AN ASSESSMENT OF THE KENYA QUARRY SUSTAINABILITY PERFORMANCE IN NAIROBI CITY COUNTY

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DECLARATION

This Research Project is my original work and has not been presented for examination in any university.

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DEDICATION

To my late dad John Obor Orimba

and

To my wife Brenda Achieng Osodo and our children Hope Right. Joanna Orimba, Nelson Just. Baruch Orimba and Edward Ehud Peter Orimba.

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First and foremost, I thank the University of Nairobi, Graduate School for granting me the opportunity to undertake the programme; the immense input of the lectures and staff at the Department of Geography and Environmental Studies whose dedication and commitment throughout the study helped me gain valuable knowledge in Environmental Planning and Management.

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Lastly, to my classmates, you made the journey memorable.

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ACRONYMS AND ABBREVIATIONS

CNEOR- City of Nairobi Environmental Outlook Report

CSR- Corporate Social Responsibility

CoK- Constitution of Kenya

EIA- Environmental Impact Assessment

EMCA- Environmental Management and Coordination Act, 2015

EMP- Environmental Management Plan

GDP- Gross Domestic Product

GDCF- Gross Domestic Capital Formation

GHG- Greenhouse Gases

GNP- Gross National Product

ICK- Information Cradle Kenya

IPCC- Intergovernmental Panel on Climate Change

ITDG- Intermediate Technology Development Group

ILO- International Labour Organization

KDCP- Kiama Development Control Plan

KMO- Kaiser-Meyer-Olkin

KNMMP- Kenya National Mining and Minerals Policy

MEF- Ministry of Environment and Forest

MPM- Ministry of Petroleum and Mining

NCC- Nairobi City County

NEMA- National Environment Management Authority

PPE- Personal Protective Equipment

QOs- Quarry Operators

RPs- Restoration Plans

SMR- Sustainable Minerals Roundtable

SPSS- Statistical Package for Social Scientists

UK- United Kingdom

UNEP- United Nations Environmental Programme

UN- United Nations

UNCHS- United Nations Center for Human Settlement

UNDP- United Nations Development Programme

USEPA- United States Environmental Protection Agency

WCED- World Commission on Environment and Development**.**

ABSTRACT

The extractive industry has visible and, sometimes, not so visible negative impacts on the operators, abutting communities and land uses. While relevant management authorities and operators have demonstrated their commitment to the restoration of the environment and attaining improved performance by formulating regulations under the key performance areas of sustainability in the industry, the Kenyan industry faces innumerable quarry-related disasters and stakeholders' complaints on safety, environmental and socio-economic concerns. The formulation of sustainable quarrying guidelines by NEMA was necessitated by such concerns.

The study investigated the establishment of sustainable quarrying factors and necessary compliance by the operators. The study aimed to determine level of awareness amongst the operators on sustainable quarrying activities and assess the overal contribution of the operators to sustainable quarrying in the investigated site. Qualitative and quantitative research designs provided details of the QOs perceptions on sustainable quarrying activities and drawing statistical conclusions respectively. The field data collection methods involved participant observation and informant interviewing of 31 QOs randomly sampled from 297 QOs using semi-structured and structured interview techniques. Secondary data on the contribution of the quarrying industry was sourced from the Kenya National Statistics Bureau.

The study found out that the majority of 71.0% of the QOs were not aware of the existence of the NEMA sustainable quarrying guidelines. The socio-economic variables of sustainability were well established and had a positive strong effects and contribution to sustainable quarrying. The environmental protection variables were least established and perceived to have no effects and contribution to sustainable quarrying. The environmental protection variables applied in the study area by QOs were the observation of buffers to river, residential units, schools, hospitals, shopping centers and aerodromes. The overall compliance levels of the QOs was poor and their activities had no contribution to sustainable quarrying in the study area. The study recommends the establishment of quarrying sustainability rating and excellent performance by the operators may be used as incentives for continued operation and access to other business opportunities. The authorizing agencies should undertake sensitization and awareness programmes within the study area on the sustainable quarrying guidelines and heighten enforcement and monitoring to ensure compliance with sustainable quarrying regulation for sustainability within the industry.

CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

The quarrying industry is deemed as the industrial segment that encompasses digging the earth surface for the purpose of extraction and processing the natural rock deposits for construction purposes. United Nations Development Programme and the United Nations Environment (UNDP and UN Environment (2018) noted that, globally the sector offers prospects and limitations and to sustainable development. The prospects are presented as the products of the extractive industries such as minerals and quarry stones which are essential for nearly all segments of an economy. However, their extraction also presents risks to sustainability as the resources are finite. The negative impacts emanating from the industry operations are progressively breeding conflicts between the quarrying operators (QOs) and the abutting communities. Furthermore, UNDP and UNEP (2018) noted that the quantities of wastes produced within the industry is expected to increase as the related environmental costs continue to pose an endless challenges.

According to (ICK, 2019), rock extraction in the country is one common industrial activity nonetheless most treacherous for workers comparative to other development sectors globally, since the QOs are subjected to a multiple of risks. This necessitates the assessment of the occupational, public health and safety concerns amongst the QOs. The quarrying industry in the Nairobi mainly involves the production of construction stones/artisanal dimension stones, hardcore/stone chippings, red soil and murram. Quarrying activities in Nairobi cover an area of 4.4km^2 which is 0.63% of the land cover (City of Nairobi Environmental Outlook Report, (CNEOR, 2007). National Environmental Management Authority of Kenya (NEMA, 2011) noted that the industrial segment has a significant role in enhancement of local construction industry, creation of wide range of income generation opportunities and basically a significant contributor to the national economy. The inputs of the construction sector which is the main consumer of the quarrying products to GDP, growth rates of GDP as an industry, percentage contribution to GDP by activity and employment as an industry, for the period 2012 to 2016 are shown in the Table below.

Table 1:1: Inputs of the Construction Industry to Economic Development

Year	2012	2013	2014	2015	2016
Key Indicator (Output) - Kshs. million	513,390	582,896	683,376	805,703	819,448
Gross Domestic Product as an Activity (At Market Prices) Kshs. million	190,851	213,565	262,090	309,046	359,656
Gross Domestic Product as an activity (At Constant 2009 Prices) Kshs. million	154,796	164,220	185,696	211,430	230,984
Growth Rates of GDP as an industry	11.3%	6.1%	13.1%	13.9%	9.2%
Sources of GDP growth, 2012-2016	10.6%	4.7%	11.0%	11.7%	8.2%
Percentage Contributions to GDP by Activity (Current Prices)	4.5%	4.5%	4.9%	4.9%	5.0%
Employment as an industry, 2012-2016 (in '000s)	98.7	111.6	132.9	148.0	163.0

Source: Statistical Abstract: Republic of Kenya, Government Printers, 2017

Conversely, the contribution of the quarrying industry is incessantly underscored as its activities constantly fail to safeguard the environment, promotes socio-economic equity and justice and arrest the degradation of the non-renewable resource base to meet the tenets of sustainable quarrying activities for development.

1.2. Problem Statement

The global extractive industry is being criticized for its visible and not so visible negative impacts on the environment, human rights, socio-economic injustices and imbalances which remains a key issue to be contented with and overcome in the coming decades (Ghose et al, 2000). UNDP and UN Environment (2018) noted that the extractive and primary industries account for around 30.0% of total Greenhouse Gases emissions (GHG) and adoption of clean production measures could reduce the emissions by 25.0%. In the Middle East and Africa the GHG emissions the extractive industry increased by 4.4% annually between the year 2015-2010

(UNDP and UN Environment, 2018). While some environmental wear is inevitable and some of the impacts are transitory such as land use, responsible regulatory authorities and operators around the globe have demonstrated their commitment to upgrading the environment and attained improved performance standards through environmental audits, new technologies for reclamation, focus on measure to ensure safety of operators and embraced the basic tenets of sustainable development both in theory and practice (Ghose et al, 2000).

OECD (2007) noted that regulatory authorities within the industry have further introduced Environmental Performance Rating and Discloser (EPRD) programmes as complementary tools for the traditional command and control environmental governance mechanisms captured within policies, laws and regulations. The EPRDs have been flaunted as a solutions to ineffective environmental protection institutions and inadequate inspection and enforcement budgetary allocations in both developed and developing countries (OECD, 2007). Powers (2018) noted that EPRD programmes used complementarily with policies, laws and regulations have been successful in Asian developing countries like Indonesia and China, and African Ghana. UNDP and UN Environment (2018) further noted that measures to mitigate impacts, safe guarding of civil rights, and promotion of social equity and enhanced economic gains from quarrying for development should be observed through the life of a quarry.

Quarrying is one industrial land use of emerging concern in Nairobi City County (NCC). CNEOR (2007) noted that quarrying within Nairobi is increasingly becoming a main exploiter of natural non-renewable resources, source of pollution to the environment, negative socio-economic impacts, quarrying accidents and deaths, and a point of continued land use conflicts. Its negative impacts on the environmental are experienced throughout the resource exploitation and processing stages, i.e. clearance of the overburden to the decommissioning of the disused quarry sites. Despite the overall socio-economic contribution to development in the Country, NEMA (2011) noted that there is a rising public discontent with the operations of quarries as various related disasters and complains are witnessed and raised respectively, which have triggered safety, environmental, socio-economic and legal institutional concerns that needed attention. These necessitated the formulation of quarrying guidelines highlighting quarrying

sustainability factors within its Integrated National Landuse Guidelines (INLGs) in 2011. The problem that the quarrying industry is facing in Nairobi is to achieve the best balance between the various constraints (environmental, occupation, public health and safety and socio-economic) and the benefits derived, in the wake of the NEMA (2011) quarrying guidelines to ensure sustainable quarrying. The inability of the QOs to comply with outlined regulations to improve the sustainability performance of the quarrying sites has led to the closure of Njiru and Kwa Hinga quarrying site leaving Kenya Quarry as the only operational within Nairobi City County. Therefore, the study seek to determine the establishment of sustainable quarrying factors amongst the QOs for sustainable resource exploitation and their relative effects on sustainable quarrying within the Kenya quarrying site in the context of sustainable development.

1.3. Study Questions

The study was aimed at answering the following questions:

1. Is there adequate awareness amongst the operators on sustainable quarrying activities?
2. Which sustainable quarrying variables are applied to the site investigated?
3. What is the overall contribution of the quarry operators to sustainable quarrying activities in the site?

1.4. Research Objectives

1. To determine level of awareness amongst the operators on sustainable quarrying activities.
2. To establish the extent to which sustainable quarrying variables are established in the site.
3. To assess the overall contribution of quarry operators to sustainable quarrying activities in the site.

1.5. Study Hypotheses

H_0: There is no significant difference on the level of awareness on the NEMA sustainable quarrying regulations based on the levels of education of the QOs.

$H_{o:}$ There is no significant difference in perception of the QOs to comply with NEMA sustainable quarrying guidelines.

$H_{o:}$ There is no significant difference in the establishment of sustainable quarrying variables among the operators in the site.

1.6. Justification of the Study

The study results are of benefit to the government and the policy makers especially NEMA, Ministry of Petroleum and Mining (MPM), Environment and Forest (MEF) and NCC. There is no comprehensive review of the NEMA (2011) Integrated National Landuse Guidelines to assess whether the outlined quarrying guidelines to ensure that the related safety, environmental, socio-economic and legal and institutional concerns addressed are effective and complied to by the QOs to ensure sustainability within the sector. The study therefore offered an opportunity for improved productive capacity, environmental quality and social and economic sustainability of the quarrying activities in Nairobi.

The study made a contribution to the existing literature on sustainable quarrying or mining in general to ensure sustainability in the industry. Future researchers will use this research as a foundation for advance research. It will benefit the QOs it highlighted their preferred variables and factors in ensuring the sustainable quarrying practices and further identifies the challenges faced in adherence to sustainable quarrying regulations and offers recommendations to ensure sustainable quarrying practices the quarry site.

1.7. Scope and Limitation of the Study

While acknowledging that there are many factors that determine sustainability within the extractive industry, the present study covers specific socio-economic, environmental protection and occupational, public health and safety relevant aspects of sustainability quarry performance applicable to the quarrying industry in Kenya. The study therefore focuses on relevant and applicable sustainable quarrying variables in the Nairobi quarry industry to ensure sustainability as outlined by NEMA (2011). The study focused on the artisanal dimension stone quarrying in Kenya Quarry whose activities are informal and labour intensive compared to other quarries crushing ballasts within Nairobi. Kenya Quarry is the only officially operation quarry site within the Nairobi City County. The geographical latitude of the study area was defined by the boundary of the quarry site. The major study limitation was the gaining access to the quarrying pits within the quarrying site.

1.8. Operational Definition of Terms

Quarrying: Extraction type where the products are mainly used for the construction purposes, and not for any other utilization.

Quarrying Industry: The sector that involves excavating the earth surface for the purpose of exploiting or extraction and processing the natural rock deposits for construction purposes'

Sustainable Quarrying: Quarrying activities that sustain benefits of the products while the net contribution of the resource has a positive impacts over the life cycle of its activities guided by laws and regulations.

Quarry Operators: Individuals who are renting quarrying pits for the extraction of stones within the larger Kenya Quarry site in Nairobi.

Sustainability: basically the improving of the economic, environmental and social impact of quarrying activities throught the quarry life cycle.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction to Literature Review

Based on the main objective of this research project, which was to determine the establishment of the suatainable quarrying factors amongst the QOs and the relative effect and contribution to sustainable quarrying, a comprehensive review of literature relevant to the study objectivest. The review focused on theoretical and practical basis of sustainability and their impications on quarrying activities in Nairobi. Sustainability paradigm in quarrying industry is about improving economic, environmental and social impact of quarrying activitiess throught the quarry life cycle.

An indepth literatures review was undertaken to identify sustainable quarrying factors and variables appropriate for the quarry industry. Further, literature on the Kenyan quarry industry was anlysed in the context of global quarrying sustainability practices and the regional situation, to comprehend the efforts being made within the industry to manage the sustainability issues. How stakeholders respond to sustainable variables that dictates their practices are important indicators of their priorities, resource use practices and the implications of the regulatory and institutional frameworks that shape environmental and resource management protection for sustainable development.

2.2. Quarrying and Sustainable Development

Quarrying activities are directly and indirectly linked to economic growth through the aggregates produced which are major resources necessary for infrastructure development. The production practices have impacts on the environment and communities. Therefore sustainable quarrying that ensures sustainability is definitely in line with Sustainable Development. United Nations Center for Human Settlement (UNCHS, 1984) noted that there are numerous challenges facing quarry operators in the production of building materials, however their proven capacity and inputs to development are more vital. If relevant effective policies are put in place, their products remains significant in the production of bulk low cost shelter.

Deborah (2005) noted that disagreements always emanates in defining of what sustainable development is, especially when it is in the context of resource exploitation because of the difficulties in balancing the different aspects of sustainability. In rural Africa, over dependence on agricultural produces can no longer offer adequate financial incomes due to decline in farm yields (Wells, 2000 and Asante, 2014). This is a common phenomenon the farmers are subjected to the unpredictable degrees of uncertainty resulting from climate change and post- production loses (Cooper, 2008).

The overwhelming environmental concern is the dereliction of abandoned quarrying pits. The restoration of the derelict lands mitigate the impacts of quarrying activities (Šolar et al, 2009). While the industry has positive wide economic significance as a source of employment and the benefits of aggregate utilization are dispersed over very large areas the community usually suffer most of the negative effects of resource development. Therefore, a sense of balance should be sought (Langer, 2009). Gisore (2015) it is also noted that the challenges from quarrying activities are unavoidable, however, most of them can be avoided throughout the quarrying cycle if appropriate measures are adopted. Negligible adversarial effects and risks results into lower costs of investment and offer prospects for fostering relationships with quarry neighboring communities, and curtail the conflicts. Gisore (2015) asserted that there is a clear direct link among environmental effects, human rights violations which are impediments to sustainable development in quarrying industry. And therefore, lessons drawn from Africa, and elsewhere, indicate that vibrant and inclusive regulatory formulations and governance processes, at all levels, can assist QOs enhance their productions, sustain socio-economic benefits and adopt good environmental practices through applying and enforcing human rights, labour and environmental regulations, norms and standards.

