

**EFFECTS OF DIMENSION STONE QUARRYING ACTIVITIES IN NDARUGO
AREA OF KIAMBU COUNTY, KENYA.**

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DECLARATION

This research project is my original work and has not been presented for a degree in any other university or any other award.

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DEDICATION

To my daughter Tiffany Faiza, my wife Eunice Wangela and my parents.

ACKNOWLEDGEMENT

I take this opportunity to express my joy and gratitude to God and to all the people whose contribution made this work successful. Special thanks go to my supervisors Dr. John M. Nyangaga and Dr. Parita Shah for their guidance and support through this work. I wish to thank the entire University of Nairobi fraternity especially my course mate for their encouragement and fruitful discussions during course work. I wish to acknowledge all quarry-related respondents who gave me ample time to collect and acquire relevant data. Last and not least, I wish to thank my family for their support both financially, physically and emotionally.

May God bless you.

ABSTRACT

Dimension stone quarrying is a vital activity that dates back since the dawn of civilization because it provided premium materials for all kinds of constructions. Stone quarrying activities have affected the quarry workers, residents near quarry sites and the country's economy at large. It creates employment opportunities, source of construction materials, recharge of underground water and source of revenues to County Government. However, despite positive effects, there are several negative effects associated with quarrying activities. This includes loss of biodiversity, land dereliction, air pollution, and water pollution among others.

There are several legislations enacted in Kenya which provide guidelines on how mining and quarrying should be done. These includes the Environmental Management and Coordination Act of 2015, the Legal Notice No. 101 (The Environmental Impact Assessment and Audit Regulation) of 2003, the Occupational Safety and Health Act of 2007 and the Mining Act of 2016 among others. These regulations are aimed at streamlining mining and quarrying sector, dimension stone quarrying not excluded, to attain environmental sustainability. Mining and quarrying activities is one of the devolved units of the County Government. This means the future and benefits of dimension stone quarrying lies on the Kiambu County Government in terms of supervision, regulation, and collection of revenue. It is on these bases that the study was conducted to unearth the effects of dimension stone quarrying activities in consideration to legal frame works in Ndarugo area in Kiambu County, Kenya.

The study employed descriptive survey design because it relied on people's opinions about different issues as stated on the questions. Using three randomly selected quarries with a population of 90 respondents, observation schedules, questionnaires, photographs, and interviews, were conducted to collect data from a stratified random sample of 34 respondents, some working, and others residing around the quarrying area. Qualitative data from interviews and observation schedules were analyzed using content analysis while that obtained from questionnaires were analyzed using descriptive tools such as SPSS to generate percentages and tabulations. The research found that 78% of the respondents depend on the quarrying sector either direct or indirect to earn their livelihood. Moreover, quarrying activities provided 83% of construction materials for infrastructural development. On the other hand, quarrying activities affected 87.5% of plants growing nearby either by producing dust or uprooting them on the first stage. It also turned 70.8% of land into pools of water and derelict ugly landscape in addition to causing 41.7% of healthy related problems. The study concluded that quarrying activities in Ndarugo area of Kiambu County have both positive and negative effects. The quarry companies are licensed to carry out their activities in Ndarugo area. The study recommends that quarrying companies should promote environmental, health and education to all the workers on safety measures and achieve sustainable development. It also suggests that existing laws need enforcement by having more National Environment Management officers on the ground.

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ABBREVIATIONS

CSR	Corporate Social Responsibility
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Coordination Act
GDP	Gross Domestic Product
GoK	Government of Kenya
Km	Kilometers
KNBS	Kenya National Bureau of Statistics
KPMG	Klynveld Peat Marwick Goerdeler
NACOSTI	National Commission for Science, Technology, and Innovation
NEMA	National Environment Management Authority
NGO	Non- Governmental Organization
SPSS	Statistical Package for the Social Science
USA	United States of America
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Sinclair (2012) has defined stone quarrying as an act whereby there is the exploitation of triangular shaped stones from the ground for their use as construction material. In Kiambu County's Ndarugo area stone quarrying has provided construction materials to it's the people for the built environment, created employment opportunities and generated revenue to county government.

While having its benefits, quarrying activities has negative effects to the environment. These range from environmental health including land disturbance, emission of dust, noise pollution, and loss of biodiversity and ground vibrations (Atieno, 2015) to human health like respiratory diseases including asthma and lung cancer due to inhaling of dust (Ozcan and Musaoglu, 2012) as well as economic consequences. All this is being experienced in the Ndarugo area.

All these negative repercussions need to have a sustainable approach which most African countries have begun to take up. Such sustainable approaches range from setting up sound environmental institutions, domesticating and implementing policies and laws and involving the non-governmental organizations. However, they all have their own challenges. In Ndarugo area where quarrying is a common activity, there are hardly any efforts by the investors to close the pit heaps after their use. This is because most of the investors feel that there is no value of the closed quarry, there is also no enforcement of

the environment impact assessment and environmental audits. Furthermore, the after impacts of quarrying like pollution and dust in the atmosphere are long to remain affecting human health in both long and short term. At the same time majority of the investors leave the pits open after the end of quarrying posing a health hazard as rainwater and at times sewage water accumulates allowing breeding of mosquitos and malaria to be a threat. Furthermore, the pits are also a crime attraction as criminals hid in them during dark and even pedestrians may not see them and fall in the dark.

Thus the safety of stone quarrying in Ndarugo area relies on implementation of laws and educating the quarry companies and the area residents on the importance of sustainable quarrying activities. All these calls for the need to investigate the effects of dimension stone quarrying activities in Ndarugo area which was identified as a gap the study intended to fill.

1.2 Statement of the problem

As the world population rises, quarrying is in demand due to the development thus the increased demand for building materials (Dong-dong et al. 2009). Urbanization is a great contributor towards increased quarrying. To add to this the quarrying industry is a great employer. A study conducted by Wang and Zhang in 2016 in Africa indicated that over 800,000 people depend on quarrying activities for survival.

Kenya's population is growing fast. In 2009 it was 37.7 million (KNBS, 2009) 9333while in the latest 2019 census it has increased to 47.9 million (KNBS, 2019). The urban areas

show a similar trend – Nairobi’s population in 2009 was 3.13 million (KNBS, 2009) while in 2019 it is 2.9 million (KNBS, 2019); for Mombasa the current 2019 population is 1.19 million and in 2009 it was 915,101 people (KNBS, 2009) and in Kiambu the 2009 statistics show the population at 1.62 million (KNBS, 2009) and in 2019 it has increased to 2.4 million (KNBS, 2019). This indicates that as the urbanites increase, there is more demand for buildings, thus the increase in demand for quarrying as an activity. This further explains the rise in real estates and increase in construction requiring stones.

This study assessed positive and negative effects of quarrying activities to human and physical environment in Ndarugo area, the legal frame works that have been put in place and the future of stone quarrying activities considering post-closure practices with an aim of using the study outcome to provide counter active recommendations that will address the observed effects.

1.3 Research questions

- i. What are the positive and negative effects of dimension stone quarrying activities in Ndarugo area?
- ii. Do quarry companies comply with legal frame works that have been put in place to regulate effects of dimension stone quarrying activities?
- iii. What is the future of dimensional stone quarrying activities in Ndarugo area in terms of post-closure practices?

1.4 Research objectives

- i) To assess the positive and negative effects of dimension stone quarrying activities in Ndarugo area.
- ii) To evaluate the level of compliance with the legal frame works that have been put in place to regulate effects of dimension stone quarrying activities.
- iii) To assess the future of dimensional stone quarrying activities in terms of post-closure practices in Ndarugo.

1.5 Justification of the study

In line with Kenya's Mining Act of 2016 (GoK, 2016) which is fully geared towards the Vision 2030 and ensuring full compliance of the Sustainable Development Goals, this study intended to assess the positive and negative effects of quarrying activities in line with the existing legal frame works and laws governing stone quarrying in Ndarugo area.

The findings of this study justify the need to carry out formal education to the quarry workers and the area residents especially on the effects of quarrying on their health. The findings will help to enforce and implement the existing legal frameworks that guide quarrying activities in Kenya in order to ensure environmental sustainability. These findings will also enable policy makers to look into the gaps in the existing legal policies in order to improve on them for the effectiveness of these laws.

1.6 Scope of the Study

This study was carried out in Ndarugo area of Kiambu County, about 35 kilometres northeast sides of Eastland Nairobi and about 11 kilometres from Thika Town. The town is connected with the Thika Superhighway so as to enable the easy transportation of the bulky stones quarry products to the market (Waweru and Mukundi, 2015). The area has nine active quarrying sites on both sides of the Thika Superhighway. Most of these mines are owned by foreigners. A quarry block is normally one acre and it is dug between 10 meters to 50 meters deep to access quality stone. Stones are cut by use of stone cutting machines that have metallic grading blades. Per each quarry five to seven lorries are loaded per day. The target respondents for this study included the quarry workers present at the time of data collection and the residents of Ndarugo area who were not more than fifty meters away from the quarry pits.

1.7 Limitation of the Study

This study encountered limitations. The main one was whereby many respondents were unwilling to give information in fear that it may taint the image of the area or fearing that the information may be traced back to them resulting in them being victims of circumstance. This was dealt with by assuring the respondents that the information they gave was to be used for academic purpose only and the data would not be released to anyone else. Moreover, the researcher briefed the respondents on the benefits of this study if its recommendations were to be implemented. Another limitation of this study was low response rate as some respondents were too busy with their daily work schedule. In case they spent time to answer the questions, they could have lost of their daily bread.

This was dealt with by having questionnaires and interview questions to be as short and precise as possible and pre-visiting the area to book appointment in advance for data collection.

1.8 Operational definitions

Abscission of leaves: Premature falling or shedding of leaves due to dust accumulation, hydration or excessive evaporation.

Biophysical environment: is the symbiosis between the physical environment and the biological life forms within the environment and includes all variables within the earth biosphere.

Chlorosis: Yellowing of leaf tissue due to lack or decrease of chlorophyll especially when leaves have no access to sunlight due to dust accumulation.

Dimension stones: Large rectangular blocks extracted from the bedrock then cut into smaller, rectangular-shaped products usually 6X9 inches or 9X9 inches that used for building and construction.

Epinasty: Bending of leaf downwards due to faster rate of growth on the upper surface.

Land dereliction: Set of ugly landscape that left after quarrying activities which is incapable of beneficial use without reclamation and rehabilitation.

Legal framework: Set of documents containing rules and regulation, rights and obligations of a government or government institutions, guiding activities in a given area.

Lithosphere: The upper most part of the earth's crust consisting of SIAL and SIMA

Necrosis: Death of some part of a leaf.

Physical Environment: Part of the environment surrounding humans that contains only physical elements, such as soil, water, and air

Quarrying activities: this is the process of extracting dimension stones, rocks, construction aggregates, ripraps, sand, gravel, or slate from the ground for commercial purpose.

