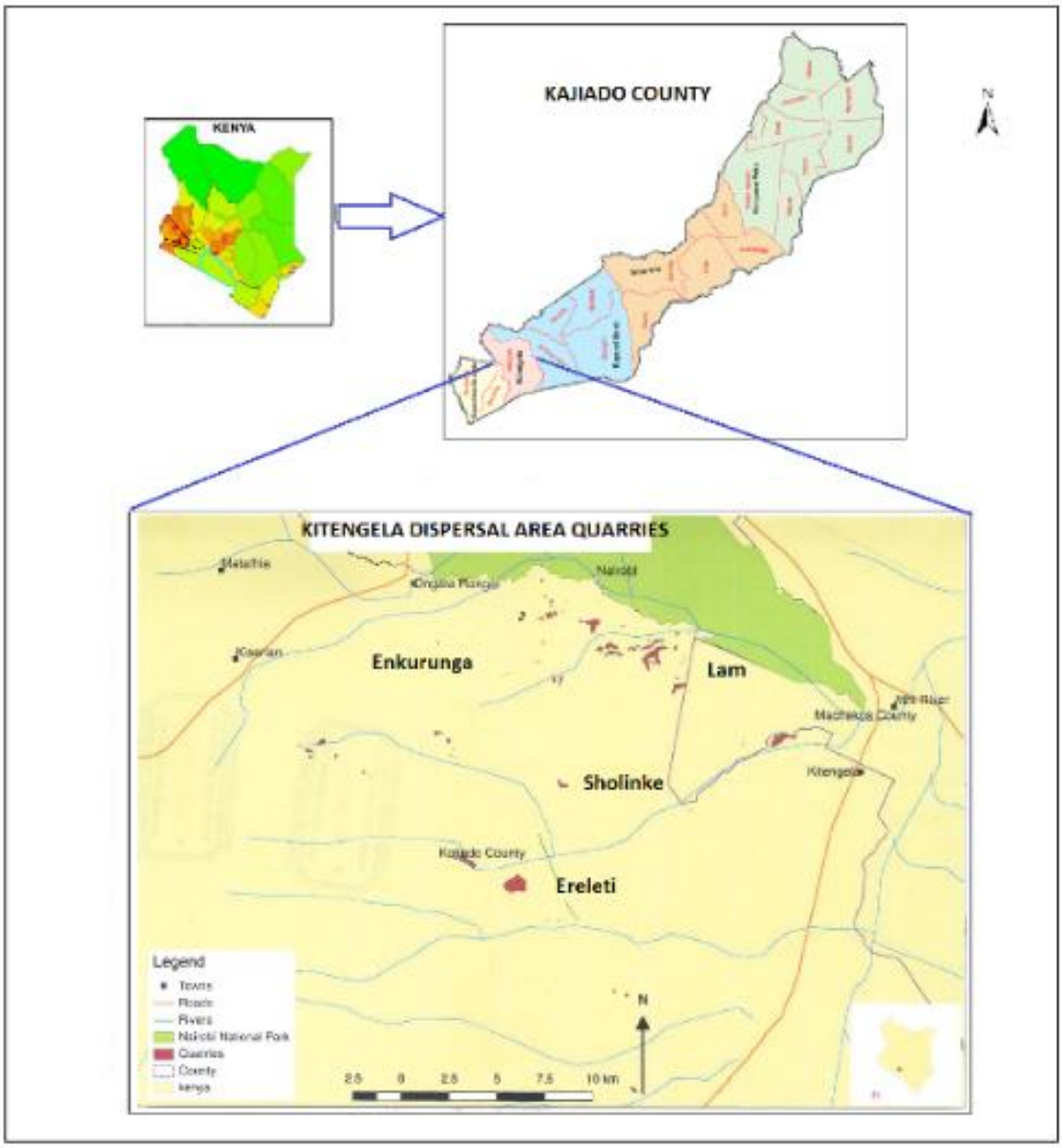
3.1 Introduction

This section defines methodological approaches used in the study including methods, procedures and instruments used to collect, analyse and present data. Reasons for the various methodologies chosen for the study and ethical considerations are also given.

3.2 Study area

Kitengela from google map is located on latitude -1.4761200 (in decimal degrees) and longitude 36.9614400 (in decimal degrees) and found Kajiado county of Kenya. Kitengela is about 390 km^2 and is a section of Athi-Kaputiei Plains (a, 2456 km^2 ecosystem).

Figure 3.1: Kitengela map



Source: A modification of Kenya Wildlife Service, (2011)

In 1970s, the aggregate acreage of Kitengela was 18,292 ha, but land selling began in 1990s to outsiders who instigated irrigated agriculture and quarrying enterprises. Over the last twenty years, Kitengela residents have realized substantial environmental shifts due to population sprawls and transformational land-use from the original pastoralist compelling the indigenous habitats to pursue new livelihood strategies (Nkedianye, et al. 2009) .

Being a peri –urban zone, Kitengela has in the recent past witnessed an influx of immigrants from the congested Nairobi city especially since 1990 (Morara et al. 2014) resulting in the rapid development of the area. The place being essentially rocky, stone mining became lucrative, consequently attracting miners from every direction.

3.3 Research design

This study used both quantitative and qualitative of research design to portray any conceivable conduct, dispositions, qualities and attributes. This sort of research method was preferred because the two methods will counterbalance each other's weaknesses and provide a broader perspective of the topic under study.

3.4 Target population

Those working at the stone mining zone and populaces within one kilometre radius from the mining sites formed the target population of this investigation, and in consideration of KNBS census report of 2009, Kitengela which covers an area of 182km^2 had a population of 58,167, and since the study targeted only those within 1km^2 radius from the four stone mining locations, the add up populace of Kitengela (58,167) was divided by its size (182km^2) so as to determine its population per square kilometre. The obtained figure of 319.6 was determined as in table 3.1

$$population\ per\ km^2 = \frac{Total\ population\ of\ Kitengela}{Total\ land\ area\ in\ Kitengela} = \frac{58167}{182\ km2} = 319.6$$

This means there are 319.6 people in Kitengela in an area of 1 km^2, and since populations living within 1km^2 radiuses were targeted in four different quarry locations, the total target

population of residents was 319 × 4 = 1278. One thousand respondents were purposely targeted from each of the four quarry sites such that the total target population became 5,278.

Table 3.1: Target population

Area	Total population	Area in km^2	Population/km^2	Target population in the 4 quarry sites
Kitengela	58,167	182	319.6	1,278
4 Quarry sites	4000	-	-	4,000
Total target population				**5,278**

Source: KNBS, 2009 & Researcher, 2016

3.5 Sample size

These are units, replicates, observations or individual pieces of data that are to be encompassed in the statistical data (Kothari 2004). Since census is time consuming and costly, sampling was done to represent the entire study population. The 4 quarries having a combined population of four thousand (4,000), sample size was determined as follows:

$$S = \frac{X^2 NP\,(1-P)}{(d^2 N - 1) + X^2 P(1-P)}$$

Where:

s = required sample size.