2.3. Indicators of Sustainable Quarrying

There are no definite guidelines for the application of sustainability within quarry industry, therefore, each industry may formulate and adopt varied operations that are deemed "sustainable" (Athousaki et al, 2011). Solar and Shields (2002) in an attempt to describe the main aspects of sustainability of quarrying industry in general noted that natural capital embodied in extracted resources should be transformed to physical, economic, or social capital of equal or

greater value. Indeed, Wagner et al, (2003) noted that non-renewable resources such as those obtained from quarrying activities could both contribute to and hinders the achievement of a sustainable future, depending upon activities are conducted. Based on this fact, the utilization and management of nonrenewable resources is subject to grater debate as some stakeholders focus on the threat to the economy if extraction does not take place, while other focus on threat to the environment if it does. The debate necessitated the creation of Sustainable Minerals Roundtable of 1999 by the United States of America (SMR, 1999) to strike a balance by creating sustainable mining and quarrying indicators. They key guiding principles to SMR (1999) included the acknowledgement that products such of those obtained from quarrying activities contribute to sustainable development by extracting the products with proficiency while taking cognizance of the necessities of other resource users and enhancement of the environmental quality for the present and future generations.

The indicators were organized into sub-categories under four of the criteria from the Montreal process deemed applicable to extracted resources by the SMR (1999). The four key performance areas of were maintenance of capacities for production, environmental impacts mitigation, maintenance and enhancement of long terms socio-economic and cultural benefit to meet the needs of societies and the legal and institutions framework to support sustainable development. By the mid of 2002, a total of 82 indicators had been selected and spread across the four criteria as follows; productive capacity – 28, environmental Impact – 8, social and economic -31 and legal and institutional -15. Priority was given to the primary questions as discussion about sustainability in the use and management of nonrenewable resources are often couched in terms of issues deemed to be of great significance to stakeholders (Wagner et al, 2002). The second primary question had two related aspects. First, a specific measure must be adopted for each indicator. Second, while the measure must be applicable at the national level, much of the data must be collected at smaller spatial scale, for example county level. A third key question concerned the scientific explanation for the collection and utilization of specific types of data. SMR (1999) considering each of these questions generated priority indicators shown in the below Table 2.1.

Table 2.1: Indicators of Sustainable Quarrying

Environmental Impacts	**Socio-Economic Benefits**
1. Ambient Environment	**1. Local Economic Benefits**
1.1. Compliance of the operator with respect to water quality, noise and air pollution	1.1. Employment and income from the quarrying sites
1.2. Number of permitted quarry sites where quarry activities is deemed to cause environmental problems/total number of permitted sites	1.2. Other income to the local communities
2. Reclamation and Restoration	**2. National Economic Benefits**
2.1. Number of sites with reclamation and restoration plans	2.1. Value of production in the quarry sites
2.2. Areas restored relative to areas scheduled for the same	2.2 Net income in the quarry industry
2.3. Rate of abandoned quarry sites in relation to rate of restoration	
3. Management of Extraction and Processing	
3.1. Sectoral water use, consumption, discharge, loss to evaporation and reinjection	
Productive Capacity	**Legal and Institutional Framework**
1. Resources	**1. Legal Framework**
1.1. Land available for quarrying	1.1. Property rights, traditional rights and dispute resolutions
2. Exploration Capacity	1.2. Resource assessment, land use planning and policy review
2.1. Annual geological studies to determine the quarry resource base	1.3. Compliance and enforcement frameworks and decision process
2.2. Annual leases and licenses for quarrying activities	**2. Institutional Frameworks**
2.3. Annual new quarrying sites generated	2.1. Public involvement activities
	2.2. Skilled workforce
	2.3. Investment and taxation policy

Source; SMR Indicators, 2003

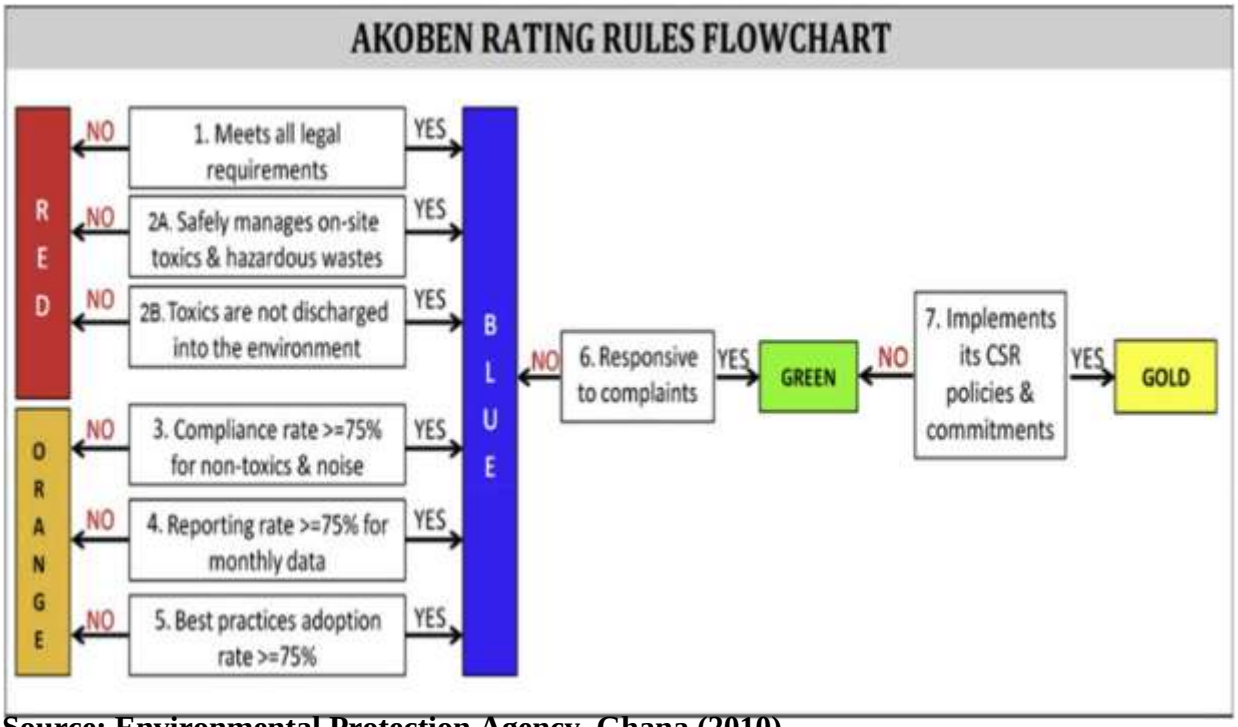
2.4. Sustainable Quarrying Rating Programmes

The above outlined indicators are captured within the environmental protection polies, legislations and guidelines aimed at mitigating the environment from the impacts of the quarrying activities. The UN Environment (2017) noted the enforcement of environmental laws and regulations remain a daunting task particularly for developing countries due lack of institutional aptitude, ineptitude of relevant enforcement authorities to enforce the laws and regulations, and lack of adequate information and national guidance materials on implementation. These eventually wane the efficacy of the laws and regulations aimed at the protection and management the environment and environmental degradation is the consequence. Enforcement and compliance performance rating, therefore, are key factors for ensuring the environmental and regulations achieve their objectives of sustainable environmental management.

Globally, varied EPRD programmes have been established around environmental and socio-economic impacts of extractive activities such as quarrying. In 1980, the AKOBEN programme was advanced by the United States. The AKOBEN programme has five colour codes namely gold, green, blue, orange and red used in a ‘‘five-colour rating scheme” to display the environmental performance of gold mining firms based on their daily operations after undertaking an environmental impact assessment and obtaining licenses. The data for the evaluation by the AKOBEN Programme included quantitative data, qualitative data and visual information acquired from the operators for rating from excellent for the best performance and poor for the worst performance. To guarantee the precision of AKOBEN ratings, the enforcement authorities conduct site appraisals to ascertain at first-hand environmental and social issues, which are challenging to capture using quantitative approaches. The rating systems on which the public disclosure of the AKOBEN Programme is publicized involve seven aspects of legal concerns, toxic waste management, toxic and non-toxic releases, monitoring and reporting, environmental best practices, community complaints and corporate social responsibility. A RED rating is awarded if an operator is nonconforming with all the outlined legal requirements of the environmental assessment regulations, is nonconforming with all requirements for safe on-site management of toxic and hazardous waste, releases effluent with

any of the toxic parameter exceeding permissible discharge levels as stipulated by the USEPA. To avoid a RED rating, a compliance rate of more than 98% is required for toxic parameters during the first twelve month period of operation. ORANGE rating is awarded if a compliance rate of an operator is <75% for conventional or non-toxic environmental parameters, compliance rate is <75% for noise pollution, best practices implementation rate is <75%, and reporting rate is <75% for monthly monitoring data. A BLUE rating is scored if there are no RED or ORANGE in relation to any criteria, the compliance rate is >=75% for all environmental categories during the rating period of twelve months, the reporting rate is >=75% for monthly monitoring, the best practices implementation rate is >=75%. A GREEN rating is scored if an operator has secured a BLUE rating with 90% or higher compliance and reporting rates, meets >=90% of the complaints management standards, and has no unsettled issue for a complaint which has been validated by USEPA. The environmental complaints covered by the AKOBEN Programme, include the complaints in relation to water resources of the abutting communities, ambient air quality due to particulate matter and total suspended particulate, noise pollution, vibrations caused by blasting at mining sites and any other environmental issue likely to hamper the welfare of the communities and abutting lands uses. GOLD rating is awarded if the mining operator has secured a BLUE rating with 100% compliance and reporting rates, meets 100% of the GREEN standards and properly follows its corporate social responsibility (CSR) policies and meets 100% of the GOLD criteria. Within the African region, the AKOBEN Programme was introduced by the Ghana Environmental Protection Agency in 2010 and outlined the general rules of public disclosures albeit having a scope of indicators reflecting the USEPA concept of the environment protection (EPA, Ghana (2010)). Figure 2.1 below illustrates the flow chart of AKOBEN rating rules.

Figure 2.1. Flow Chart of AKOBEN Rating Rules



Source; Environmental Protection Agency, Ghana (2010)

Indonesia established EPRD, Programme for Pollution Control, Evaluation, and Rating (PROPER) to promote the adherence to environmental laws and regulations in 1995 (UN Environment, 2017). PROPER is a national-level public environmental reporting initiative and an innovative attempt to mitigate the problems associated with pollution under the umbrella of the Government of Indonesia's Environmental Impact Agency. It is aimed at promoting compliance with pollution control regulations and to guarantee better environmental management system. The programme uses a color-coded rating to grade factories' environmental compliance performance against the regulatory standards. The rating system is based on five colors—gold, green, blue, red, and black as shown in Figure 2.2 below.

Figure 2.2. Programme for Pollution Control, Evaluation, and Rating (PROPER)

Methodology Mining: Color Code requirements		Below cut-off point on evenon gets a RED	Below cut-off point on even on gets an ORANGE	Must meet the benchmarks for all applicable rating categories to get a BLUE,GREEN or GOLD		
Rating Category		RED	ORANGE	BLUE	GREEN	GOLD
1	Regulatory requirements	<100%	N/A	=100%	=100%	=100%
2A	Toxic wastes-on- site management	<100%	N/A	=100%	=100%	=100%
2B	Compliance rate with toxic discharges	<98%	N/A	≥98%	=100%	=100%
3	Compliance rate-non-toxics and noise pollution & vibrations	N/A	<75%	≥75%	≥99%	=100%
4	Monitoring and reporting rate	N/A	<75%	≥75%	≥99%	=100%
5	Best practices-environmental management	N/A	<75%	≥75%	≥99%	=100%
6	Complaints management	N/A	N/A	N/A	≥99%	=100%
7	Corporate social responsibility	N/A	N/A	N/A	N/A	=100%

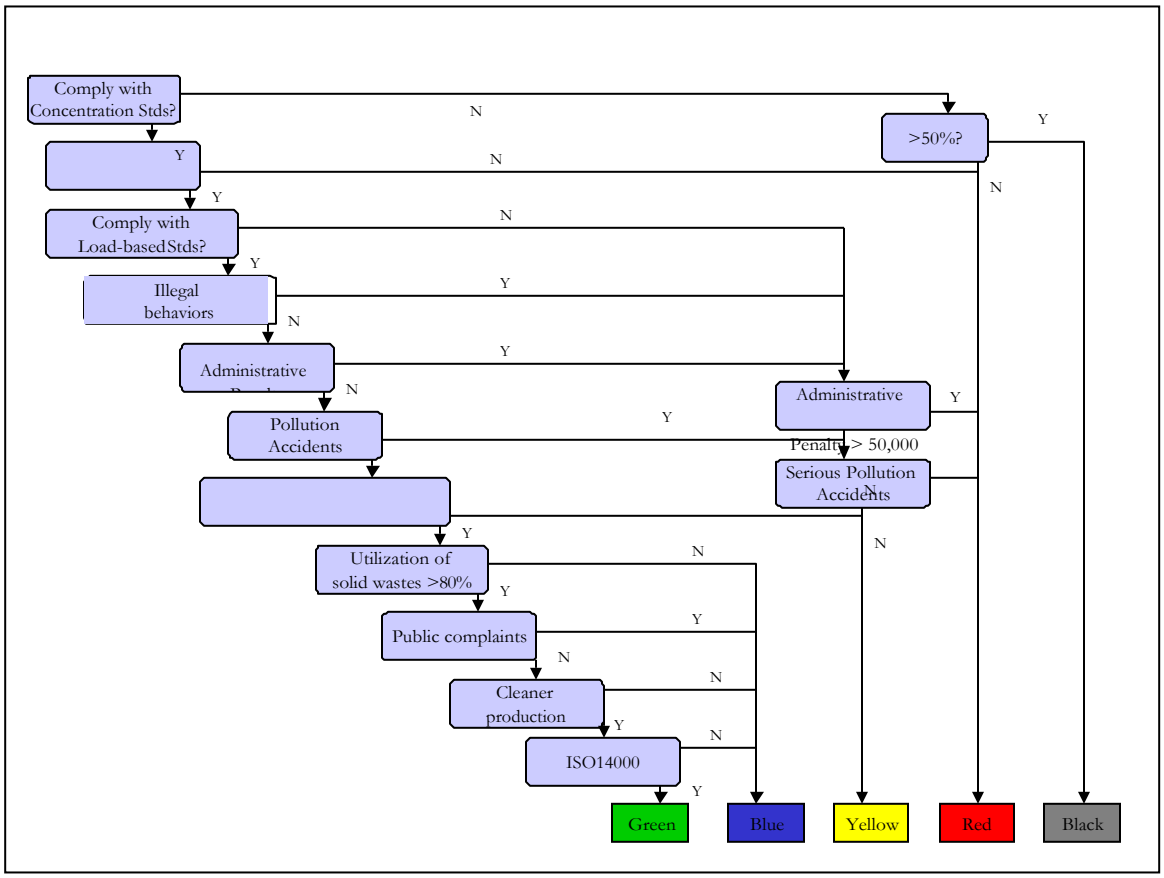
Source; UN Environment (2017)

The colors denotes the different echelons of performance in regards to pollution mitigation. Gold is scored if an operator exhibits excellent performance by going beyond the stipulations of regulations, and also attain similar results in control of air pollution and toxic waste. Green means the environment impacts mitigation process of an operator go beyond the expected compliance level, as Blue denotes compliance with national regulatory standards. Red denotes poor performance, where operators do not fully observe the regulatory standards. Black is awarded if there is no effort to mitigate pollution. The enticement concomitant to operators rated gold and green is public approval, which allow them to gain a competitive edge in the market, whereas the deterrents for factories rated blue, red and black are public pressure and legal enforcement.

UN Environment (2017) reported that PROPER had led to a significant shift of factories from noncompliance to compliance in Indonesia. Between 1995 and 1997, the compliance level of the experimental program factories had increased from 35% to 51%. It has further significantly enabled deliberate participation of factories in adopting compliance ratings and better consciousness regarding environmental protection.

In 2002, a related EPRD; the "GreenWatch" was espoused from the Indonesian PROPER by China (UN Environment, 2017). The program score the operators' compliance from best to worst based on five colors codes. The EPRD programme colour-coded ratings are determined by an elaborate accounting of environmental performance pointers. UN Environment (2017) noted that in Kenya, NEMA and Kenya National Cleaner Production Centre (KNCPC) have since 2013 put in place a programme on compliance promotion and facilitation of developers towards meeting laid down requirements for environmental protection. The programme seek to address challenges of industrial pollution. NEMA and KNCPC is yet to develop monitoring and evaluation systems and sustainability rating systems for mining and quarrying industry in Kenya.