CHAPTER TWO

LITERATURE REVIEW

The section starts with a review of empirical literature related to the research objectives. The themes guiding this section include the positive and negative effects of quarrying activities and legal legislation guiding quarrying activities, research gap, theoretical and conceptual frameworks.

2.1 Positive effects of quarrying activities

Globally quarrying is regarded to be a very important activity for the survival of man. This is because it facilitated has been facilitating development and growth of all regions, sub-regions and nations. The United States of America's (USA) Minnesota State is a concrete evidence of this. Research carried out by Green *et al.* in 2015 indicated that the construction materials including gravel, sand and crushed stones generated \$245,000,000. This is a very high contribution to the Minnesota State's economy as it helps the State to develop its infrastructure in terms of roads and bridges and at the same time to have concrete buildings. Moreover, it had also generated direct and indirect jobs aiding individuals to have jobs and sustain themselves.

The job opportunities as indicated by Afeni & Adeogun (2015) are high globally and cater for both non-skilled and skilled workers. Another example in line with this is of the in Mendips District in the United Kingdom. Farrant conducted a study in 2017 and revealed that quarrying was a very sustainable activity as it helped people sustain their wellbeing through economic empowerment. His statistics indicated that the quarrying industry provided 1846 direct jobs and 734 indirect jobs. His results further indicated that

the industry catered for 20% of the area's semi-skilled and unskilled local workforce. To add to this, the industry in Mendips District generated £150 million annually and from this amount £40 million trickled into the local economy of the District.

Developing countries have seen an opportunity in the quarrying industry and they are expanding. This is because it not only generates revenues but employs people. In 2007 Ibrahim through his studies '*Towards a Sustainable Quarry Industry in Malaysia: Some Issues and Challenges in Malaysia*' analysed that the industry employed 30% of its total working population. Moreover the industry also expanded itself to 13 states with the Sbah State having 62 quarries followed by the Perak State with 55 quarries.

Pakistan is another example of a developing country where the industry is doing extremely well. A study by Ilyas and Rasheed (2010) indicates that the country's Sorgodha Consituency had the largest stone crushing qaurry market in Asia. The country earns over one billion US dollars annually through quarrying and the Sorgodha Consituency is the largest contributor to this revenue. Furthermore, the country employs 500,000 in the stone crushing sector alone. This indicates that besides agriculture, quarrying is another major source of livelihood for the Pakistanis.

Furthermore, in developing countries, besides agriculture being the backbone to the economy, mining is another sector that contributes heavily to the growth of these developing countries' economies. Like agriculture mining is also a major backbone of the rural economies. Future forecasts predict that with climate change, agriculturally based

economies may not be able to survive the challenge until and unless they have alternatives to trade and survival opportunities (Nene, 2011; Cooper and Dimes, 2012; Mogambi and Mohamed, 2016). In order to combat the climate associated problems, people are looking for alternative livelihood opportunities (Ibrahim, 2007). According to Wang and Zhang (2016), over 800,000 people in Africa and Asia have chosen to turn over to quarrying as it has a sustainable future in line with the demands of the ever increasing population.

Studies have shown that quarrying will be sustainable in terms of employment especially with the growth of urban areas where the real estate market is on the upward surge. In line with this is the infrastructure industry where roads, rail and bridges are being built for better interior linkages for efficient trade. For example, Asante et al, (2014) has carried out studies in Ghana to indicate that both rural and urban population are increasingly shifting to quarrying as alternative livelihood activity. A similar study was carried out in Mukono District of Uganda in 2006 by Birabwa. His studies also indicated that people opted to carry out quarrying activities as it helped in sustaining their livelihood and it brought in more income. This industry was also more profitable especially when it was carried out in areas of volcanic activities as Mukono District had the Hills of Ksenge formed by volcanic activity millions of years ago.

Like the rest of the developing countries, Kenya is also building its economy on the quarrying sector. According to Kenya National Bureau of Statistics (KNBS, 2009) there were more than 30,000 stone mining locations in Kenya. This figure is on the rise as

indicated by the ceic data (<https://www.ceicdata.com/en/kenya/sna-2008-gdp-by-industry-current-price/gdp-mining-and-quarrying> accessed 21st November 2019). The quarrying and mining industry generated 5 million Kenya Shillings in June 2009 while in June 2019 it generated 17.5 million (*ibid*). The results indicate that the revenue has more than tripled which is also an indication that the number of mines and quarries in the country have increased (*ibid*).

In Nairobi's Embakasi Constituency, quarrying is one of the leading employers Eshiwani (2014). It facilitates trading, businesses, building of homes, transport industry as well as improvement of residents' lives as many a times the quarry companies leave some extracted materials which the residents use for improving their day-to-day livelihoods. In Ndarugo area, dimension stone quarrying is a great source of construction material. It also creates employment to both local residents and outsiders. Stone quarrying activities has been a large source of revenue to the county government.

2.2 Negative effects of quarrying activities

Stone quarrying is associated with many challenges which negatively affect workers and area residents. These challenges range from emission and generation of dust, land dereliction, air pollution, loss of biodiversity and habitats, emission of ionization radiation among others. According to Isara and Adam (2016) a lot of dust is generated from quarrying operations such as drilling, blasting and crushing of stones, loading and transportation of quarry products. The heavy dust particles settle nearby, while the

thinner dust particles spread far and wide depending upon the direction of the wind and are aided by the speed of the wind.

Many times it has been observed that quarry workers also fail to adhere to health and safety measures. They often neglect the wearing of protective gear like helmets, dust masks and full cover coats. This leaves them exposed to the fine dust particles. In turn it has detrimental effect on their health. Inhalation of dust causes health problems such as respiratory and pulmonary diseases, lung infections and collapse of lungs, skin and eye infections among other illnesses (Atieno, 2015).

Nwibo and Ugwuja (2012) found that the quarry workers in Nigeria had developed various respiratory problems like chest pain, coughing, wheezing and shortness of breath – all were in relation to the dust from quarries and not wearing protective gears. According to the study, 98.3% of the workers did not practice safety measures in terms of wearing protective gear to protect themselves from dust. The workers were always exposed to dust for long hours and on a daily basis which resulted in their immune systems becoming poor and their bodies becoming a home to respiratory diseases. A similar study was done in Ghana by Ugbogu, *et al.* (2009). His basis was to investigate the occurrence of respiratory and skin problems among stone crushing workers. His results indicated that 85% of the workers had respiratory symptoms and 70% had skin infections. The result indicated that this was because of minimal use of protective gear and clothing. The finding also indicated that the workers were always educated on their health and the use of protective gear but the workers failed to hear to the guidelines. This

also indicates a weakness in the management of the quarry as from their side they did not ensure implementation of the company policies and in turn increasing the health and insurance costs.

Quarrying and mining is known to have detrimental effects on the landscapes as they usually leave behind very ugly scars. In 2012, Langer through his geological surveys identified that quarrying led to changes in geomorphology and it also led to the transformation of useful land into a waste land due to the ugly 'pit heaps'. His survey also revealed that the industry was highly responsible for sedimentation, loss of habitat, dust emission and abandonment of mines before they restored the landscapes in line with the environmental, health and social impact assessments. His recommendations state that if all environmental, health and social impact assessments and laws are implemented, then such problems can be reduced or totally avoided.

Like Langer (2012), Devi and Rongmei (2015) had carried out studies in India on the impacts of quarrying. Their results were similar to Langer's (2012). Their study indicated that landscapes had been converted from productive to non-productive landscapes and the whole ecosystem had become disturbed and this in turn affected the biodiversity through land degradation and deforestation. It also brought in more non-communicable diseases like malaria as the open mines collected rain water and became a breeding ground for mosquitos.

Like India, Lebanon has also experienced ecosystem collapse due to deforestation. This country was highly forested amongst its neighbors. However, research conducted by Diab in 2017 indicated that during the fifteen-year civil war in the country, most of its forests were destroyed by the Mafia gangs who dug quarries to hide explosives. The country's famous biblical cedars trees have all disappeared. This has led to severe environmental problems due to the path taken by the gangs resulting in the unsustainable approach of destructing the forests which in turn have affected the weather and climate of the country (Diab, 2017).

Quarrying also has a strong relationship between property distance from quarry site and property sale price. This has been proved by Erickcek's study (2016) in the Richland Township in USA. The study indicates that building properties near or next to quarry sites result in 30% reduction in sale price. He also observed that with every 10% distance from the quarry sites there was 1% increase. This was the opposite of the Distance decay theory.

Quarrying has also been blamed to be responsible for bringing in acid rainfall. This type of rainfall is very common in Europe and North America (Fugiel *et al*, 2017). Through his studies in four European countries namely Great Britain, Poland, Norway and Germany he analyzed that quarrying resulted in bringing acid rain which is known to vegetation, contributes towards air pollution and triggers human and livestock diseases.

Quarrying comes with unlimited problems to well being of humans. A study conducted by Mohamed and Abuo (2013) in Egypt revealed that there were cracks associated with vibrations caused by quarrying activities. This can lead to collapse of buildings and associated deaths and injuries. The first casualties reported are always the workers and the associated occupational health officers. Such incidences have prompted the setting up of regulations and guidelines on mining that are implemented within all quarries so as to ensure that all vibration levels are kept within a specific limit.

Quarrying has also impacted biodiversity negatively. This is due to the dust generated from the quarries. According to a research conducted by Oyinloye and Olofinyo (2017) in Nigeria, quarrying brings in dust which is a large contributor to air pollution which in turn is associated with necrosis (death of some part of a leaf), chlorosis (yellowing of leaf due to loss or decrease of chlorophyll), epinasty (bending of leaf downwards due to faster rate of growth on the upper surface) and abscission of leaves (premature leaf fall). Due to all these plant related problems, the study revealed that crop production was declining around the quarries and the dust affected the photosynthesis processes. This was due to the prevalence of dust in the atmosphere. In Malawi the effects of quarrying on plants through the dust spread in the atmosphere due to quarrying have shown that the tree species diversity in relation to the chlorine content increased further away from the quarry sites (Missanjo *et al.*, 2015). This relationship fits in well with the distance decay model.

Eshiwani's (2014) study in Embakasi in Nairobi revealed that quarrying leads to land degradation, loss of vegetation cover, noise and air pollution that affect area residents. Furthermore several quarry sites have been left abandoned with increase in crime rates. To add to this, households and companies dump their waste in these quarries contrary to the environmental laws harbouring more diseases and pests. A similar study conducted in Kajiado by Atieno (2015) analysed that quarry workers were exposed to dust particles due to their neglect in terms of wearing of protective gear that led to coughing, skin and eye irritation. Moreover, health of the workers deteriorated with many complaining of muscle pain, eye problem, asthma and malaria.