$\boldsymbol{X^2}$ = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

N= the population size.

P= the population proportion (assumed to be .50 since this would provide the maximum Sample size).

d= the degree of accuracy expressed as a proportion (.05).

Calculation of sample sizes of both groups were undertaken independently and their sum formed the sample size.

Table 3.2: Sample size

Population	Sample size (N)	Sample size (S)
Kitengela residents (living within 1Km^2 radius in the 4 quarry sites)	1,278	291
Workers in 4 Quarry sites	4000	351
Total sample size		**642**

Source: Researcher (2016)

3.6 Sampling procedure

Respondents who participated in this research were initially categorized as either residents or stone miners before sampling them in a simple random mode to get respondents from both pools. Pieces of papers written YES and NO were folded and raffled, those who picked yes were selected to participate in the study.

3.7 Validity of the research instruments

More reliable instruments minimize the errors of measurement that are likely to occur. To establish validity, the researcher pursued direction from the supervisor to ensure the instrument meets this standard. Varied, permitted data collection instruments were used in order to eliminate weaknesses inherent in each of the instruments

3.8 Reliability of research instruments

To ascertain dependability of the instruments, preliminary testing was done on a few respondents and the received feedback used to establish whether the used instruments captured the desired information and in a consistent manner.

3.9 Data gathering processes

Questionnaires were the primary data collection tool and assistance of research aids was sought to aid this process but training on ethics and procedures was done prior before each of them was assigned specific location. Other than the questionnaires, there were additional sources of data used in this study and they included observations, key informants and photographs.

3.10 Data analysis techniques

Responses from both the local residents and quarry workers on the same thematic areas were merged and analysed descriptively as one data set. The study used Statistical Package (SPSS) to analyse the data where descriptive statistics was used to recognize connections between dependent and independent factors. The below Chi-square formula was used to determine variables relationship;

$$x^2 = \sum \frac{(O-E)^2}{E}$$

Where:

O = Observed & **E** = Expected

This test was used to determine the strength between study variables under study i.e. consequences of stone mining on people and environment. The significance of the established variable associations assisted in accepting or failing to accept null hypothesises.

3.11 Ethical considerations

Prior to data collection in the field, researcher sought authorization from both the University and NACOSTI to facilitate data gathering process. To prevent the respondents from shying away and withholding information, confidentiality was assured and guarantee given that the information provided would strictly be for academic purposes only. Respondents' personal information was also made optional and those who provided theirs were also kept confidential by coding them.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The segment presents analysed and interpreted data of the thematic areas of study. The collected data were processed in response to the pertinent research questions.

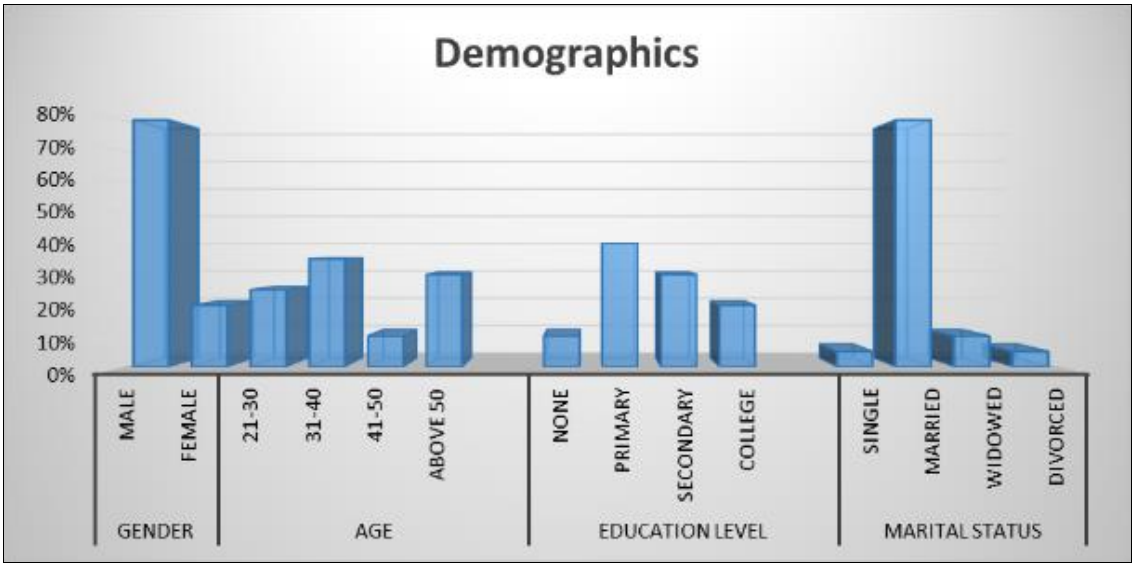
4.2 Questionnaire return rate

Six hundred and forty two (642) questionnaires were allotted in this research and it corresponded to the study sample size. Upon collection and data cleaning, only 392 questionnaires were found suitable for data analysis purposes. It comprised of 168 local residents and 223 quarry workers representing 58% and 64% of their respective categories. Combined questionnaire return rate was 61% above the suggested 50% considered suitable for generalization. (Mugenda and Mugenda, 2003).

4.3 Demographics of respondents

This subsection embodies data on the socioeconomics of respondents in order to give a general comprehension of study populace and draw correlations among respondents on different study aspects.

Figure 4.1: Demographic information



Source: Researcher (2016)

Figure 4.1, unevenness on sex portrayal was observed where the group studied was fundamentally of male gender (80%). This was expected as stone unearthing is monstrously manual and transcendently attempted by men. Age wise, 31 to 40 years constituted a majority of 35% while those aged 41 to 50 years were the least.

Those above 50 years being surprisingly many against researcher's anticipation due to nature of industry that require mostly energetic people is thought that this elderly group perhaps mainly perform guiding and administrative roles. Stone excavation mostly doesn't require advanced abilities hence the greater conformation of study individuals had primary (40%) and secondary school education (30%) credentials. 80% had matrimonial relations even though 10% were widowed, a sign that salary from the segment bolstered huge number of family units.