Figure 2.3. GreenWatch Compliance Rating System



Source; Environmental Protection Agency, Ghana (2010)

2.5. Case Study on Sustainable Quarrying

The achievement of safe, environmentally and socio-economically sustainable quarrying is made possible through the consideration of safety, environmental protection and conservation by the coexistence of other land uses to ensure they continue coexisting healthily in the course of operation as case offered by the Barney Street Quarry located South Sidney Australia. According to Kiama Development Control Plan No. 22 of 2002 (KDCP), the operations of Barney Street Quarry located South Sidney in Australia that started in the 1800s as a blue metal quarrying supplying aggregate and ballast for local railway works illustrates a well-integrated principles of compatibility and sustainability in achieving safe and an environmentally sustainable quarry activities. The aims and objectives of the Kiama Development Control Plan No. 22 of 2002, as contained in section four of the plan include the recognition of the fact that the Barney Street Quarry is sited within a residential area, the identification of uses of the Barney Street Quarry which are considered inappropriate because of their likely impact upon the health and amenity of neighboring residences, the ensuring that the activities undertaken in the Barney Street Quarry do not interfere with developments of adjoining and adjacent residences due to the hour that the activity is conducted or the manner in which the quarry activities are conducted, the ensuring that the activities undertaken in the Barney Street Quarry do not pollute or degrade the environment and the identify a geotechnical constraint which exists in Barney Street Quarry and appropriate remedial measure which may be undertaken.

To ensure safe and ambient environment despite the proximity of surrounding residential developments, the KDCP (2002) general trading laws or operation hours are restricted to hours between seven in the morning to six in the evening for the week days and seven in the morning to four in the evening for Saturday. Sunday or public holidays are strictly no working days. These hours were also applicable for the general delivery vehicle or movements to and from the quarry sites. The plan further stipulates that all delivery vehicles or equipment should have their engines switched off while loading or unloading or queuing to load or unload and leave as soon as possible after arrival, all delivery vehicles should leave the quarry immediately after starting of engines vehicles should not be allowed to idle for unnecessary lengths of time, where possible the loading or unloading vehicles and the moving of bulk materials should not be carried out

before 8.00 a.m to avoid this, early loads should be loaded into vehicles prior to 6.00 p.m on the previous day, employees advised to take reasonable time to load or unload their vehicles without unreasonable impact, including the shutting and closing of tailgate, all drivers of truck should be instructed that when leaving the quarry they should turn right into Barney Street and observe 'drive neighborly' procedure and finally trucks and other equipment should be fitted with noise reduction equipment to achieve performance standards set down by the NSW environment protection authority. Regular maintain and checking of compliance should undertake

Fumes, smoke, dust and other oduors not only create an air pollution problem but can also cause disturbance to persons through aggravating allergies and diseases, dirty laundry or entering homes. To ensure activities in Barney Street keep these potential impacts to a minimum, the KDCP (2002) adopted the guides such as access roads, driveways and car packing arrears are sealed, all vehicles and equipment are regularly checked to ensure that they meet maximum emission standards, activities do not cause perceptible oduors, exhausts smoke, gasses, steam soot, ash, and dust or grit that will affect neighboring properties and large unsealed areas, although not encouraged, are watered down regularly to reduce dust. To control other likely pollutions, activities conducted in the Barry Street Quarry must not involve vibration being felt in neighboring premises, the erection of building or structure that is clearly visible from the street, other public places and an adjoining residential property that is unsightly constructed of highly reflective, lightly colored materials, the likely discharge of contaminates solid and liquid into the sewerage system, ground contamination of soils when liquid and solid wastes are deposited on the soil, the buildup of wastes on the site other than properly being stored to be disposed of by a reliable collection system and the washing down of vehicles or machinery, save the installation of an appropriate wash bay to meet the necessities of the environmental protection authority and Sidney Water Corporation.

Moreover, the KDCP (2002) encouraged adequate provision for on-site collection and storage of waste products and recyclable materials, generated by the quarry activities. The waste collection and storage area is designed and located such that it does not adversely influence in neighboring premises. Finally, landscaping is used to screen building, parking and storage areas from

adjoining residential properties and from public vantage points. Landscaping is also used to boost development within the Barney street quarry, and provide relief from large areas of hard paved surface (e.g. car parking area, storage area). As stated above, it is evident that the operation of quarries can increase land use and public health and safety, and environmental issues which should be mitigated and controlled through a comprehensive environmental planning and management. The KCDP (2002) guidelines established the related emerging issues and suggested best practice in mitigating them. Sound environmental planning as well as management guidelines provide direction to planning and enforcement agencies on how to plan for the quarrying industry. In addition, offering an empirical guide to the operation and development of quarrying activities in relation to other land uses especially in the urban areas.

2.6. Quarrying Sustainability in Kenya

In Kenya, NEMA developed an Integrated National Landuse Guidelines (INLGs) for sustained societal attributes-infrastructure, environmental resources and public safety for mining and quarrying activities among other related land uses that have environmental implications. The guidelines for the quarrying industry were outlined upon the realization that despite the major inputs of the sector such as support for the vibrant construction sector, opportunities for vast employment and the overal input to the national economy, there has been mounting public displeasure the operation of the quarries. The nation has recorded varied quarry disasters and related complaints which have generated safety, environmental and socio- economic disquiets that need to be arrested appropriately. The NEMA (2011) guidelines are based on three key sustainable quarrying performances areas of occupation, public safety and health, environmental and socio-economic guidelines to ensure sustainable quarrying activities. The study adopted the NEMA (2011) guidelines that basically mirrors the SMR (1999) indicators to establish key environmental, socio-economic, and occupation, public safety and health sustainability variables which influenced quarrying in Nairobi and further investigates their establishment and contribution to sustainable quarrying activities within the study area which mainly forms Objective 1, 2, and 3 of the study. The variables are as illustrated Table 2.2 below.

Table 2.2: Variables of Sustainable Quarrying

Occupation, Public Health and Safety Factors	Environmental Protection Factors	Socio-economic Factors
1. No undercutting and tunneling in the sites to avoid damage to property, injury or loss of life.	1. Compliance status of QOs with respect to water quality regulations; observing 40 meters buffer zone between the quarry and the edge of the river.	1. Employment and income from the quarrying sites
2. Avoidance of vertical faces more than 2.5 m when quarrying.	2. Compliance status of QOs regarding to noise, air and excessive vibration pollution (control) regulations	2. Other income to the local communities (opportunities for food vendors)
3. Hard rock quarry faces benched	3. Permit to undertake the quarrying activity (Mines Department)	3. Equitable benefits sharing among the stakeholders (remittance of taxes and levies)
4. Avoidance of loose hanging rocks/material near or on the face of excavation/quarry.)	4. Availability of reclamation and restoration plans	4. Existence of quarrying community based organizations (Welfare)
5. Ensuring that all loose rocks/ materials are scaled down before commencement of any quarry operation	5. Areas reclaimed or restored relative to areas scheduled for the same	5. Compliance with rules and regulations quarrying community based organizations
6. Warnings signs of appropriate font size and in the appropriate language erected in all quarry entries and in areas with high cliffs.	6. Quarrying sites undertake EIA before quarrying starts	6. Compliance with child labour regulations as stipulated in the Children Act of 2008 (No employment to persons under age 18 yrs)
7. Provision of well-equipped first aid kit with trained first aiders	8. Physically planned sites and appropriate land use determined	7. Compliance with alcohol and drug consumption and use regulations in the quarrying site.
8. Provision of protective gear for persons working in quarries.	7. Sites with EMP	8. Awareness creation activities and fora on diseases related quarrying and HIV/AIDs in the quarrying sites
9. Site having someone in charge of safety	8. Quarrying activities within forested land restricted to forest land without trees with plan of	9. Provision of basic utilities and facilities in the quarrying sites (Water points, Lavatories and

	restoration.	stores)
10. Quarrying site have suitable skilled blaster	9. Quarries observing buffer zones between the quarries and other land uses (500m to aerodromes),	10. Improved infrastructure (e.g., roads) network o the quarrying sites
11. Explosives acquired and conveyed legally through acquisition of relevant permit(s) from Mines and Geological Department	10. Quarries observing buffer zones between the quarries and other land uses (100m to shopping centre),	
12. Licensed storage facility for blasting materials	11. Quarries observing buffer zones between the quarries and other land uses (100m to schools),	
13. Change-of-User permits effected before the operations	12. Quarries observing buffer zones between the quarries and other land uses (100m to Hospitals),	
14. Training of quarry operators on disaster preparedness and response through training and provision of appropriate equipment.	13. Quarries observing buffer zones between the quarries and other land uses (50m to residential neighbourhood),	
	14. Quarry sites undertaking "blocking" for progressive quarrying operations and restoration and/or reclamation.	
	15. Quarrying sites restored within 12 months of depletion and restoration compliance certificate issued	
	16. Quarrying site using PPES/Watering of materials during crushing and blasting.	

Source; Constructed from NEMA-INLG (2011)

2.7. Institutional and Regulatory Frameworks for Sustainable Quarrying in Kenya

Regulating of quarrying activities is grounded on the fact the management resources, including quarry stones is conferred to the central government and the devolved governments. As such, the two levels of government are the bodies in in-charge of quarrying operations in the country from licensing, exploration to extraction. It has, however, emerged that the management of extraction

of resources, especially exploration and quarrying, poses great challenges to the state and local communities. Table 2.3 below summarizes the institutional and regulatory frameworks for sustainable quarrying in Kenya.

Table 2.3: Institutional and Legal Frameworks for Sustainable Quarrying In Kenya

Key Institutions	**Mandate**	**Ancillary Acts of Parliament**
1. Ministry of Environment and Forest	Overall development of policy and provide direction in the sustainable use of natural resources,	The CoK (2010)
2. NEMA	Implementation of environmental management policies, laws and guidelines.	Environmental Management and Coordination (Amendment) Act of 2015 (EMCA) The Water Act 2002
3. Kenya Revenue Authority	Assessment and collection of taxes and also interpreting taxation law and its application in the extractives sector	
4. National Treasury	Formulization of finance and economic policy as well as other functions related to its role as custodian of national assets and financial resources. Its policies have an effect on the investment environment of the extractives	Public Finance Management Act of 2012-*Governs the principles of public finance in Kenya*
5. Ministry of Lands, Housing & Urban Development.	Key for a well-organized administration and sustainable utilization of land resource in the country.	
6. National Land Commission	Administration of transactions related to public land & those involving exploitation of natural resources. providing approvals for public land use and resolves any other land matters	National Land Commission Act of 2012 The Physical and Land Planning Act of 2019
7. Devolved Governments	Developing of counties and administration of activities in their jurisdictions. Provision for approval prospecting and extraction	County Government Acts of 2011 Urban Ares and Cities Act 2012
8. Committee on Policy and Legal Framework for Geology, Mining and Minerals	Responsible for leading the implementation of policy and legal frameworks relating to the extractives sector	
9. Ministry of Health		Public Health Act-

The adequacy of Legal and Institutional Framework Sustainable Quarrying in Kenya

Quarrying activities in Kenya has continuously affected the environment through increasing derelict quarry sites and pollutions from its extraction as seen elsewhere in Africa and other mining economies. For instance in South Africa, by comparison with all sources responsible for the generation of hazardous waste, the mining sector produces the largest percentage of waste in the country (Mwalimu, 2010). In establishing whether Kenya's legal and institutional framework, and more specifically the framework contained in the Mining Act 2016, is sufficient to regulate mining in the country in respect to safeguarding the environment, the local community and the welfare of the people working in the mines, Mwalimu (2010) conducted a comparative study of intuitional and regulatory frameworks in other mining nations with the Kenyan framework. He noted that governments have taken measures to strengthen the policies and legal frameworks governing mining in reaction to challenges that have curbed the sector. South Africa, for instance, which has a volatile mining sector, has put in a place a policy where the government undertakes to improve the efficiency in legal and regulatory compliance.

In Kenya, however, very little has been done, or proposed to be done mitigate impacts on the operators. This renders operators at the quarrying sites vulnerable to health hazards and other unhealthy practices associated with quarrying (Mwalimu 2012). He further noted that Kenyan Mining Act of 2016 does not recognize that lack of coherent framework geared towards occupation, public health and safety of the operators is the source of mining crises. This is further stressed by UN, Environment (2018) noting that the local regulatory frameworks for extractive industry have to be consistent with the international laws. To address this there is a need to create a department under the mining regime with a technical capacity to ensure mine environmental compliance and approve all Environmental Impact Assessment Reports required under the EMCA. A license from NEMA should not be conclusive evidence that the applicant has complied with environmental requirements (Mwalimu, 2010). As explained above, it is therefore evident that the requirement of the environment impact assessment, which is stipulated in the EMCA is ignored by large scale miners and likely similar amongst the quarry operators.

2.8. The Development of Quarrying in Nairobi

The genesis of quarrying in Nairobi can be traced about a century ago when the colonialist introduced the application of artisanal stones for construction. Before then, the traditional or artisanal materials such as twigs and cow hides were used for construction houses by the indigenous people in the Nairobi (Rukwaro et al, 2001). Williams (1967) noted that upon establishing Nairobi as the Railway headquarters of the Colony, the European colonizers quickly discovered the existence of natural rock suitable for use as building blocks. The identity of the geological resources were given as Kerichwa Valley Tuffs. Studies on quarrying activities in Nairobi were first undertaken by the Intermediate Technology Development Group (ITDG) as noted by Wells (2000). The studies were basically consultancy works and are not published hence limiting their accessibility for wide readership. Wells (2000) and Wells and Wall (2001 and 2003) published academic papers based on these research works. Academic studies mainly on the environmental and socio-economic implications of quarrying activities have been undertaken by Nganga (2010), Eshiwani (2014), Kindiga (2017) and Mbadi (2017). Wells (2000) was majorly concerned with the environmental impacts of artisanal stone quarrying in Nairobi. Published in the *Small Enterprises Development journal*, the paper aptly situates quarrying of artisanal dimension stone in Nairobi in the context of small enterprises that are noted to contribute to employment creation and provision of basic goods at low cost (Wells 2000). The publication recommended remedies to the two issues of environmental sustainability and occupation, public safety and health concerns by use of appropriate quarrying techniques such as breaking rock with wedges i.e. benching other than blasting as also outlined within the NEMA INLG (2011). The publication further highlighted a legal and institutional framework aspect for sustainable quarrying when it suggests that the wastage is enhanced by the balance of property rights in which the QOs are not the owner of the land being quarried and hence tends to extract the greatest possible advantage without caring about the value and state of the land after quarrying.

The latter publication, Wells and Wall (2001, 2003), looking at the 'The expansion of artisanal stone quarrying in Kenya' situates quarrying activities in the informal sector context or what the co-author has termed 'the informal construction industry' (Wells 2001, 2007). What is relevant for the research according to the publication is its highlights on the socio-economic benefits or

aspects of sustainability of quarrying activities by noting that the production of artisanal dimension stone is greatly influenced by factors related to the liberalization and eventual informalization of the building industry. The liberalization of the economy leads to the decontrol of cement prices which further leads to sharp increase in cement prices. The increase in cement prices on the other hand led to the rise in the cost of the main competing walling material i.e. concrete blocks of which cement is a significant component, to rise thereby ceding part of its market to dimension stone. Therefore, the demand for stones obtained from quarrying or the preference of stones to the concrete blocks ensure the continued quarrying activities and hence source of income to QOs.

Wells and Wall (2001, 2003) further noted that despite the facilitating factors for the expansion of the quarrying industry discussed above, the artisanal stone as a product remains hampered and may not penetrate the formal sector market owing to the inherent inability of artisans to produce large quantities of stone at short notice due to the artisanal techniques of production that are generally labour intensive and slow. Furthermore, artisanal producers generally operate at subsistence level hence capital limitation prevents them from stockpiling stone for large scale orders. This becomes relevant for the research as it raises the question of the ability of the QOs to meet the requirement of the quarrying regulations especially those that require capital investment or expenditure to ensure environmental protection and enhanced socio-economic benefits. The academic study by K'Akumu (2010) based its overal objective on investigating the interrelationships of the socio-technical forces (variables) influencing the production, marketing and utilization of artisanal dimension stone for use in building construction within the city of Nairobi. The study was more comprehensive as it covered the market environment for artisanal dimension right from production to sale in Nairobi City County. Unlike the study by K'Akumu (2010), this study focuses more on the operation of the quarrying activities and what factors influences the sustainable operation of the quarry activities based on the NEMA INLG (2011).