Noise generation is a major problem of quarrying (Aloui et al., 2016). The blasting, crushing process, the machinery used and transportation of final products by vehicles generate much noise to the workers and surrounding environment (Kumar, et al., 2016). During blasting when an explosive charge is detonated in a short hole, there is sudden release of stored energy in the form of an explosion of gas at high temperature and pressure. The effect of this energy is to break the rock in the vicinity of the short hole. However, not all the energy is used in breaking the rocks. A significant percentage of the energy is dissipated away in the forms of noise, dust, heat and noxious gases together with ground vibration and flying rocks. (Abayomi and Kehinde, 2014). The noise produced can affect livestock growth, development and productivity. The noise can also affect other species of living things by influencing their reproductive systems (Atieno, 2015). In Ndarugo area, the main effects of stone quarrying are production of dust that affect both people and vegetation, emission of ionization radiation that can cause cancer,

loss of biodiversity especially when clearing bushes to start quarrying activities, water pollution and land dereliction.

2.3 Legislations guiding quarrying activities in Kenya

There are several legislations set up in Kenya which have guidelines on how mining and quarrying should be conducted so as to ensure environmental sustainability. The Environmental Management and Coordination Act (EMCA) (Government of Kenya [GoK], 1999) is one such legal framework aimed at ensuring that quarrying takes place in a sustainable way. This legal framework is aimed at providing the basis for mining in relation to the health of humans, other living beings, safeguarding the waters and land. EMCA (1999) has tried to implement environmental principles for good environmental governance. It has done this through cross-cutting across all sustainability measures and in turn being the guideline framework for all environmental policies, environmental planning, protection and conservation of the environment.

Another framework is the Legal Notice No. 101 (The Environmental Impact Assessment [EIA] and Audit Regulation) (GoK, 2003). This framework ensures that no quarrying companies would undertake a quarrying project until a successful EIA has been done. This is to ensure that before the start of quarrying activities, during and after quarrying all measures undertaken would be sustainable.

In terms of safeguarding of the human well-being is the Occupational Safety and Health Act (GoK, 2007) that takes into account the safety of workers at work place. According

to the Act, employers are required to ensure safety, good health and welfare of their employees. This is done by ensuring that every action taken at the work place is not a hazard and if it is, then protective mechanisms must be put in place. To add to this, it is the company's responsibility to provide adequate health cover as well as protective mechanisms for all its workers in any events of hazards or risks (GoK, 2007).

The Mining Act (GoK, 2016) has set up the National Mining Corporation. This institution is mandated to protect all the mineral wealth of the country for sustainability. Together with the Act the institution ensures that all quarrying companies comply with the NEMA regulations of EIA and at the same time get the valid permits for any quarrying activities to go on. This is aimed at ensuring sustainable use of the land by restoring quarries after the end of the activity. Most of quarry companies in Ndarugo area have been approved to carry out quarrying activities, but there are cases where quarry pits have collapsed, killing people. Most of the quarry workers don't wear safety attire and some abandoned quarry pits have been left without reclamation or rehabilitation.

2.4 Research gaps

From the literature review, no previous research done on effects of dimensional stone quarrying, review on laws, and regulation compliance, and post-closure management of quarry pits in Ndarugo area. The study intends to bring forth both positive and negative effects of dimension stone quarrying activities in Ndarugo area. Draw attention to the policy makers on the level of environmental laws and regulation compliance in terms of the health of the people, environmental sustainability, and post-closure procedures. When

rehabilitating a quarry pit, the process is supposed to be inclusive based on a clear set of objectives that are tied on policy requirements, not excluding the local, social, economic, and environmental considerations for the future use of the site.

2.5 Theoretical framework

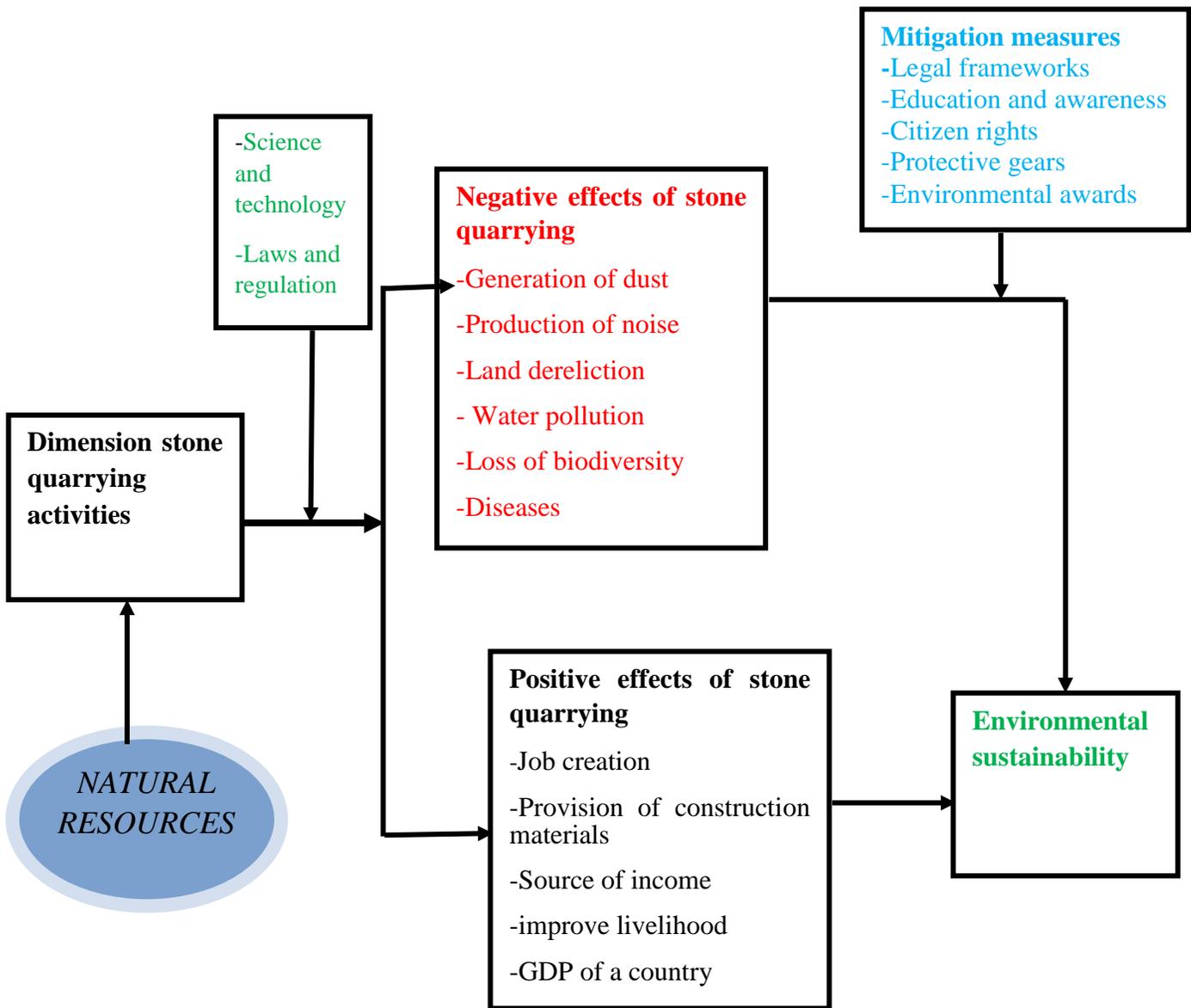
General System Theory advanced by Bertalanffy (1950) which states that a system is a complex of interacting elements and that they are open to and interact with their environments forms the bases of this research. Ashby (1968) furthered the theory by describing nature as an intricate arrangement of society and science and that they are interdependent to attain a shared purpose. In this context, the biophysical elements include human beings, plants and animals as well as water, land, minerals and air, are inter-dependent on each other. Interfering with one of the elements will have trickledown effects on all others or more sub-sets thus interfering with the functioning of the entire system. Dimension stone quarrying activities in the case of Ndarugo have interfered with biophysical environment resulting into several effects. Based on this theory, dimension stone quarrying is an independent variable, which results into both positive and negative effects as dependent variable hence upsetting the physical and biological sub-sets of an environmental unit in Ndarugo area.

2.6 Conceptual framework

The conceptual framework is drawn from the General System Theory whereby environment is conceptualized as a system with many elements in terms of natural resources. Therefore, stone-quarrying activities are processes of extracting natural

resources. On the conceptual frame work, dimension stone quarrying shows that interfering with the environment leads to either positive or negative effects. Science and technology together with laws and regulations are the moderating efforts made to influence either positive or negative effects of dimension stone quarrying activities. Mitigation measures are put in place to ensure environmental sustainability and include legal frameworks, policies and education.

Figure 2.1: Conceptual framework



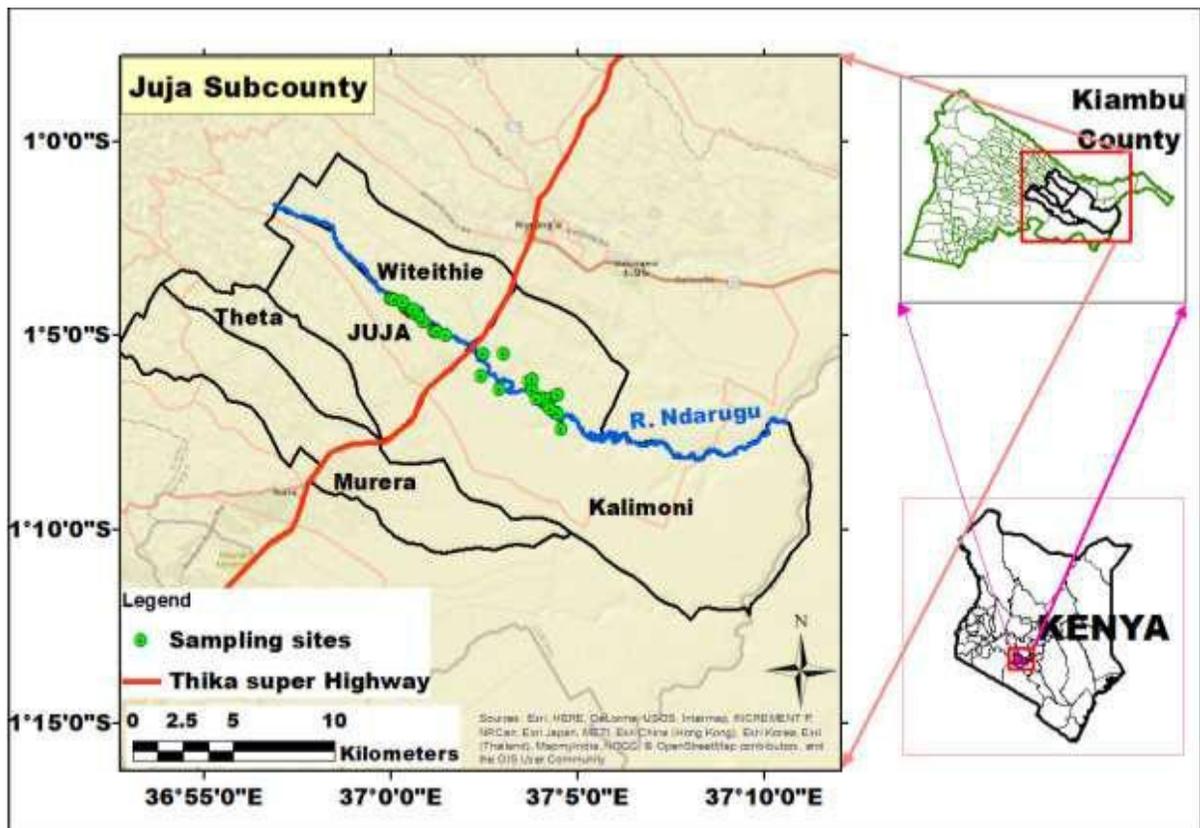
Modified Bertalanffy Model (1950)

CHAPTER THREE

AREA OF STUDY

The study was undertaken in Ndarugo area, Juja sub-county in Kiambu County, Kenya. Ndarugo area is located about 36 km northeast sides of Nairobi and about 12 km from Thika Town. The Thika Superhighway shown by red line on the study map, subdivides the quarry zone strip into two sections - eastern and western sides that enhance transportation of the quarry products. The green dots on the map represent quarry sites on both sides of The Thika superhighway and along river Ndarugo.

