ENVIRONMENTAL AND LAND USE IMPACTS OF QUARRYING ALONG NGONG RIVER IN EMBAKASI

A THESIS SUBMITTED IN PARTIAL FULFILLMENT FOR MASTER OF ARTS DEGREE IN

URBAN REGIONAL PLANNING, IN THE DEPARTMENT OF URBAN AND REGIONAL PLANNING, UNIVERSITY OF NAIROBI.

NOVEMBER 2017

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

Signature………………………. Date………………………

SAMUEL W. KINDIGA

B63/76648/09

Supervisor's approval

This thesis has been submitted for examination with my/our approval/knowledge as university supervisor.

Signature…………………... Date………………………...

Dr. FRIDAH MUGO

DEDICATION

To them that spare thoughts to the reclamation of quarries and those who toil in them, and without whom the former would not imagine.

ACKNOWLEDGEMENT

Foremost to God almighty. To all that was needed he provided**.**

Special thanks to my supervisor Dr. Fridah Mugo for her guidance, much valuable criticism and even patience. May the good Lord bless her.

Credit to all the quarry workers, quarry owners, quarry products customers, the quarry neighbors, the local administration officers and officers from both Nairobi County and National Environmental Management Authority(NEMA).

Least but not least, thanks to Samuel Otieno and Wathugi then as student interns at the planning department, Nairobi County for their contribution as research assistants.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF MAPS

LIST OF ABBREVIATIONS

CEMAC- Central Africa Economic and Monetary Community

EMCA – Environmental Management and Coordination Act

EMP- Environmental Management Plan

ETP- Effluent treatment plant

IUCN- International Union for the Conservation of Nature

NCQ- National Council of Quarrying (Lebanon)

NEMA- National Environmental Management Authority

ECODIT-Environmental Coordination and Development in Technology

ABSTRACT

Quarrying is a human activity that involves the extraction of natural resources from the earth's surface. Like any other extractive activity, quarrying alters the physical environment, and when unchecked has the potential to impact adversely on the environment and the surrounding land uses. This study focusses on the landscape, physical development, settlement, environmental and socio-economic impacts of quarrying along the Ngong river basin in Embakasi division and limited to the area between the Outering Road Bridge and Kangundo Road Bridge. The study also sought to evaluate the environmental and land-use impacts of quarrying along Ngong River, determine the social economic significance of quarries to the workers and the neighboring communities, identify and analyze the impacts of quarrying on the health of neighboring communities and physical facilities as well as formulate planning interventions for sustainable quarrying. The study collected data from the quarry neighbors, quarry managers, policy institutions. The findings show that quarrying activities have impacts on the environment, land use and physical facilities along the Ngong' river, that there is need to assess the effectiveness of environmental impact assessments and audits in the area, that quarries have impacted on the health of neighboring communities and that planning interventions are required to minimize the effects of quarrying on the environment, health and land use decisions. The study recommends proper planning of reclaiming closed quarries, adoption of closure mechanism for all quarries, reverting depleted quarry land to the government, creation of buffers between quarries and other land uses, introduction of cess to all trucks transporting quarry materials, planting of fast growing trees with dense foliage around quarries and regular environmental auditing of all quarries and regular health awareness campaigns in quarry neighboring communities.

CHAPTER 1 – INTRODUCTION

1.1 Background to the research problem

Quarrying is a form of mining that is centered on the extraction of rocks or minerals from the earth's surface through the use of manpower and machinery (International Stone Symposium, 2011). Quarries are generally used for extracting building materials that include sand, gravel, limestone, building stones and other relatively cheap and bulky raw materials. Quarries are shallower than other types of open–pit mines. However, there are instances when a part of a quarry or an entire quarry is located underground. The extent of the quarry depth is based on factors like the level of technology employed, the value of the mined products, government regulations, the relative ease of abandoning quarrying operations in one quarry and starting another elsewhere among other factors.

Quarrying is a big investment venture both in the volumes of output, the sophistication of machinery employed, the spatial area involved and the noise levels produced and hence comparable to large industrial and manufacturing activities. Quarries are by themselves open factories with minimal housing and staffing requirements. The quarry establishments are notable for basic construction, reason being that, the working life of the quarry is not very permanent as it depends on the extent of the rock deposit. Low staff population and the low levels of office skills required also contribute to the limited physical development of the site.

Quarrying history in the study area

The history of quarrying along the Ngong River in Embakasi dates back to the origins of Nairobi as an administrative colonial center. The setting up of the Nairobi administrative post, led to investment in physical infrastructure that included the construction of roads, rail network, administrative buildings as well as residential buildings for the workforce. As the colonial town expanded, so did, the activities related to the growth of infrastructure, and key among them, construction materials supply sector leading to heightened quarrying activities.

The inception and expansion of industries is associated with several factors that include the availability of markets, ease of access to raw materials, supply of affordable labor, availability of sizeable land for siting of the industries and for their growth, attractive government policy, accessible technology, access to affordable credit etc. In the early years of the 20th century, the present day Mukuru area offered an ideal spot for quarrying activities.

The siting of quarrying activities along the Ngong river basin was necessitated by the presence of a suitable and easily accessible hard igneous rock -a key component for construction aggregate on the sub-surface, without which the combination of all other factors would not have rendered quarrying activities in this area viable. Further to this, the heightened development in physical infrastructure activities in Nairobi contributed to increased demand of construction materials and chiefly quarried aggregates. The increased demand led to the economic viability of quarrying activities and thus the domination of the Ngong River basin by quarrying activities.

The colonial government policy of racial segregation in Kenya as espoused by the colonial planning of 1948 policy had resulted to the confinement of Africans into crowded native reserves while the fertile highlands were reserved for the white settlers. The scenario in urban areas was markedly different in the sense that only employed Africans were allowed access and accommodation. This meant that urban areas were less populated and therefore the government could easily sanction the reservation of large areas yet proximate to the main town center for light industrial use and in essence quarrying activities.

The 1973 Master plan that guided the development of the city of Nairobi provided the greatest impulse in the development of quarries within the study region as it guided development to the eastern side of the City. This led to the opening up of new industrial and residential zones in areas that were previously under commercial agriculture namely, cattle rearing and sisal plantations. Examples of this conversion is the Tassia, Kayole and Donholm ranches that later become residential estates under the same names. This resulting conversion led to a rise in demand for construction materials resulting from the main industrial area to far flung areas of Embakasi that is presently known for industries and factories. These development activities resulted to greater viability of investment in the field of construction materials and hence the opening of even more quarries along the Ngong River basin. The depletion of previously established quarries in the Mukuru kwa Njenga area, coupled with decreased development activities- as the main industrial area attained near full development, accelerated the setting up of other quarries further downstream.

Later developments in the area

The present day informal settlements of Mukuru and parts of Kibera slums upstream of the Ngong River in Nairobi are founded on soft soils resulting from the filling of quarries with dump materials namely poor soils as well as household and industrial waste. This extent of this vast land stretches from the neighborhood of Mater Misericodie Hospital in Nairobi's South B estate on the Southern side of Ngong River, to industrial area on the Northern side and runs further downstream on each side of this river to the Outering road bridge. Significance of quarrying activities in this area is demonstrated in the naming of a slum village and commuter waiting station as Quarry or Kware.

The establishment of the Nyayo -Embakasi Estate by the National Social Security Fund in the mid 1980's contributed to more quarrying activities in the area. Unique to this grand study was the specification of the design, in that, the entire three thousand units (3000) were to be of 100% concrete walling while the over eight kilometer boundary wall was to be made of concrete blocks. The huge demand for ballast (course aggregate) led to the establishment of the then biggest quarry in the area by the study contractor- Mugoya construction company on land belonging to the department of defense namely- Embakasi Garrison. Other construction companies namely, Nyoro construction company, Garuda quarries, KarsanMurjietc established their own quarries further down the frontage of Ngong River in later years.

With the end state of quarrying pre-determined, the aim of this study is to examine the impacts of quarrying on the environment, the physical state of the land as well as its relationship with the people working in the quarries as well as those in the neighborhood. This study will investigate the gains expected from quarrying, the impact on land cover, land use and the environment.

1.2 Problem statement

Quarrying represents critical components in a country's economic development. Construction aggregates and various other raw materials play a central role in the development of modern economies. The scope of quarrying in a developing country is an indicator of the level of shift from traditional housing as well as the upgrading of the particular country's transport infrastructure. This in essence is borne from the fact that construction aggregates are rarely exported, and thus the volume of quarried material is in response to the local demand.

Quarry dust is the finest product of the crushing process. This product is significant in the molding of precast construction elements like culverts, concrete drainage pipes, paving blocks, drainage channels etc.

Dust blowing from the crushing plant also plays a role in degrading the environment. The effect of this is on the surrounding vegetation (grass, trees, and on cultivated plants). Due to continued surface covering by the dust, photosynthesis is hampered leading to stunted growth of flora. On human beings, the dust blowing from the quarries has a greater impact on quarry workers than any other persons living in association to quarries as it takes a toll on skin and human respiratory system.

The accumulation of dust on buildings increases routine maintenance costs thus leading to low return on investment. The low return on investments is also occasioned by high turn-over in tenancy as well as high depreciation of the investments. However, the greatest impact of quarries on humans and buildings lies in the explosive nature of material extraction. This process involves heavy blasting of the hard rock surface by the use of explosives. The impact of blasting on the neighborhood is comparable to heavy armor explosion with likelihood of causing shocks on human beings and negatively impacting on the health of expectant women. On buildings, the effect of explosion is akin to earth tremors and in cases of uncontrolled blasting, can have effects synonymous to earthquakes with the end result of structural cracks on nearby buildings.

Quarrying alters the landscape more than any other localized industrial activity. On land cover, quarrying depletes the natural ground cover and continues to change the natural environment deep down by exposing the earth's stratum. The clearing of land to develop access roads and to open up mining sites destroys habitats for wild animals, reduces grazing areas for cattle, sheep and goats and reduces sources of plant life for human beings and animals (Chizoro, 1997). The process of quarrying starts with the removal of top surface soil (overburden cover) that has to be removed before the commencement of real quarrying. The heaps of the removed top soil degrade the environment in that the existing vegetative cover is buried and life of small animals destroyed. The aftermath of quarrying activities can only be understood as man-made canyons, craters or gorges.

Noise pollution can best be exemplified by the movement and workings of heavy machinery in an open environment. The use of heavy machinery in the crushing of stones, and more so in an open environment is a major cause of environmental pollution in the sense of the decibels of noise produced. Explosions are expressed by the intensity of sound and resonance produced, and thereby a key contributor to noise pollution in quarries.

Quarrying is thus a major activity along the Ngong river basin, with the history of these activities dating back to the last 80 years, implying that the process of quarrying has gone full circle - from material prospecting to restoration. The later though with mixed levels of success. Along this stretch, restoration of quarries has been attempted in some areas and with the effects of such efforts being openly manifest. In other places and along the same stretch of Ngong River, abandoned quarries are apparent. Further downstream there are several active quarries albeit a government ban on quarrying activities in the area. Literature review on quarrying in Kenya shows that very few studies on impacts of quarrying have been done on quarrying, more so in Embakasi area along Ngong River. The presence of many quarries along the Ngong River, and at different stages of their activity provides essential basis for this study in that vital information pertaining to quarrying processes will therefore be readily accessible.