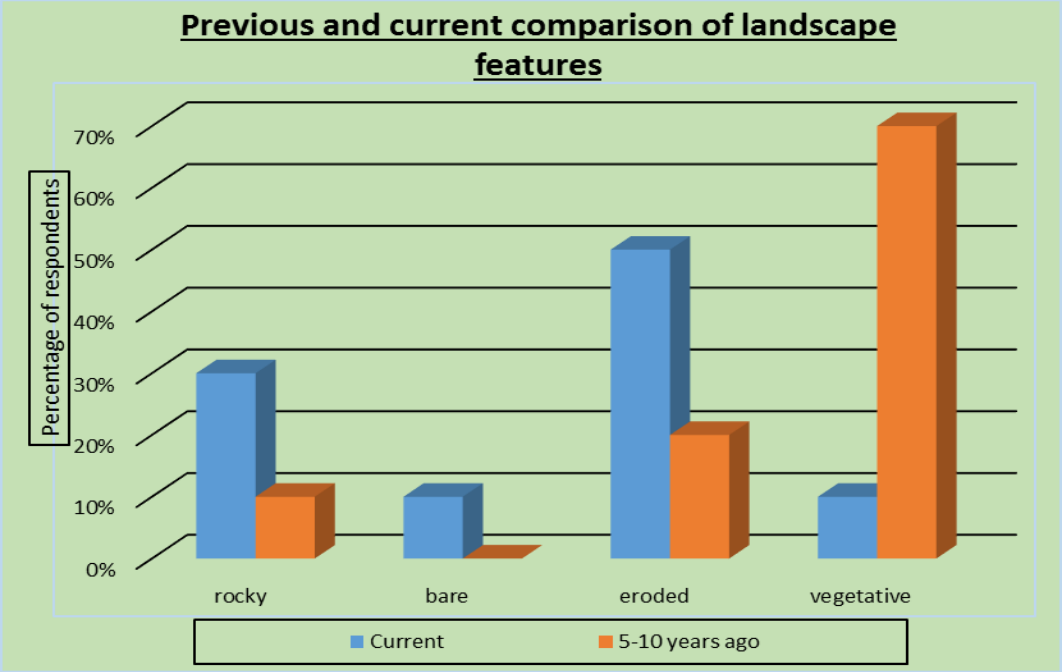
4.4 Ramifications of stone excavation

Stone mining repercussions researched herein included consequences on nature, scenery, nuisance of dust, annoyance of noise and annihilation of structures through tremors.

4.4.1 Land status

In surveying quarrying upshots on landform, respondents contrasted the present scene appearance 5 to 10 years ago. Towards accomplishing a reasonable appraisal, this inquiry coordinated with respondents who'd resided in the region for equivalent or more years.

Figure 4.2: Scenery of Kitengela



Source: Researcher (2016)

From above, obviously there has been extreme scene changes in the preceding 5 to 10 years as presented in Figure 4.2. Remarkably, 70% reported vegetative scenery previously but had now transformed. 50% referred soil erosion as a typical phenomenon right now that contrasted with 20% in the last 5-10 years. By and large, the scene of Kitengela can be

portrayed as rough, exposed and disintegrated as asserted by 30%, 10% and half of the reporters correspondingly.

Plate 4.1: Kitengela scenery

Source: Researcher (2016)

Plate 4.1 taken amid the field visit indicates sparse vegetation of acacia and bushes which relates with investigation data. In this express, the land is inclined to substantial disintegration especially during stormy seasons and most respondents recognized further that cultivation lands had been wrecked and quarry dissipates had turned into a blemish.

Table 4.1: Correlation analysis between previous and current landscape status

			Destroyed or not?		
			Yes	**No**	**Total**
landscape current status	Rocky	Respondents' tally	85	55	140
		%	60.7%	39.3%	100.0%
	Bare	Respondents' tally	125	2	127
		%	98.4%	1.6%	100.0%
	Eroded	Respondents' tally	120	0	120
		%	100.0%	0.0%	100.0%
	Vegetative	Respondents' tally	0	5	5
		%	0.0%	100.0%	100.0%
Total		Respondents tally	330	62	392
		%	84.2%	15.8%	100.0%

Source: Researcher (2016)

Where landscape stood stony, uncovered or windswept, 60.7%, 98.4% and 100% of respective study composition thought of it as smudged with ruinous depths and gravels, contrasting cases before. Essien et al, (2014) included that exhumed quarry pits and trenches amid mining alters and devastate previous sceneries creating repulsive sights and makes the land useless.

H_0: There are no significant ramifications of stone mining on landscape appearance in Kitengela Sub County

H_1: There are significant ramifications of stone mining on landscape appearance in Kitengela Sub County

Table 4.2: Chi-square tests for landscape appearance and stone mining

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	126.420[a]	3	.000
Likelihood Ratio	134.128	3	.000
N of Valid Cases	392		

Source: Researcher (2016)

The Chi-square outcomes demonstrated a considerable relationship amongst stone mining and scenic realities X^2 (3, N=392) = 126.42, P< 0.05. Probability exists in this manner that rough, exposed and eroded land surface is possibly because of human obliteration. The study subsequently rejected the null hypothesis and accepted the alternative.

4.4.2 Air pollution

Quarry dust often contaminates the encompassing air. In deciding the degree of contamination, the pollster displayed interrelated articulations to informants who were requested to illustrate their understanding of the pronouncements in table 4.3.

Table 4.3: Air pollution

Statement	Strongly agree		Agree		Disagree	
	f	*%*	*f*	*%*	*f*	*%*
The main source of dust in your village is from quarrying activities	353	90%	39	10%	0	0%
Concentration of dust in the atmosphere is highest during blasting of rocks	157	40%	196	50%	39	10%
Vehicles transporting quarry products on the unsurfaced roads also generate much dust	392	100%	0	0%	0	0%
Rainy and Cold weather reduce the amount of dust in the air	353	90%	39	10%	0	0%
Dry weather promotes dust emission	392	100%	0	0%	0	0%

Source: Researcher (2016)

From table 4.3, quarrying exercises produce the most elevated amounts of dust recounted in the investigation by 90% of the respondents. The outcomes likewise demonstrated that concentration of dust was astounding during blasting processes amid dry seasons. Other than blasting, all respondents likewise named quarry trucks as dust producers; a sign that quarry administration barely attempts any counteractive measure like sprinkling water on earth roads to settle it.

Walton et al, (n.d) in an investigation in East Anglia expressed that "Quarries spew dust". The Institute of Air Quality Management in UK likewise in their regulatory handbook

reported that dust emerging from quarries caused annoyance. Mkpuma (2015) similarly recounted elevated dust levels amid low humidity.

Plate 4.2: Trucks emitting dust

Source: Researcher (2016)

Plate 4.2 exhibits how quarry trucks pollute the atmosphere with dust

Table 4.4: Dust nuisance

Statement	*Yes*		*No*	
	f	***%***	***f***	***%***
Does dust settle on your roofing sheets or clothing?	392	100%	0	0%
Are the leaves of your crops or plants in the area covered with dust?	392	100%	0	0%
Do crops (plants) grow well when dust coats leaves?	353	90%	39	10%
Does dust prevent you from seeing things a distance away?	157	40%	235	60%

Source: Researcher (2016)

Majority of the respondents recognize that dust caused disturbance by settling on rooftops, hanged garments and plants leaves. This, as indicated by 90% of the respondents made crops to fail. 40% announced that dust influenced visibility risking occurrence of accidents by especially bikers wearing no defensive eyewear. This finding verified with Prajapati, (2012), who found that plants photosynthesis decreases because of condensed leaf area. Lameed and Ayodele, (2010); Doley and Rossato, (2010) and Paoli et al. (2015), also showed that the degree to which dust adversely influenced vegetation was subject to plant species.