2.9. Research Gaps Identified in Literature Review.

Most studies on quarrying especially in Nairobi and the region has been academic works. The studies have endeavored to highlight mainly the positive and negative environmental and socio-economic implications of the quarrying activities on the QOs and the local communities abutting

the quarrying sites. Prior to the formulation of the INLG (2011) by NEMA outlining the sustainable quarrying guidelines, academic studies by Wells (2000) recommended the immediate rehabilitation of the derelict lands resulting from the used quarrying sites, the need of the quarrying site to formulate plans and designs to guide their operations beforehand and further the need identify the and bridge the gaps within the regulatory, legal and institutional frameworks to ensure the sustainable quarrying practices within Nairobi. The INLG by NEMA (2011) seeks to address the concerns above, and this study is significant as it seek to assess the awareness on and the establishment of the guidelines amongst QOs and whether the outlined quarrying guidelines are effective to ensure sustainability within the sector.

The academic studies undertaken in the wake and after the formulation and operationalization of the INLG (2011), by Mwangi (2014), Eshiwani (2014), Kindiga (2017) and Mbadi (2017) have noted ineffective compliance to prescribed regulations to ensure sustainable quarrying practices and recommended the need for improved technology to ensure low impacts, enhanced surveillance and enforcement of laws and regulations, need of environmental impacts assessment and audits in the neighborhoods abutting the sites, and enhanced physical planning interventions. These indicate challenges with regards to the implementation of the NILG (2011). The UN Environment (2017) attributed these challenges to lack of information and awareness on the environmental protection regulations therefore, necessitating the current study.

Non-academic research work on the globalization of construction industry, with the objective of identifying the research opportunities by Ofori (2000), emphasized the need for the expansion of the construction industry by the unindustrialized nations to achieve their obligations of sustaining national socio-economic development. Ofori (2010) noted that more research were need in the areas of construction materials. Therefore, this study contribute to the sustainable development of the construction sector in Kenya especially on the sustainable production of the construction materials from the quarrying sites. A study by the Kenya Building Research Center (2006) noted the significance of materials in the building industry as they are the greatest component of building erection unit costs. Hence, a study on the sustainable production of the building materials is paramount to the housing sector and the housing component of the Big 4 Agenda.

The therefore, offers opportunity for participatory governance of resources through the involvement of QOs with the objective of exploring the well-established variables amongst them that they deem to influence sustainable quarrying practices and further highlight the challenges they face in their operations; as recommended by Gisore (2015) for good environmental practices, enforcing human rights, labour and environmental norms and standards.

As earlier noted as key significance of the study, there is no comprehensive study undertake to assess the impacts of the NEMA (2011) INLG outlining the quarrying guidelines on the safety, environmental and socio-economic within the industry to ensure sustainability. The study therefore offers opportunity to assess the establishment of the regulations amongst the QOs and the overall contribution of the guidelines to improve occupational, public health and safety, environmental quality and socio-economic sustainability of the quarrying activities in Nairobi and further highlight the operational challenges of QOs in relation to the guidelines and the recommendations to ensure sustainable operations.

2.10. Theoretical Framework

2.10.1. The Location Theory

The location of quarrying activities; a type of industrial land use in an area follows patterns derived from the models of industrial location theory. The theory of industrial location uses the notion of “linked” and “foot loose” or “immobile” and “mobile” industries, respectively as advanced by Weber (1929). Linked industries in their location depends, on the distribution of raw materials, sources of power and the network of road and markets, water supply sewerage etc. The location of quarrying activities would be linked to the notion of linked or immobile industries since quarrying activities tend to locate where the raw materials and markets are available. Quarrying activities locate, along the riverbeds where the bed rocks which are mainly igneous rocks of volcanic origin are available for exploitation and in areas which provide the market for the exploited building materials, as for the case of quarrying activities within the urban area such as Nairobi to provide raw materials to the vibrant construction industry (CCN, 2007). For the foot loose with the foregoing factors are of secondary importance.

A number of philosophical models were developed to explain industrial location patterns. The location of quarrying activities within the urban areas like Nairobi can be further illustrated by the Least-Cost Location Model developed by Weber (Weber, 1929). This considered more the cost of transportation as a factor in location of industries. It suggests that operators locate either at the sources of the raw materials or close to the market in order to minimize distribution costs. The location of industrial activities such as quarrying operations depends on the localized raw materials which are suitable rocks that are quarried to obtain construction materials. This explains the trend of location of this type of industrial activities along the river banks which have the bed rocks. Nevertheless, as quarrying activities within the urban areas, such as Nairobi city are limited to locate where their localized raw materials exist and access market for their products; the vibrant construction sector within the city, the high urbanization rate encompassed by high population growth and increased land demand, has led to competition for space among different land uses. (Kariuki, 2002). The location of the quarrying activities along the river beds in Nairobi is the genesis of land use conflicts due to the negative impacts on the rivers and abutting communities. Hence the need for sustainable quarrying that is explained by sustainability discussed below.

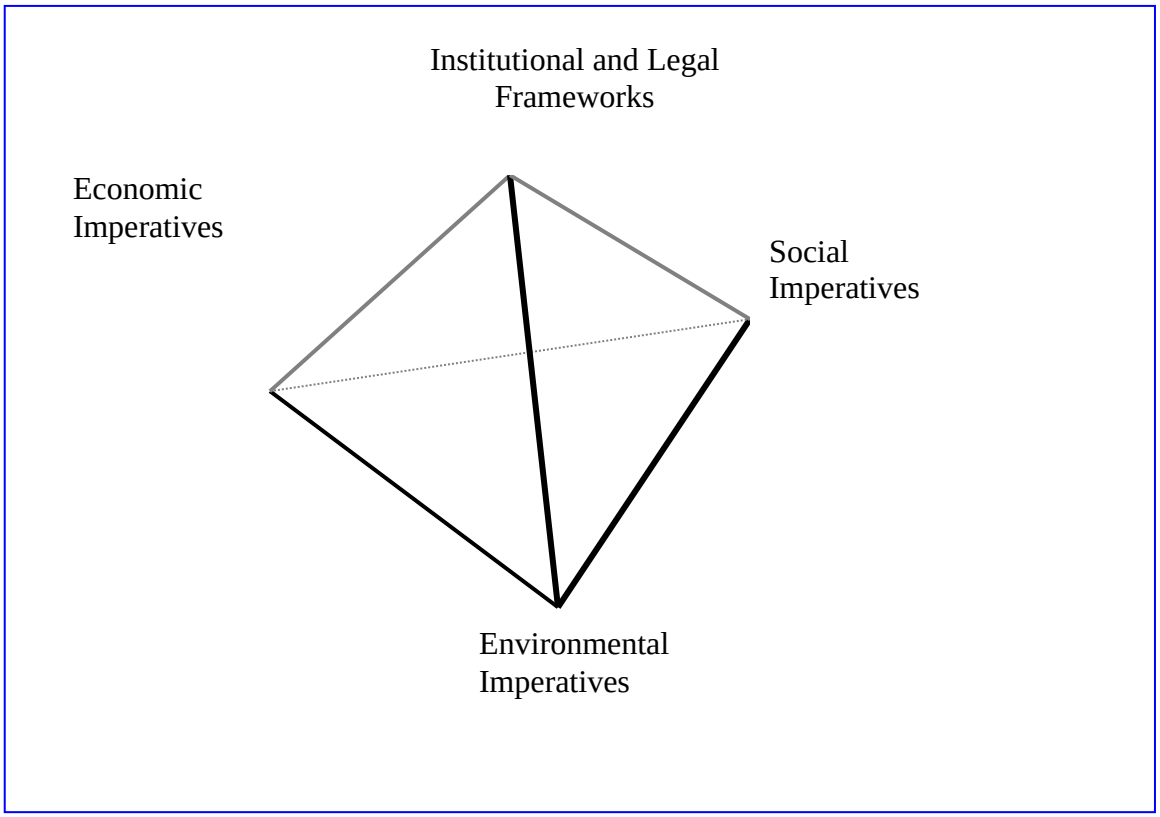
2.10.2. The Sustainability Theory

The study on sustainability within the quarry industry is anchored on sustainability theory. The sustainability theory is anchored first, in realization of the biological limitations of growth. Sustainability in this view denotes environmental sustainability. Ecologists and scientists are more concerned about the depletion of the non-renewable resources. The second foundation is sustainained economic growth which refers to the growth af an economy over a period of time and overcoming the periods of recession. Ecological economists favours the merging of environmental and economic concerns into one theoretical framework (Barbier, 1993; Pearce, 1993; Tisdell, 1993; Common, 1995).

A third foundation is based on sustained societies. The approach considers the poor people and their needs first (Chambers, 1986). Another key element of the social approach is an emphasis on social equity, justice and liberation. A fourth foundation has been advanced as debate on dimensions of sustainability rages on; legal and institutional frameworks for participation.

Instituions and legal frameworks are considered as sets of rules for the growth, relevant societal decisions facilitation societal orientation (Göhler 1997). Figure 2.3 below illustrate the interaction of the four dimension of sustainability. Several scholars defines sustainable development based on the four key foundations as above and as illustrated in Figire 2.3 below. Sustainability in quarrying is to sustain the stream of benefits derived and ensuring the contributions of the resources are having positive impacts over the life cycle of quarry activity and its products. This is achievable through vibrant legal and institutional frameworks to manage exploitation processes, prevents reverse impacts on environment and society and ensuring continuous provision of products for economic growth. The legal and institutional frameworks and related regulations when complied with, should ensure participatory governance of the resources, guaranteeing shared responsibility and benefits derived as further explained by the theory of regulatory compliance in the subsection below.

Figure 2.4. Prism of Sustainability



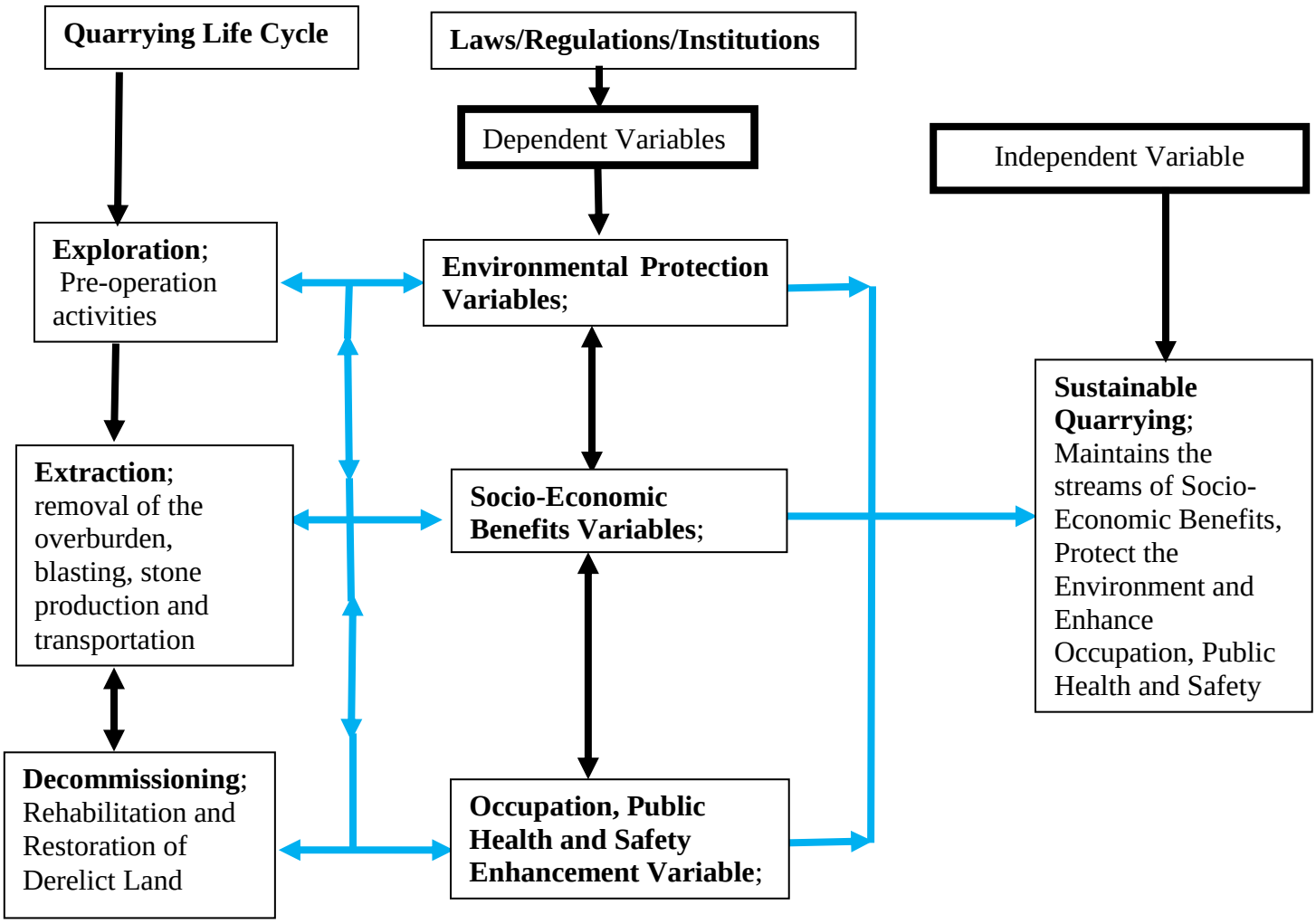
Source: Adapted from Valentine and Spangenberg (2000)

2.10.3. Theory of Regulatory Compliance (TRC)

A third theory that the study is anchored on is the theory of regulatory compliance (TRC). TRC give emphasis on the significance of complying with rules or regulations. What is relevant about the TRC is its emphasis on formulation of the right regulations rather than having more or less rules and the maturing of these regulation as being significantly predictive of positive outcomes by being in compliance with said rules. RTC argues that being in "full" or 100% compliance with all regulations does not necessarily means a good policy or regulations and that all rules or regulations are not created equal (Sutinen, 1999). The study therefore seeks to determine the sustainable mining regulations that are well-established amongst the QOs and their contribution in ensuring sustainable quarrying.

2.11. The Study Conceptual Framework

Figure 2.5: Conceptual Framework



Source; Author; Constructed from NEMA-INLG (2011)

Quarrying is connected to economic growth; through the products which are primary resources needed for development of the different sectors and sub-sectors of the economy such as the construction sector. Quarrying process poses negative impacts on the environment and communities abutting the quarrying activities especially when the likely environmental concerns are not considered and mitigation measure are put in place throughout the life cycle of the quarry. Balance is needed and should be sought that ensures the environmental and socio-economic negative impacts are minimized as the positives are maximized for the continued production of the materials and services for development. The evaluation of quarrying sustainability to ensure that the derived benefits are presently enjoyed without comprise of the benefits of the future generation is based on the key phases of quarrying activities which are; exploration, extraction and decommissioning phases. At the different phases there are environmental protection, socio-economic benefits and occupation, public health and safety enhancement variables that are outlined within the regulations, laws and institutions to ensure that the quarrying activities are sustainable. These variables are dependent and are both inter and intra-related in their influence on sustainable quarrying.