Many studies on quarrying have been done both locally and internationally. The studies have researched various aspects relating to quarrying ranging from land use, social, environmental and economic. Okoko and Kamwelle, (2015) conducted a study on the impacts of stone quarrying in Thika municipality. The study examined the continued alienation of agricultural viable land to quarrying. The study highlighted the land use conflict between agriculture and the extractive industry of quarrying. Musyoka (1997) conducted a study in Kangundo division on the impact of quarrying to the environment. The study observed the land degradation on steep slopes and the consequent soil erosion that resulted due to surface run-offs. The study observed the rise of construction industry in other areas had both positive and negative impacts on the environment and land use. Waweru and Mukundi (2015) conducted a study centred on post quarry land use and along Ndarugu river in Kiambu County. The study established that there are no attempts that are employed towards full restoration of the quarries upon depletion of the dimension stones resource. Mogambi and Mohamed (2016) did a study conducted in Mandera County focused on the economic and environmental impact of stone quarrying in Mandera County. The study observed that quarrying has a positive impact on the livelihoods of the local community than the predominant nomadic pastoralism. Mathu, Nyamai and Ngecu,

(2003) conducted a study in the Tala, Kangundo. The study focused on the environmental impacts of quarrying. The study observed the lack of rehabilitation of quarries upon cessation of quarries as well as the degradation of beautiful landscapes and grazing fields. The studies were centered on the environment and social economic effects of quarrying in areas outside the Ngong river in Embakasi. However, Eshiwani (2007), conducted a study of quarrying in Embakasi that centered on the environmental effects of quarrying. The study covered the then entire Embakasi district and not specific to the quarries along the Ngong river. The study also dwelt on the environmental effects of quarrying only. This study thus has relational basis with the studies mentioned but focusses on both the environmental and land use impacts and specifically on the quarries along the Ngong river.

In Lebanon, quarrying has contributed to environmental degradation, alienation of land from other land uses, noise pollution, destruction of natural habitats for biodiversity and landform deterioration (Khawlie,1998). In Ghana, the impacts of quarrying on the environment include impact on buildings, farmlands, crops and water systems (Kadzo,2012). A study done on the region identified that open cast system of quarrying causes massive damage to land and vegetation cover. It also identified the spatial pattern of quarrying activities in the six Local Government Areas for Ebonyi State where quarrying activities are concentrated and active (Okafor,2007). Quarrying in the Mendips in UKhas led to the destruction of the countryside and especially the many hills that are dominant in the area and thus impacting negatively on tourism (King, 2000). However, quarrying in the Mendipsis strictly guided by the planning regulations of Somerset County. The regulations oversee quarrying to the last stages of restoration and thus guaranteeing sustainable quarrying. The different approach employed in the UK, the mentioned cases in the African region, and in Lebanon offers different study models relevant to extracting comparative understanding with the study area.

By having relational basis with the case areas albeit contextual dissimilarity, the study seeks to ascertain whether the impacts of quarrying along the study area compares with the rest of the mentioned cases and more so why quarrying is not carried out sustainably.

Plate 1: Example of an active quarry within the study region

1.3 Purpose of the study

Life takes several dimensions. In many ways, the survival of man is characterized by the influence of social forces - for man is a social being, living and surrounded by environmental forces and dictated by economic and structural forces. The interplay of socio-economic forces in an environmental context is an everyday phenomenon that goes unrestricted spatially. The process of quarrying has social, economic as well as environmental implications on any setting and therefore its relevance to the study. The study is therefore purposed to gather, highlight and document information related to environmental and land use impacts of quarrying activities along the Ngong river basin and make recommendations towards sustainable quarrying.

1.4 Scope of the study

The study covers the Ngong River basin from the outer ring road bridge area to the Kangundo road bridge. This represents a stretch of 9 Km and a total of 445 acres (180 Ha) land surface. Theoretically, the study examined the impacts of quarrying activities on the environment and land use aspects of the same activities on the surrounding area and in the greater urban setting. On the environment, the study explored the impact of mining on the landscape, the effect of noise and dust on the environment, the impact of quarrying on the natural flow of Ngong River, the natural habitat, drainage pattern, vegetation, and the environmental impact of decommissioning of quarries among others. On land use, the study explored the impact of quarrying on the residential development of the surrounding settlements and examined the physical infrastructure.

1.5 Research questions

i. What effects do quarrying processes have on the physical environment?

ii. What are the effects of environmental impact assessments and audits in the area?

iii. Does quarrying pose a health risk in the study area?

iv. Does quarrying affect the stability of neighboring buildings?

v. What planning interventions can minimize adverse effects of quarrying in the study area?

1.6 Study objectives

1) To evaluate the impacts of quarrying on the environment, land use, and physical facilities along Ngong river.
2) To assess the effectiveness of environmental impact assessments and audits in the study area.
3) To identify and analyze impacts of quarries on the health of neighboring communities
4) To propose planning interventions to minimize adverse effects of quarrying in the environment, health of communities and land use typologies.

1.7 Justification and significance of the study

Quarrying is an important activity in the economic development of many nations. Quarrying along the Ngong River presents a planning problem in that, the quarrying process as well as end state of the quarrying process is not as would be envisaged in a planned context and thus explaining the presence of many informal settlements in abandoned quarries sites. Quarrying along the Ngong River has been on-going for many years and a few studies have been done on the area. However, the study area is the only location in Nairobi where quarrying for ballast takes place as other quarries within Nairobi are exploited for building stones. The uniqueness of ballast crushing as compared to stone quarrying is that it continuously generates noise, vibration and dust throughout as compared to stone quarrying in which noise and dust are emitted only when blasting the rock.

Further justification on the study area is from the fact that, this is the only ballast crushing area where both active and abandoned quarries can be found both of which are central to the study. Worth noting is the fact that this massive, open industrial activity takes place in a densely populated neighbourhood and thus representing a land-use conflict in the area which is a key planning issue.

1.8 Assumptions of the study

The study assumes that quarrying is an industrial activity taking place in a zoned activity area and takes place in spatial and environmental context and thus the realization of strong links between quarrying, land use zoning, the environment and the social systems. It was also assumed that the area of study bears sufficient information and data pertaining to quarrying, the environment as well as the existing physical infrastructure.

1.9 Definitions of terms and variables

Environment

All those elements which in their complex inter-relationships form the framework, setting and living conditions for mankind by virtue of their very existence or by virtue of their impacts (Stockholm declaration, 1972).

Natural resource

Natural resource refers to anything that is useful to an organism, population or ecosystem. They include resources of the air, land, water, animals and plants including their aesthetic qualities (Njuguna, 2004).

Land use policy

Land use policy establishes the basic type and intensity of uses permitted by the general plan for each land use category, including the overall maximum density for residential development and maximum intensity of development for commercial and industrial uses (Robinson, 1991). Effective land use policy adapts to fast-changing environmental, social and economic conditions. The general plan is the foundation for all of the land uses that occur in a country, and provides the framework for how the Country will plan for and address the numerous land use challenges it faces (Kenworthy, 1996).

Land use zoning

This is a device of land use planning used by local governments as a tool for creating land use order. It involves the practice of designating permitted uses of land, based on mapped zones which separate one set of land uses from another. Zoning can be use-based (regulating the uses to which land may be put), or it may regulate building height, plot coverage (Lambin, 2011).

The primary purpose of zoning is to separate land uses that are thought to be incompatible. In practice, zoning is used to prevent new development from interfering with existing residents or businesses and to preserve the "character" of a community. Zoning is commonly controlled by local governments such as counties or municipalities, though the nature of the zoning regime may be determined or limited by state or national planning authorities or through enabling legislation.

Zoning may include regulation of the kinds of activities which will be acceptable on particular lots (such as open space, residential, agricultural, commercial or industrial), the densities at which those activities can be performed (from low-density housing such as single family homes to high-density such as high-rise apartment buildings), the height of buildings, the amount of space structures may occupy, the location of a building on the plot, setbacks, the proportions of the types of space on a lot, such as how much landscaped space, impervious surface, traffic lanes, and whether or not parking is provided. In some countries, zoning usually includes building design, very specific green space and compensation regulations. The details of how individual planning systems incorporate zoning into their regulatory regimes vary though the intention is always similar (Talen, 2005).

Most zoning systems have a procedure for granting variances (exceptions to the zoning rules), usually because of some perceived hardship caused by the particular nature of the property in question.

Urban zones fall into one of five major categories: residential, mixed residential-commercial, commercial, industrial and special (e. g. power plants, sports complexes, airports, shopping malls etc.). Each category can have a number of sub-categories, for example, within the commercial category there may be separate zones for small-retail, large retail, office use, lodging and others, while industrial may be subdivided into heavy manufacturing, light assembly and warehouse uses.

Economic system

An economic system is a mechanism which deals with the production, distribution and consumption of goods and services in a particular society (Bonnie, 1995). The economic system is composed of people, institutions and their relationships. Economic systems address the problems of economics like the allocation and scarcity of the resources.

The scarcity problem requires answers: what to produce, how to produce it, and who should get what is produced. An economic system is thus a way of answering these basic questions. Different economic systems answer them differently.

The four most basic and general economic systems are:

- Market economy such as capitalism
- Mixed economy -centrist economic system
- Planned economy such as socialism

Quarry face

This refers to slopes in a quarry where the required mineral is in the process of being worked, or is exposed but not yet extracted. It also refers to any exposed rock faces within the quarry, including areas where permitted extraction is complete.

Shot holes

These are drilled round holes drilled on the surface of a quarry into which explosives to be denoted are fed upon which when detonated end up blasting the rock surface.

Restoration

This refers to relying on spontaneous natural processes/dynamics and assisting the recovery of the pre-existing (ICUN, 2015)

ecosystem (closer to what it was before the anthropic disturbance) (ICUN, 2015)

Reallocation

This is the adoption strong technical measures aiming to orient the future use of the site. (ICUN, 2015)

Rehabilitation

This refers to assisting the restoration/rehabilitation through the adaption of technical measures to orient natural/ spontaneous succession due to a limited in time intervention (ICUN, 2015)

CHAPTER 2 – LITERATURE REVIEW

2.1 Introduction

The vast bulk of the built environment that include buildings, roads, and bridges is formed from raw materials sourced from the earth by the extractive industries, (American marbles, 1988). Stone quarrying is the process by which rock is extracted from the ground and crushed to produce aggregate, which is then screened into the sizes required for immediate use, or for further processing, such as coating with bitumen to make bituminous macadam or asphalt.

There are several locational factors to quarrying. This factors include; the proximity to study sites. The development of housing meant to cater for the increased population in the city, the development of road and rail infrastructure all of which are dependent on quarried aggregate positively influenced the location of the quarries along the Ngong river stretch.

The volume of the overburden soil cover that has to be removed also influences the viability of the natural resource to be extracted from underneath the surface. Quarried aggregates are of less value even in their volumes and thus not viable if located far down the surface thus requiring costly technology and resource for extraction. The Ngong river basin is steep sided on both sides. This aspect coupled with soil erosion over a long period of time has led to the exposure of the rock strata to the surface and thus rendering it inexpensive to exploit the resource.

The geological structure of the rock impacts on the viability of quarries. A well-developed rock structure ensures a longer quarry life and thus profitability. Other factors influencing location of quarries include environmental factors, the degree of weathering etc., (Little, 1969).

Resource exploitation in the study area is in large scale with several quarrying companies actively involved in crushing stones into ballast in the 12 kilometer stretch along the Ngong River.

Quarrying as a resource exploitation process is to a great extent not sustainable in that quarries cannot regenerate once depleted. This means that the processes involved in quarrying should maximize on efficiency and thus ensuring minimal wastage just like any other case of non-renewable resource. Once depleted the quarried areas should be restored through processes of backfilling and following the environmental guidelines and mitigating the adverse effects of the quarrying activities.

Quarrying also has implications on other areas of national development including transport, urban and regional planning, agriculture, environmental management and housing. Being a primary activity, quarrying activities determine the rate of activities in the associated sectors mentioned and it's in turn influenced by the activities of other sectors; for instance, demand of building materials which include quarried materials.