4.4.3 Seismic and noise ramifications

To learn whether stone excavation in Kitengela kept vibrations at negligible levels, the study asked adjoining community members whether they had encountered any seismic impacts.

Plate 4.3: Seismic impacts

Source: Researcher (2016)

The assembled field depictions evidently exhibited some houses developed splits accredited to seismic impacts. Respondents also said they endure noise nuisance as an extra annoyance from quarry locales. In light of these discoveries, it’s presumed that stone excavation in the locality cause tremors beyond desired limits. A comparative report by Afeni, & Osasan, (2009) in Nigeria uncovered that walls close to Ewekoro limestone quarry, were "split and broken down". Ramulu et al. (2009) also revealed that rehashed shake impacting triggered debilitation of walls and railroad burrow in India.

Table 4.5: Explosions and structures

			Caused by blasts		
			Yes	**No**	**Total**
Cracked building	Yes	Respondents' tally	3	81	84
		%	3.6%	96.4%	100.0%
	No	Respondents' tally	0	96	96
		%	0.0%	100.0%	100.0%
Total		Respondents' tally	3	177	180
		%	1.7%	98.3%	100.0%

Source: Researcher (2016)

Seventy eight instances of split structures were affirmed by 3.6% were ascribed to quarry blasts.

H_0: There is no connection between blasts and splitting of structures in Kitengela.

H_1: There is connection between blasts and splitting of structures in Kitengela.

Table 4.6: Chi-square tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.487[a]	1	.062		
Continuity Correction[b]	1.648	1	.199		
Likelihood Ratio	4.631	1	.031		
Fisher's Exact Test				.100	.100
N of Valid Cases	180				

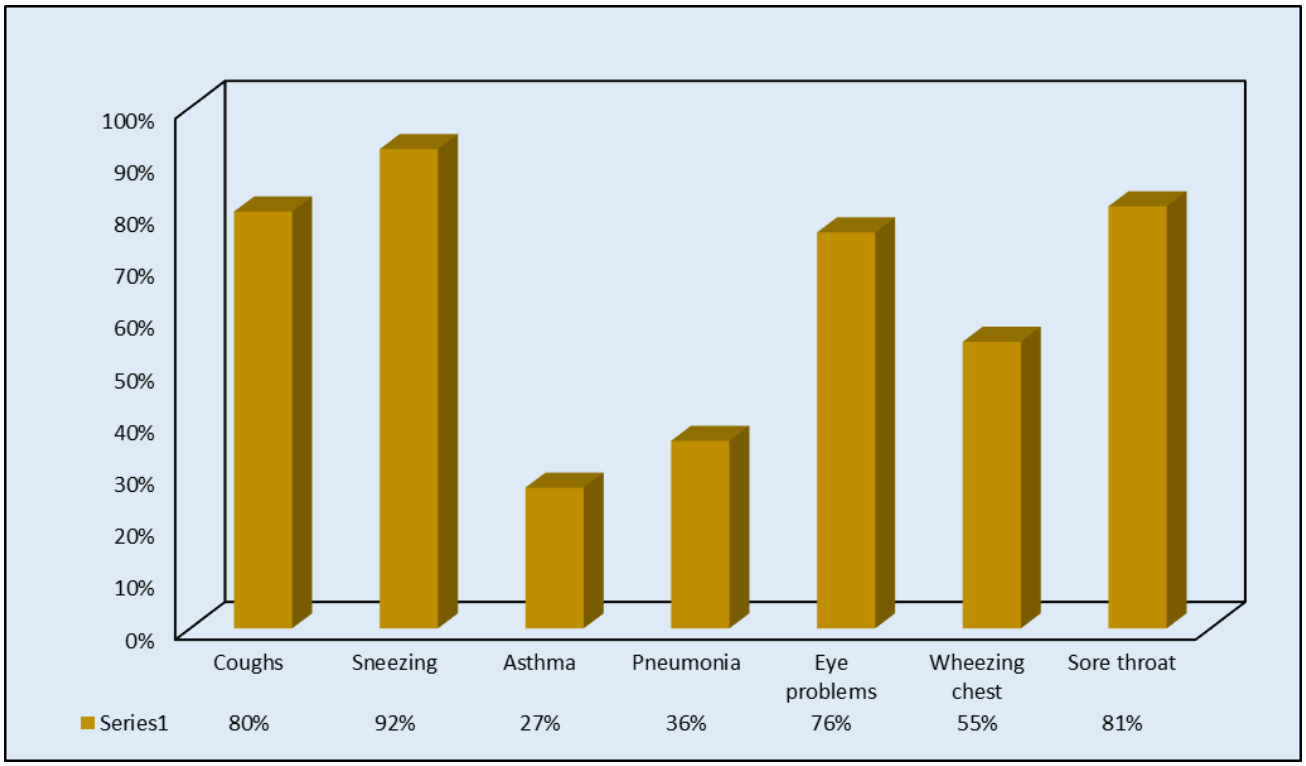
Source: Researcher (2016)

At 95% certainty, the tests demonstrated connection between excavation detonations and splitting of structures as not substantial X^2 (1, N = 180) = 3.487, P> 0.05. Splits of structures in Kitengela cannot in this manner be connected to tremors from rock detonation. The study therefore failed to reject the null hypothesis.

4.4.4 Ramifications on health

In view of the information that quarries produce noteworthy measure of dust, the researcher additionally examined if there were any health ramifications. Gathered information was broken down and displayed in figure 4.3.

Figure 4.3: Disease pervasiveness



Source: Researcher (2016)

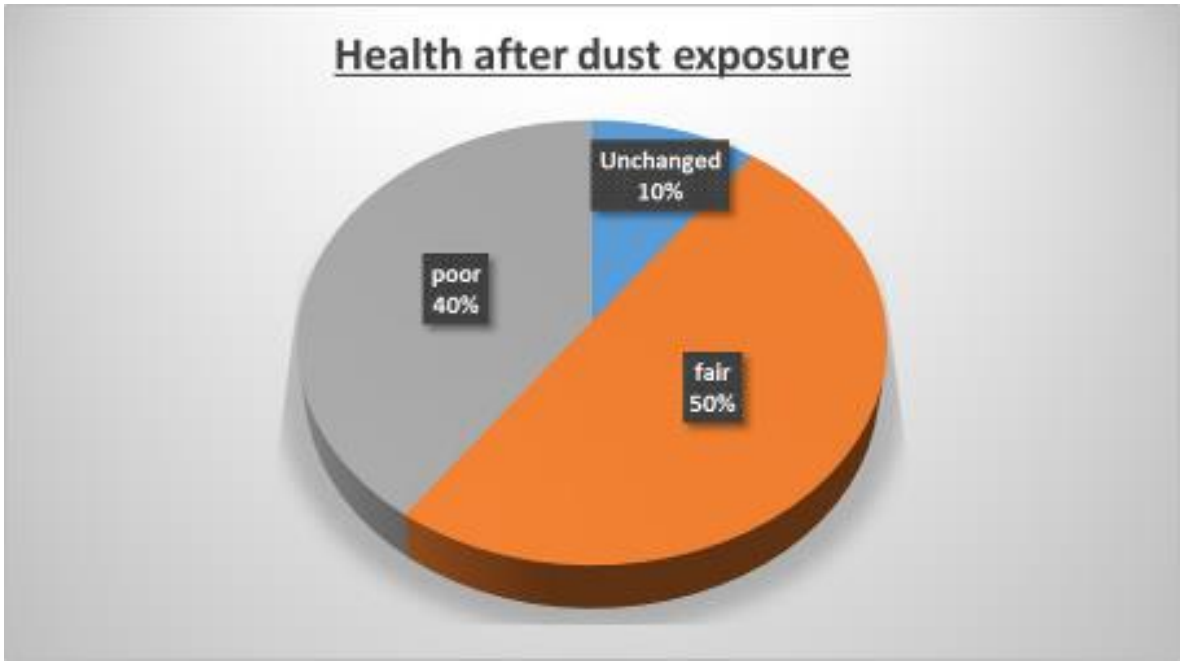
The acquired result demonstrated that 80%, 92%, 76% and 81% of informants endured cold, sneezing, eye issues and sore oesophagus difficulties in that order.