CHAPTER THREE: RESEARCH METHODOLOGY

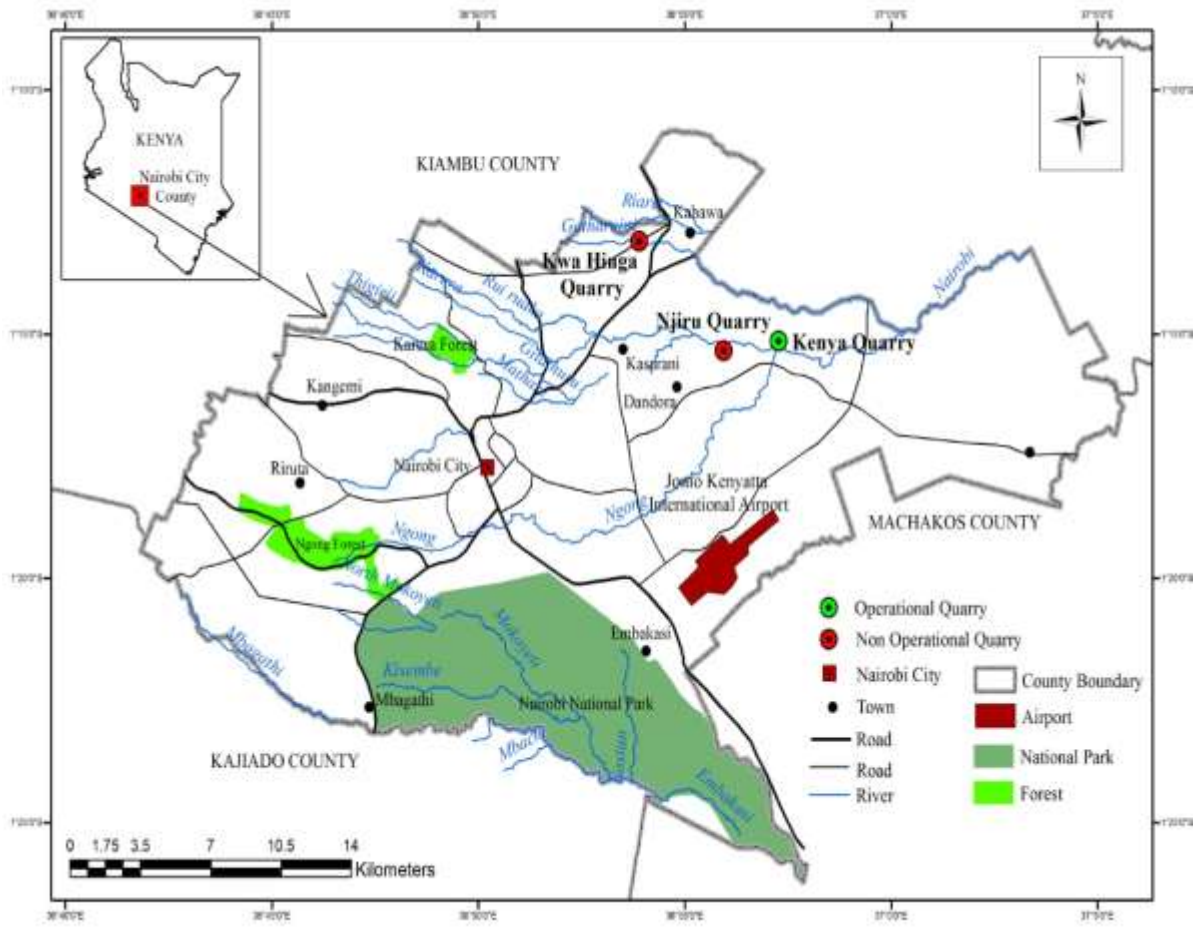
3.1. Introduction

This chapter outlines the methods that were used in the study including the procedures of data collection, analysis and presentation of data for the study indicating their bases and rationale in line with the objectives.

3.2. The Study Area

Kenya quarry as per the google map is located on latitude -1.2355816 and longitude 36.9461443 within Kasarani Sub-County; Nairobi City County of Kenya. Currently Kenya Quarry is the only legally operational quarrying site in Nairobi City County producing artisanal dimension stones, hardcore and murram for the construction industry and has about 297 operators operating different pits within the larger Kenya Quarry site. The location of study area is as in Figure 3.1 below. Kwa Hinga and Njiru quarrying sites have been shut down and are non-operational due to their impacts on the abutting land uses and communities.

Figure 3.1. The Location of Study Area



Source; Modified from Survey Maps of Kenya (2019)

3.3. Study Design

The main study designs used were quantitative and qualitative research designs as per the study objectives. The qualitative research provided the details of the QOs perceptions on sustainable quarrying activities that addressed objective 2 of the study. The quantitative research aided the study to draw statistical conclusions indicating actionable insights that addressed objective 1 and 3 of the study. The insights drawn from the numerical data and analysis provided better perspective in making decision to address he research problem. The use of both methods enabled the study to counterbalance their weakness and in-depth analysis.

3.4. Data Types and Sources

3.4.1. Primary Data

For the purpose of obtaining primary data for the study the researcher adopted three strategies of field research techniques, data access strategies and primary data collection techniques. The techniques aided the researcher to seeing the QOs in the context of their operations. The research used participant observation technique; defined by Smith (1981) as the observation and interviewing of participants while limiting relationships with participants. The researcher and the research assistant went into the quarrying pits of artisanal dimension stones as evident in appendix V with the aim of experiencing the activities of the QOs. This was helpful for documenting and verification of the QOs compliance with sustainable operations within the quarrying. The research also adopted semi-structured and structured interviews technique. Structured interviews follow a standardized interview guide for surveys whose objectives involve quantitative analysis.

3.4.2. Secondary Data

The study relied on published and unpublished studies carried out globally, regional and locally pertaining the different elements of sustainability of quarrying activities. National Statistics Bureau were suitable in providing convenient information on the contribution of the quarrying industry to construction industry and overal national development.

3.5. Data Collection Instruments

Sample survey was deployed for collection data from the field as it was a shorter survey than a census designed and administered to a sub-population that is representative of the total population, selected from QOs within the quarry sites. Mainly structured questionnaires, which included different levels of questions, were used in the study. Incidental interview guides were also used to obtain answers on specific issues affecting the sustainability of the quarrying activities within the site. The interviews included a wide range of semi-structured and open questions that were formed differently in the process of interviews. Notebooks were used to extract data from secondary sources and record observations.

3.5.1. Design of Measurement Instrument

The design of the questionnaire was in line with the two main research designs adopted for the study as indicated in the previous section above. The questionnaire was in three main parts involving structured and semi-structured parts. The first part was to enable seeking demographic information about the QOs. From literature review and secondary data analysis, the study identified 14, 17 and 10 variables under occupation, public health and safety, environmental protection and socio-economic enhancement performance areas in quarrying sustainability respectively. The variables were structured as prompts for the second part of the measurement instrument attached as appendix I. In the instrument the respondents were to rank the variable that influence sustainable quarrying within the quarrying site using the scale; 1 no effect, 2 positive weak effect and 3 positive strong effect. The underlying idea was to identify the well-established variables amongst the QOs for occupation, public health and safety, environmental protection and socio-economic enhancement and to establish their perceived ability to comply with the variables based on the perceptions on variables as to have effects and contribution to sustainable quarrying. The researcher with the assistance of the research assistant were able to independently indicate if the QOs comply or observed the variables.

The last part of the instrument included two open-ended questions to identify the challenges and the improvements to enhance sustainable operation of the quarrying site. Responses to these questions were coded and included in the dataset with the structured questions. These were necessary for recommendations and identification of areas for further research. After designing the measurement instrument it was administered to a sample of respondents in terms of an interview schedule and dataset generated was thereafter subjected to quantitative process, analysis and reporting as explained in the subsequent sections.

3.5.2. Pilot Study to Test the Data Collection Instruments

A pilot study was implemented on QOs, but not on those who formed part of the final sample, in order to avoid their influence on the study findings. The pilot study enabled the testing of the data collection instrument in the field and evaluation of feasibility, time, cost, adverse effects, and statistical variability and reliability in an attempt to confirm the appropriate sample size and improve upon the study design prior to performance of a full-scale research study.

3.6. Sampling Design and Procedure

Simple random sampling technique was deployed for the study illustrated in the preceding section 3.7 below. The targeted populations in the research study were the QOs operating different quarry pits within the study area.

3.7. Sampling Frame

The main concern which helped shape the sampling in the identified quarry site in Nairobi area for the field survey was related to the boundary of the identified quarry site. The sampling frame included all quarry operators (QO) within Kenya Quarry site. Since the purpose of this project is based on awareness, establishment and effects of the QOs activities to sustainable quarrying, these were the people who have experienced the daily operation and management of the different quarry sites. To obtain the sampling frame lists of the current QOs from the quarrying site in Nairobi, the researcher used a contact person from the quarrying site. The list was then cleaned by and renumbering the lists to give the definite sample frames.

3.8. Sampling Techniques and Sample Size

The QOs operating different quarrying pits distributed within the vast Kenya Quarry site were sampled using a simple random sampling without replacement technique. And since virtually nothing is known about the population Nassiuma's formula was used to determine the appropriate sample size needed. Considering an acceptable coefficient of variation of 30.0% and relative standard error of 5.0% on the (297) QOs already identified, the sample size for the study will calculated as follows:

$$n = \frac{NC^2}{C^2 + (N-1)\,e^2}$$ (adopted from Nassiuma, 2000)

Where; n is the sample size being determined

N is the total population of the QOs in the quarry site.

C is the coefficient of variation 30% usually acceptable (Nassiuma, 2000).

e is the relative standard error, 5% is acceptable.

Plugging the data into the formula, the sample size (n) for the quarry site was obtained as shown in Table 3.1 below.

Table 3.1: Sample Size for the Study

Quarrying Site	Number of Operators (Quarry Pit Owners in Kenya Quarry Site)	Sample Size
Kenya Quarry	**297**	**40**

Source; Author, 2019

After determining the targeted sample size, the sample was drawn from a numbered list (sample frame) using the universal random sampling table. The digits of the total population within the sample frame was considered. QOs in Kenya Quarry being 297, a 3 number digits was required; 001-297. Numbers larger than 297 were not considered and passed over, while those less than 297 but repeating themselves were considered only once. Random numbers were picked by reading across the columns from left to right on each successive line of the universal random table until the determined sample size was achieved. The numbers obtained were then marked on the sample frame to identify the specific QOs to be incorporated in the survey.

3.9. Data Collection Procedure

Having obtained the authorization from both the university and the National Commission for Science, Technology and Innovation (NACOSTI) attached as Appendices II and III, the researcher embarked on primary data collection. The data was obtained by using the questionnaires given to the primary respondents as identified in section 3.8 and secondary sources relevant to quarrying and quarrying sustainability in general and specifically in Nairobi region, including reports, plans, documents, laws and regulations both from public and private archives. Where an assigned operator refused to be involved in the study, or an operator was available in the site after three visits, another operator was randomly selected instead. One Research Assistant (RA) was recruited to support the researcher. After a day of training on in the interview techniques and the processes to handle the interviews in the field, one day was spent in the field testing the questionnaires.

3.10. Quantitative Data Processing, Analysis and Reporting

The collected data was cleaned, coded appropriately, analyzed and presented through relevant statistical tools mainly Statistical Package for Social Scientists (SPSS), a spreadsheet such as Ms-Excel and Ms-Word, a word processor. Multivariate analysis, referring to statistical techniques applied to multiple variables were applied to the data collected. Five analyses were carried out on the dataset using the SPSS software were as outlined below.

3.10.1. Reliability Analysis

Reliability, in this case, refers to the ability of the scale to measure consistently the concepts or constructs under study across different populations (Hinton et al. 2004). Reliability was determined by calculating Cronbach's Alpha. A low correlation indicates that there is a lot of error and the items are not reliably measuring the same thing. Cronbach's Alpha values ranging from 0 (i.e. a completely unreliable measure) to 1 (i.e. a completely reliable measure). Hinton et al. (2004) suggested that a Cronbach's Alpha value of 0.5 to 0.75 is generally acceptable.

3.10.2. Frequency Analysis

The second set of analysis involved analysis of frequencies, which gave the descriptive statistics of the scales within the data collection instrument.

3.10.3. Regression Analysis

The analysis was run to determine how the demographic information on the QOs; gender, level of education and the duration of work in the current quarry pit predicted awareness on sustainable quarrying guidelines under the 3 key performance areas of sustainable quarrying, how the statistical variation in awareness is explained by each of the demographic information and their relative contribution in explaining the variance in awareness.

3.10.4. Analysis of Differences

The chi-squared test was performed to determine if there was a difference on awareness of the NEMA sustainable quarrying and difference in establishments of the guidelines in the site. Friedman Test was carried out to determine the mean rank of the perceptions categories and further if there were differences in perceived ability to comply with the NEMA guidelines based on the QOs perceptions on the guidelines.

3.10.5. Multi Response Analysis

Multi-responses analysis performed on responses from the semi-structured part of the interview schedule. The results were used to construct Chapter Five of the study. The main research strategy involved the use of both qualitative and quantitative techniques.

CHAPTER FOUR: RESULT AND DISCUSSIONS

4.1. Introduction

This section presented the analyzed and interpreted data as per the three objectives of the study. The data was processed and the results discussed in response to the outlined research questions.

4.2. Questionnaire Return Rate

The study targeted 40 QOs who formed the total sample size. 31 QOs (77.5%) positively responded to the survey request and returned the questionnaires. The response and return rate of 77.5% was statistically acceptable for analysis as Babbie (2007) suggested that response rate above 50.0% can be reported, that over 60.0% is good, and that over 70.0% is deemed as excellent as was the case of the study survey's return rate. The return rate was summarized as indicated in Table 4.1 below.

Table 4.1: Questionnaire Return Rate

Category	**Sent**	**Returned**	**Return Rate (%)**
Quarry Operators (QOs)	40	31	77.5%

Source; Researcher, 2019

4.3. Reliability Analysis

After data cleaning and entry into the SPPSS, the Cronbach's Alpha Statistic was computed to test the reliability and consistency of the results of the study for further analysis and discussions. Table 4.2 below indicated a values of 0.72, which was acceptable as also noted by Hinton et al. (2004) that values of Cronbach's Alpha Statistic between 0.50-0.75 are generally acceptable in a study. This basically meant that a similar study will produce similar results.

Table 4.2: Cronbach's Statistics

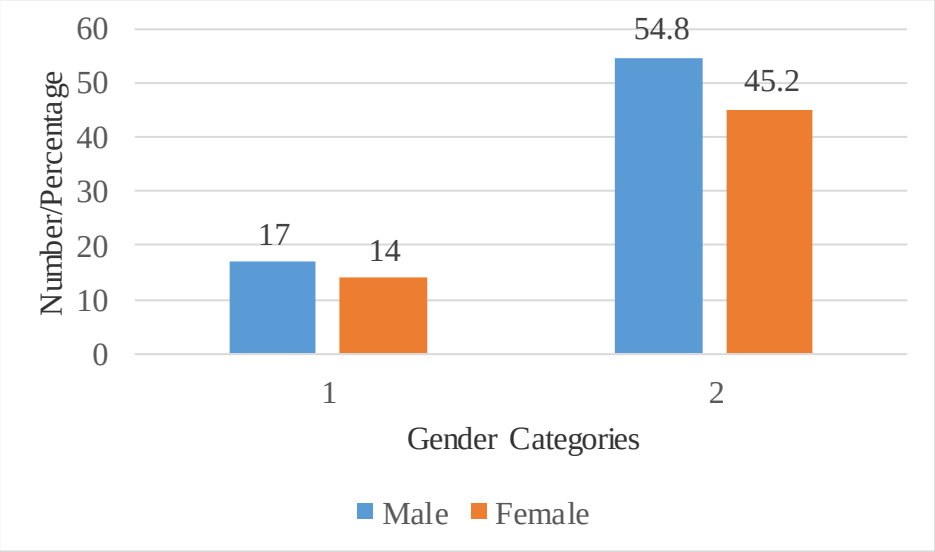
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.717	.280	85

Source; Researcher, 2019

4.4. Demographics of the Respondents

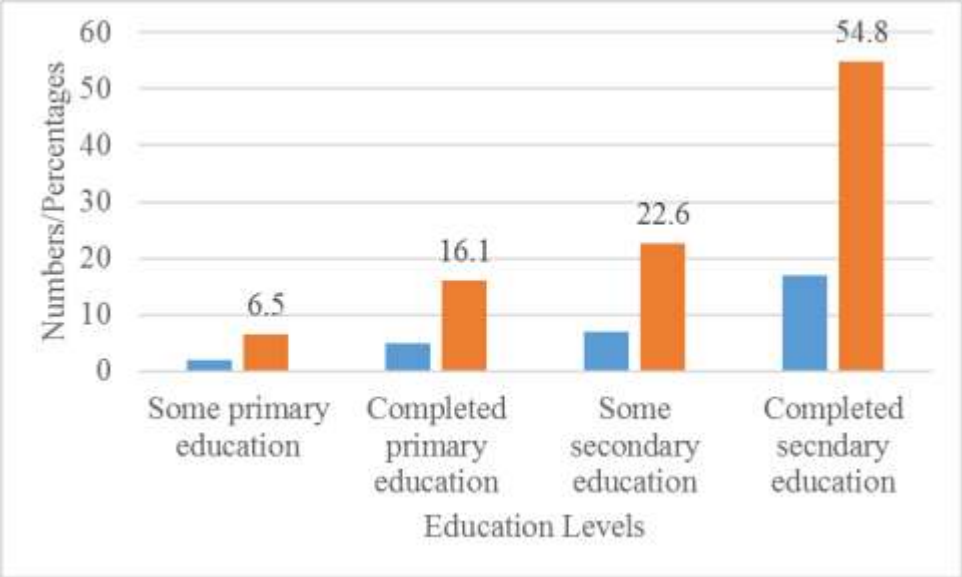
Three (3) key demographic information on the respondents were considered to enable wider comprehension of study populace and draw correlations amongst the respondents and other study aspects and analysis of differences.