Quarrying in Embakasi area like in other areas is both capital and labour intensive. The use of machinery is restricted to drilling of deep shallow shafts that are filled with explosives to aid in blasting. The blasted rocks range in size from small particles, to small and medium stones to large boulders. The large boulders are then fragmented by means of either human labour or machinery to preferable volumes that can be fed to the crushing plant. The crushing of boulders results into aggregates of distinct sizes.

2.2 Quarrying process

The process begins with a detailed three-dimensional survey of the quarry face (Ramcharan, 2008). This allows the explosives expert to design the blast and to plot where the shot holes should be drilled so that the blast can be carried out safely and efficiently. The survey shows if there are any bulges or hollows in the face. A bulge will need more explosive than normal to ensure that it is completely fragmented and not left in place in the face. Hollow areas require less explosive than normal. The placement of explosives is professionally planned to ensure that the required fragmentation of the rock is achieved with the minimum environmental impact.

After the face profiling survey, bulges within the ground are removed first by ground levelling and then drilling commences, and this may require the use of an air operated drilling rig, drilling at the marked spots corresponding to the hole positions on the blast design, and at the angles and depths required for determined material removal. The drilling action consists of two drillers facing each other, rotating the chirange clockwise and anti-clockwise in continuous motion. Water is then added and the pole withdrawn, thus, removing the stone dust that has accumulated from the drilling process. After the shot holes have been drilled, they are surveyed to check that they correspond to the blast design and the two surveys are combined to allow the blasting operatives to work out how the shot holes are to be filled with explosives. When blasting, a detonator cord is placed in each hole and the holes are then loaded with high explosives to within a few metres of the top (Dey, 2008). The remaining depth is filled with quarry dust or fine aggregate to act as the explosives cover. The site is then cleared and for precaution a siren sounded or a red flag is waved or both in order to ensure that everyone nearby is warned. The detonators are connected to the electric trigger wire and only when all is done, does the shot firer set off the explosives. A single blast can fragment up to 20,000 tonnes of rock. When a blast is detonated, some energy escapes into the atmosphere causing disturbances in the air. Part of this disturbance is sub-audible (air concussion) and part can be heard (noise). Poorly designed or poorly controlled blasts may cause rocks to be projected long distances from the blast site (flying rock), which can be a serious hazard to both the quarry workers themselves and the neighbourhood. After the blast, the face and shot pile are inspected to check that all the shot holes have fired correctly and all explosive detonated. Boulders which are too big to go through the crusher are set to one side for secondary breaking at a later date. Secondary breaking is typically done using a hydraulic digger fitted with a rock hammer, though crawler cranes with steel drop-balls may be used in some quarries.

Crushing is done in three or four stages, primary (first stage), secondary (second stage), tertiary (third stage) and, in some quarries, a quaternary (fourth stage). Crushed rock, or product, is transported along the process line on conveyor belts or down chutes. The primary crusher is fed via a chute and vibrating feeder. The base of the feeder is made of steel bars and it is here that the first screening operation is done. Fine material and dust produced by the blast, along with any remaining subsoil or weathered rock from the top of the quarry face, drops through the bars onto a separate conveyor belt and onto a stockpile (Northstone materials). Primary crushing is usually by a jaw crusher consisting of a heavy metal plate which moves backwards and forwards against a fixed plate. The moving plate is kept in motion and given its crushing energy by a large flywheel. The crusher is wider at the top than at the bottom. Rock from the quarry face is fed into the top of the crusher and crushed rock falls out of the bottom of the jaws. The size of the crushed stone which passes through the jaws is partly governed by the gap set at the bottom of the jaws, though larger size rocks can pass through if the rock being crushed is slabby or elongate in shape (Northstone materials). The output from the primary crusher is conveyed onto the primary stockpile from which the secondary crusher is fed. There is a screen house just after the secondary crusher which screens out small size crushed stone and dust onto blinding stockpiles. The larger sized stones pass through to the final crushing stages where they are fed through a series of cone crushers and screens. The output from the final cone crushers is conveyed to a screen house where large multiple deck screens sort the crushed stone into the required aggregate sizes by constant vibration which is achieved by the mounted motor or diesel driven machine. Secondary, tertiary and quaternary crushers operate on the principle of a steel mantle mounted on an eccentric bearing and vertical shaft assembly. As the mantle gyrates inside the concave, the gap between it and the concave at any one point opens and closes on each gyration, this produces the required crushing action. Stone is fed in at the top and crushed product falls out from the bottom of the cone (Northstone materials). The positioning of the mantle can be raised or lowered within the concave, allowing the gap, and therefore the size of the crushed aggregate, to be varied to a considerable degree and thus ensuring that each stage of crushing produces progressively smaller sized stones. In order to produce a usable end-product, the crushed rock has to be screened into various size categories. Screening is carried out at various stages in the crushing process (Northstone materials). Screens are basically box frames into which sheets of screen meshes of the required apertures are inserted, clamped and tensioned. Screens are usually multi-deck", i.e., two or more screen meshes are stacked vertically within the screen frame. The whole screening compartment is coupled to its support frame by springs or resilient rubber mountings. Screens are made to vibrate by a rotating transverse shaft. The shaft is machined to be unbalanced, and when driven by an electric motor by v-belts, the required vibratory motion to agitate the aggregate is imparted (China South mining machinery co ltd). Screen decks are mounted at a determined angle so that the aggregate moves down them. Aggregate is fed onto the high end of the top deck and the vibration causes the aggregate to jiggle down the screen until it either drops through a mesh aperture or falls off the end of a deck (Northstone materials). The aggregate is then sorted or 'screened' according to the mesh sizes fitted, from large aperture mesh at the top, to small aperture mesh at the bottom. The limiting sizes are based on laboratory test sieves with a square aperture (small aperture sizes are of woven wire mesh, larger sizes of perforated plate). However, screen mesh apertures are, as a rule of thumb, 2mm greater than the specified sieve sizes. This is to account for screening plant efficiency. Screen mesh sizes are chosen with regard to the nature of the aggregate being crushed (e.g., shape –cubical, flaky, elongate, or any combination), and the characteristics of the screen e.g., screen efficiency, throughput, and whether screen is over, under, or correctly loaded (Northstone materials). In many instances the dust forms substitutes to sand. Courser aggregates range in size from 10mm to 50mm and are used in casting of construction blocks while the larger aggregates are used as aggregates in the reinforcement of steel in construction as well as in providing firm base for rail lines.

2.3 Quarry products

A stone quarry typically produces different products: This includes, large size blocks blasted from the quarry face, from approximately 0.5 cubic metres (approximately 0.36 tonne weight) to 1.25 cubic metres. Those measuring less than 0.5 cubic metres or (approximately 5-6 tonne weight), are referred to as rip rap or rock armour and are used in coastal and river flood defence schemes to shore up sea fronts and river banks. The rubble drawn direct from the shot pile is called face fill and is used as large scale fill on construction sites. Material screened immediately prior to primary crushing is called scalping and is also used as fill on construction sites. The direct, unscreened output from a crusher contains a complete mix of sizes from dust up to the maximum size that the crusher can pass. Output from the primary and secondary crushers is fed, unscreened, to intermediate or separate stockpiles. Material drawn from these stockpiles is called crusher run and is used for construction fill. Screened out fine material from the secondary crusher is called blinding. Some screens have multiple decks and can screen out several grades of blinding. As with run, blinding materials contain a mix of sizes, from the maximum size that the screen mesh can pass, down to dust. Blinding, because it is finer than crusher run, is used for final shaping up of construction sub bases, particularly in road construction, where the sub base is the last unbound layer before coated materials are laid. Screened aggregate is heated and mixed with bitumen, according to certain recipe proportions, to make different grades of bituminous, or, mixed with sand, ground limestone filler and bitumen, to make hot rolled asphalt. The words tar or tarmac, though very frequently used, are incorrect as tar is no longer available. For coated materials, bitumen, derived from the distillation of petroleum crudes, has been in almost universal use as a binder for the last four to five decades. 2.5 Impacts of quarrying on the environment, land use and physical facilities 2.5.1 Global perspective 2.5.1.2 Quarrying in Lebanon The famed biblical cedars of Lebanon are fast disappearing courtesy of the quarry Mafia in the forested mountainous regions of this country (Hayat, 2016). Lebanon has been the most forested country among its neighbours. The proliferation of quarries began in the early 1990s, at the end of the civil war, as the country tried to rebuild itself after 15 years of a large-scale destruction. While quarrying can be performed in a sustainable way, most of the country's quarries are illegal, unregulated, and are rapidly flattening Lebanon's mountains. This has caused environment problems due to the chaotic approach of destruction of the forest and trees and thus affecting climate. On landform, years of unregulated quarrying has left hundreds of abandoned quarries across Lebanon (Khater, 2010). Lebanon, located on the eastern shores of the Mediterranean Sea has a typical Mediterranean climate with a complex geomorphology and average annual rainfall ranging from 400 mm in the inlands (semi-arid bioclimatic zone) to 700 mm on the coast (sub humid bioclimatic zone), and up to 1400 mm in the mountains (peri-humid bioclimatic zone) (Abi Saleh, 1996). With a country that has expansive dry and desert regions, it would be environmentally affordable if quarrying was concentrated on such land; of which it is not the case. In Lebanon, quarrying activities exert increasing pressure on limited soil and water resources, thus accelerating erosion processes and subsequent destruction of existing arable lands (Dharwesh, 2004). Despite the existence of several regulations providing the legal framework for quarry exploitation and management, and even with the promulgation of laws defining measures and rules to manage and preserve natural landscapes in Lebanon, quarries steadily expanded in a largely unregulated manner. The spatial distribution of quarries over Lebanon has followed the same trend as urban development, by predominantly encroaching upon forest and arable lands. A total of 32.5 per cent of quarries were located in Mount Lebanon before 1989. By 2005, the percentage of quarries decreased in Mount Lebanon due to saturation (Dharwesh,2011). In Lebanon, most quarries are located on sloping lands (62.2 per cent) and steep or very steep slopes. Quarries in this topography frequently have a negative visual impact in addition to causing increased susceptibility to landslides, soil loss and mass movements. Quarries located on steep slopes, particularly those with fragile lithology and restricted drainage, are the most exposed to erosion processes and mass movement (Abdallah, 2005). Rapid urban expansion in Lebanon during the 1990s was accompanied by an increased need for construction material (Faour, 2005). Due to the lack of integrated land use planning, quarries did not expand according to land suitability leading to hundreds of scars over the territory (Khawlie, 1999). Rocky lands were the most affected by quarries (2240 ha) representing 1.03 per cent of total rocky lands in Lebanon, estimated as (217 000 ha). However, even if rocky lands are commonly regarded as non-arable lands and low productivity wasteland, they nevertheless represent a valuable natural water recharge zone and an important potential ecotourism attraction. Many quarries occur on fissured karst bedrock, which increases the risk of adverse effects on ground water quality beside the loss of the natural karst landscape. For the last two decades, the expansion of open quarries to urban areas of Lebanon caused a decline of land values and apartment prices estimated at 156.2 million US $ (World Bank, 2007).This provoked localized landslides and vertical cracks in the walls and destabilized the buildings resulting in population displacement Assessing the environmental impact of quarrying, which represents an important economic and development activity encroaching upon natural resources, could help to orient land use planning by suggesting answers to whetherland areas that have the greatest ecological resilience to disturbance could be the most suitable regions for quarries. In the absence of restoration plans, the cost of land degradation can be compared with the income from quarrying activities. Even action-oriented plans resulted in low and moderate survival rate of reforested areas, varying between 10 and 40 per cent (ECODIT, 2002). The economic need for quarries as a source of construction material does not justify the mismanagement of scarce eastern Mediterranean soil-forest ecosystems. Past and current quarrying activities have exerted great pressure on natural resources and the state of the environment in Lebanon. The country needs to develop quarries as a means for urban development; however, quarries should be integrated into national and regional master plans. Quarrying legislation in Lebanon until 1996, Quarries in Lebanon were regulated by a decree that was issued during the French mandate period (Decree 235, 1935). This decree mainly set guidelines on technical issues and did not regulate the licensing procedure. As a result, there were no set conditions or guidelines for obtaining a license and various government entities issued quarrying licenses. In 1994, with the first minister of environment, the council of ministers issued decree 5616 that clarified the regulatory framework and regulated the licensing procedure (making the Ministry of environment the sole government entity permitted to issue licenses). The National Council for Quarrying (NCQ), a committee that comprised of representatives from different ministries, was established under the jurisdiction of the ministry of environment to provide recommendations to the ministry on the quarrying sector. However, in 1995, the Council of ministers repealed decree 5616 stating that the Ministry of environment had overstepped its jurisdiction.