In spite of the fact that the investigation did not setup a component to find out how health disintegration among a few respondents was completely due to quarry dust, 90% who viewed themselves as to have already been healthy, as of now see their wellbeing as fair or poor. Just 10% saw no distinction in their wellbeing status previously and after presented to dusty environment.

Chen et al. (2012) confirmed that long-term dust exposure caused heightened death of Chinese workers. Also Ohakwe et al. (2009); Nwibo et.al. (2012); Olusegun et al. (2009);

Johncy et al. (2011); Mohapatra et al. (2010) and Diaz-Guzman et al. (2012), ascribed respiratory inconveniences to micro-particles.

Figure 4.4: Dust and health



Source: Researcher (2016)

Other than dust issues, respondents likewise stated that timeworn relinquished excavation pits (plate 4.4) collected rainwater amid stormy periods giving an appropriate ground to malaria causing mosquitoes. While this was the situation, the pits were useful to some pastoral groups who used it as drinking focuses for their domesticated animals.

Plate 4.4: Collection of surface runoffs in an abandoned site

Source: Researcher (2016)

Plate 4.4 demonstrates an old quarry site in Kitengela now used by domesticated animals whereas Table 4.7 demonstrates a connection between health and years in stone excavation.

Table 4.7: Relationship between health and years in stone excavation

			Experience in quarrying industry				
			<1 year	**2-5 years**	**5-10 years**	**>10 years**	**Total**
Health status	Good	Respondents' tally	63	56	44	9	172
		%	36.6%	32.6%	25.6%	5.2%	100.0%
	Poor	Respondents' tally	8	18	8	5	39
		%	20.5%	46.2%	20.5%	12.8%	100.0%
Total		Respondents' tally	71	74	52	14	211
		%	33.6%	35.1%	24.6%	6.6%	100.0%

Source: Researcher (2016)

From table 4.7, those with minimum experience depicted great health as proved by 36.6%, 32.6% and 25.6% of informants who had respective ordeals a year or less, 2-5 and 5-10 years correspondingly. Then again, substantial group of persons with deteriorated condition (46.2%) reported a working duration in the vicinity of 2-5 years. This size lessened with increment in years and it's thought that individuals with extended fitness impediments relinquished the industry.

Table 4.8 Chi-square displays connection between stone excavation and health.

H_0: There is no critical connection between stone excavation and commonness of ailments among quarry laborers and Kitengela populace.

H_1: There is critical connection between stone excavation and commonness of ailments among quarry laborers and Kitengela populace.

Table 4.8: Chi-square tests on health and stone excavation

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.219[a]	3	.065
Likelihood Ratio	6.986	3	.072
Linear-by-Linear Association	2.570	1	.109
N of Valid Cases	211		

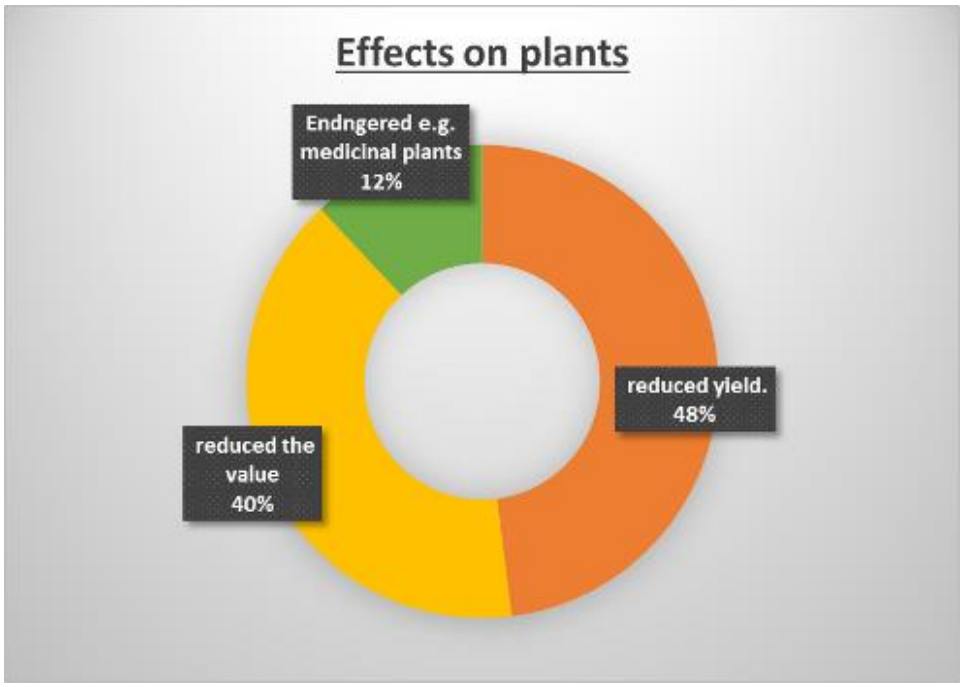
Source: Researcher (2016)

At 95% certainty index, X^2 (3, N = 211) = 7.219, P =.065. Because P>0.05, there's no critical connection between wellbeing status and duration one spent excavating rocks. The study therefore failed to reject the null hypothesis.

4.4.5 Quarrying ramifications on plants

The informants were additionally requested to state how stone excavation affected plants in their locality.

Figure 4.5: Stone excavation effects on plants



Source: Researcher (2016)

48% of informants demonstrated that excavation dust that settled on plant surfaces brought about lessened harvest yields while 40% revealed that produce value diminished. 12% however expounded that clearing of vegetation and rendering the land desolate subsequent to quarrying exercises jeopardized uncommon plant species habitats putting them in danger of elimination. Concurring with this, Van Beynen, (2011) recognized quarrying among other human exercises as the real reason for crust deterioration. In an investigation by Devalsam, et al (2014), 35.7% of informants ascribed vanishing ground cover to Laterite excavation in Calabar, Nigeria. Eshiwani, (2014) and Ming'ate & Mohamed, (2016), also demonstrated that diminished ground cover was because of unregulated stone excavation exercises both in Embakasi and Mandera.