Figure 3.1: Location of the study



Source: (Researcher 2019)

3.1 Land use system

Initially, the area was purely an agricultural land dominated by sisal and coffee plantation, but today, the area has attracted dense settlement. Town such as Nyachaba and Waitethia has just emerged. The local residents lease their piece of land to quarry companied for approximately three to five years. One stone quarrying block is approximately one acre. The quality of stones deteriorates with depth such that a quarry pit goes between 20 to 50 meters. The quarry companies obtain permit from NEMA to carry out their activities. The quarry companies are responsible of the consequences of their activities including land rehabilitation and reclamation after quarrying business.

3.2 Climate

The area receives an annual rainfall of 856 mm and experiences two rainy seasons; long-rains occur between March and May while short-rains occur between October and December. The mean annual temperature of the area is 19.6⁰C with the hottest month been March with 21.3⁰C and the coldest month being July with 18.4⁰C (Mwangi, 2014). Most part of the year, the area is dry making dust a big challenge to quarrying activity.

3.3 Drainage

There are two streams in the area that joins the Nairobi River at the lower boundary of the wider Juja. The quarry sites are located along River Ndarugo, recognized for its diverse flora and fauna and offers natural beauty to the area. The river provides water for both domestic and agricultural use. The area got its name from River Ndarugo basin whose ridges have an outcrop of soft volcanic rock that is easy to shape providing a

favorable site for quarrying activities. The abundance of soft volcanic rock is responsible for the presence of many quarrying companies in the area.

3.4 Vegetation

Ndarugo area was initially an agricultural land but now the main economic activities are quarrying and horticulture. Large tracks of land have been cleared to create room for quarrying activity. The entire Ndarugo quarrying area covers over 10 hectares of arable land. There are several quarry companies, which own flower farms including Penta Flower and Benvar Limited among others in the area. These companies have established green houses on exhausted quarry sites as a method of reclaiming the land. There are also traces of indigenous trees species and bushes on the abandoned quarry pits that are in the process of recovering from man's interference.

3.5 Topography

The slope of the area is oriented to the northeast-southwest direction and its physiographic consists of scarps formed by the extensive quarry activities in the area. The underlying bedrock in Ndarugo area is granite, which is suitable for building stones (Mwangi, 2014).

3.6 Stones

An extensive layer of igneous rocks dominates Ndarugo area. According to Mwangi (2014) the eastern side of Thika Road is covered by granite and basalts hence the area has specialized in crushing construction aggregates and ballast. On the western side of Thika

Road, it is dominated by pholonite, a soft volcanic rock that is easy to shape into rectangular blocks. Pholonite is formed when basalt or trachyte are compacted to acquire a laminar structure. Pholonite is found between 10 to 50 meters below the earth's surface.

CHAPTER FOUR

RESEARCH METHODOLOGY

This chapter covers the research design, sampling technique, data collection methods, and data analyzing tools.

4.1 Research design

The study employed descriptive survey design because it relayed on people's opinions and researcher's observation. The research used proportionate stratified random sampling to collect data from different categories of people sampled from selected quarry companies hence a sample of 34 respondents. The design enabled the researcher to collect information on environmental effects of dimension stone quarrying activities in Ndarugo.

4.2 Target population

The research targeted two categories of respondents, which are the quarry workers, and quarry-related respondents. Quarry workers include the quarry managers, loaders, and the machine operators. While quarry-related respondents include the area residents, drivers who frequently visit the quarry sites, health officers, NEMA officers, and the area chief. There are nine active quarry companies in Ndarugo area on both sides of Thika Superhighway and include Benva Limited, Kingstone, Diamondstone, Tita block Silverstone, Jinan block, Greystone, Bostonstones and Sandvic. Due to the size of population, three quarries sites which include Greystone, Kingstone and Silverstone were selected because they share similar characteristics to make the objective audience. Each

quarry has two managers, two machine operators and between five to twelve loaders. On the other hand, twenty three people live less than 50 metres from the quarry sites, the area has two dispensaries with six nurses, a NEMA office at Thika and one chief thus making a target population of 90 respondents.

4.3 Sample size and sampling procedure

A sample is a part of the entire population selected for study to obtain information for generalization on the entire population (Kothari, 2006). Three quarrying sites were randomly selected in terms of their accessibility, which includes Greystone, Kingstone and Silverstone. Using proportionate random sampling on a ratio of 1:3, the following categories of respondents were selected; three managers, three machine operators, nine loaders, six lorry drivers, eight area residents, three health officers, a NEMA officer and a chief to obtain a sample size of 34 respondents as tabulated in Table 4.1. Since quarry sites were in same region, one NEMA office in Thika and one chief was key resource person especially on data concerning effects of stone quarrying to the residents of Ndarugo area. Using the hat method, a tool that involved critical and creative thinking before making decision, the researcher carefully selected respondents after interrogation. Those who were not actively involved in the quarrying activities were not engaged as respondents. Same to those who had not stayed in the area for more than five years.

Table 4.1 Sample size and sampling procedure

	Quarry				Quarry			Quarry		
Respondents	Greystone	Target category	Sample size		Kingstone	Target category	Sample size	Silverstone	Target category	Sample size
Managers		2	1			2	1		2	1
Machine operators		3	1			2	1		2	1
Loaders		9	3			12	4		5	2
Drivers		6	2			7	2		5	2
Local residents		9	3			9	3		5	2
Health officers		2	1			2	1		2	1
Total		32	11			36	12		22	9
NEMA officer										1
Area Chief										1
TARGET POPULATION										90
TOTAL RESPONDENTS										34

Source: Researcher 2019

4.4 Research instruments and data collection methods.

In this study questionnaires, interviews, photographs and observation schedule were developed and used as a tool to collect data. Questionnaires containing open and close ended questions were used to collect qualitative and quantitative data from the respondents. The researcher had designed questionnaires for managers, other quarry workers and the quarry-related respondents. After booking for an appointment, the researcher administered questionnaires where he obtained 100% feedback. Interviews were conducted to solicit for more information that were not captured by questionnaires. Photographs were taken as evidence especially where information required can not be written while observation schedule were used to collect data concerning spatial-temporal change on biophysical environment to complement information obtained by interviews and questionnaires.

4.4.1. Validity and reliability of the instruments

To ascertain the content validity of the questionnaires, the researcher administered the research instruments in two quarry sites, which were not included in the study sample. The instruments used were valid to collect data for research purpose because the instrument collected enough data on matters of interest on the study.

Blischke and Murthy (2011) define reliability as a measure of the degree to which a research instrument yields consistent results or data after repeated trials. In this study, test-retest technique was used to assess the reliability of the research instruments. The

method involves administering the same test twice to the same group of subjects, which gave similar results without bias.

4.5 Data analysis techniques

According to Orodho (2009), data analysis involves arranging data collected from the study in groups or classes based on common characteristics in order to make a conclusion. In this study, the data obtained from the field study were analyzed using descriptive techniques to generate frequency, tabulations, and percentages. Qualitative data, which was in textual, form from open-ended questions and interview schedule was analyzed using content analysis where responses were grouped into themes. The information was presented by use of graphs and pie charts.

4.6 Ethical considerations

The researcher sought clearance from both NACOSTI and the University of Nairobi before he got the permit to carrying out research. A visit to the quarry sites to book appointments was done. On the material day, the researcher explained the purpose of the study to the respondents. Those who were sampled to participate in this study were assured of confidentiality. Respondents were not required to give their names or any other identifying information except their work position.

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 Introduction

The research sought to assess the effects of dimension stone quarrying activities on the environment, the legal framework put in place in relation to stone quarrying and the future of stone quarrying in Ndarugo area of Kiambu County, Kenya. This chapter presents the results and discussion of the data analysis thematically, based on the objectives of the study.

Ndarugo area has nine active quarrying companies, cutting and crushing stones on both sides of the Thika Superhighway. The quarrying companies are owned by foreigners who lease the land from the local people. A quarry block is normally one acre at a depth of between 10 meters to 50 meters to access quality stone. The quarry companies are licensed by NEMA to carry out their activities. Stones are cut by use of stone cutting machine that has a metallic grading blade. Around five to seven Lorries a loaded per day per quarry. The target respondents included the quarry works present at the time of data collection and the quarry-related workers.

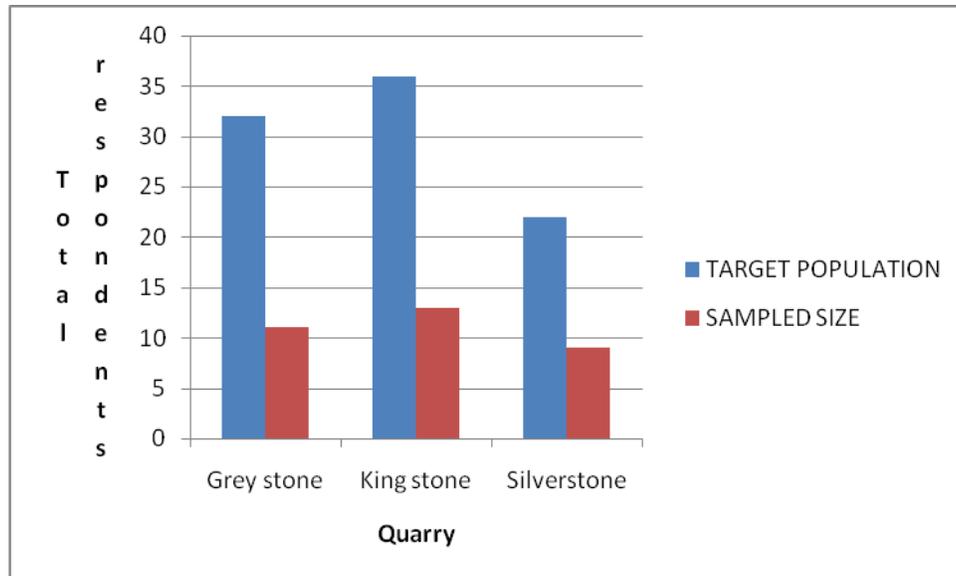
5.2 Demographic information

5.2.1 Response rate

The researcher had a target population of 90 people where 34 respondents were sampled. A good sample size is supposed to be more than 10% of target population participating in a study. In this case, the sampled size is 37.8% of target population. The researcher

delivered 34 questionnaires and all respondents (100%) responded. Therefore, the response rate in this study was a sufficient representation of the target population that can be reliable for data analysis. Figure 5.1 presents the target population and the sample size.