Figure 4.1. Gender of the Respondents



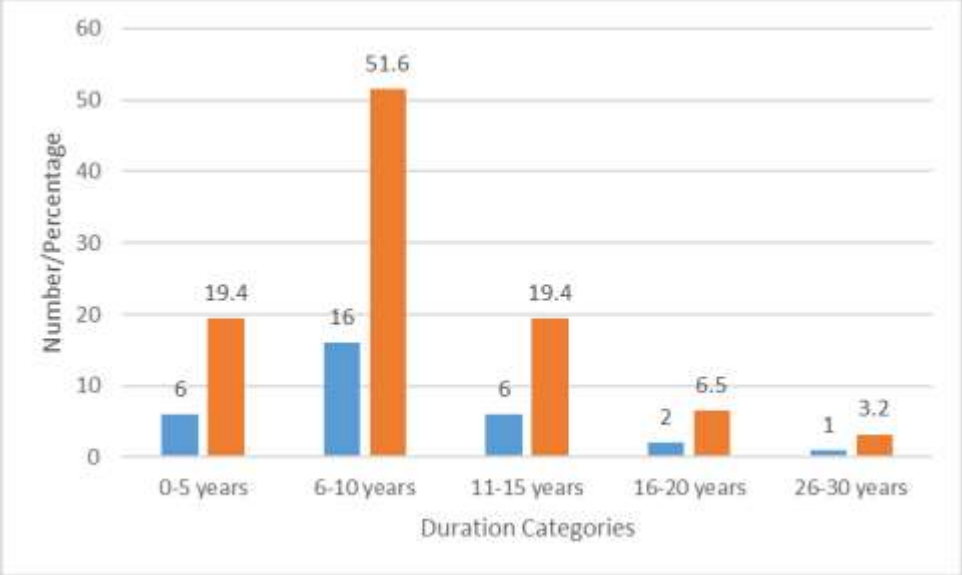
Source; Researcher, 2019

Figure 4.2. Level of Education



Source; Researcher, 2019

Figure 4.3. Duration of Quarry Pit Operation



Source; Researcher, 2019

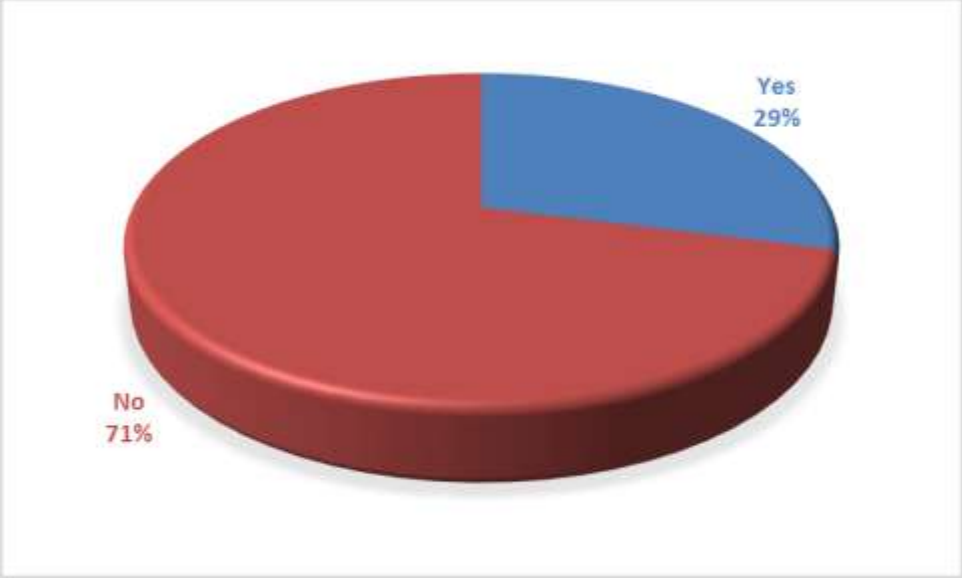
As shown in Figure 4.1 above, a majority of 54.8% the QOs within Kenya Quarry are male. The survey further established that a similar percentage, 54.8% of the QOs had completed secondary education while 6.5% had attained some primary education as indicated by Figure 4.2. 51.6% of the QOs had operated the quarrying pits for a period of 6-10 years while 3.2% had operated the

pits for the longest period of 26-30 years as illustrated by Figure 4.3. The three (3) key demographic information on QOs were considered as independent variables and subjected to multiple regression analysis by the study using SPSS to determine how they predicted awareness of the QOs on the sustainable quarrying regulations and how the variation in awareness is explained by each of the demographic information and further analysis of differences are discussed in the subsequent section below.

4.5. Awareness amongst the QOs on Sustainable Quarrying

The QOs included in the study were asked if they were aware of the existence of the NEMA quarrying guidelines developed in 2011 to ensure sustainable quarrying guidelines. A majority of 71.0% of the QOs were not aware of the existence of the sustainable quarrying guidelines. The 29.0% who were aware of the existence of the quarrying guideline noted they were informed about the guidelines as a precautionary measure by the land owner as they were seeking lease to operate the quarrying pits within the Kenya Quarry Site. None of the respondents had ever interacted with the NEMA quarrying guidelines and never had the opportunity to participate in the formulation of the guidelines despite being key stakeholders in the sector. Figure 4.4 below illustrates awareness on the NEMA quarrying guidelines amongst the QOs.

Figure 4.4. Awareness on Quarrying Guidelines



Source; Researcher, 2019

Multiple Regression Analysis was performed to determine how the demographic information on the QOs predicted awareness on sustainable quarrying regulations, how the variation in awareness is explained by each of the demographic information and their relative contribution in explaining the variance. The outputs obtained from the multiple regression analysis using the SPSS were as discussed below. Appendix IV contained the multiple regression analysis correlations table. The predictor variables gender (-0.3), level of education (-0.4) and the duration of work in the current quarry pit (-0.7) had a strong negative correlations with the outcome; awareness on NEMA quarry guidelines (1.0). Weaker correlations are indicated by statistics below -0.3. The correlations between the predictor variables were low and not higher than 0.7, which depicted multi-collinearity, therefore the study considered the three independent variables as predictors.

Normality and linearity assumptions were checked by the normal probability path as depicted by the normal P-P plot. The points laid reasonably close to the line of best fit with minimal deviation. To determine the outliers that would affect the outcome, the χ^2 critical value using the number of predictor variables (3) as degree of freedom, and at a significant level of 0.005, is 16.27. The score that exceeded the critical value of 16.27 were deemed outliers. From the residual statistics table under the raw mahal distance, the maximum value in the data file was 15.23 which is lesser than the critical value of 16.27 and therefore there were no outliers.

Table 4.3 below contained the model summary that evaluated the statistical significance of the prediction outcome. R Square explained how much the variance in awareness on the existence of the NEMA sustainable quarrying guidelines was explained by the model predictor variables. The R Square value 0.52 was expressed as a percentage, resulting to 52.0%. Therefore, the predictor variables explained 52.0% of variance in awareness on sustainable quarrying guidelines by the QOs. 48.0% could be explained by other factors.

Table 4.3: Model Table

Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate
1	.723(a)	.523	.468	.3400

Source; Researcher, 2019

To determine how true the model predicted the outcome amongst the QOs, the P value in the ANOVA Table 4.4 below was considered. The P value of 0.000 was less 0.05, therefore there was a statistical significance for the model meaning the outcome was a true prediction of what was the case amongst the QOs rather than chance.

Table 4.4: Analysis of Variance Table

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.294	3	1.098	9.494	.000(a)
	Residual	3.006	26	.116		
	Total	6.300	29			

a Predictors: (Constant), Duration of work in the current quarry pit, highest level of education you attained, gender
b Dependent Variable: Awareness on the existence of the NEMA quarry guidelines

Source; Researcher, 2019

Table 4.5 below illustrated the model coefficients and was use to analyze the predictor variables contributions to the model outcome. Under the row standardized coefficients, the larger Beta values was determined ignoring the signs which was the duration of work at the current quarry site by the QOs at 0.67 which made the strongest contribution in explaining the model outcome. The other predictor variables; level of education attained and gender followed respectively at 0.16 and 0.12. The statistical significance of the contribution of the independent variables were further checked, and only duration of work in the quarry pits by QOs significantly contributed to the prediction of outcome. Highest level of education attained and gender had no statistical contribution to the prediction of outcome because of the significance values higher than 0.05 and greater than t lower bound values.

Table 4.5. Coefficients (a)

Model		Unstandardized-Coefficients		Standardized - Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta	Lower Bound	Upper Bound	B	Std. Error
1	(Constant)	2.825	.409		6.906	.000	1.984	3.665
	Gender	-.147	.135	-.120	-1.090	.286	-.424	.130
	Highest level of education attained	-.058	.069	-.159	-.840	.409	-.200	.084
	Duration of operation of th quarry site	-.294	.061	-.671	-4.832	.000	-.419	-.169

a Dependent Variable: Awareness on the existence of the NEMA quarrying guidelines

Source; Researcher, 2019

Therefore from the multiple regression analysis, the duration of the operation of the quarry pits by the QOs within the Kenya Quarry site statistically significantly explained the variance in awareness on the NEMA sustainable quarrying guidelines. And from the correlations table in Appendix IV, awareness on NEMA quarrying guidelines had a strong negative correlation with the duration of operation of the quarry pits. These indicated that the longer an operator had been operating the quarry pit within the Kenya Quarry site the more likely the operator was unaware of the existence of the NEMA sustainable quarrying guidelines. The operators who had joined the quarrying activities more recently were likely more aware of the quarrying guidelines. Therefore, NEMA ought to put more efforts on awareness creation and sensitization on significance of compliance with the guidelines amongst the operators who had been operators for longer duration especially those who started the operations before publication and operationalization of the guidelines in the year 2011.

Nominal data obtained from the 31 QOs incorporated in the study was used to undertake analysis of difference using Chi-Square (X^2), a non-parametric test to determine if there was difference on awareness of the NEMA sustainable quarrying guidelines based on level of education of the QOs. Table 4.2 below indicates the observed (O) values for the different levels of education of the QOs who are either aware or not aware of the existence of the NEMA sustainable quarrying regulations and the calculated expected (E) values used for the Chi-Square test.

Table 4.6. Observed and Expected Values for Chi-Square Test

Level of Education / Awareness	Not completed primary education		Completed primary education		Not completed secondary education		Completed secondary education		**Total**
	O	**E**	**O**	**E**	**O**	**E**	**O**	**E**	
Aware	0	0.65	1	1.61	4	2.26	5	5.48	**10**
Not Aware	2	1.35	4	3.39	3	4.74	12	11.52	**21**
Total	**2**	**2**	**5**	**5**	**7**	**7**	**17**	**17**	**31**

Source; Researcher, 2019

$$\chi^2 = \Sigma \frac{(O-E)^2}{E}$$

$$\chi^2 = \sum \frac{(2-2)^2}{2} + \frac{(5-5)^2}{5} + \frac{(7-7)^2}{7} + \frac{(17-17)^2}{17}$$

$$\chi^2 = 0.00$$

The calculated overal chi-squared statistics is equals to zero *(0),* which denotes null hypothesis as the observed values are equal to the expected values exactly, like as the case in Table 4.2 above. Zero indicated that the sample data exactly matched what was expected if the null hypothesis is correct.

4.6. Establishment of Sustainable Quarrying Variables in the Site

In the establishment of which sustainable quarrying variables were well-stablished in the site, the QOs were prompted to indicate their perceptions on the variables influence and contribution to

sustainable quarrying based on the key three (3) performance areas in sustainable quarrying. The QOs perceptions on the influence and contribution of the NEMA outlined sustainable quarrying variables were deemed to determine the establishment of the variables amongst the QOs within the Kenya Quarry Site. The QOs perceptions on the variables were based on three categories as to have no effect, positive weak effect and positive strong effect on sustainable quarrying activities.

The percentage scores of the QOs were recorded under the three categories of perceptions based on the three (3) performance areas of sustainable quarrying. The study analyzed the QOs perceived ability to comply with the outlined NEMA regulations to achieve sustainable quarrying based on the operators' perceptions on the regulations effects to ensure sustainable quarrying within the site. Friedman Test was undertaken to determine the rank by means rank of the three perceptions categories and further if there were differences in perceived ability to comply with the NEMA regulation based on the QOs perceptions on the regulations under the three (3) performance areas in sustainable quarrying as outlined in the subsequent sub-sections.

4.6.1. Occupation, Public Health and Safety Variables

The data summarized in Table 4.7 below on occupation, public health and safety variables were entered into the SPSS to undertake the Friedman Test. The outputs from the test generated are as illustrated in Table 4.8 and 4.9 below. The Ranks Table 4.8 highlighted the mean rank for different perception categories perceived to determine the ability of the QOs to comply with the outlined guidelines under the occupation, public health and safety.

Table 4.7. Mean Ranks

Perception Categories	Mean Rank
No Effect	1.79
Positive Weak Effect	2.39
Positive Strong Effect	1.82

Source; Researcher, 2019

The test compared the ranks by means between the different perception categories and indicated the perception categories differences as illustrated in Table 4.9 below.

Table 4.8: Rank and Compliance with Occupation, Public Health and Safety Variables

Occupation, Public Health and Safety Factors	1. No Effect	2. Positive Weak Effect	3. Positive Strong Effect	Compliance (%)
1. No undercutting and tunneling	9.7	67.7	22.6	**100.0**
2. Avoidance of vertical faces exceeding 2.5 m	16.1	38.7	42.0	**45.2**
3. Hard rock quarry faces benched	16.1	54.8	25.8	**22.6**
4. Avoidance of loose hanging rocks	6.5	58.0	35.5	**35.5**
5. Ensuring that all loose rocks are scaled down	9.7	45.2	45.2	**71.0**
6. Warnings signs of appropriate font size	74.2	22.6	3.2	**3.2**
7. Provision of first aid kit and aiders	45.2	48.4	6.5	**6.5**
8. Provision of protective gear	51.6	41.9	3.2	**25.8**
9. Site having someone in charge of safety	16.1	45.2	32.2	**98.3**
10. Quarrying site have suitable skilled blaster	3.2	12.9	83.8	**96.7**
11. Explosives acquired and conveyed legally	9.7	22.6	67.8	**83.9**
12. Licensed storage facility for blasting materials	74.2	19.4	6.5	**6.5**
13. Change-of-User permits effected	61.3	32.3	6.5	**0**
14. Training of quarry operators on disaster preparedness and response	74.2	22.6	3.2	**3.2**

Source; Researcher, 2019

Table 4.9: Statistics Test Table

N	14
Chi-Square	3.309
df	2
Asymp. Sig.	.20

Source; Researcher, 2019

The above Table 4.8 indicating the ranks by mean of the perceptions of QOs on the regulations under the occupation, public health and safety, most of the QOs perceived that the regulations had a positive weak effect and contribution to sustainable with a mean rank of 2.39, followed by a positive strong effect with a mean rank of 1.82 and no effect with a mean rank of 1.79. Furthermore, as illustrated in Table 4.9 above indicating the statistics test result of no significant difference in perceived ability of the QOs to comply with the occupation, public health and safety regulations based on their perceptions on the effects and contribution of the regulations to ensure sustainable quarrying, $\chi^2(2)=3.309$, $p=0.20$ hence the study failed to reject the null hypotheses that there was no significant difference in perceived ability of the QOs to comply with NEMA regulations based on their perception on the effects and contributions of the regulations to ensure sustainable quarrying.

NEMA should therefore endeavor to sensitize the QOs on the significance and the contribution of the occupation, public health and safety regulations ensuring sustainable quarrying in the site. The sensitization will change their perception from either no effect or positive weak effect and contribution to sustainable quarrying activities to positive strong effect and contribution of the occupation, public health and safety regulations to sustainable quarrying on the site. As illustrated in Table 4.9 above, the study noted that regulations that required financial inputs from the QOs such as obtaining of change of user permits, training of operators on disaster preparedness and response, establishment of licensed storage facilities for blasting materials and erection of warnings were highly perceived as to have no effect and contribution to sustainable quarrying and equally had low compliance levels within the quarrying site. Therefore, the revenues obtained by AAs and the licensing authorities should be ploughed back to the quarrying site to meet the costs in establishing the regulations requirements.