4.5 Mitigation processes

There’re different methods through which stone excavation negatives can be alleviated; some earlier mentioned in the second chapter. In such manner, the investigation proposed some recommendations to informants with a specific end goal to decide their levels of consent to the given options.

Table 4.9: Recommended measures to mitigate quarrying effects

Statement	Strongly agree	Agree	Disagree	Strongly disagree
Dust barriers/traps should be erected round the quarry sites	70%	30%	0%	0%
Dusty haul roads should be watered regularly to settle dust	56%	44%	0%	0%
Quarry workers to be provided with necessary protective wear	94%	6%	0%	0%
Violators of quarrying regulations to be prosecuted	68%	32%	0%	0%
Quarries close to residential places should not be licensed	56%	44%	0%	0%
Alarm should be given before blasting.	98%	2%	0%	0%
Channels must be made to drain off stagnating water from quarry depressions during wet seasons	51%	31%	18%	0%
Quarry waste must be used to restore degraded land.	63%	37%	0%	0%
Developers should avoid putting up residential structures close to quarrying zones	58%	28%	8%	6%
Strict measure be undertaken to rehabilitate abandoned quarry sites	91%	9%	0%	0%

Source: Researcher (2016)

The respondents from the investigation were practically consistent on the suggestion that caution/sirens ought to be sounded before blasting (98%), quarry labourers be given fundamental defensive gear (94%) and recovery apportions be undertaken on ancient relinquished mining locales. Other noteworthy processes that investigation informants firmly concurred with encompassed formation of obstructions round excavation locales (70%), indicting violators of excavation guidelines (68%) and reclamation of distorted sites (63%). The proposal for creating waterways for mines was rejected by 18% of informants because stagnating water gathered amid blustery seasons was utilized by a few local people in watering their yields and domesticated animals.

4.6 Summary

In this investigation, respondents were primarily semi-unskilled wedded men (80%) matured in the range of 31- 40 years. Ramifications of stone excavations on scenery, the investigation uncovered that Kitengela not at all like some time recently, was rough, exposed and eroded and this can be credited to loss of vegetation cover through quarrying.

From the investigation, most respondents additionally grumbled of air contamination with 90% referring to dust from quarries as the primary source. This circumstance is more awful amid dry seasons due to the degree it interferes with visibility. Albeit a few respondents related splitting of structures to blast impacts, chi-square demonstrated that the association wasn’t substantial at 95% certainty.

The discoveries additionally found expanded instances of common colds, wheezing, eye issues and sore oesophagus because of dust. The investigator however in this case relied on provided information in light of the fact that there was no capacity of medically ascertaining the connection between worsening of one's robustness and excavation dust. On plants, 48%

depicted an understanding that yields in the region were never again performing fine because dust layering leaves impedes photosynthesis. Clearing foliage to create routes to excavation sites was likewise referred to as reason for reduction of biodiversity.

To lessen detrimental quarrying outcomes, dominant part of the respondents were in support for quarry organizations to erect dust hindrances, quarry labourers to be furnished with shielding wear, cautioning alerts to be sounded before blasting and recovery of relinquished quarry locales made obligatory.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This section outlines brief of findings, conclusion and at last propose some suggestions on the subject of investigations in line with the study objectives and questions.

5.2 Summary of findings

Informants to this investigation were mostly male, aged 21 to 40, wedded, with basic credentials. Inclination in sexual orientation portrayal was however expected in light of the fact that many females shy from quarry activities.

Regarding geological scenery, 70% of respondents affirmed that the area was beforehand genuinely vegetative and was currently stony and uncovered subjecting the earth surface to extreme disintegration.

Air in the investigation region was likewise observed to be contaminated with 90% of study members alluding that significant dust was exuded from blasts and quarry trucks particularly amid dry seasons. Other than health ramifications, dust caused disturbance settling on garments, plants and cleaned tops e.g. of buildings, autos and tables. Some respondents additionally implied that thick tidy mists influenced visibility among drivers. On blasts, there were 84 instances of split structures out of which 3 were ascribed to seismic impacts. Chi-square test showed, X^2 (3, N = 211) = 7.219, P =.065, subsequently indicating no huge connection on weakening of structures and detonations impacts.

Dry coughing, wheezing, eye contaminations and irritating oesophagi were widely recognized infirmities distinguished in the investigation area at 80%, 92%, 76%, and 81% respectively were all ascribed to dust contamination. In connection to this, 40% of study informants affirmed their wellbeing presently as bad, and that 46.2% spent 2 – 5 years in the industry. The situation notwithstanding, correlation showed P>.05, signifying no critical connection amid duration in the excavation business and decline of one's wellbeing. A conceivable clarification is that defensive wear accorded mine labourers as indicated by a few informants is useful to certain degree.

5. 3 Study conclusion

Investigation informants were generally youthful and samples from the four quarry destinations was 100% of male sexual orientation. Stone excavation in Kenya is consequently male dominated. It's certain though that stone excavation bolsters Kitengela's economy. Livestock keepers alike were discovered to regard old and abandoned excavation locales helpful to their animals amid dry spells. An evaluation on abuse of excavation resources nonetheless, demonstrated a confirmation on worsening of both environment and people's health. The study likewise found that there were adequate regulations on stone mining business but laxity in authorization exists and stone excavation will soon be unsustainable if the present standard proceeds. The experts, for example, NEMA in this manner must guarantee conformity to excavation guidelines and violators rebuffed or penalized appropriately.

Kitengela scenery for the preceding 5-10 years as per this investigation was genuinely green and attractive. This transformed with the current increment in stone excavations to a degree that it's nowadays stony and uncovered making the soils vulnerable against extreme soil

disintegration. It can in this manner be reasoned that the current eroded scenery of Kitengela which is a blemish, is a result of unregulated quarrying exercises.

Dominantly, individuals employed and residing near stone excavation locales were discovered to regularly endure coughing, wheezing and eye issues. Confirmations existed of dust soiling cleaned garments outside, clogging plants and shiny autos or tables. In light of this investigation outcomes, dust produced from excavation practises is a disturbance as well as have health ramifications on people.

In spite of the fact that there were protests of split or debilitated structures because of vibration from blasts, chi-square (P =.062) established no huge connection of the variables at 95% certainty. Splitting of constructions in Kitengela could consequently be ascribed to utilization of poor materials or negligence.

5.4 Recommendations

The investigation prescribes stern authorization and enactment of excavation rules by agencies, communities and NGOs to evade ecological deterioration since restoration, as denoted by Sayara et al. (2016), is an exceptionally costly practise. Rehabilitation can nevertheless be embraced on already relinquished locales that can possibly be transformed to parks or golf course.