Figure 5.1: Target population and sample size



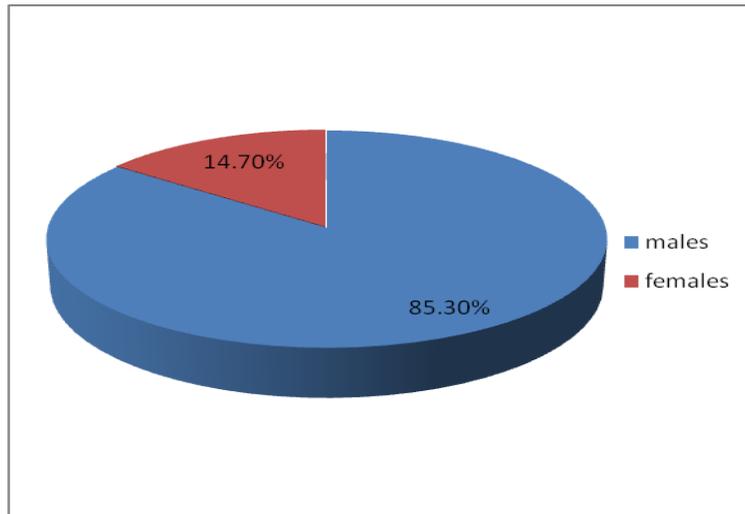
Source: Researcher 2019

5.2.2 Respondents' gender

Male except the area residents and the health officers dominates the quarrying sector in Ndarugo. There were no female employees among managers, machine operators, drivers, loaders, and the Area Chief. Five questionnaires were obtained from females (14.7%) who run either food kiosk or work as nurses in the nearby dispensaries. The pie chart on figure 5.2 shows a lot of gender parity in the quarrying sector with 85.3% dominated by male due to the nature of the work. This could also be a factor influencing effects of

quarrying activities in terms of policy implementation in the sector. Figure 5.2 presents gender of respondents on a pie chart.

Figure 5.2 Gender of the respondents

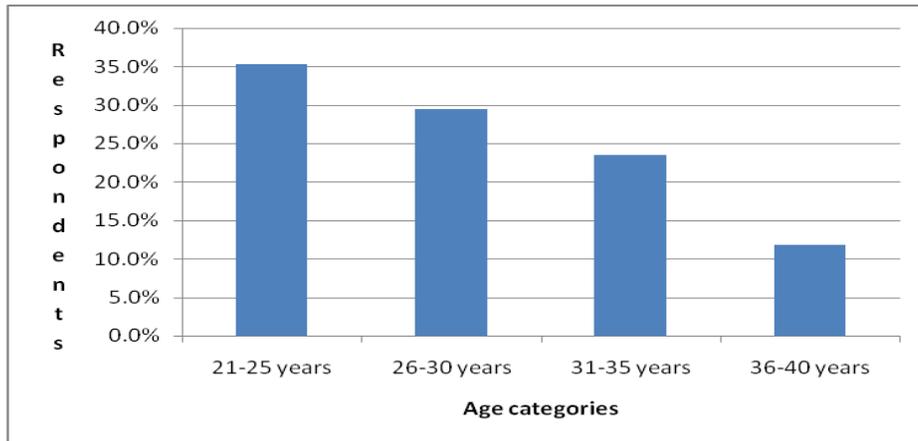


Source: Researcher 2019

5.2.3 Respondents' age

A total of 34 questionnaires were administered and the respondents' age category was as follows: 12 (35.3%) questionnaires were obtained from respondents aged between 21-25 years, 10 (29.4%) questionnaires obtained from those between 26-30 years, 8 (23.5%) questionnaires obtained from those between 31-35 years and 4 (11.8%) questionnaires obtained from respondents between 36-40 years. Majority of quarry workers are youth. This is because quarry activity is a manual work that requires a lot of energy hence suitable for young generation. Quarrying activities are associated with health risk hence most of workers do not spend more than twenty years in it. That is why the population decreases with increase in age as shown on Figure 5.3.

Figure 5.3 Respondents' demographic by age

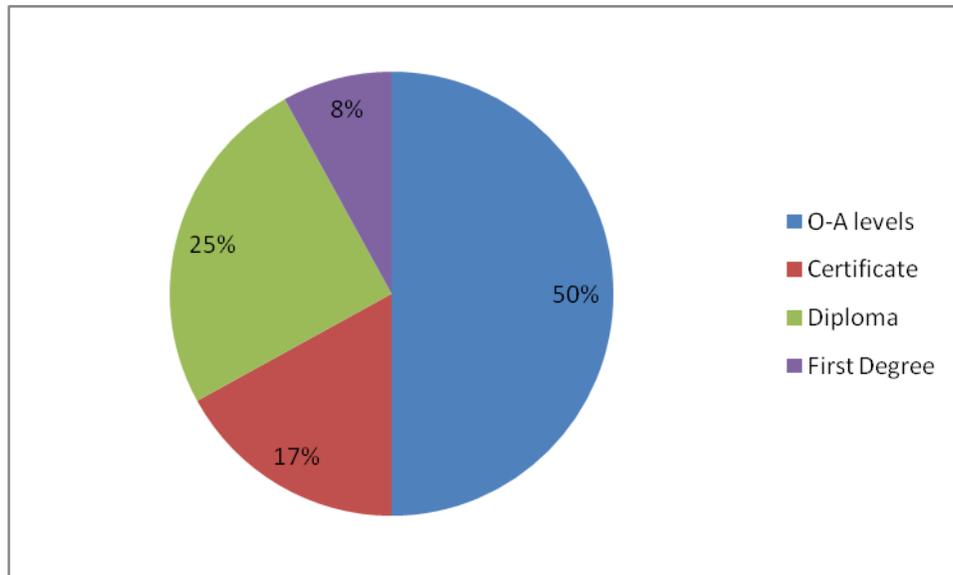


Source: Researcher 2019

5.2.4 Respondents' academic qualifications

The study sought to find out the academic qualifications of the respondents. Figure 5.4 shows the academic qualifications of the respondents.

Figure 5.4 Academic levels of the respondents



Source: Researcher 2019

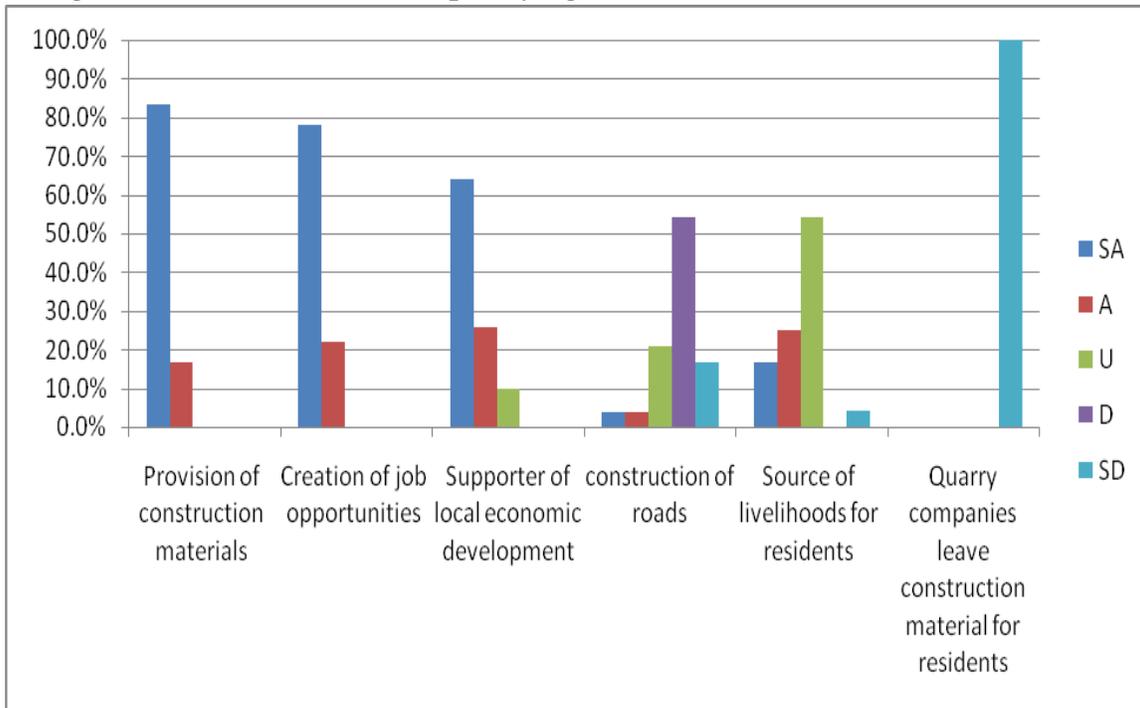
The findings on Figure 5.4 shows that 50% of quarry workers had either class eight or form four leavers. This is because most of the work require semi-skilled or unskilled personnel especially loaders who form the largest part of the population. 25% had diploma education which included nurses and machine operators, 17% had a certificate mostly drivers, and 8% have first degree mostly the managers. The information on the level of education in this research was aimed at collecting data about the laws and regulations governing stone quarrying as well as health and safety people awareness of people with an aim of proposing the possible solution for future stone quarrying business. Stone quarrying has generated so many negative effects such as land dereliction, air pollution, and water pollution because most of quarry workers are not educated. They work to meet their basic needs, hence compromising their health.

5.3 Effects of quarrying activities

5.3.1 Positive effects of quarrying activities

The study sought to determine the positive effects of dimension stone quarrying activities, assessed by statements in a likert scale to seek the opinion of respondents on various positive effects of quarrying activities. The results are shown in Figure 5.5 where SA = strongly agreed; A = agreed; U = uncertain; D = disagreed and SD = strongly disagreed.