The variables with high perceptions as to have a positive strong effect and contribution to sustainable quarrying, 83.8% and 67.8% had equally high compliance levels of 96.7% and 83.9% are the availability of suitable skilled blasters and the acquisition and conveying of blasting materials legally respectively.

4.6.2. Environmental Protection Variables

The SPSS statistics output for the Friedman Test generated using the summarized data in Table 4.10 on environmental protection variables were as illustrated in Table 4.11 and 4.12 below. The mean ranks Table 4.11 indicated the mean ranks for the different perception categories perceived to determine the ability of the QOs to comply with the outlined regulations under the environmental protection. Most of the QOs perceived that the environmental protection regulations have a positive weak effect and contribution to sustainable with a mean rank of 2.28, followed no effect with a mean rank of 1.91 and a positive strong effect with a mean rank of 1.81.

Table 4.12 below contained the statistics test that indicated no significant difference in perceived ability of the QOs to comply with the environmental protection regulations based on their perceptions on the effects and contribution of the regulations to ensure sustainable quarrying; $\chi^2(2)=2.000$, $p=0.37$ and failed to reject null hypothesis. NEMA should put more effort on sensitization on the environmental protection guidelines compared to occupational, public health and safety discussed above since the mean rank of perceptions of the QOs as to the guidelines having no effects and contribution to sustainable quarrying was highest while as having a positive strong effects and contribution ranked third and lowest.

As illustrated in Table 4.10 below, the study noted that the environmental protection variables that were highly perceived as to had a positive strong effect and contribution to sustainable quarrying such as observation of 40 meter buffer to the abutting river (54.8%), site restricted to forest land devoid of trees (70.0%), observation of buffer of 100 meters to schools (77.4%), observation of 100 meters to hospitals (77.4%) and observation of 50 m. buffer to residential units conversely had higher compliance levels. The variable with higher compliance levels had no direct financial implications on the QOs. Those with direct financial implications on the

operators such as obtaining of permits from mines department, undertaking of EIA, availability of EMP, RPs, sites restoration within 12 months of depletion and certificate issued and the QOs using PPEs were highly perceived to had no effect and contributing to sustainable quarrying and had low compliance levels. NEMA should therefore enhance sensitization and enforcement to ensure compliance with the environmental protection regulations to ensure sustainable quarrying activities within the site.

Plate 4.1: Quarry Operators without PPEs

Source; Researcher, 2019

Table 4.10: Rank and Compliance with Environmental Protection Variables

Environmental Protection Variables	1. No Effect	2. Positive Week Effect	3. Positive Strong Effect	Compliance%
1. Observing 40m meters buffer to river	-	45.2	54.8	**100.0**
2. Compliance to noise, air and excessive vibration regulations	5.4	41.9	51.6	**87.1**
3. Permit from Mines Department	45.2	29.0	22.6	**3.2**
4. Availability of reclamation plans	45.2	45.2	9.7	**0**
5. Sites reclaimed & slated for the same	48.4	29.0	16.1	**16.1**
6. Quarrying sites with EIA	45.2	35.5	16.2	**12.9**
7. Physically planned sites (CoU)	29.0	41.9	19.4	**29.0**
8. Sites with EMP	45.2	25.8	22.6	**22.6**
9. Site restricted to forest land devoid of trees with RP	3.2	19.4	70.0	**83.9**
10. Observing buffer of 500m to aerodromes	12.9	45.2	41.9	**93.5**
11. Observing buffer of 100m to shopping centre),	9.7	58.1	32.3	**87.1**
12. Observing buffer of 100m to schools	6.5	16.1	77.4	**87.1**
13. Observing buffer of 100m to Hospitals	3.2	19.4	77.4	**90.3**
14. Observing buffer of 50m to residential	16.1	32.3	51.6	**90.3**
15. "blocking" for progressive operations and restoration	12.9	58.1	25.9	**61.3**
16.sites restored within 12 months of depletion and certificate issued	61.3	25.8	12.9	**0**
17. Quarrying site using PPES	77.4	19.4	3.2	**0**

Source; Researcher, 2019

Table 4.11: Mean Ranks

Perception Categories	Mean Rank
No Effect	1.91
Positive Weak Effect	2.28
Positive Strong Effect	1.81

Source; Researcher, 2019

Table 4.12: Statistics Test Table

N	16
Chi-Square	2.000
df	2
Asymp. Sig.	.368

Source; Researcher, 2019

4.6.3. Socio-Economic Enhancement Variables

Table 4.14 indicates the mean ranks of the related perception categories perceived to determine the ability of the QOs to comply with the variables under the socio-economic enhancement. Unlike the subsections above, most of the QOs perceived that the socio-economic variables had a positive strong effects and contributions to sustainable quarrying with a mean rank of 2.70 ranked as first and high, followed positive weak effect with a mean rank of 2.00 and no effect with a mean rank of 1.30.

Table 4.15 below contained the Test Statistics indicating there was significant difference in perceived ability of the QOs to comply with the socio-economic enhancement variables based on their perceptions on the effects and contribution of the regulations to ensure sustainable quarrying, $\chi^2(2)=9.800$, $p=0.01$. Therefore, the study rejected the null hypotheses that there was no difference in perceived ability of the QOs to comply with socio-economic enhancement guidelines based on their perception on the effects and contributions of the guidelines to ensure sustainable quarrying. From Table 4.9 below, only awareness on HIV/AIDs (58.1%) was highly perceived as to have no effect and contribution to sustainable quarrying and had the lowest compliance level of 6.5% within the quarrying site.

Table 4.13: Rank and Compliance with Socio-Economic Enhancement Variables

Socio-economic Enhancement Variable	1. No Effect	2.Positive Weak Effect	3.Positve Strong Effect	Compliance %
1. Employees on quarrying sites	6.5	25.8	67.7	**96.8**
2. Opportunities for food vendors	13.0	41.9	45.2	**96.8**
3. Remittance of taxes and levies	6.5	38.7	51.6	**93.5**
4. QO member of Welfare	6.5	35.5	54.8	**58.1**
5. Compliance with Welfare regulations	25.8	29.0	45.2	**45.2**
6. No employment to persons under age 18 yrs	3.2	9.7	87.1	**96.8**
7. Compliance with alcohol and drug use regulations	16.1	22.6	61.3	**96.8**
8. Awareness creation on HIV/AIDs	58.1	25.8	16.1	**6.5**
9. Provision of Water points, Lavatories and stores	16.1	64.5	19.4	**54.8**
10. Improved infrastructure (e.g., roads) network o the quarrying sites	22.6	19.4	77.4	**80.6**

Source; Researcher, 2019

Table 4.14: Mean Ranks

Perception Categories	Mean Rank
No Effect	1.30
Positive Weak Effect	2.00
Positive Strong Effect	2.70

Source; Researcher, 2019

Table 4.15: Statistics Test Table

N	10
Chi-Square	9.800
df	2
Asymp. Sig.	.007

Source; Researcher, 2019

The study further summarized the scores of the QOs in terms of compliance with the sustainable quarrying regulations based on the three (3) key performance areas of sustainable quarrying; occupation, public health and safety (OPHS), environmental protection (EP) and socio-economic enhancement (SEE) as indicated in Table 4.12 below for analysis of difference using Chi-Square (X^2) to test the third study hypotheses of the study outlined below. Table 4.16 below indicates the observed (O) scores of the 31 QOs in the three different performance areas of sustainable quarrying within the site and the respective calculated expected (E) values used for the Chi-Square test using the formula;

$$\chi^2 = \Sigma \frac{(O-E)^2}{E}$$

$$\chi^2 = \sum \frac{(186-186.07)^2}{186.07} + \frac{(272-271.99)^2}{271.99} + \frac{(228-237.92)^2}{237.92}$$

$$\chi^2 = 0.00 + 0.00 + 0.41$$

$$\chi^2 = 0.41$$

At 60 degrees of freedom (df) and at the critical value at 0.05 confidence levels, the calculated value (0.41) is not greater the critical value (79.08) and there the study noted that there was no difference in the establishment of sustainable quarrying variables amongst the QOs in the site. Hence they study failed to reject the null hypotheses.

Table 4.16: Compliance Score Table for QOs for the Chi-Square Test

QOs	**OPHS**		**EP**		**SEE**		**Weighted**
	14		**17**		**10**		**41**
	(O)	**(E)**	**(O)**	**(E)**	**(O)**	**(E)**	**Score**
1	4	4.87	7	7.12	7	5.97	**18**
2	7	6.76	9	9.88	9	8.28	**25**
3	8	7.57	9	11.07	9	9.28	**28**
4	6	5.95	10	8.70	6	7.29	**22**
5	5	4.87	7	7.12	6	5.97	**18**

6	5	6.22	9	9.09	9	7.62	**23**
7	9	6.22	9	9.09	5	7.62	**23**
8	5	4.87	7	7.12	6	5.97	**18**
9	7	5.68	8	8.30	6	6.96	**21**
10	7	6.49	9	9.49	8	10.05	**24**
11	5	6.76	12	9.88	8	8.28	**25**
12	5	5.41	9	7.91	6	8.37	**20**
13	7	5.95	8	8.70	7	7.29	**22**
14	3	4.87	9	7.12	6	5.97	**18**
15	5	4.60	5	6.72	7	5.63	**17**
16	5	6.76	10	9.88	10	8.28	**25**
17	8	6.76	8	9.88	9	8.28	**25**
18	6	5.95	9	8.70	7	7.29	**22**
19	5	5.68	8	8.30	8	6.96	**21**
20	8	7.03	9	10.28	9	10.88	**26**
21	4	5.68	10	8.30	7	6.96	**21**
22	3	5.41	10	7.91	7	8.37	**20**
23	8	6.76	8	9.88	9	8.28	**25**
24	5	6.76	12	9.88	8	8.28	**25**
25	6	6.22	10	9.09	7	7.62	**23**
26	5	5.68	8	8.30	8	6.96	**21**
27	6	5.95	9	8.70	7	7.29	**22**
28	8	6.49	9	9.49	7	10.05	**24**
29	6	5.68	8	8.30	7	6.96	**21**
30	7	5.95	8	8.70	7	7.29	**22**
31	8	6.22	9	9.09	6	7.62	**23**
TOTAL	**186**	**186.07**	**272**	**271.99**	**228**	**237.92**	**688**

Source; Researcher, 2019

4.7. Overal Contribution of the QOs to Sustainable Quarrying

After using the SPSS for data analysis, the cumulative percentage scores obtained by the QOs under the three (3) sustainable quarrying performance areas were used for sustainability rating of the QOs based on the AKOBEN rating rules to determine the overall contribution of the operators to sustainable quarrying activities in the site. The cumulative percentage scores of the QOs were matched-up against the AKOBEN sustainability rating system as captured in below Table.

Table 4.17: AKOBEN Sustainability Rating System

Rating Level	Performance	Rating Rules
R E D	P O O R	Nonconformity with outlined regulations, to evade RED must attain 98% compliance with regulations.
O R A N G E	U N S A T I S F A C T O R Y	At least 75% compliance with outlined regulations, undertaking best practices and audits undertaken to attain ORANGE rating.
B L U E	G O O D	No RED rating and ORANGE rating and attained more than 75% compliance with outlined regulations to attain BLUE rating.
G R E E N	V E R Y G O O D	Attained BLUE rating with 98%, no unresolved complaints regarding to water resources, ambient air quality, noise pollution, vibrations due to blasting and any other environmental issues to attain GREEN rating
G O L D	E X C E L L E N T	Meets 100% of BLUE rating , 100% of GREEN rating and an operational corporate social responsibility (CSR) policies

Source; www.epaghanaakoben.org [Accessed 10th October, 2019]

As illustrated in Table 4.18 below and based on the applicable rating components of the AKOBEN rating system in Table 4.13 above, all the QOs within the study area were rated RED because of nonconformity with the outlined NEMA regulations for sustainable quarrying. The AKOBEN rating system emphasizes on zero tolerance for non-compliance to the legal and regulatory requirement for environmental protection. To evade the RED rating all the QOs should attain a compliance rate of more than 98% with the sustainable quarrying regulations. The regulations were published in the year 2011, and none of the QOs had attained at least 75% compliance with the regulations to attain the second rank of ORANGE rating. According to the

AKOBEN rating rules, quarrying sustainability is achieved when the QOs attains a GOLD rating and attaining a performance of EXCELLENT which is compliance of 100% with absolutely outlined regulations to ensure sustainable operations and going an extra mile to develop CSR policies. Therefore the QOs within the study area have made no contribution to sustainable quarrying as the operators performances were rated as POOR based on the AKOBEN sustainability rating system.

As summarized in Table 4.15 below of the SPSS multi-response analysis of the challenges faced by the QOs in the study, key was the lack of training and awareness creation on the NEMA sustainable quarrying regulations and sensitization on the benefits of compliance with the regulations as noted by a majority of 23.1% of the QOs. Other challenges were related to lack of capital for investments required to comply with regulations such as meeting the high costs of removal of debris, draining off of the quarry pits when flooded during the rainy seasons, provision basic sanitary and storage facilities and lack of unity amongst the QOs that hindered the capacity of the operators to collectively determine ways of solving the challenges experienced within the quarry set that would a step towards the formalization of the quarry activities to ensure sustainability.

Therefore, NEMA should train the QOs on the application of the sustainable quarrying regulations and sensitization on the benefits of compliance with the regulations. NEMA need to develop and appropriate rating system for the extractive industry to enhance environmental management and governance. NEMA should identify incentives to motivate voluntary compliance, reporting and self-audits as catch points for licensing of the QOs for operations.

Table 4.18: AKOBEN Sustainability Rating of QOs in the Study Area

QOs	OPHS		EP		SEE		Weighted		Sustainability Rating (AKOBEN)				
	14		17		10		41						
	Score	%	Score	%	Score	%	Score	%	RED	ORANGE	BLUE	GREEN	GOLD
1	4	28.6	7	41.2	7	70.0	18	43.90					
2	7	50.0	9	52.9	9	90.0	25	60.98					
3	8	57.1	9	52.9	9	90.0	28	68.29					
4	6	42.9	10	58.8	6	60.0	22	53.66					
5	5	35.7	7	41.2	6	60.0	18	43.90					
6	5	35.7	9	52.9	9	90.0	23	56.10					
7	9	64.3	9	52.9	5	50.0	23	56.10					
8	5	35.7	7	41.2	6	60.0	18	43.90					
9	7	50.0	8	47.0	6	60.0	21	50.00					
10	7	50.0	9	52.9	8	80.0	24	58.54					
11	5	35.7	12	70.5	8	80.0	25	60.98					
12	5	35.7	9	52.9	6	60.0	20	48.78					
13	7	50.0	8	47.0	7	70.0	22	53.66					
14	3	21.4	9	52.9	6	60.0	18	43.90					
15	5	35.7	5	29.4	7	70.0	17	41.46					
16	5	35.7	10	58.8	10	100.0	25	60.98					
17	8	57.1	8	47.0	9	90.0	25	60.98					
18	6	42.9	9	52.9	7	70.0	22	53.66					
19	5	35.7	8	47.0	8	80.0	21	50.00					
20	8	57.1	9	52.9	9	90.0	26	63.41					
21	4	28.6	10	58.8	7	70.0	21	50.00					
22	3	21.4	10	58.8	7	70.0	20	48.78					
23	8	57.1	8	47.0	9	90.0	25	60.98					
24	5	35.7	12	70.5	8	80.0	25	60.98					
25	6	42.9	10	58.8	7	70.0	23	56.10					
26	5	35.7	8	47.0	8	80.0	21	50.00					
27	6	42.9	9	52.9	7	70.0	22	53.66					
28	8	57.1	9	52.9	7	70.0	24	58.54					
29	6	42.9	8	47.0	7	70.0	21	50.00					
30	7	50.0	8	47.0	7	70.0	22	53.66					
31	8	57.1	9	52.9	6	60.0	23	56.10					

Source; Researcher, 2019

Table 4.19: Multi-Response Analysis Table of Challenges of QOs

	Responses		Percent of Cases
Challenges Experinced	N	Percent	N
Lack of training and awareness creation on the regulations and the benefits of regulations	5	23.1%	16.1%
Capital investment required to adhere to the regulation are high and expensive on the operators.	4	10.3%	12.9%
Removal of debris and underground water is expensive.	4	10.3%	12.9%
Poor infrastructure; road network within the quarry site.	2	5.1%	6.5%
Flooding and underground water that hinders quarrying activities	9	12.8%	29.0%
competition from other products such as machine cut stones	2	5.1%	6.5%
Inadequate basic utilities such as water latrines and storage faciliies	4	10.3%	12.9%
Coming together through associations is a challenge	5	12.8%	16.1%
Risky method of quarrying to the operators; environmental disruptions	1	2.6%	3.2%
Lack of investment on modern technology, informal view of the quarrying activities.	3	7.7%	9.7%
Total	39	100.0%	125.8%

Source; Researcher, 2019

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

This chapter highlighted the summary of the study findings, conclusions and recommendations for the subject of investigations based on the study objectives and questions.