Subsequent Ministers pushed for an adoption of a quarry masterplan but were never approved by the Council of Ministers. The quarry legislation stayed in this state until 2002. During this time, quarry licenses were being issued by different government entities and quarries operated throughout the country. The Cabinet passed decree 8803 in 2002 which finally regulated the licensing process. The decree allowed quarrying activities to be operated freely in the Anti-Lebanon mountain range bordering Syria. Outside that region, quarries were to be regulated and the NCQ responsible for issuing licenses. Despite this being a promising step, the decree lacked enforcement mechanisms making it easy for quarry owners to bypass it. In 2010, 8 years after Decree 8803 was issued, there were an estimated 700 to 1,300 illegal quarries in Lebanon. The lack of regulation and high profits had attracted many influential people, including politicians, to invest in these quarries.

2.5.2 Continental perspectives 2.5.2.1 South Eastern Nigeria

The Ebonyi State located in the south eastern region of Nigeria is bounded to the north by Benue State, to the west by Enugu State, to the east by Cross River State and to the south by Abia State. The climate is situated within the Warm-Humid Equatorial climatic belt. It falls within the rainforest belt of Eastern Nigeria. The area is characterized by high relative humidity of about 75% and surface temperature of about 27° to 30ºC. The state also has great potential for solid minerals exploitation and mineral-based industries. The issue of land degradation as an emerging phenomenon, negatively on the biodiversity and the vegetation (Akanwa, 2007). A study done on the region identified that open cast system of quarrying causes massive damage to land and vegetation cover. It also identified the spatial pattern of quarrying activities in the six Local Government Areas for Ebonyi State where quarrying activities are concentrated and active. It also explained the quarrying area magnitude, distribution and the rate of de-vegetation of quarrying activities. The area extent of quarrying activities in Ebonyi state is 402.855 hectares. The continued extraction of stone at the unprecedented rate without the strict enforcement of government policies, guidelines and monitoring poses a serious threat to vegetation cover (Osibajo, 2003). This is contrary to the goal of sustainable development and may further escalate other environmental problems. Open pit quarrying method was mostly employed during the quarrying process in Ebonyi State. It is mostly associated with massive environmental damage to the vegetation cover. However, there is need to reduce its negative effects on the environment by paying close attention to geology of the area, geotechnical planning, scheduling of earthmoving equipment, drill and blast technology and safety through constant monitoring and improvement (CEMAC, 2007).

2.5.3 Local Perspective& theoretical framework

(Okoko and Kamwelle, 2015) conducted a study on the impacts of stone quarrying in Thika municipality. The study examined the continued alienation of agricultural viable land to quarrying. The study highlighted the land use conflict between agriculture and the extractive industry of quarrying. The conflict between the two government/ regulatory agencies, i.e. the County authority and the National Environmental Management agency. This scenario was replicated went NEMA withdrew the licence of one quarry and those stopping its operations leading to protest by the County authority. The study also explained the mushrooming of illegal structures around the quarry sites. The illegal structures provide accommodation to the quarry workers many of whom are immigrants to the quarry areas.

(Musyoka, 1997) conducted a study in Kangundo division on the impact of quarrying to the environment and land use. The study observed the land degradation on steep slopes and the consequent soil erosion that resulted due to surface run-offs. The study observed the rise of construction industry in other areas had both positive and negative impacts on the environment and land use. This study compares with the study by (Okoko and Kamwele, 2015) in that quarrying in both cases is on private and freehold parcels of land and thus restrictive in enforcement of procedures and practices.

(Waweru and Mukundi, 2015). The study was centered on post quarry land use and along Ndarugu river in Kiambu County. The study established that there are no attempts that are employed towards full restoration of the quarries upon depletion of the dimension stones resource. The study observed that the only measure adopted towards quarry site restoration was backfilling with dump soils without an attempt to levelling the dump soil. This scenario was noted as leading to declining acreage of land per household that can be exploited for agriculture or any other land dependent activity. The study noted that most of the former quarries turned to man-made dams and those posing more harm to the neighborhood.

(Mogambi and Mohamed, 2016). The study conducted in Mandera County focused on the economic and environmental impact of stone quarrying in Mandera County. The study observed that quarrying has a positive impact on the livelihoods of the local community than the predominant nomadic pastoralism. However, the study also noted the depletion of vegetation cover in search of the suitable rock structure and the lack of conservation of the soil over-burden leading to massive erosion. The lack of measures towards quarried land reclamation was also observed as part of land degradation.

(Mathu, Nyamai and Ngecu, 2003) conducted a study in the Tala, Kangundo. The study focused on the environmental impacts of quarrying. The study observed the lack of rehabilitation of quarries upon cessation of quarries as well as the degradation of beautiful landscapes and grazing fields. The study also noted land degradation by the quarry sites having become eyesores with extensive and numerous heaps of dumps of unused quarry rock fragments. The open and unguarded quarries were also noted to pose dangers to both animals and humans.

The impacts of quarrying in Kenya cannot be well understood without focusing on the major cement factories in the country. Bamburi cement factory, Athi river Portland cement are the oldest cement factories in Kenya. Bamburi cement that forms the factory located in Mombasa is the oldest cement factory in the country having started operations in 1954. Over the years, the quarrying of the quarrying of the Portland stone that forms the main ingredient has led to massive depletion of material from the cement quarries. By the early 1970's the first quarry site had been depleted of this resource and had posed a big environmental challenge. This led to attempts to rehabilitate the quarries which later turned to a successful story under Dr. Rene

Haller. The Haller park, named after Dr. Haller is now an eco-tourism site and a good example on quarry site reclamation.

In recent years, Mavoko area of Machokos County has become the epicenter of the impacts of quarry activities. Until the year, 2000, the only cement factory in the area was Athi River Portland cement. Lately other companies namely, Simba cement, Mombasa cement and Savanna cement have also opened quarries and plants in the area. This concentration of dust industries has resulted to both land degradation and air pollution of Mavoko area. The naked emission of dust from this plants and quarries is a good example of the neglect of environmental consciousness in the country.

2.6 Impacts of quarrying on the health of neighbouring communities. A case of the lower Manya Krobo district of the eastern region of Ghana

Potential health impacts are almost exclusively linked to the presence of airborne dusts, have the potential to affect human health, including effects on the respiratory and cardiovascular systems (Banez, 2005). A survey of the communities and the quarries by the chemistry department, University of Ghana in 2012, revealed worrying issues concerning the impacts of the mining activity on the environment which included impact on buildings, farmlands, crops and water systems (Kadzo,2012). Several buildings were observed to have developed different degrees of cracks with some near collapse. These cracks were basically due to strong vibrations coming from rock blasting. It was observed that farmlands are flooded by waters pumped from the quarry pits and run- offs. Dust from rock processing and unpaved (dusty) roads settle on crops and other plants as a result of sedimentation. High concentrations of dust on the plants result in poor plant performance and yield.

Cases of cough were on the increase with pneumonia and eye infections noticeable among the people. Water related sicknesses, noticeably malaria infection rose significantly from 2005 onwards and cases of diarrhea also rose slightly. There was also an observed rise in cough, pneumonia, chest pains, Headache, eye infection, ear infection and asthma have also increased significantly. The increase in respiratory tract infection from 2005 was attributed to patients suffering from the effects of quarry dust. Records of some water-related or borne diseases obtained from local clinics showed an upsurge in malaria cases from 2005 to 2010.

There was also high malaria infection was attributed to flooded lands as a result of quarrying leading to mosquito breeding in stagnant waters created by the quarrying activities. All dust related diseases had risen sharply from 2005 to the time of the study. The most observable diseases were cough, chest pains, common cold headache, pneumonia, asthma, ATI and eye infection.

Best practice in quarry management: case of Somerset county UK

Quarrying in Somerset, UK, has been declining since the late 1800's when quarrying was most robust (Burr, 1996). In 1898 there were 54 working quarries in the region. The construction of roads canal-building enterprises and a reasonable network of railways and tramways in the 1870's led to the establishment and growth of twelve quarries by the County. Thereafter, many other private quarries were licensed to cater for the rising demand of quarried material for the growing construction sector. In modern times the demand for Mendips stone in Somerset County is due to the technical requirements for roads and building which dictate less use of sand and gravel with preference to hard rock crushed aggregate sourced from Mendips which has the major advantage of strength to withstand traffic weight.

Despite rationalization in the 1930s, there were still 44 quarries active in 1948. By 1971 this had fallen to about 24 and had halved again by 1984 and by only ten quarries were operational by 2006 (British geological survey, 2008). However, the volumes of extracted materials have increased efficiency and mechanization. The bulk of the scheduled areas consist of permission granted in the period between 1946-1948 by the district exercising planning powers under the town and planning Act ,1932. Since 1948, the Somerset County Council became the planning authority, concessions became rigourous to be granted with many conditions being imposed to safeguard environmental balance. This policy was justified by the bold statement that existing concessions contain adequate reserves for the next hundred years. By 1965, the ratio of the already quarried land to the total available land was 1: 72 acres (Frank, 1994)

Like in all quarrying regions, there has been disputes with neighbouring residents. The destruction of Milton and Dulcote hills by the quarries led to dispute with citizens (Stanton, 1965). The resulting public enquiry determined that quarrying must continue. But Bleadon hill was spared with reasoning that areas of great landscape value needed preservation. The major physical problems encountered in Mendips is the destruction of the countryside and especially the many hills that are dominant in the area and thus impacting negatively on tourism (King, 2000).

The breaking into hitherto unknown caves is another major problem in the Mendips. Such caves are normally destroyed as the extraction of stones proceed. The result has been difficulties and great loss of stone when such caves are encountered (Gunn and Bailey, 1993)

Disruption of ground water by quarrying is another problem encountered in Somerset County. Fairy Cave quarry for instance opened the hillside between St. Duncan's well, which is a large and complex spring supplying water and the springs feeding it. The quarry operations broke into the whole series of underground passages, waterways and chambers. This risk has continued to grow as the quarry extends (British geological survey, 2010).

The mineral operators submit planning applications for quarrying operations. Such applications must normally be accompanied by an Environmental Statement setting out the measures proposed to be taken to reduce the inevitable environmental impact.

The local planning authority (LPA) which takes the decision on the planning application normally in relation to mineral operations. This is the County or Unitary Council relating to the location where the proposed operations are to take place; (e.g. in relation to the Mendips, Somerset County Council). The planning authorities when taking the decision, must weigh up all the factors such as the local and national need for the extracted stone, the environmental impact of the operations, the local economic benefits and views of the local community (Bishop, 2000). In making these judgements they may well refer to local planning documents which they have previously adopted (e.g. a Minerals Local Plan). When planning permission is granted, conditions are attached setting out requirements which must be met, for example restriction on hours of working, landscaping requirements, limits on noise levels (Cullingworth,2002). The monitors operations and, if conditions are not being met, enforcement action can be taken to ensure that they are. The Government, through the Secretary of State for the Environment, the Regions and Transport. This involvement usually applies if the mineral operator's planning application is refused by the local planning authority or agreed but with conditions unacceptable to the operator. The Secretary of State will give a decision on an application after a Public Inquiry has been held before an Inspector. At the inquiry all the different arguments both for and against the proposed operations are examined. Again the policies in the Local Plan will be a key issue, but also national government policies on mineral issues.