Government and its partners ought to consider doing normal medical screening for Kitengela populace. Persistent presentation to fine dust particles cause respiratory tract contaminations. Quarrying organizations can thus set up health centres inside in the area as a corporate social obligation.

Trucks produce a considerable measure of dust causing aggravation to individuals in their premises. Excavation companies ought to possibly utilize paths far from populations or

frequently water access roads to settle dust. Measures, for example, erection of dust obstructions edges can help limit spread of dust produced amid smashing procedures.

To limit clashes between quarry entrepreneurs and nearby occupants because of vibration, and dust contamination, recommended separation between the two ought to dependably be seen amid permitting of quarrying organizations.

Quarry organizations ought to dependably refill the uncovered pits keeping in mind the end goal to re-establish the scene to its unique state. Also, stone excavation pits can drown children or even animals when waterlogged.

Government organizations and NGOs ought to contemplate educating people in general through specialized training of populaces and undertake awareness campaigns on repercussions impelled by unfettered excavations of stones on health and ecosystems.

5.5 Further study

1. Advance research is proposed to define detachment of the current controlling systems on boulder excavation and execution practicability.
2. Research ought to likewise be done on most appropriate restoration measures for Kitengela’s deserted quarry locales

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Appendix I: Questionnaire to Kitengela inhabitant

Dear respondent,

I am a scholar at the University of Nairobi, undertaking an investigative study as a prerequisite for the award of my honours degree. This survey is to assess ramifications of stone excavation in Kitengela whereby personal congregated data will be classified and responses received used for academic purposes only. Your positive reaction is exceptionally valued.

SECTION A: BACKGROUND INFORMATION

1. Gender: Male [ ] Female [ ]
2. Age: 15 -20years [ ] 21 – 30 years [ ] 31 – 40 years [ ]
3. 41 – 50 years [ ] Above 50 years [ ]
4. Highest level of education: None [ ] Primary [ ] Secondary [ ] College [ ]
5. Marital status: Single ([ ] Married [ ] Widowed [ ] Divorced [ ]

SECTION B: IMPLICATIONS OF QUARRYING ACTIVITIES

a) Environment and Landform

6. How would you describe landscape appearance in this place compared in the past few years?

   Rocky [ ] Bare [ ] Eroded [ ]

   Vegetative [ ] can't tell [ ]

7. How would you describe the landscape now?

Rocky [ ] Bare [ ] Eroded [ ]

Vegetative [ ] can't tell [ ] Unchanged [ ]

8. Please tick appropriately for the following statements

Statement	Yes	No
Have lands in and around the concession been destroyed?		
Are heaps of quarry waste and holes filled with water found around the sites?		
Farmlands near the concession cannot be used to grow crops?		
Immediate restoration of degraded land is necessary		
Do you have any farmland covered with water?		
If yes, have the flood waters ever been drained?		
Does run-off from the quarry enter the river or stream in your area?		
Stretch of water is likely to breed mosquitoes and other disease causing organisms.		

b) <u>Air pollution</u>

9. How do you agree on the following statements? Please tick where applicable

Key: Strongly agree (**SA**), Agree (**A**), Disagree (**D**), strongly disagree (**SD)**

Statement	SA	A	D	SD
The main source of dust in your village is from quarrying activities				
Concentration of dust in the atmosphere is highest during blasting of rocks				
Vehicles transporting quarry products on the unsurfaced roads also generate much dust				
Rainy and Cold weather reduce the amount of dust in the air				
Dry weather promotes dust emission				

c) Nuisance dust emissions

10. How do you agree on the following statements? Please tick where applicable

Statement	Yes	No
Does dust settle on your roofing sheets or clothing?		
Are the leaves of your crops or plants in the area covered with dust?		
Do crops (plants) grow well when dust coats leaves?		
Does dust prevent you from seeing things a distance away?		

d) Noise Pollution / Vibration Effets

11. How do you agree on the following statements? Please tick where applicable

Statement	Yes	No
The main source(s) of noise at the quarries are from excavation machinery, blasting of rocks, processing and haulage trucks.		
Has any of your buildings developed cracks due to blasting vibrations		
The main cause of cracks in buildings in the village is vibration blasts.		
Has any of the cracked buildings collapsed?		

SECTION C: ENVIRONMENTAL COMPLICATIONS

a) Human health issues

12. Respond to the following statements by ticking "Yes or No" or the applicable one.

Statement	Yes	No
Dust is a nuisance to you.		
Dust affects your health		
Water harvested from roofing spouts is usually unclean (contains dust).		
Your frequent ill health may be associated with dust, flooded farmland or rain water from roofs.		

13. Respond to the following statements by ticking “Yes or No” or the applicable one.

Statement	Excellent	very Good	Good	Fair	Poor
How was your health status before quarrying started?					
In general, what would you say about your health since quarrying started?					

14. Which dust related disease do you usually suffer from? (You may tick more than one).

Disease	Yes
Cough	
Sneezing	
Asthma	
Pneumonia	
Eye problems	
Frequent bringing out of phlegm	
Wheezing or whistling of chest	
Heart problem	
Sore throat	

15. Which of the following water- related or water-borne diseases have you ever suffered from before quarrying started? (You may tick more than one)

Disease	Yes
Malaria	
Cholera	
Typhoid	
Elephantiasis	
Diarrhoea	
Bilharziasis (Schistomiasis)	

16. Which of the following water- related or water-borne diseases did you ever suffer from during quarrying? (You may tick more than one)

Disease	**Yes**
Malaria	
Cholera	
Typhoid	
Elephantiasis	
Diarrhoea	
Bilharziasis (Schistomiasis)	

17. How fearful are you about your future health?

All of the time ☐ Most of the time ☐ some of the time ☐ a little of the time ☐

None of the time ☐

b) <u>Flora and fauna</u>

Statement	**Yes**	**No**
Coating of crop leaves with dust has resulted in reduced yield.		
Coating of crops has reduced the value of agricultural products.		
Some valuable plants (e.g., medicinal) and animals (e.g. game) have been lost due to dust and land degradation in the area.		

SECTION D: MITIGATION MEASURES

18. Show how you agree on the following statements using the following responses by ticking the appropriate one.

Strongly agree (**SA**), Agree (**A**), Disagree (**D**), strongly disagree (**SD)**

Statement	Strongly agree	Agree	Disagree	Strongly disagree
Dust barriers/traps should be erected round the quarry sites				
Dusty haul roads should be watered regularly to settle dust				
Quarry workers to be provided with necessary protective wear				
Violators of quarrying regulations to be prosecuted				
Quarries close to residential places should not be licensed				
Alarm should be given before blasting.				
Channels must be made to drain off stagnating water from quarry depressions during wet seasons				
Quarry waste must be used to restore degraded land.				
Developers should avoid putting up residential structures close to quarrying zones				
Strict measure be undertaken to rehabilitate abandoned quarry sites				

Suggest any other mitigation measure…….....