5.2. Summary of the Study Findings

The study established that; there was no sufficient awareness amongst the QOs on sustainable quarrying. As earlier hypothesized, there was no significant differences in awareness on the NEMA sustainable quarrying guidelines based on the levels of education of the QOs. A majority of 71.0% of the QOs were not aware of the existence of the NEMA sustainable quarrying guidelines. The variance in awareness on the sustainable quarrying guidelines amongst the QOs was statically significantly explained by the duration of the operation of the quarrying site by the QOs. Meaning the QOs who had begun their operations after the publication of the sustainable quarrying guidelines were like aware of their existence, and the operator who had begun their operations before the publication operationalization of the guidelines were more likely unaware of the existence of the sustainable quarrying guidelines.

Regarding to the establishment of the sustainable quarrying variables in the site, the socio-economic enhancement variables, unlike the occupation, public health and safety, and the environmental protection variables, were perceived by most of the QOs to have a positive strong effects and contribution to sustainable quarrying with the highest mean rank of 2.70 and the lowest mean rank of 1.30 as to have no effects and contribution to sustainable quarrying. Furthermore, contrary to the study second hypotheses that there was no significant difference in perceived ability of the QOs to comply with the NEMA guidelines based their perception on the effects and contribution of the guidelines to ensure sustainable quarrying, there was a statistically significant difference in perceived ability of the QOs to comply with the socio-economic enhancement variables based on their perception on the effects and contribution of the guidelines to ensure sustainable quarrying. Therefore, the study rejected the null hypothesis under the socio-economic enhancement variables as a key performance area of sustainable quarrying.

However, the study failed to reject the second null hypotheses that there was no statistically significant difference in perceived ability of the QOs to comply with NEMA guidelines based on their perception on the effects and contributions of the guidelines to ensure sustainable quarrying under the occupational, public health and safety and the environmental protection variables. As illustrated in Table 4.9, only awareness on HIV/AIDs was highly perceived by the QOs by 58.1% as to have no effect and contribution to sustainable quarrying under the socio-economic enhancement variables.

More awareness creation, sensitization on the benefits of compliance with the guidelines and compliance enforcement was needed for the environmental protection guidelines compared with the occupational, public health and safety guidelines. The mean rank of the perceptions of the QOs as to the environmental protection guidelines having no effects and contribution to sustainable quarrying was the highest at 1.91 while as having a positive strong effects and contribution ranked third and the lowest at 1.81. For the occupational, public health and safety guidelines, the perceptions of the QOs as to the guidelines having no effects and contribution to sustainable quarrying was ranked at 1.79 and as having a positive strong effects and contribution ranked second at 1.82.

The occupational, public health and safety variables with high perceptions as to have a positive strong effect and contribution to sustainable quarrying, such as quarrying site having suitable skilled blasters (83.8%) and explosives acquired and conveyed legally (67.8%) had conversely high compliance levels of 96.7% and 83.9% respectively. The study noted that the environmental protection variables that were highly perceived as to have a positive strong effects and contributions to sustainable quarrying such as observation of 40 meter buffer to the abutting river (54.8%), site restricted to forest land devoid of trees (70.0%), observation of buffer of 100 meters to schools (77.4%), observation of 100 meters to hospitals (77.4) and observation of 50 meters buffer to residential units conversely had higher compliance levels and had no direct financial implications on the operators. The environmental protection variables with direct financial implications on the operators such as obtaining of permits from mines department, undertaking of EIA, availability of EMP, RPs, sites restoration within 12 months of depletion

and certificate issued and the QOs using PPEs were highly perceived to had no effect and contributing to sustainable quarrying and had low compliance levels.

Regarding the third hypotheses, the study noted that there was no difference in the establishment of the sustainable quarrying variables amongst the QOs in the study area based on the three (3) key performance areas of sustainable quarrying. The study rating of QOs based on the applicable rating rules of the AKOBEN sustainability rating system noted that all the QOs within the study area were in nonconformity with the outlined guidelines hence rated RED and performance of all the QOs were rated as POOR. The QOs were therefore deemed to have made no contribution to sustainable quarrying within the study area. Unsatisfactory contribution to sustainable is attained when the operators attain at least 75.0% compliance with the guidelines, adopt best practices and undertakes self-audits of their activities and excellent or absolute contribution to sustainable quarrying is attained by the operators upon 100.0% compliance with all the regulations and the establishment and operationalization of CSR policies.

5.3. Conclusions

As per the study questions, specific objectives and hypotheses that guided the study, the study concluded that there was no sufficient awareness amongst the QOs on sustainable quarrying as defined by the NEMA sustainable quarrying guidelines. A majority of 71.0% of the QOs included in the study were not aware on the existence of the NEMA sustainable quarrying guidelines. The minority of 29.0% who noted that they were aware of the existence of the sustainable quarrying guidelines had not physically interacted with guidelines but had been informed by the land owner as a precautionary measure before leasing the pits for operation.

The sustainable quarrying socio-economic enhancement variables were comparatively well established in the study area and were perceived by most of the QOs as to have positive strong effects and contributions to sustainable quarrying with the highest mean rank of 2.70. The environmental protection variables were comparative least established within the study area with the highest mean rank of 1.91 as to have no effects and contribution to sustainable quarrying. The QOs complied with the sustainable quarrying guidelines that had no direct financial implication on their operations while tended to disregard the sustainable quarrying guidelines

with direct financial implications. The sustainable quarrying guidelines having financial implication on the QOs were further perceived to have no effects and contribution to sustainable quarrying within the study area.

Due to the POOR overal compliance levels of the QOs with the sustainable quarrying guidelines under the key performance areas of sustainable quarrying, the QOs activities within the study area have no significant contribution to sustainable quarrying. None of the 31 QOs included in the study had attained at least 75.0% overal compliance with NEMA sustainable quarrying guidelines.

5.4. Study Recommendation

The study recommended that NEMA. NCC and MEF, as the key authorizing and licensing agencies of the quarrying activities, should undertake awareness programmes and sensitization of the QOS on the outlined sustainable quarrying guidelines to ensure sustainability within the industry in Kenya. Awareness on the existing sustainable quarrying guidelines and other regulations on environmental protection amongst the QOs as key stakeholders within the industry is a prerequisite to compliance with the regulations and guidelines for sustainable quarrying activities. The current study revelation that none of the QOs has had an access to sustainable quarrying guidelines indicated the critical need for awareness creation and sensitization of the QOs on the existence and the significance of compliance with the guidelines. The sensitization and awareness programmes should be a companied with practical training and demonstration on how some of the activities on how to undertake sustainable quarrying outlined by the guidelines ought to be undertaken by the QOs to ensure sustainability.

The licensing and authorizing agencies should heighten the levels of compliance enforcement activities to ensure the QOs complies with the sustainable quarrying guidelines. The low levels of compliance with the guidelines especially those geared towards environmental protection raises questions on the ability of the licensing and authorizing agencies to undertake effective compliance enforcement of the guidelines for sustainable quarrying industry. New compliance enforcement concepts such as joint enforcement action should be adopted to ensure coordination

among the licensing and authorizing agencies clearly dividing their responsibilities through a high level advisory committee.

Acute shortage of funds remains the biggest impediment to the growth of the quarrying industry as noted by the QOs. Both the central and county governments should incentivise the QOs by ploughing back the revenues obtained from the operators to the industry to enable the QOs meet the cost implications of compliance with the sustainable quarrying guidelines. Being a nascent, capital intense and high-risk industry, the funds will provide capital for investment by the QOs on the modern quarrying techniques and adoption of best practices to ensure sustainability within the industry. NEMA KNCPC should establish quarrying sustainability rating system for the Kenya quarry industry. The excellent performance of the operators within the industry should be used as incentive for licensing and recommendation for further business opportunities. Awards should also be established for excellent performance to promote self-audits and voluntary compliance and information disclosure amongst the QOs to the general public on their activities.

5.5. Further Areas of Studies

The study identified the following areas for further studies. The first area is on management opportunities and challenges faced by the quarrying authorizing agencies in the implementation of sustainable quarrying regulations in Kenya. The challenges relate to capacity of the institutions and ensuring compliance. The second challenge is on adequacy and opportunities offered by the sustainable quarrying regulations for the formalization of the quarrying industry in Kenya. Several quarries operate informally and therefore unable to establish sustainability measures discussed in the present study. Finally, further research on the role of stakeholder in the formulation and of environmental management regulations is important to ensure monitoring and evaluation performance of these quarries.

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APPENDICES

Appendix I: Research Questionnaire

UNIVERSITY OF NAIROBI

DEPARTMENT OF GEOGRAPY AND ENVIRONMENTAL STUDIES

M.A RESEARCH PROJECT: QUARRYING SUSTAINABILITY FACTORS IN NAIROBI: THE CASE OF KENYA QUARRY QUARRYING SITE

QUARRYING OPERATORS QUESTIONNAIRES

Declaration: This information is confidential and is meant for academic use only.

Questionnaire Number	
Date of Interview	
Location	

Part I: General information

1. Which of the following is your current quarrying site?

Site	**Tick appropriately**
1. Kwa Hinga	
2. Kenya Quarries	
3. Njiru	

2. What is your gender?

Gender	**Tick appropriately**
1. Male	
2. Male	

3. What is the highest level of education you attained?

Education Level	**Tick appropriately**
1. No Primary Education	
2. Some Primary Education	
3. Completed Primary Education	
4. Some Secondary Education	
5. Completed Secondary School	
6. College Graduate	
7. University Graduate	

4. Duration of operation of the current quarry site?.....Years

5. Are you aware of the existence of the NEMA quarrying guideline?

Options	Tick appropriately
1. Yes	
2. No	

Part II:

Kindly rank the variable that influence sustainable quarrying within the quarrying site? Using the scale; **1. No Effect, 2. Positive Weak Effect 3.Positive Strong Effect**

(Underlying idea: To identify the well-established variables amongst the QOs for occupation, public health and safety, environmental protection and socio-economic enhancement and to establish their perceived ability to comply with the variables based on the perceptions on variables as to have effects and contribution to sustainable quarrying).

Occupation, Public Health and Safety Variables	**1**	**2**	**3**	**Independently indicate compliance with the variable**		
				1. Yes	**2. No**	**Score**
1. No undercutting and tunneling						
2. Avoidance of vertical faces exceeding 2.5 m						
3. Hard rock quarry faces benched						
4. Avoidance of loose hanging rocks						
5. Ensuring that all loose rocks are scaled down						
6. Warnings signs of appropriate font size						
7. Provision of first aid kit and aiders						
8. Provision of protective gear						
9. Site having someone in charge of safety						
10. Quarrying site have suitable skilled blaster						
11. Explosives acquired and conveyed legally						

12. Licensed storage facility for blasting materials						
13. Change-of-User permits effected						
14. Training of quarry operators on disaster preparedness and response						

Environmental Protection Variables	**1.**	**2.**	**3.**	**Independently indicate compliance with the variable**		
				1. Yes	**2. No**	**Score**
1. Observing 40m meters buffer to river						
2. Compliance to noise, air and excessive vibration regulations						
3. Permit from Mines Department						
4. Availability of reclamation plans						
5. Sites reclaimed & slated for the same						
6. Quarrying sites with EIA						
7. Physically planned sites (CoU)						
8. Sites with EMP						
9. Site restricted to forest land devoid of trees with RP						
10. Observing buffer of 500m to aerodromes						
11. Observing buffer of 100m to shopping centre),						
12. Observing buffer of 100m to schools						
13. Observing buffer of 100m to Hospitals						
14. Observing buffer of 50m to residential						
15. “blocking” for progressive operations and restoration						
16.sites restored within 12 months of depletion and						

certificate issued						
17. Quarrying site using PPES						

Socio-economic Enhancement Variable	**1.**	**2.**	**3.**	**Independently indicate compliance with the variable**		
				1. Yes	**2. No**	**Score**
1. Employees on quarrying sites						
2. Opportunities for food vendors						
3. Remittance of taxes and levies						
4. QO member of Welfare						
5. Compliance with Welfare regulations						
6. No employment to persons under age 18 yrs						
7. Compliance with alcohol and drug use regulations						
8. Awareness creation on HIV/AIDs						
9. Provision of Water points, Lavatories and stores						
10. Improved infrastructure (e.g., roads) network o the quarrying sites						

Part III:

1. Kindly identify the challenges you face in the sustainable operation of the quarrying sites?

……
……

2. Kindly identify the improvements you would suggest to enhance sustainable operation of the quarrying sites?

……
……
……

Appendix II: Research Letter

UNIVERSITY OF NAIROBI

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

Telephone: +254 2 318262
Extension: 28016
Fax: +254 2 245566
Email-geography@uonbi.ac.ke

P.O. BOX 30197-00100
NAIROBI
KENYA

October 8, 2019

The Director,
National Commission for Science & Technology
Nairobi, Kenya.

Dear Sir/Madam,

RESEARCH PERMIT: ORIMBA PETER OKEYO

This is to confirm that the above named is a Master of Arts student (Registration Number – C50/72910/2012) at the Department of Geography and Environmental Studies, University of Nairobi registered.

Mr. Orimba is currently undertaking research on a topic titled: **Quarrying Sustainability Factors in Nairobi: The Case of Kenya Quarry. Kwa Hinga and Njiru Quarrying Sites.**

Any assistance accorded to him will be highly appreciated.

CHAIRMAN
Department Of Geography
and Environmental Studies
UNIVERSITY OF NAIROBI

Dr. Boniface Wambua
Chairman, Department of Geography & Environmental Studies

Appendix III: Research Permit from NACOSTI

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **917421**

Date of Issue: **07/November/2019**

RESEARCH LICENSE

This is to Certify that Mr.. PETER ORIMBA of University of Nairobi, has been licensed to conduct research in Nairobi on the topic: QUARRYING SUSTAINABILITY FACTORS IN NAIROBI: THE CASE OF KENYA QUARRY, KWA HINGA AND NJIRU QUARRYING SITES for the period ending : 07/November/2020.

License No: **NACOSTI/P/19/2515**

917421

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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3. The Licensee shall inform the relevant County Director of Education, County Commissioner and County Governor before commencement of the research
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Mobile: 0713 788 787 / 0735 404 245
E-mail: dg@nacosti.go.ke / registry@nacosti.go.ke
Website: www.nacosti.go.ke

Appendix IV: Multiple Regression Analysis Correlations Table

		Awareness on NEMA quarry guidelines	Gender	Highest level of education attained	Duration of work in the current quarry site
Pearson Correlation	Awareness on NEMA quarry guidelines	1.000	-.262	-.369	-.704
	Gender	-.262	1.000	-.315	.210
	Highest level of education attained	-.369	-.315	1.000	-.002
	Duration of work in the current quarry site	-.704	.210	-.002	1.000
Sig. (1-tailed)	Awareness on NEMA quarry guidelines	.	.081	.359	.000
	Gender	.081	.	.042	.129
	Highest level of education attained	.359	.042	.	.496
	Duration of work in the current quarry site	.000	.129	.496	.
N	Awareness on NEMA quarry guidelines	30	30	30	30
	Gender	30	31	31	31
	Highest level of education attained	30	31	31	31
	Duration of work in the current quarry site	30	31	31	31

Appendix V: Researcher Collecting Data

Appendix VI: Declaration of Originality Form

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: PETER OKEYO ORIMBA

Registration Number: C50/72916/2012

College: OF HUMANITIES AND SOCIAL SCIENCES

Faculty/School/Institute: FACULTY OF ARTS

Department: GEOGRAPHY AND ENVIRONMENTAL STUDIES

Course Name: RESEARCH PROJECT

Title of the work: AN ASSESSMENT OF THE KENYA QUARRY SUSTAINABILITY PERFORMANCE IN NAIROBI CITY COUNTY

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
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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: 12/11/2020

Appendix VII: Turnitin Originality Report

1/11/2020 Turnitin

Turnitin Originality Report

11th November 2020

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