The Planning Officer working for a Local Planning Authority is involved in a number of ways during the licensing processes.

-Preparation of a Minerals Local Plan: this sets out policies regarding the location of, and conditions required for the future working of minerals.

-Assessment of Planning Applications; reporting on these to the Local Planning Authority Committee, usually recommending approval or refusal of the application negotiating with the mineral Operator and seeking clarification on the proposals and possible improvements/changes.

-Monitoring the operations; to ensure that the planning conditions are being met and if necessary, initiating enforcement action.

-Explaining the proposals to the local community and organizations (e.g. Parish Council)

-Defending the Local Planning Authority's decision at a Public Inquiry if permission is refused (Toke, 2005).

Landscaping

In many cases quarry workings are screened from view by landscaped banks - often planted with mature trees, shrubs and plants. These help screen the quarrying activities and also create good wildlife habitats, enhancing the local ecology. Such actions go some way to compensating for the inevitable impact of quarry working on local flora and fauna.

Dust Control

Inevitably the blasting, processing and transport of rock products produce large amounts of dust. To tackle and reduce this problem, most new processing plants are enclosed and water spraying is undertaken in many areas - e.g. on road ways within the quarry area. Lorry wheel cleansing facilities reduce the amount of mud and dust carried on to public roads. In practice, some of the dust control measures are not always fully successful and problems do arise.

Noise and vibration reduction

Quarry operations are noisy and create vibrations. Blasting poses the danger of fracturing of quarry walls, increasing permeability and increasing drainage towards quarry face (Gagen,1987). Reduction techniques include careful siting of processing plants, appropriate cladding of buildings and the fitting of silencers to static and moving machinery. At night, flashing reversing lights replace 'bleepers' on quarry vehicles.

Control of operations

The hours of operation are controlled through the terms of the planning permission. The planning authority in Somerset through its regulations ensures that no quarrying is carried out during holidays or at night during weekends.

Restoration and after-use

Old sites of mineral working which have been left to regenerate naturally often provide good, relatively undisturbed habitats for flora and fauna - indeed several such sites in the Mendips have been designated as Sites of Special Scientific Interest by English Nature, the Government's nature conservation agency (Gun and Bailey,1993). Modern quarrying techniques today incorporate phased restoration of worked out areas in parallel with continuing extraction. New planting techniques encourage rapid establishment of vegetation. Some completed quarries may become nature reserves or open spaces for leisure and recreation, while others are backfilled and returned to agricultural use. Further option that is adopted considers the use of former quarry as locations for the disposal of waste. Such proposals like in many other areas bring as much, or even more, controversy than the original mineral extraction operations.

2.7 Impacts of environmental impact assessment and audits in quarry areas

Due to diverse impacts, quarrying projects have significant environmental and social footprint, caused primarily due to change in land use and release of significant amounts of dust that is generated during various activities such as drilling, blasting; excavation, breaking, stockpiling, conveying, loading etc.

The magnitude of environmental and social impacts of mining and quarry project depends on the size of the project and location sensitivity (Ayodele, 2008). The mode of extraction and selection of mining technology depends on the mine characteristics such as geology, depth, thickness and configuration of the mineral. Besides geological setting, economic and environmental considerations also influence mining methods (Environmental assessment guideline for mines and quarries in India, 2012). The initial stages of mine or quarry development, the impacts include loss of biodiversity due to forestland diversion and land clearing; displacement, diversion of agricultural land; loss of local water resources due to reduction in catchment areas and destruction of streams and natural drains. Some other land-related impacts such as air and water pollution from waste dumps are more pronounced at the operational stages. Post-operational impacts stand out prominently when reclamation is not carried out properly.

In open-cast mining projects, these impacts on land depend on a number of factors: the existing land use pattern, topography of the area, characteristic of deposit, stripping ratio, mining technology and quarry depth.

Impact on environment

The degradation process usually starts with on-site destruction of natural habitat, continues with sheet erosion of the thin soil film formed from the weathering of exposed hard rocks, and ends up with the alteration of biodiversity and modification of natural recolonization (Khater, 2004). The impact of mining on air starts from the exploration phase, increases during the operational phases, and extends beyond the mine or quarry closure. Quarrying operations have very high impact on both the quality and quantity of water resources – both groundwater and surface water. Water is used for activities such as dust suppression — spraying on haul roads, conveyors, waste dumps, loading and unloading points etc.

The water consumption at a mine site depends on the size, method of mining, environmental consciousness and the equipment used. Quarries also reduce the surface water resources by disturbing the catchment area and by destroying streams and natural drains in the lease area. The impact is more pronounced on the local communities if they depend on these streams and waterways to meet their water requirements (Lameed, 2010). The severity of impact on water resource depends on a number of factors: drainage patterns, the hydrology of the area, characteristics of the water, wastewater being discharged from the mine and the quantity of discharge, chemical composition of the mineral and overburden. If a quarry intersects the water table, ground water commonly will flow out of the rock into the quarry. Water may just trickle into the quarry or it may flow into the quarry at a rate of hundreds or thousands of litres per second (L/s), especially if quarrying intercepts, a phreatic conduit (Foose,1953).

Dust from quarries is an ever present feature throughout the quarrying process. During site clearing, all the soil over-burden is removed and carted from the proposed quarry face. The huge earth movers carting away the soil cannot work well during rainy seasons when dust is suppressed. Working during the dry weather is thus preferred and thus creating dust into the environment. Drilling, blasting, and crushing of the blasted rocks are also dust producing processes. The heavy earth moving equipment transporting the quarry stones within the quarry and outside the quarry continually release dust to the environment. The emitted dust has greater negative effect on the flora proximate to the quarries. The effect of this is stunted growth and production due to clogged pores (Vediya, 2014)

Noise and vibration

Besides affecting the locals, the noise from blasting and transport activities has caused migration from the surrounding areas, affecting ecological balance by disrupting the food chain (Muyandri, 1998). High level of noise is a key concern in mining and quarry projects. Noise pollution from quarry operations is caused during drilling, blasting, loading and unloading, transportation and crushing, etc. This leads to occupational hazards and causes annoyance to the local community (when human settlements are located close to the quarries or when the transport route passes through human habitation). On underground water, shock waves from blasting operations poses the danger of loosening clay particles from solution cavities causing “muddying” of the ground water(Spigner,1978).

2.8 Best quarrying practices.

Mitigation is the process of providing solutions to prevent impacts, or reduce them to acceptable levels (Environmental assessment guideline for quarries, India, 2012). Mitigation is aimed at enhancing the environmental and social benefits of the proposed quarry, minimizing the adverse impacts and to ensure that the residual adverse impacts are kept within acceptable levels. A good mining project should incorporate environmental and social alternatives at the initial stages of project development. However, there are some which are only managed after impact identification and prediction.

The EMP discusses the mitigation measures to be taken against each impact, the timeline for completion, the responsible departments for implementation, the budget for the EMP, post monitoring provisions and reporting to the concerned regulatory authority.

Mitigation for land

Quarrying starts with the scrapping of the topsoil prior to drilling and blasting. The scrapped top soil being the most fertile soil should be earmarked for agricultural use either within the quarry site or be made available to those in need of the resource.If it is not possible to use the topsoil immediately, then it should be stacked at a designated area. The location of the storage site should ensure that it does not lead to erosion. The probability of erosion is high if the storage site is proposed at an elevated area. The stacked topsoil heap's height should not exceed more than 6 meters to avoid over exposure to wind erosion. The soil stack must be done in a pyramidal form, with garland drains all around to control erosion by water run-off. In case the topsoil is to be stored for a long duration, it should have a vegetative cover of, preferably, leguminous species (grasses and shrubs).The vegetation needs to be grown to stop the erosion of soil so that the fertility derived from the fixing bacteria can be leached down the soil strata and thus improving the fertility of the entire heap/mould and improve aesthetic value. The stockpiled, overburden or topsoil materials should also be protected by silt arrestors such as garlands, so that the loose material does not flow away or escape. If biological reclamation is not done in time, leaching will drain away the nutrients and impair the nutrient cycle, thereby making the soil unproductive.

Mitigation for water

Quarry pits cover large areas of land. Some pits cover almost a hundred metres. This wide expanse is likely to affect the drainage patterns of the local area more so if the topography is steep. The diversion of the natural flood patterns should be mitigated as this can render the surrounding areas more prone to erosion. There should thus be detailed mitigation measures for local catchment area improvement. The mitigation measures should encompass information on the design of sedimentation pond for handling run-off and quarry seepage. The local community's water needs, if affected by the quarry operation should be met through a water assistance plan. Committees for overseeing this plan should be formed in conjunction with the quarry management. If applicable, treated quarry seepage water should be utilized as far as possible to meet the needs of the mining operation, the township, as well as the local community, wherever applicable. However, the quarry water should be used for domestic purposes only after an assessment of its quality.

The disposal of quarry seepage water or the water resulting from the raised water table during the rainy season should be treated in a treatment plant and discharged into the water bodies as per the standards, or supplied to local communities free of cost for agricultural activities. Physical and chemical characterization of the water is advisable prior to its reuse for agricultural purposes. The water should be pumped out only after the rains have subsided otherwise this can lead to increased flooding downstream. Gabion walls (loose boulders packed in wired crates) should be provided at the toe of active dumps and across the water course with filter pads to check the silt from escaping into the water body. Peripheral bunds should also be created on the outer edge of abandoned benches before reclamation, so as to minimize any surface run-off by storm water. Water gradients should be kept at every bench, towards the inside, to prevent the formation of gullies in the bench slopes; these gullies can cause serious erosion though this can be mitigated if the stockpiled, overburden and topsoil is placed in a stable area which is less prone to erosion. This would, in turn, reduce the silt load on water bodies.

Waste water in quarries is the product of the method of sewerage employed in the quarry. Since most quarries are sited in far flung areas away from other land uses, septic tanks and soak pits have largely been used in quarry sewer disposal and lately sewer bio digesters. Details of sewage treatment plant (STP) in the quarry and effluent treatment plant (ETP) in the quarry should be presented to the local planning authority, the local public health office and in the environmental office for approval. The submission of this plan cannot be done in isolation without the submission of a comprehensive environmental management plan (EMP). The EMP should also mention the treatment technology, layout plan and final disposal of treated wastewater.

Mitigation for air quality

Air pollution resulting from quarry activities has the biggest footprint as compared to land and noise pollution. The dust emanating from the activities of drilling, blasting, crushing and transportation within the quarry. There is also dust from material handling, loading and unloading and storage. The quarry is supposed to detail the dust mitigation in all the stages mentioned above. To address the levels of emissions the quarry is expected to explain the level of mechanization incorporated in the quarry management. The EMP should ensure that the impact of air pollution does not exceed statutory limits or cause undesirable effects on human health. The dust emitted while drilling is mitigated by the use of hydraulic drills with automatic water feed. The water feed ensures that the surface being drilled is moist and thus emitting less or no dust.

Dust produced during blasting remains a challenge even in advanced mining processes. However, this can be mitigated by employing weather observation patterns. No blasting should be done during windy and dry weather. The dust emitted while blasting is nevertheless insignificant considering that blasting is not a regular activity in quarries as one blast can produce material that can used for a long period of time. The crushing plant is usually the biggest contributor of dust to the environment. This is mitigated by watering the materials as they are fed to the crusher. The crushing plant need securing all round by use of dust absorbent fabric to act as dust sieve. Dust from material transportation from the pit calls for consistent watering of the quarry route during the entire working hours. The same procedure is useful in mitigating dust emitted by customer trucks. A water bath at the quarry entrance and exit is a mandatory requirement. This is aimed to eliminate all the dust in the truck tires. The trucks are also supposed to be covered to mitigate the spread of dust during material transportation.