Figure 5.5: Positive effects of quarrying activities



Source: Researcher 2019

The findings in Figure 5.5 shows that quarry sites provide construction materials mostly dimension stone. Each quarry can produce five to seven Lorries with a carrying capacity of 1000 pieces hence producing between 5000 and 7000 pieces of stones per day. A quarry pit is approximately one acre with a depth of between 10 to 50 meters. The depth of a quarry pit is determined by the quality of stone. The quality of stones deteriorates with increase in depth. Figure 5.1 shows dimension stones being loaded on a lorry. This is in line with a study done in Australia where quarrying generate different types of rock that can be shaped to different dimension stone such as gypsum, slate, serpentine, or marble (O’Kane, 2016).

Plate 5.1: Dimension stones at Silverstone quarry site



Source: Researcher 2019

Almost 41% of the population in Ndarugo area rely on quarrying activities direct or indirect. Some work as loaders, machine operators, nurses, managers while others have established food kiosks around the quarry sites. Each quarry pit has an average of twelve workers. Therefore, stone quarry activities support local economy and improve their livelihood.

Quarrying is known to create many job opportunities during its initiation. This has been proved in the research by Singh and Singh (2016). In a case study in Dharibad west Bengal, India, the development of quarries resulted in creating employment for over 3,500 people for a period of three years. That was not direct through the digging of quarry, but afforestation activities around the quarry. This is because in an EIA

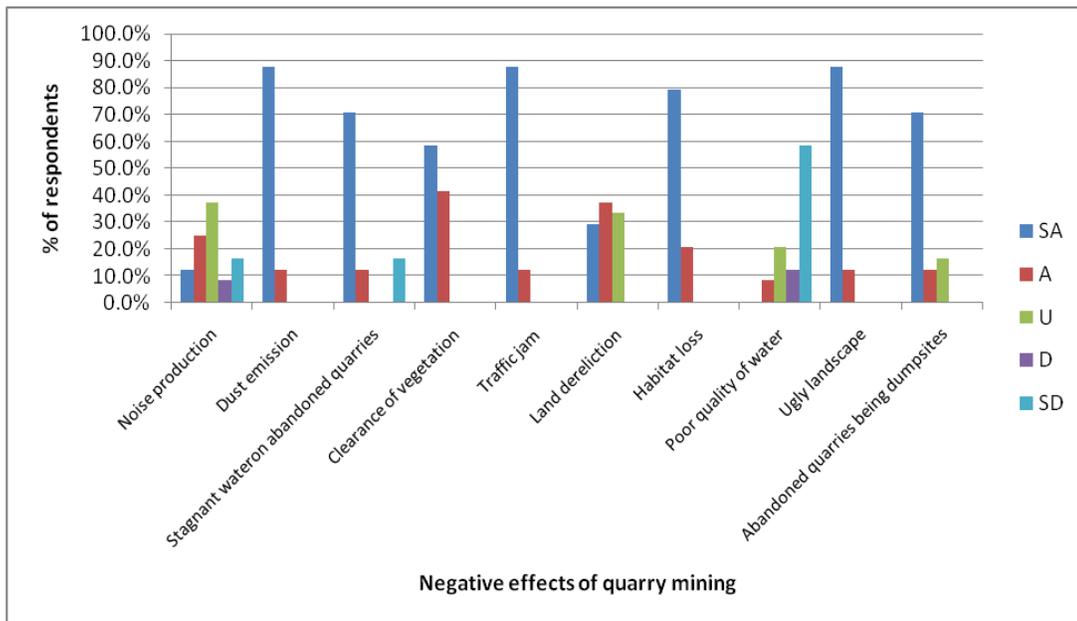
conducted before the onset of the quarry digging, it indicated that there would be a lot of dust, destruction of vegetation, noise and vibrations. The EIA report indicated tree planting as a strategy to reduce the impact of dust, deforestation, noise, and vibrations. Furthermore, the EIA report indicates jobs would be lost after the closure of the quarry. However, it gave a solution that the trees planted during afforestation could bring in employment and generate revenue continuously, as they would mature after 25 years. Some of the species which were suggested to be planted include *Artocarpus heterophyllous*, *Tectona grandis* and *Mangifera indica* (ibid).

Although quarrying is seen as a theft business, in most cases the corporate social responsibility is far reaching hence supporting economic development of the quarrying area. According to Paul H. (2002), a new community is created around every quarrying zone. This is because technocrats from other places with different artisan skills come looking for job in those areas. As a form of CSR, Ndarugo quarry companies offers 80% of jobs to the local residents, provides attachments to students specializing in those areas as well as funding neighbouring schools and Nyachaba dispensary. In developed countries such as Australia, the OZ mineral company spent over \$336,165 on community investment such as sponsor schools, flying doctors services, and award of best environmental practices as forms of CSR.

5.3.2 Negative effects of quarrying activities

The study sought to assess negative effects of quarrying activities in Ndarugo area by use of several statements on a likert scale. The results are shown in Figure 5.6 where SA = strongly agreed; A = agreed; U = uncertain; D = disagreed and SD = strongly disagreed.

Figure 5.6: Negative effects of quarrying



Source: Researcher 2019

It was found that dimension stone quarrying bring in several negative effects such as noise pollution, dust emission, pools of stagnant water, loss of biodiversity, and land dereliction among others. Noise was not an alarming problem in Ndarugo area because stone are cut by machine unlike other quarries where blasting is done. An observation schedule in the area found that, the company use modern stone cutting machine that

produce less noise. The machine operator is well equipped with earplugs and helmet to protect him from air damage. Plate 5.2 shows a machine operator in safety attire.

Plate 5.2: A machine operator at Silver stone quarry site wearing safety attire



Source: Researcher 2019

The machine has a diamond-cutting blade that enables it to cut easily through the volcanic rock. A light rail track is set to the size of dimension stones. The diesel-propelled machine has two blades, one cutting vertically, and the other horizontally simultaneously. The most common stone sizes cut by the machine are 6X9 inches or 9X9 inches. Therefore, no blasting is done in all quarry sites in Ndarugo area. All the three quarry sites visited use machines to extract stones from the basement rock. A study done

in India revealed that stone quarrying generates a lot of dust that affect the quality of fodder for cattle, destroy electronic home appliances and other human and livestock related diseases.

Dust emission is a major challenge in the area. The area receives low rainfall and most of the season it experiences dry spell, worsening the situation. The results in Figure 5.6 shows that dust affect 90% of the population. This is evidenced by dust related sickness treated in the nearby dispensary. Dust accumulation on vegetation growing near the quarry sites as well as the evidence of leave chlorosis and epinasty. The excavators generate dust during stripping stage and stone cutting stage while Lorries ferrying dimension stones to consumers produce the rest. The loaders and lorry drivers who are indirect conduct with dust have no dust masks exposing them to health-related problems. Therefore, dust is the greatest threat to the sustainability of physical and biological environment in Ndarugo area. Plate 5.3 shows photos of plant growing near Greystone quarry site covered with dust which can close stomata that are necessary for gaseous exchange in plants. This interferes with plants' growth rate as crops yield are also reduced with some vegetation drying up.

Plate 5.3 Dust accumulation on vegetation near Silverstone quarry site.



Source: Researcher 2019

Stone quarrying leads to land dereliction especially where land most of the exhausted quarry pits has not been rehabilitated. This leaves stagnant pools of water in quarry sites that are breeding site for vectors. A total of 83.3% exhausted quarry sites have turn into pools of stagnant water especially during the rain seasons. Some pits have been converted in dumping sites while others are prone to landslides especially during the rainy season. A dimension stones quarry block occupies one-acre (0.5 hectares) piece of land and it can go up to between 10-50 meters below the earth surface. There is no policy identified in this research that guides the depth of a quarry pit in Ndarugo area but deeper than 50 meters the quality of dimension stone deteriorates. Although pools of stagnant water known to be breeding site for vectors, they help to recharge underground water.

Plate 5.4 Pool of water at Kingstone abandoned quarry pit



Source: Researcher 2019

The process of starting a quarry pit involves stripping stage that deals with clearing of vegetation and scooping the upper most part of lithosphere to access quality stone. Either vegetation is wiped away during stripping stage or a hip of soil is dumped on them. This process led to loss of biodiversity and emission of dust. Plate 5.5 shows some plants that are almost being uprooted because of the quarrying activities. According to Lameed (2010), quarrying activities cause disruption of natural ecosystems such as habitat for wild animals, blockage of streams, gully erosion and alluvial deposit in rivers aand dams. This makes it expensive to desilt irrigation canals and man-made lakes.

Plate 5.5: Plant roots exposed at Greystone quarry site due to quarrying



Source: Researcher 2019

Stripping stage is followed by stone cutting stage. This involves setting light rail to the size of stones to be cut and running the stone cutting machine on the rail to obtain dimension stone. The last stage involves sorting and grading ready for market.

The researcher made an observation schedule to check on leaves of plants growing near the quarry sites for necrosis, chlorosis, epinasty, and abscission of leaves. The results in Plate 5.6 shows that plant leaves growing near the quarry site suffered Chlorosis exhibited by yellowing of leaves. Other plants suffer from necrosis exhibited by dark and brown spots. This can cause low yields of crops and other plants growing near quarry

sites. Hence, Ndarugo neighborhoods have been experiencing low yield due to spillover effects of dust to the neighboring areas.

Plate 5.6 Chlorosis and necrosis in leaves near Silverstone quarry

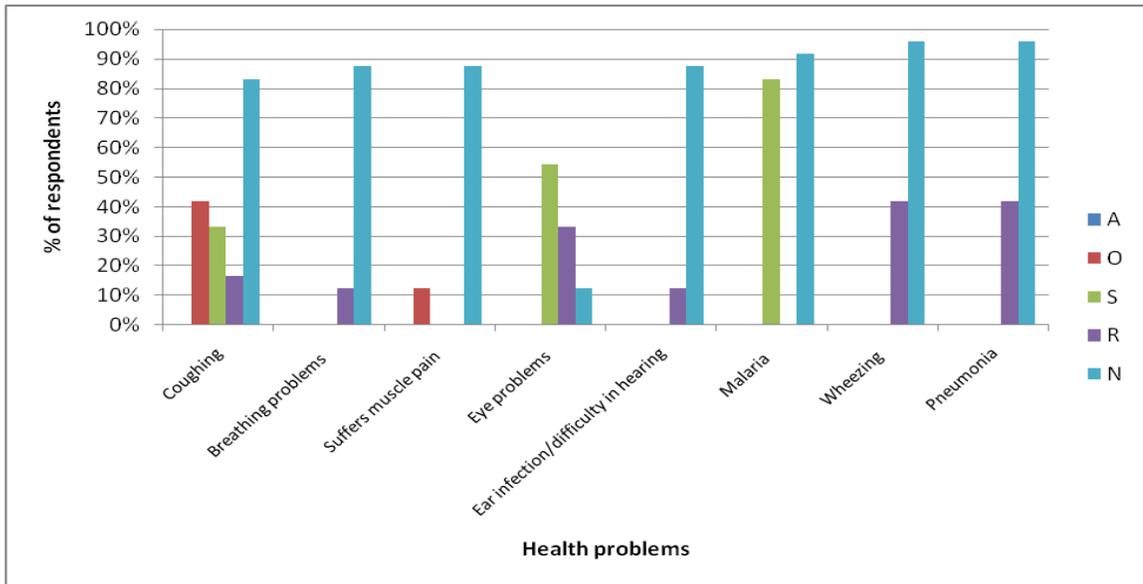


Source: Researcher 2019

5.3.3 Health related problems

The study sought to find out whether quarry workers within Ndarugo area have health complications related to quarrying activities. The results are presented in Figure 5.7 where A = Always; O = Often; S = Sometimes; R = Rarely and N = Never.