……

Appendix II: Questionnaire for quarry workers

I am a scholar at the University of Nairobi, undertaking an investigative study as a prerequisite for the award of my honours degree. This survey is to assess ramifications of stone e excavation in Kitengela whereby personal congregated data will be classified and responses received used for academic purposes only. Your positive reaction is exceptionally valued.

SECTION A: BACKGROUND INFORMATION

1. Gender: Male ( ) Female ( )

2. Age: 15 -20years ( ) 21 – 30 years ( ) 31 – 40 years ( )

3. 41 – 50 years ( ) Above 50 years ( )

4. Highest level of education: None ( ) Primary ( ) Secondary ( ) College ( )

5. Marital status: Single ( ) Married ( )Widowed ( ) Divorced ( )

SECTION B: SAFETY AND HEALTH ISSUES

1. How long have you worked in this quarry site?
   Less than 1year ( ) 2 to 5 years ( ) 5 to 10 years ( ) above 10 years ( )

2. On average, how many hours do you work per day?

Less than 8 hours ( ) 8 to 12 hours ( ) Over 12 hours ( )

3. How would you best describe the work that you do in this quarry?

Breaking stone ( ) Loading stones ( ) Remove rock waste & spoilage ( )

Others (Specify).....

4. The noise levels within the quarry site can best be described as;

Deafening ( ) Tolerable ( ) Not audible ( )

5. What are the sources of high noise levels in the quarry site?

Vehicles ( ) Stone cutters/tools ( ) Detonators ( )

6. Have you ever had any of the following occupational illnesses/conditions?

i.	Nasal discharge (cold)	Yes ( )	No ( )
ii.	Dry cough	Yes ( )	No ( )
iii.	Productive cough	Yes ( )	No ( )
iv.	Chest pains	Yes ( )	No ( )
v.	Difficulty in breathing	Yes ( )	No ( )
vi.	Eye irritations	Yes ( )	No ( )
vii.	Skin irritations	Yes ( )	No ( )
viii.	Back pain	Yes ( )	No ( )
ix.	Noise induced hearing impairment	Yes ( )	No ( )
x.	Physical injury	Yes ( )	No ( )

7. Where do you go for treatment?

Self-medication [ ] Local dispensary [ ]

Local hospital [ ] Witch doctor [ ]

Health professional [ ]

Appendix III: Key informants Interview guide

1. What are the main environmental effects quarrying has had in this area?
2. How has quarrying affected the local communities
3. What are some of the benefits brought about by quarrying activities?
4. What are the challenges experienced in regulating the industry?
5. What appropriate measures do you think should be put in place to address the mentioned challenges?

Appendix IV: Research letter from the department

UNIVERSITY OF NAIROBI
Department of Geography & Environmental Studies

Telephone: +254 2 318262
Extension: +28016
Fax: +254 2 245566

P.O. BOX 30197-00100
NAIROBI
KENYA

October 19, 2016

TO WHOM IT MAY CONCERN

This is to confirm that **Ms Isabella Juliet Mbandi** (Reg. No. C50/7496/2006) is a postgraduate student at the Department of Geography and Environmental Studies, University of Nairobi. She is pursuing her Master of Arts Degree in Environmental Planning and Management and is currently undertaking a research project on **"Assessment of the Environmental Impacts of Quarrying in Kitengela, Kajiado County in Kenya".**

Any assistance accorded to her will be highly appreciated.

Dr. Samuel Owuor
Chairman, Department of Geography & Environmental Studies

Appendix V: Research Permit

THIS IS TO CERTIFY THAT:
MS. ISABELLA JULIET MBANDI
of NAIROBI UNIVERSITY, 0-200
Nairobi,has been permitted to conduct
research in *Kajiado County*

on the topic: *ASSESSMENT OF THE ENVIRONMENTAL IMPACTS OF QUARRYING IN KITENGELA. KAJIADO COUNTY IN KENYA*

for the period ending:
15th March,2018

Permit No : NACOSTI/P/17/43982/16124
Date Of Issue : 15th March,2017
Fee Recieved :Ksh 1000

Applicant's Signature

Director General
National Commission for Science, Technology & Innovation

CONDITIONS

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

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEACH CLEARANCE PERMIT

Serial No.A 13253

CONDITIONS: see back page

Appendix VI: Declaration of originality form

Declaration Form for Students

UNIVERSITY OF NAIROBI

Declaration of Originality Form

This form must be completed and signed for all works submitted to the University for examination.

Name of Students:	ISABELLA JULIET MBANDI
Registration No:	C50/7496/2006
College:	HUMANITIES AND SOCIAL SCIENCES
Faculty/School/Institute:	ARTS
Department:	GEOGRAPHY AND ENVIRONMENTAL STUDIES
Course Name:	M.A. ENVIRONMENTAL PLANNING AND MANAGEMENT
Title of the work:	ASSESSMENT OF THE ENVIRONMENTAL EFFECTS OF QUARRYING IN KITENGELA SUBCOUNTY IN KAJIADO

DECLARATION

1. I understand what Plagiarism is and I am aware of the University's policy in this regard.
2. I declare that this……(Thesis, project, essay, assignment, paper, report etc) is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work or my own work has been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements.
3. I have not sought or used the services of any professional agencies to produce this work.
4. I have not allowed, and shall not allow anyone to copy my work with the intention of passing it off as his/her own.
5. I understand that any false claim in respect of this work shall result in disciplinary action in accordance with University Plagiarism Policy.

Signature: ……

Date: 2ND NOVEMBER 2017

Appendix VII: Turnitin originality report

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Turnitin Originality Report

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ASSESSMENT OF THE ENVIRONMENTAL EFFECTS OF QUARRYING IN KITENGELA SUBCOUNTY OF KAJIADO IN KENYA BY ISABELLA J. MBANDI C50/7496/2006 SEPTEMBER 2017 ABSTRACT Quarry locations, abandoned without any scheduled rehabilitation processes thereafter have posed environmental challenges globally, in addition to being among the most risky industry to work in due to high number of reported health hazards. In Kenya, stone mining in the past few years has been on the increase due to an increase in their demand by both commercial and residential property developers. And as such, this study aimed at evaluating some problems stemming from stone mining in Kitengela, one of the sub-counties of Kajiado County. The specific objectives that guided the study are; to gauge ecological upshots of stone mining in Kitengela, to scrutinise quarrying ramifications on health of labourers and on Kitengela populace, to detect mitigation processes that alleviate stone mining impacts on the environment and lastly make recommendations that address undesirable stone excavation effects on the environment. For this study, both quantitative and qualitative or mixed methods of research design was adopted targeting 5,278 people whose composition included quarry labourers and people residing within Kitengela. Out of the targeted population, a sample size of 642 was drawn using a cluster and simple random sampling techniques. The sampling process involved dividing the respondents into quarry workers and residents then randomly sampled from both categories. The procedure involved writing 'yes' and 'no' on small pieces of papers, folding them, shuffling and asking respondents to pick them. Those who picked paper pieces indicated 'yes' were chosen to