Systematic and planned green belt development so as to reduce fugitive dust and check run-off, besides improving the aesthetic beauty of the quarry. Planning for green belt development should be done at the inception.

Mitigation for socio-economic impacts

Preparation of a Resettlement and Rehabilitation plan (R&R), if displacement of communities is involved in the establishment of a quarry. The plan should include details of the compensation provided, including land-for-land compensation, employment or money; provisions at the resettlement colony (such as basic amenities including housing, educational facilities, infrastructure and alternate livelihood potential); a clear timeline for implementation; responsibility; budgets; grievance mechanism, etc.

The resettlement and rehabilitation plan should analyze and take into consideration the impact of displacement on women and vulnerable communities such as landless labourers, etc., and prepare a detailed management plan to improve their status. Such groups are identified as first beneficiaries of the quarry operations. A detailed compensation package for the community likely to lose their livelihood due to diversion of forest or agricultural land needs to be put in place. Other benefits like employment and business opportunities emanating from the quarry activities are also expected to benefit the affected or neighbourhood communities.

Mitigation plans geared towards improvement and enhancement of the socio-economic condition in and around the project site must be submitted to the planning authorities and to the communities as well. This plans may include the setting up of community centres like social halls, schools, health facilities etc. The regulatory agencies should ensure that these facilities are done prior to the commencement of quarrying operations. The socio- economic plan should also incorporate the occupational health and safety of the workers or the socio- economic plans for the two groups i.e. the workers and the neigbouring communities be intergrated.

Water conservation and management

With regard to water conservation and management, the best quarrying practices should ensure that:

- The surface layout of open-cast mines in such a way that the impact on water bodies as well the surface drainage system remains minimal.
- Natural drains or streams should be disturbed as little as possible. However, in case of diversion, re-alignment should be made by constructing artificial drains.
- Constructing check dams to check the silt or runoff from the quarry
- Garland drains should be constructed all around the periphery of the quarry.
- These drains should be connected to the natural drain or routed to water bodies after treatment in a settling pond.
- Non-mineral zones, external waste dumps, haul roads, etc., should be improved by vegetation cover. Higher vegetative cover in the mine areas will reduce siltation and increase the groundwater recharge.
- To assess the impact on local water levels in time and space coordinates, a monitoring network of dug-wells in the zone of influence should be established and the water

levels should be monitored. A location for a piezometer should be selected in consultation with the regulatory authority, if applicable.

Noise and vibration

The best practices in noise and vibration abatement include:

- Use of controlled and advanced blasting techniques like shock tube technology;
- Conducting blasting only during the day time, as per a predetermined time schedule;
- Use of hydraulic drills;
- Provision of sound-insulated chambers for workers deployed on machines producing higher levels of noise like bulldozers, drills, etc.
- Enclosing crusher units in covered buildings to minimize sound propagation;
- Providing silencers or enclosures for noise generating machines such as compressors etc.
- Creating a green belt around potential noise-prone areas
- Provision of protective devices like earmuffs/earplugs to workers, who are continuously exposed to high levels of noise; and
- Reducing the exposure time of workers by practicing work rotation.

Resettlement and rehabilitation

The best practices in land acquisition and R&R are: Land should not be acquired without the consent of the majority of the project affected population (PAP). The project proponent should receive 'free, prior and informed consent' from the PAP.

- The PAP should include not only landholders but also people dependent on land for livelihood like share-croppers, landless labourers, etc.
- The R&R plan should be a comprehensive framework within which compensation, benefit sharing and community development plans are integrated and the roles of local communities, governments and mining companies are clearly delineated.

- Compensation for land should be based on the current market price.
- The R&R plan should be framed in consultation with the PAP.
- The PAP should have a say in the selection of the resettlement site and design of the housing and other infrastructure facilities.

2.9 Policy framework for quarrying in Kenya

The mining act 2016

The quarrying sector in Kenya is regulated by the mining Act 2016. The Act governs issues relating to the exploration, prospecting, mining, processing and dealings in Kenya. The Act establishes the Kenya Geology, Minerals and mining Authority and minerals and mining board and addresses grant of licences and conclusion of mining contracts, conditions for grant of exploration and exploitation licences, the formation and functions of the Kenya Geology, minerals and mining authority and mining and minerals board and the offences prescribed in case of violation (Mining Act, 2016).

The Environmental Management and Coordination Act

(EMCA) address environmental matters relevant to sustainable mineral exploration and exploitation in Kenya by making provisions relevant to regulation of environmental issues arising during exploration and extraction of minerals in Kenya. The Act establishes national environmental principles to provide guidance and coherence to good environmental management.

The Act also makes provisions dealing with issues that cut across all sectors of environmental protection and management including environmental policy, environmental planning, protection and conservation of the environment

In other words, every person entitled to enjoy the right to a clean and healthy environment has a duty to protect the environment and promote sustainable development (EMCA, 1999).

2.10 Legal framework for quarrying in Kenya

The Artisanal Mining Permit as per the mining Act 2016, regulates quarrying in Kenya. It explains the person to be granted the license, where the quarrying is to take place.

2.11 Institutional framework for quarrying in Kenya

The main institution tasked with mining in Kenya is the Mines and Geology department previously under the Ministry of Environment and Mineral resources which now falls under the Ministry of Mining. Under the Mining Act, Cap 306, the department is mandated to carry out geological survey and research of geo-scientific database and information; administration of legislation relating to mineral resources development; mineral and mining policy formulation; advising government on mineral policy matters; supervision of quarry and mine safety; and security of commercial explosives

The key institutions proposed in the Mining act in Kenya are, the Kenya Minerals and Mining Authority, the Kenya Mining Corporation and the Mining Disputes Resolution Tribunal. These institutions are meant to improve the efficiency and effectiveness in mineral resources management and policy implementation Tribunal. The purpose and object of the Geology, Minerals and Mining Authority is to exercise supervision and coordination in all matters relating to geology, minerals and mining and to be the principal instrument of the government in implementing all policies relating to geology, minerals and mining. The authority has the mandate to conduct geo-hazard investigation, mapping and monitoring. The authority is also mandated to monitor and ensure that mining takes into account local and community values. The Minerals and Mining Board is empowered to make recommendations to issue a mining license if it is satisfied with the following conditions:

The area of land over which the mining license is sought is reasonable having regard to the applicants proposed programme of mining operations.

The applicant has adequate financial resources, technical competence and experience in the mining industry, the applicant has obtained an Environmental Impact Assessment license in respect of the proposed mining operation and that the applicants' proposals with respect to employment and training of Kenyan citizens are acceptable.

Buffering quarries

Buffer zones are intended to provide protection of health in core functions, and provide transition towards increasing disturbance of development. Social health is determined by the economic and social conditions that shape the health of individuals, communities, and jurisdictions as a whole (Raphael 2008). Buffer zones are needed in a long term way that protects human health and well-being. The use of buffers will require the consideration of the significance of the operation and other matters outlined in assessing and providing appropriate access to aggregate resources, including the effects likely to be generated from quarrying and reasonable measures taken to internalise them.

In considering the use of a buffer zone, authorities must be satisfied the effects from the activity are internalised as far as is reasonable and consider the appropriate distance to mitigate the effects in question against the significance of the quarrying activity. Compliance with buffers means that effects are measured from the notional boundary of the buffer rather than the site rule. In New Zealand, new dwellings should not be constructed closer than 500 metres to a site used for mineral extraction or where a consent has been granted for mineral extraction. This is typical of Canadian and other international buffer zone standards for quarries. In theresidential activity restriction area, a new residential dwelling is a restricted discretionary activity and must be set back 500 metres from a working quarry.

Quarry buffers also aid in the pacifying social activities like learning in schools especially where learning comprise of young children. This is because young learners are easily distracted by interruptions in the learning environment. Where blasting is involved, this has a higher impact as the hearing abilities of such young children stand the risk of impairment. The authorities also restrict discretion to a number of conditions including the extent to which the dwelling may individually or cumulatively compromise the efficient use of a quarry area or an existing quarry.

The extent of the buffer requirement depends on the size of the quarry, whether blasting is utilised, the nature of production methods, the extent of crushing and screening operations, topography and site conditions and the intensity of surrounding development and land uses. A two level buffer standard is recommended with the primary and secondary buffer as follows:

Primary Buffer Secondary Buffer

Large quarries	500 metres	800 metres
Medium quarries	400 metres	600 metres
Minor quarries	300 metres	500m

2.11 Restoration of quarries

Quarrying has an appalling public image. While the industry can take some of the blame for this, given a historical track record of contempt or ignorance of its impacts, much of this has to do with the fact that the impacts of quarrying are often far more visible than those of other industries(Moutlang,2006). The extent of degradation of any quarry depends on where it is situated and the natural vegetation of the area and the biodiversity surrounding it (ICUN, 2015). Degradation is primarily driven by material extraction leading to deep modification in topography and hydrology, as well as vegetation and soil removal. This degradation though occurring within relatively small areas, but their proximity to modified or in highly valued natural areas explains that, the main social concerns are economic, aesthetic and recreational.

Quarries should be restored to forms suitable to their surroundings once they come to the end of their economic life. The final form should be chosen in consultation with the local community and government. The restoration process varies, depending upon the location of the site and the intended final use. Rehabilitation is progressive, with overburden material and topsoil stockpiled before the beginning of real quarrying. Extraction of minerals is a temporary land use that may last no longer than a decade for sand and gravel and perhaps 40 years for a rock quarry. Restoration of quarries provides opportunities for land use change to new uses such as and not limited to recreational facilities, agriculture, wildlife habitats and country parks that are beneficial to the community. Restoration of quarry land is progressive and involves a return to agriculture – which is also one the easiest to undertake (Down and Stocks, 1978).

order to accommodate its original use or any other type of use suitable for the existing conditions (economic, socio-cultural and physical). Hackett (1977) identified the following objectives of quarry reclamation:

1. To restore the chemical and structural health of the soils. Before reclamation, soils in quarries could have chemical and structural composition that can inhibit plant growth.
2. To restore the health of vegetation in order to enhance biodiversity.
3. To create a safe environment in and around the quarry in order to create opportunities for human activity.
4. To improve the visual and environmental qualities of the quarry landscape.
5. To preserve aspects of interest such as geological features, wildlife, and plant habitats.
6. To create habitats for wildlife and plants. Even though quarrying is an ancient activity, reclamation of quarries in England dates back only to the late 18^{th} Century. Examples of these include coal and iron works in the North east and

Reclamation is a process that involves creation of appropriate landform to support any envisaged post mineral extraction after-use, and creation of appropriate surfaces for the establishment of vegetation. The success of any reclamation scheme is aided by proper implementation of these two processes. The importance of adequate planning for both the extraction and reclamation processes during the planning stages of a quarry cannot be over emphasized (Darmer, 1992).

Planning for reclamation takes into account a number of factors. They include the public's preference for the type of after-use, the intended final topography of the site, depth of the extraction pit, whether extraction was wet or dry, availability of fill material, soil characteristics, availability of top soil, quarry setting, cost, availability of technical expertise, character of the surrounding landscape, and land ownership. These have an influence on the type and choice of reclamation techniques that can be applied as well as the final appearance of the reclaimed quarry landscape.

The success of these techniques lies partly, but more importantly, on the proper management of all processes that precede reclamation (Wolf, 1980). These include site clearing (vegetation removal), stripping of topsoil and subsoil, and the removal of overburden and its storage on or off site.

The mitigation of visual impacts during operation is an important aspect which can be tailored to build up to the final reclamation scheme. However, because of the long life span of quarries, changes in the reclamation scheme envisioned are bound to happen, and thus it is not always possible to ascertain that the post extraction land use and the reclamation scheme that was envisioned during the initial stages of quarry planning will be implemented.