Figure 5.7 Health related problems associated with quarrying activities



Source: Researcher 2019

Stone-quarrying activities leads to several health-related problems such as coughing, body muscle pain, eye problems, ear infections, malaria, and pneumonia. 75% of people working in the quarry site suffer from coughing while 54.2% suffer from eye infections. This is because the activity produces a lot of dust. The quarry workers do not use dust mask except the machine operator. The quarry companies have not prioritized the health of workers. This means that the NEMA officers have not enforced the law. Malaria was not a common problem in the area as most of the homesteads were far away from the stagnant pools of water.

5.3.4 Socio-economic effects

Quarry companies have not developed roads in the area as a form of corporate social responsibility. Most of roads have no marran neither tarmac. All quarry companies in

Ndarugo area are own by foreigners who includes the indians and chinese nationality. These companies are after profit maximization before the lease period is over which is normally two to five years. That why they can not incur extra cost or time to develop the area. Plate 5.7 shows roads in the nearby area which is not tarmacked despite the quarry company having left the place after exhausting extraction of materials.

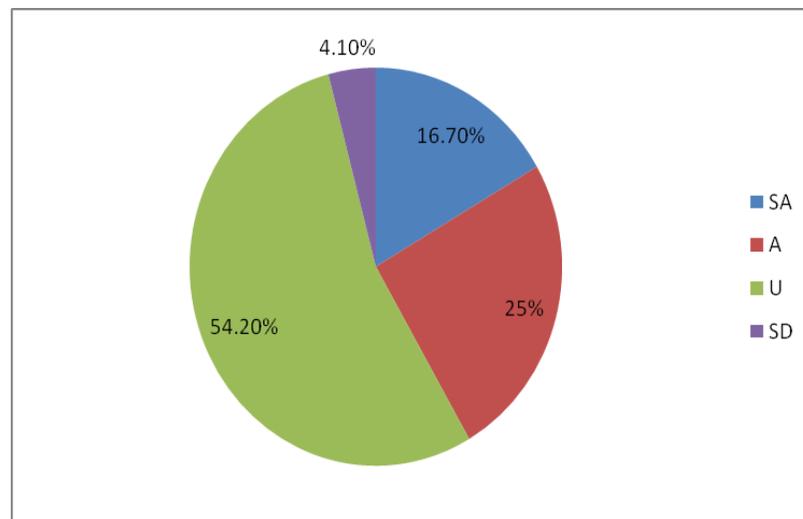
Plate 5.7 Undeveloped roads on an abandoned Silverstone quarry site



Source: Researcher 2019

Majority of residents near the quarry sites do not depend on quarrying activities, as many people were casuals and their jobs in quarries not permanent. Only 41% of the population depends on quarry activities for their livelihood as shown by Figure 5.7. The quarry companies do not leave anything of value after exhaustion. Plate 5.8 shows a recently left quarry pit with nothing of value left to the local residents.

Figure 5.8: Respondents dependence on quarrying



Source: Researcher 2019

5.4 The legal frameworks guiding quarrying activities in Kenya

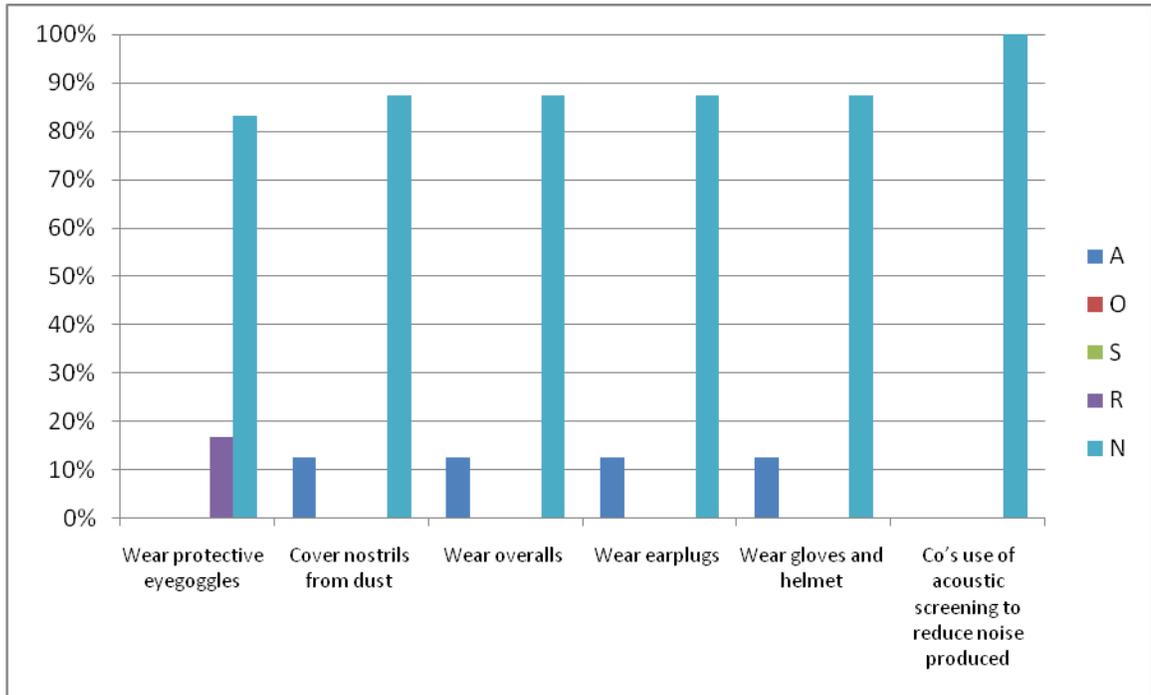
There are several legislations enacted in Kenya, which provide guidelines on how mining and quarrying should be done to reduce negative environmental impacts. These includes, The Environmental Management and Coordination Act of 1999, Legal Notice No. 101 (The Environmental Impact Assessment [EIA] and Audit Regulation) (GoK, 2003, The Occupational Safety and Health Act (GoK, 2007), The Mining Act (GoK, 2016). The

research found that all quarry companies are register and they have NEMA approval certificates to carry out their activities. Mining and quarrying activities are devolved unit under Kiambu county government. Once a quarry company applies for license, the NEMA officers carry out EIA report and award certificate of approval or propose recommendations before giving approval. All managers are aware of legal requirement in the quarrying sector especially legal notice 101 and occupation health and safety but no quarry site visited that displayed occupation healthy and safety chart. Most of workers were not wearing safety attires except the machine operators. Either the company had not provided or they are not aware of the dangers associated. In Zanzibar The Revolutionary Movement of Zanzibar formulated several policies that govern environment. This includes the Environmental Policy of 2013, the Water Policy of 2004 and the Strategy for Growth and Reduction of Poverty among others.

5.5 The future of dimension stone quarrying

The future of dimension stone quarrying activities relays on Kiambu county government in terms of enforcing legal frame works, making by-laws, involving non-governmental organization, and implementing mitigation measures to curb the negative effects of quarrying activity. To assess the future of stone quarrying, the results are presented in Figure 5.9 where A = Always; O = Often; S = Sometimes; R = Rarely; N = Never.

Figure 5.9: Mitigation measures



Source: Researcher 2019

Devolution has given a good avenue to manage and implement regulation related to quarrying and mining sectors. Although most quarry companies have NEMA approval, the findings in Figure 5.9 indicate that most quarry sites do not take mitigation measures to reduce negative effects of quarrying activities. Quarry workers do not wear safety attires while on duty. No acoustic screening to moderate noise although the companies used stone-cut machine that makes less noise compared to where blasting is done. Therefore, only the machine operators were provided with earplugs because they work directly with the machines.

In terms of dust, the open-ended questions revealed that every two out of the three quarries investigated gave their workers dust masks although sometimes the workers did not wear them. This explains why results in Figure 5.8, show that some workers were coughing and had eye problems.

All quarries companies investigated intended to fill the pits after their tenure was over. They also intended to plant trees around the quarries. The quarry pit that are said to have been reclaimed they are not leveled. The unwanted material that have been scooped from new quarry pit have been dumped into the exhausted pit in the name reclamation as shown in Figure 5.8.

Figure 5.8. An abandoned Silverstone quarry site



Source: Researcher 2019

The results revealed that NEMA officials inspected quarries before and regularly after quarrying process began in order to ensure that they complied with the existing guidelines on how quarrying should be done.

The study sought to find out whether quarry companies were in any way socially responsible to the neighboring community. The results revealed that they contributed in funding construction of schools and gave attachments to students training on the use of excavators and tractors. Furthermore, the study sought to know challenges quarry sites experienced. The results revealed that they experienced several challenges such as theft by the locals, filling of pits by water during rainy season and sometime quarry pits would collapse especially in rainy season.

CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter is a summary of the findings, conclusions, and recommendations based on the research conducted at Ndarugo area. The chapter also provides suggestions for further research on environmental effects of dimension stone quarrying activities.

6.2 Summary of the findings

The study intended to assess the environmental effects of dimension stone quarrying activities on the environment, the legal framework put in place and the future of stone quarrying in Ndarugo area of Kiambu County, Kenya. The results revealed that stone-quarrying activities in the region have both positive and negative effects. For instance, it creates 41% of jobs direct or indirect, hence supporting the local economy. It provides dimension stones to its rich hinterland including Nairobi and Thika. It is a source of county revenue and it helps to recharge underground water.

Stone quarrying is associated with the following negative effects. It produces a lot of dust that leads to respiratory, eye infections and death or decline of yield in crops. 87.5% of exhausted quarry pits form ugly landscape and derelict land that is unproductive for agricultural activities unless reclaimed. The pools of stagnant water form breeding site for mosquitoes that causes malaria. Some quarry pits have experienced landslides leading to the death of people. There is 90% loss of biodiversity especially during stripping stage.

There are several legal frame works enacted in Kenya concerning mining and quarrying activities. These include the Environmental Management and Coordination act, the Legal Notice No. 101, The Occupational Safety and Health Act among others. All quarry companies in the area are approved by NEMA.

The future of dimension stone quarrying activities relays on Kiambu county government in terms of enforcing legal frame works, making by-laws, involving non-governmental organization, and implementing mitigation measures to curb the negative effects of quarrying activity.