The need for change could be caused by a number of factors, including improvements in reclamation technologies, improvement in technical knowledge, changes in extraction technologies, change in planning policy, and sociological factors (Department of Environment, UK 1995).

The changes in the reclamation plan from a pre-planned path and design calls for reconciliation with the reclamation scheme. This might necessitate updating of the scheme to align it with the new strategies and thus the need for periodic review of the reclamation scheme.

There are two major elements that are of importance in quarry reclamation: landform and vegetation (Cripps et al.,2004). They are the most important aspects that drive the success of quarry reclamation.

It is important that attention is given to the design of the landform at the onset as a foundation for all other elements that will make up the reclaimed landscape (Nicolau, 2003).

Quarry pits have three main components, i.e. the quarry floor, face, and bench. In many situations, the quarry floor becomes the focus for any intended after-use. It can either be flooded or dry depending on the depth of the water table and depth of extraction (Department of Environment,1989). It can also be ripped to develop a suitable planting surface for vegetation establishment. Quarry faces have crevices that attract a variety of plant and animal species and can present an invaluable ecosystem with the least disturbed plant and wildlife habitats (Yundt et JASMR, 2015 Volume 4, Issue 2 60 al.,2002).

Because of their heights and steep slopes quarry faces also attract activities such as rock climbing. Benches on the other hand can be used to provide access to different parts of the quarry for reclamation management, as well as for recreational purposes where public access is allowed.

Overall, there is a great potential for treating these sections of quarries to attain a wide range of landscapes and facilities for both environmental and social benefits. In a spectrum of after-uses of quarries worldwide, there is on one end, landscapes that are purely natural with very little or no human activity like Miller’s Dale Quarry in the Peak District, England, to highly urban, high-tech, and highly used human centred areas, such as the Songjiang hotel in China (Yundt et JASMR, 2015 Volume 4, Issue 2 60 al.,2002).

The three main components of a quarry landform, pit, benches and faces, which make up the quarry wall, present the most challenge in the reclamation process. This is so because of the safety and visual quality challenges they present. They also cause contrast in form and colour between the quarry landform and the undisturbed landscape around quarries. The earth surface of a natural landscape is usually dominated by vertical structure in the form of vegetation, whereas horizontal lines caused by the edges of quarry faces dominate the quarry wall. This causes the quarry landscape to fall out of place with its context (Cripps et al., 2004).

Quarries are hostile environments for plant establishment (Wheater and Cullen, 1997). This is mainly because of poor soils, unavailability of topsoil, steep slopes, and size of the quarries. Topsoil is a very important factor in the success of vegetation establishment in any reclamation schemes (Mouflis et al.,2008; Defra, 2009). Because of its importance, sometimes it has to be imported from outside the reclamation area (Land Use Consultants, 1992), or engineered onsite from soil forming substances. Although they come at a cost, these soils do not always produce desired character of vegetation at their new sites because of their quality (Bradshaw, 1984). This is especially so for limestone quarry sites. Soils that lie above limestone mineral are alkaline and are referred to as calcareous soils. They support calcareous vegetation, which is characterized by grassland with sparse woodlands. The use of highly nutritious soils on these sites may therefore produce vegetation that is out of place with that in its surroundings (Riley and Rimmer, 2003). One of the techniques applied in the industry is to mix the topsoil with limestone dust to mimic the highly alkaline calcareous soils.

There are several techniques that may be applied to reduce the visual impact of quarries and provide potential for the creation of biodiversity, including the creation of rollover slopes, backfilling, bench planting, and restoration blasting (Gunn and Bailey, 1993; Walton et al., 2004). The success of both natural recovery and other schemes, benefit from the use of local soil. The re-establishment of sustainable vegetation is likely to be more successful if locally derived roots and seeds are already present in the soil.

Native plants and seed used in the countryside should be of appropriate origin and from the same region if possible. Local origin stock should be used if the quarry site is adjacent to a Site of special scientific interest or in an ecologically sensitive zone, such as an island, coastal locality or national park. If seed or plants are to be collected, sufficient time and funding should be allocated for this approach. Collections should take place over a period of successive years and may be used to establish stock in cultivation or to establish directly on site.

The proposals for restoration are often designed many years before the quarry is started, and will probably accompany a mineral company's planning application for quarrying. At this point it is essential that the landscaping team includes a qualified ecologist with a good knowledge of native flora. The ecologist must put into context the site in relation to its geographical and ecological setting, identify the potential for incorporating biodiversity into the restoration specification, taking into account other factors (such as land tenure, after-use, soils, geology and final site contours) and specify principles and detail for using and sourcing native flora (including promoting natural regeneration).

The success of reclamation schemes is greatly enhanced by the use of combinations of techniques, sometimes selectively, to address different challenges and achieve an intended outcome. The choice of any one or a combination of the techniques is dependent on: The intended after use of the site, the character of the surrounding landscape, availability of topsoil, availability of fill material, the cost of using any particular technique, the significance and character of the regional landscape, the intended final grade of the site and availability of technical expertise.

The main objectives of restoration of quarries are geared towards the use of the best available technologies in quarry restoration, to improve restoration interventions, developing standardized quality control processes, to promote the rational and sustainable use of natural resources. On the other hand, quarry reclamation should be guided by the following principles:

- Reintegrate the exhausted parts of a quarry into the surrounding natural landscape;
- Make the site safe and stable for future land use;
- Return land to a beneficial post-quarrying use, balancing environmental, social and economic factors;
- Minimize adverse long-term environmental, social and economic impacts after quarry closure (international union for the conservation of nature, 2015)

The restoration initiatives are aimed at:

-Favoring landscape integration within the surrounding area;
- Targeting site naturality (appearance and functionality);
- Restoring the native vegetation cover;
- Limiting soil erosion;
- Improving biodiversity onsite through habitat creation and management;
- Increasing biomass;
- Serving for educational .and research purposes;
- Minimizing adverse long-term environmental, social and economic impacts after quarry closure;
- Returning land to a beneficial post-quarrying use, balancing environmental, social and economic factors;

- Making the site safe and stable for future land use. (ICUN, 2015)

Quarrying activity often leaves long-term social, economic and environmental footprints (Lad and Samant,2013). The restoration of quarries results to the development of wetlands recreational areas, residential developments, industrial or commercial estates – even golf courses. One of the best-known examples is the Sydney Olympic rowing course for the 2000 Olympic Games, created by the Penrith lakes development corporation. In Kenya, the restoration of limestone quarries by the Lafarge cement group has led to one of the best built eco-recreational facilities in the country and thereby transforming degraded lands to economically and environmentally sustainable establishments. Situated in Bamburi, 10 km north of Mombasa, on the Mombasa - Malindi road along the Indian Ocean coastline is the Haller Park. The Park is part of a large complex of Baobab farm, comprising Bamburi forest trails, the farm and the park under the Lafarge Ecosystems.

Restoration techniques

Rollover slopes

This method involves tipping and pushing material over the top edge of the quarry and spreading it on the underlying benches creating gentle slopes over quarry faces. It is often used in highly visible parts of a quarry, although because of the smoothness of the surfaces the landform may not look or behave like the natural landforms (Wheater and Cullen, 1997). Natural topography tends to have uneven slopes with depressions and knolls which create different microclimatic conditions and soil moisture conditions throughout the landform (Cripps et al., 2007; Water-Front-Trail, 2010).

This provides an opportunity for a number of different plant species to establish naturally in the different portions of the reclaimed quarry (Moffat and McNeill, 1994; Nicolau, 2003). Rollover slopes technique is the most common and technically easier method of quarry restoration.

Advantages

1. The presence of fill material provides an opportunity for vegetation establishment. The type of vegetation that establishes will however be limited by the amount of material deposited and its chemical and structural composition.
2. The covering of quarry walls reduces the potential for rock falls which provide safe conditions and opportunities for public access.

Disadvantages

1. The technique require a lot of soil or other fill materials which might need to be sourced externally.
2. This technique may result in the presence of steep slopes which may limit the options for after- uses of the site. The slopes could also make access to the upper parts of a quarry for planting and maintenance very difficult (Down and Stocks, 1978).

3. The covering of rock faces reduces establishment of biodiversity on rock crevices. It also removes industrial archaeological interests of a site.

4. There is a high potential for soil erosion and mudslides especially during rainy seasons and before vegetation is established. Care has to be taken to ensure that the fill material has suitable structure to withstand erosion as well as being suitable for plant growth.

Natural regeneration

Natural regeneration will not always be an acceptable approach, but can work spectacularly well on gravel workings and where open water will be left. It can work well on many other sites, but may be considered unacceptable if the ground is likely to remain bare or only sparsely vegetated for a considerable time.

Restorative blasting

Restoration blasting seeks to create restoration slopes way up the face or to extend across two benches. Restoration blasting is a technique which has some challenges due in part to its unpredictable nature regarding resultant slope angle (often too shallow), large size of scree blocks and unstable adjacent faces. Therefore, the scale of some of the restoration techniques applied should be related to the scale of the quarry itself. Restoration blasting, whilst not a precise method to reduce the engineered appearance of quarry benches and faces, it can nonetheless help to reduce adverse impacts.

Restorative blasting cannot create landforms that appear to be completely natural but aims to create landforms that appear more natural and acceptable within the landscape setting. If possible and in selected areas, restoration material and soilneed to be spread along the edge of the bench prior to blasting, so that once the resultant blast slope is created, the material would have mixed with the scree, lodged in cracks and crevices and generally been spread about the slope. In this way, it would prevent the need to subsequently place or tip the material onto the screen slope by mechanical means.

When Shallow Blasting is done in restorative blasting, the crests of faces tend to be left very angular and uniform due to efficient modern extraction techniques and it is the intention of restoration works to effectively reverse this and introduce irregularity to help break up and soften the appearance of faces themselves and in particular the top crest. This can be achieved by removing the sharp crest by mechanically so that it has more of a less rectilinear appearance.

The tops of buttresses/headwalls are mechanically broken up and rounded off after blasting, and/or by drilling and blasting, to a shallow depth close to the crest after the main restoration blast. This is combined with spreading a suitable growing medium on the tops of the rounded buttresses/headwalls and covering with grass or trees. This lessens the visually obtrusive crest of the quarry terraces and simulate the rounded tops of buttresses/headwalls. It also improves safety by providing a gradual transition to the vertical face, which will inform people that they are approaching the edge.

Shrub planting on lower benches is another approach in restorative blasting. scrubby planting on lower benches and restoration slopes, close to the bottom of the quarry lake level can be attempted to provide a feature that is characteristic of other, lower, slopes in the surrounding area. The deposited material need to be placed either straight onto the bench or on the restoration slope to sufficient depth to enable tree/shrub planting with suitable species. The aim of the planting would be to create large enough areas of vegetation to help mitigate against the visual effects of a large water body that will eventually form in the base of the quarry. The planting would also help to screen some of the lower faces which would be at least partly visible from higher locations on land surrounding the quarry.

Creating new floristically diverse grasslands

The objectives for new grasslands must be decided at an early stage, as these will dictate the species and methods to be used. In determining objectives, the means for managing grasslands, and resources required, must be considered. The eventual site tenure will finally determine what options will be realistic and achievable with the likely resources available. Natural regeneration can be an option where there is an adjacent seed source, but is usually slow. It can be speeded up by collecting seed or hay from existing grasslands and spreading this on the site to be restored. The use of nutrient-rich topsoil should be avoided, and subsoil sourced from onsite used in preference wherever possible. It is inadvisable to import topsoil as more often than not it will originate from building sites and may have a seedbank of invasive non-native weeds that will become difficult to remove if they become established (Yundt et JASMR, 2015 Volume 4, Issue 2 60 al.,2002). If weed-free subsoil is used, this can be sown with a wild flower and grass seed mix after preparing a level seedbed.