6.3 Conclusions

- Stone quarrying is a viable economic activity in Kenya that needs a kin study for generalization purpose. It creates employment opportunities, sources of construction materials, recharge underground water, and sources of revenue to the government hence boosting the local economy and living standards of residents.
- There are several negative effects of quarrying activities, which if not taken care of can outweigh the benefits of quarrying. These include air pollution, water pollution, loss of biodiversity, land dereliction leading to non-sustenance of our environment.
- There is a policy gap in terms of land rehabilitation and reclamation procedure after quarry pits are exhausted.

- There are laws and guidelines in Kenya on how quarry companies should carry their activities but unfortunately, the regulatory authorities do not enforce these laws effectively.

6.4 Recommendations

- i. The study recommends all artisans quarry companies to be registered and approved to ensure sustainable quarry business.
- ii. The government should give environmental best practice awards and certificates to the complying companies as well as revoking licenses of non-compliance companies.
- iii. The quarry companies should provide safety attires and ensure safety of the worker place either by sprinkling water to reduce dust.
- iv. NEMA officers should regularly inspect the quarrying activities during and after quarrying process and carry out environmental impact assessment after a quarry pit is exhausted.
- v. The county government should engage non-governmental organization to help reclaim and rehabilitate derelict land.

6.5 Suggestions for further studies

The following are some of the areas for further research

- There is need for further study on policy gaps related to quarry post-closure practices.
- There is need for research on impacts of quarrying activities in relation to county infrastructural development.

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APPENDICES
Appendix 1 - Letter of introduction

The Human Resource Manager

Dear Sir/Madam

RE: INTRODUCTION LETTER

I am a postgraduate student from the University of Nairobi in the Department of Geography and Environmental Studies. I am carrying out a research on “*Environmental effects of dimension stone quarrying activities in Kiambu County, Kenya: A case study of Ndarugo area in Kalimoni sub-location, Juja location*”. This quarry site has been selected for consideration in this study.

The attached questionnaires have been designed to assist the researcher gather data for the purpose of the research only. Respondents will not be required to write their name. Respondents are kindly requested to respond to all items thoughtfully and honestly. You are hereby assured that the information you will give will be treated with confidentiality it deserves and used strictly and only for academic purposes.

Thank you in advance.

Yours faithfully

Solomon Wangela

Appendix II: Questionnaire

This questionnaire is aimed at collecting data on effects of dimension stone quarrying activities in Ndarugo area of Kiambu County, Kenya for a master's project. The data will be used for academic purpose only and will be treated with strict confidence. You are requested to participate in the study by providing answers to the items in the sections as indicated. Where appropriate use tick

(✓)

SECTION ONE: GENERAL INFORMATION

1. Indicate name of the quarry site.....
2. Please tick your Gender
Male [] Female []
3. Please tick your age
a) 20-25 [] b) 26-30 [] c) 31-35 [] d) 36-40 [] e) 41-45 []
f) 46-50 [] h) 50 years and above [] i) other age
(specify).....
4. What is your highest level of formal education
a) O'level/A 'level [] b) Certificate [] c) Diploma [] d) First Degree []
e) Master's Degree [] f) Postgraduate Diploma [] h) PhD []
5. Please tick your Position in the quarry site
a) Resident [] b) Accountant [] c) Loader [] d) Gatekeeper [] e) Manager []
F) Clerical Officer [] g) Truck Driver [] h) Blaster [] I Stone Breaker []
j) Crushing plant operator [] k) others (specify).....

SECTION TWO. POSITIVE IMPACTS OF QUARRYING ACTIVITIES

Please indicate to what extends do you agree or disagree with the following statement regarding quarrying activities in this site.

Use the scale where SA= strongly agree A = agree U = uncertain D = disagree SD = strongly disagree

	Statements	SA	A	U	D	SD
1	This quarry site provide construction materials for buildings					
2	This quarry site has created job opportunities					
3	Quarry site in this area are huge supporter of local economic development					
4	New roads have been built to facilitate transportation of extracted materials since inception of this quarry site					
5	People around this quarry site depend wholly on their livelihoods from quarrying activities					
6	Quarry site owners in this area leaves some extracted materials to be used by the residents					

Briefly describe any other benefits of quarry site in this region not included in the questions above

.....

.....

SECTION 3: NEGATIVE EFFECT OF QUARRYING ACTIVITIES

Please indicate to what extends do you agree or disagree with the following statement regarding quarrying activities in this site

Use the scale where SA= strongly agree A = agree U = uncertain D = disagree SD = strongly disagree

	Statements	SA	A	U	D	SD
1	There is a lot of noise produced from activities in this site					
2	There is emission of dust as a result of activities in this site					
3	There are pools of water in quarry sites left unattended that are breeding site for pest					
4	Quarrying activities in this area has led to cutting down of trees to set up the site					
5	Quarrying activities in this area has altered the land surface making it unproductive for agricultural activities					
6	There are a lot of traffic in the roads in this region due to trucks transporting extracted materials from the quarry sites					
7	There have been loss of habitat of some living things after quarrying activities took place					
8	The quality of water in this region has reduced due to quarrying activities					
9	Quarrying activities in this region has led to ugly scenes of land left					
10	Some Quarry sites in this region have been abandoned to act as dumping site					

Briefly explain other disadvantages or negative impacts of quarrying activities in this region

.....

.....

.....

.....

SECTION FOUR: HEALTH RELATED PROBLEMS

In the table below, use a tick (√) to indicate the extent to which you experience the following health complications related to quarrying activities. Where A = Always; O = Often; S = Sometimes; R = Rarely; N = Never

NO.	Statement	A	O	S	R	N
1	Since I started working here I cough					
2	I experience shortness of breath due to working or staying here					
3	I experience muscle pain due to working here					
4	Since I started working I have eye problems					
5	Since I started working here I have ear infection or have difficulty in hearing					
6	I get infected with malaria					
7	I experience wheezing					
8	I experience pneumonia					

Briefly describe any health related problem or illness that is common to people working in quarry site here or residents of this area

.....

.....

.....

.....

.....

SECTION 5: MITIGATION MEASURE

In the table below, use a tick (√) to indicate the extent to which you agree with the following mitigating measure. Where A = Always; O = Often; S = Sometimes; R = Rarely; N = Never

NO.	Statement	A	O	S	R	N
1	I wear protective goggles for my eyes while working					
2	I cover my nostrils from dust while working in this quarry site					
3	I wear overalls during my working hours in this site					
4	I wear earplugs when working					
5	I wear gloves and helmet while working					
6	The company use acoustic screening to moderate noise produced					

Briefly describe any other measure used to prevent or reduce negative impacts of quarrying activities in this region

.....
.....

SECTION 6: QUESTIONS FOR THE MANAGER OR OWNERS OF THE QUARRY SITE

1. Name of the Company.....

2. When was the quarry started

3. How many employees do you have

4. What is the nature of employment casual/contract/permanent?

5. What do you provide towards the safety of your employees?

.....
.....

6. What plans do you have after the completion of the quarrying activities in the area?

.....
.....

7. How do you control

(i) Dust

.....

(ii) Noise

.....

(iii) Loss of vegetation cover

.....

(iv) Risks associated with the use of explosives in quarrying

8. Do you have any waste management programs in your quarry?

a. If yes which one

B.If no how do you dispose off your waste

9. What was the land used for before the quarrying started

10. What are some of the challenges do you experience in your quarry

11. What is the size of land where the quarrying is taking place?

12. There are several legislations enacted in Kenya which provide guidelines on how quarrying should be done to reduce negative environmental impacts. One of the legal frameworks is the mining act 2016. Which legal framework or regulatory institutions have you complied?

13. Are you in any way socially responsible to the neighboring community?

Yes. No... If yes, what are those measures/activities?

Appendix III: Observation schedule

The researcher shall observe the following and the data will be recorded accompanied by pictures, which shall be taken

1. The quarry site area, to check whether there are ugly scene of land left and take photos
2. Condition of roads leading to quarry site and general area near the quarry site to observe whether living standard of residents has been raised compared to area far from the quarry site
3. Check whether the workers are wearing protective clothing.
4. Check the leaves of the plant near the quarry site area for the following characteristics
 - i) Necrosis (death of leaf part which may be black)
 - ii) Chlorosis (yellowing of leaf)
 - iii) Epinasty (bending of leaf downwards due to faster rate of growth on the upper surface)
 - iv) Abscission of leaves (premature leaf fall)

Appendix IV: Research Certificate

THIS IS TO CERTIFY THAT:
MR. WILLIAM WANGELA SOLOMON
of UNIVERSITY OF NAIROBI, 531-216
GITHUNGURI, has been permitted to
conduct research in Kiambu County
on the topic: NEGATIVE
ENVIRONMENTAL IMPACTS OF
QUARRYING ACTIVITIES ON THE
PHYSICAL ENVIRONMENT IN KIAMBU
COUNTY, KENYA: A CASE STUDY OF
NDARUGO AREA IN KALIMONI
SUB-LOCATION, JUJA LOCATION.
for the period ending:
12th October, 2019.

Permit No. : NACOSTI/P/18/22694/25370
Date Of Issue : 17th October, 2018
Fee Received :Ksh 1000



Applicant's Signature
Signature

Director General
National Commission for Science, Technology & Innovation

Appendix V: Research Permit



NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471,
2241349,3310571,2219420
Fax: +254-20-318245,318249
Email: dg@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref. No. **NACOSTI/P/18/22694/25370**

Date: **17th October, 2018**

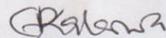
William Wangela Solomon
University of Nairobi
P.O. Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on *“Negative environmental impacts of quarrying activities on the physical environment in Kiambu County, Kenya: A case study of Ndarugo Area in Kalimoni Sub-Location, Juja Location”* I am pleased to inform you that you have been authorized to undertake research in **Kiambu County** for the period ending **12th October, 2019**.

You are advised to report to **the County Commissioner and the County Director of Education, Kiambu County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.


GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kiambu County.

The County Director of Education
Kiambu County.

Appendix V: Plagiarism report

22/11/2019,

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Turnitin Originality Report

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**EFFECTS OF DIMENSION
STONE QUARRYING
ACTIVITI... By Solomon
Wangela**

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Handwritten signature: Wangela Solomon

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Declaration Form for Students

UNIVERSITY OF NAIROBI

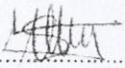
Declaration of Originality Form

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

Name of Student:	SOLOMON WANGELA WILLIAM
Registration No:	CS0168884/2013
College:	HUMANITIES AND SOCIAL SCIENCES
Faculty/School/Institute:	ARTS
Department:	GEOGRAPHY AND ENVIRONMENTAL STUDIES
Course Name:	ENVIRONMENTAL PLANNING AND MANAGEMENT
Title of the work:	EFFECTS OF DIMENSION STONE QUARRING

DECLARATION

1. I understand what Plagiarism is and I am aware of the University's policy in this regard.
2. I declare that this PROJECT(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: 26/11/2019