A wide array of vascular plants – grasses, forbs, legumes, shrubs and trees - are traditionally used to re-vegetate disturbed areas in various habitats. Bryophytes and lichens, on the other hand, are often overlooked and seldom considered when it comes to restoration. The oversight of mosses and lichens in restoration may be in part due to a lack of knowledge about these plant groups, as their taxonomy and identification are not as widely taught as those of vascular plants and are considered difficult by many. In peatlands, in mosss and in boreal, alpine or arctic environments, these plants make up a significant portion of the ground cover. They inhabit rock outcrops, colonize nutrient-poor, disturbed areas of sand and gravel and establish spontaneously on stone walls, pavement. Being frost hardy, desiccation tolerant, and requiring little in terms of nutrients, pioneer mosses form colonies that retain water, trap seeds and open the way to soil development and to the establishment of plants of higher stature.

Establishing mosses on quarry limestone quarry floors present challenges to revegetation, the major ones being very shallow or non-existent soils and harsh environmental conditions (Larson et al., 2006). The advantages of restoring quarries to mosses is two-fold. Firstly, rehabilitated quarry floors become habitat extensions for moss species. Secondly, the development of a simple but effective method to establish moss communities on limestone quarries reduces the need for costlier rehabilitation alternatives, such as the importation and placement of large quantities of topsoil, while still resulting in the restoration of a highly valuable natural habitat. Richardson (2009) showed that a number of moss vascular plant species can be established in quarries by seeding and simple soil amendments, suggesting that simple, inexpensive restoration techniques could be developed to speed up the transition from quarry floors to mosses.

The use of straw mulch greatly improves moss establishment and is a key factor contributing to success at all sites and for most species. Straw mulch act in two ways. By retaining moisture and reducing substrate temperature, straw mulch creates a sheltered environment with a microclimate more favorable for the mosses. It also reduces the probability of propagules getting dispersed by water or wind. The presence of a thin layer of mineral soil on the bare limestone improves moss establishment, but to a lesser extent than mulch. Like mulch, this thin layer of material may act both to retain moisture and to reduce the probability of moss propagules being dispersed.

Woodland and scrub establishment

Natural regeneration can be a long process. Assisted regeneration is relatively cheap and likely to provide a more natural woodland or scrub habitat than one that is established by planting trees. A nurse crop of grass need to be used to reduce weed infestation. Whether seed or plants are to be used, they should be of known origin. If planting is the preferred option, it ought to be designed with the final habitat objective in mind. For schemes that aim to create a good habitat for wildlife, regimented plantings should be avoided.

Wetlands

Plants for wetlands should be very carefully sourced from known locations, whether seeds, rhizomes or vegetative shoots. Reeds are easily propagated from cuttings, and large reed beds can be rapidly established by planting out seedlings. Many other aquatic plants regenerate vegetatively and can be established by planting rhizomes or rooted stolons. Many other species colonise at their own accord.

Backfilling

Backfilling is the process of partly or completely filling a quarry void with soil, soil forming materials, and/or waste rock in order to restore the original grade (Haywood, 1979) or create a new landform. It has been used widely to restore sites where material has been extracted using open-casting methods. Backfilling sites are designed and developed to accommodate an agricultural after-use.

This method is dependent on the availability of a significant amount of backfill material either onsite or from external sources. However, such schemes have been used in other locations where the void has been used to dispose of domestic and other wastes. Depending upon the nature of the waste, a lining and leachate capturing system might be required to prevent pollution to local surface and groundwater resources.

A combination of landforms and restoration techniques is likely to be the most acceptable solution for a whole quarry. The application of ‘roll over’ along the highest bench and the introduction of grass or tree covered slopes above buttress/headwall formations is likely to have the greatest effect in creating a more appropriate and less visually obtrusive restored quarry’.

Case studies

Yepes-Ciruelos quarry

The former limestone quarry extends over 600 ha in Castilla La Mancha, Toledo, in a semi-arid part of Spain and was an ambitious project funded by Lafarge, the giant cement maker after the depletion of cement making deposits and later transformed it to a natural reserve.. The University of Castilla La Mancha's Botany Department carried out research to monitor the changes in habitats and how biodiversity improves following rehabilitation. This helped to understand how to recreate certain habitats on restored land, allowing the development of a large number of different species.

Bees were reintroduced into part of the site, to allow the pollination of numerous plant species. This helped to restore and protect local fauna. The restored nature reserve includes a 2.5 km2 enclave exclusively reserved for university research work. There is also a botanical and bird field observation path, along with a cycle track and visitors' and education center. The reclaimed quarry has more than 190 vascular plant species recorded inside the rehabilitated quarry, some of them classified as having high ecological importance. There is also a honey-harvesting activity has also been established, from the many bees reintroduced onto the site

Plate 2: Yepes-Ciruelos quarry

Greenham Common, Berkshire

The concrete runways werere moved in the early 1990s, and the aggregate recycled, leaving large areas of bare gravel. The rest of the common species is rich grassland and lowland heath, so seed from these areas was mechanically harvested and strewn over the bare gravel to assist regeneration. These areas were left to regenerate naturally. Cattle were introduced to graze the common and helped in the process of spreading seeds and establishing soil. No aquatic plants were introduced, but the ponds were colonised by aquatic plants.

Plate 3: Greeenham quarry

Glenridge Quarry

Glen ridge Quarry was restored with an aim of preserving the processes of quarrying through the various stages. The intention was to provide information to visitors on the processes of quarrying and its effect on landscape upon the cessation of quarrying and thus preserving providing a look into the region's topographical heritage. The placement of interpretive panels makes it possible to trace the evolution of the site from a geological point of view. The Glenridge quarry, located on the Niagara Escarpment is a place where nature flourishes, wildlife is sustained in a biodiversity habitat, and people with various interests have opportunities for environmental education and recreation. With input from local residents and support from the Niagara Region, the landfill was transformed into Niagara's natural park. The site is one of the most significant environmentally based initiatives undertaken in Niagara.

Plate 4: Glenridge Quarry

Berwick Woods Project

Essex Restored by Tarmac Southern Limited in partnership with Thames Chase12, 000 trees and shrubs have been planted to transform this derelict quarry to a community forest which is now London’s largest area of wet woodland. The local residents from Rainham and Hornchurch have been closely involved throughout the restoration and a significant programme of artistic events have involved over a hundred students from local schools.

Plate 5: Berwick Woods Project

Whisby Nature Park

Restored by Lafarge Aggregates Limited in partnership with Lincolnshire Wildlife Trust, and the local and district councils and the Lincolnshire Wildlife Trust have restored over 150 hectares to lakes, woodland, ponds, scrub and grassland home to more than 60 species of breeding birds and 100,000 human visitors each year. The park also includes the Natural World Centre and the Lafarge Education Centre.

Plate 6: Whisby Nature Park

Forest Rock Wood

Leicestershire Restored by Hanson Aggregates. Some 15,000 trees and shrubs planted on an 11-hectare landform now form part of the National Forest providing valuable new wildlife habitats. Public access has been encouraged by the construction of over half a mile of footpaths linking into the wider local network.

Plate 7: Forest rock wood

Carmel Woods

Carmarthenshire Restored by Tarmac Western Limited in partnership with the Countryside Council for Wales. This 63-hectare area has been regenerated and recolonised and now forms part of the Carmel National Nature Reserve, widely appreciated both for its beauty, its geological and archaeological wealth. A site of Special Scientific Interest for both its biology and geology Carmelawaits still higher designation as a Special Area of Conservation.

Plate 8: Carmel Woods

Kirkby Gravel Pit Nature Reserve

Lincolnshire Restored by Woodhall Spa Sand & Gravel Limited in partnership with the Lincolnshire Wildlife Trust. This nature reserve consisting of three lakes, surrounding trees and grassland makes an important contribution to the Lincolnshire Biodiversity Action Plan. Subject to seasonal wetting and drying out the main lake provides a variety of habitat popular with many wildfowl and migratory birds.

Plate 9: Kirkby Gravel Pit Nature Reserve

Cheviot Quarry

Northumberland Restored by Tarmac Northern Limited As quarrying of this former wartime training aerodrome proceeds, progressive restoration has seen the land returned to use by gliding enthusiasts from the Borders Gliding Club. Other restored areas include tree planting and lakes which have also become a haven for birdlife.

Plate 10: Cheviot Quarry

Brockholes Quarry

Lancashire Restored by Hanson Aggregates. ProvidED several priority habitats, this nature conservation area makes a significant contribution to biodiversity attracting over 130 species of birds to date. These include the threatened song thrush, the little ringed plover and the reed bunting.

Plate 11: Brockholes Quarry

Waterford Heath

Hertfordshire Restored by Lafarge Aggregates Limited in partnership with Hertfordshire County Council, East Hertfordshire District Council, Groundwork Hertfordshire, Herts and Middlesex Wildlife Trust and the local community. This old quarry has been transformed into a community nature park through a plan which called for the management of existing habitats, creation of new habitats and access routes and community involvement. The site is in two parts, each having a unique soil structure providing a variety of habitats.

Plate 12: Waterford Heath

Boxgrove Quarry

Boxgrove Quarry is a former ballast quarry in West Sussex. Following the cessation of quarrying operations, the site was only partially restored with inert material before the planning permission lapsed and the gates closed. The 14 ha quarry site was bought in 2009 by inert Recycling (UK) with a view of restoring the land by filling it with inert recyclable clays. This was permitted by the planning authority in consideration of the inertness of the fill material and thus the low environmental risk to the environment. The site was planted with flora ranging from woodland, wetland and grassland.

Plate 13: Boxgrove Quarry

Haller Park, Mombasa,Kenya

This is a nature park in Bamburi, Mombasa, on the Kenyan coast and borrowed from other quarry reclamation processes run by Lafarge- the giant cement maker. The quarry was transformed from quarried wasteland to the ecological park that is home to diverse plant and animal species. Lafarge through Bamburi Cement undertook the rehabilitation of the wastelands then known as Bamburi Nature Trail until 1999. The park is a is a sanctuary for lost and orphaned wildlife from endangered habitats and is named in honor of Dr. Rene Haller in recognition of the restoration efforts he contributed in conjunction with Bamburi Portland Cement Company in Kenya, in transforming the quarry wasteland to ecological success it is today. Dr. Rene Haller started the first of the rehabilitation process by planting of mosses and other small plants. He started experimenting with the extensive open quarries, marked by planting trees in the hard coral. Later, the rehabilitated area attracted the interest of people. The rehabilitated quarries later become a green recreation space for Mombasa residents and an attraction for visiting tourists.

Plate 14: Haller Park, Mombasa, Kenya

Landfills

There are various problems that need to be controlled in the Landfill management. This includes blowing garbage, leaking of garbage, gases from putrefication and vermin. Waste compaction is a daily activity in a landfill. The waste is spread evenly by earth movers and then covered with a layer of soil to reduce odours and thus offering a conducive work environment of the dumpsite operatives. The soil cover also curbs blowing garbage, and limits the attractiveness of the site to vermin and birds. The soil layer is scraped off the next morning and the sequence of pacing, spreading and compacting waste ensues. The liquid leachate is a combination of percolating water and decomposing garbage that can percolate from the landfill site to adjacent lands and seep to deep ground levels. To overcome this, a leachate collection system consisting of plastic pipes placed within a gravel drainage layer at the base of the clay liner is put in place. The collected leachate is then transported by the sanitary sewer and treated at the local wastewater treatment plant (ISWA 2010).

Worth noting is that it takes a long time to fill quarry pits with fill material more so in an environment where strict adherence to regulations is adhered to. In such scenarios, there is also the potential inconsistency in regulatory interpretation that makes it difficult for mineral operations to obtain appropriate fill material due to competition with other engineering projects, and reduces their ability to deliver the best environmental solution for wider society.

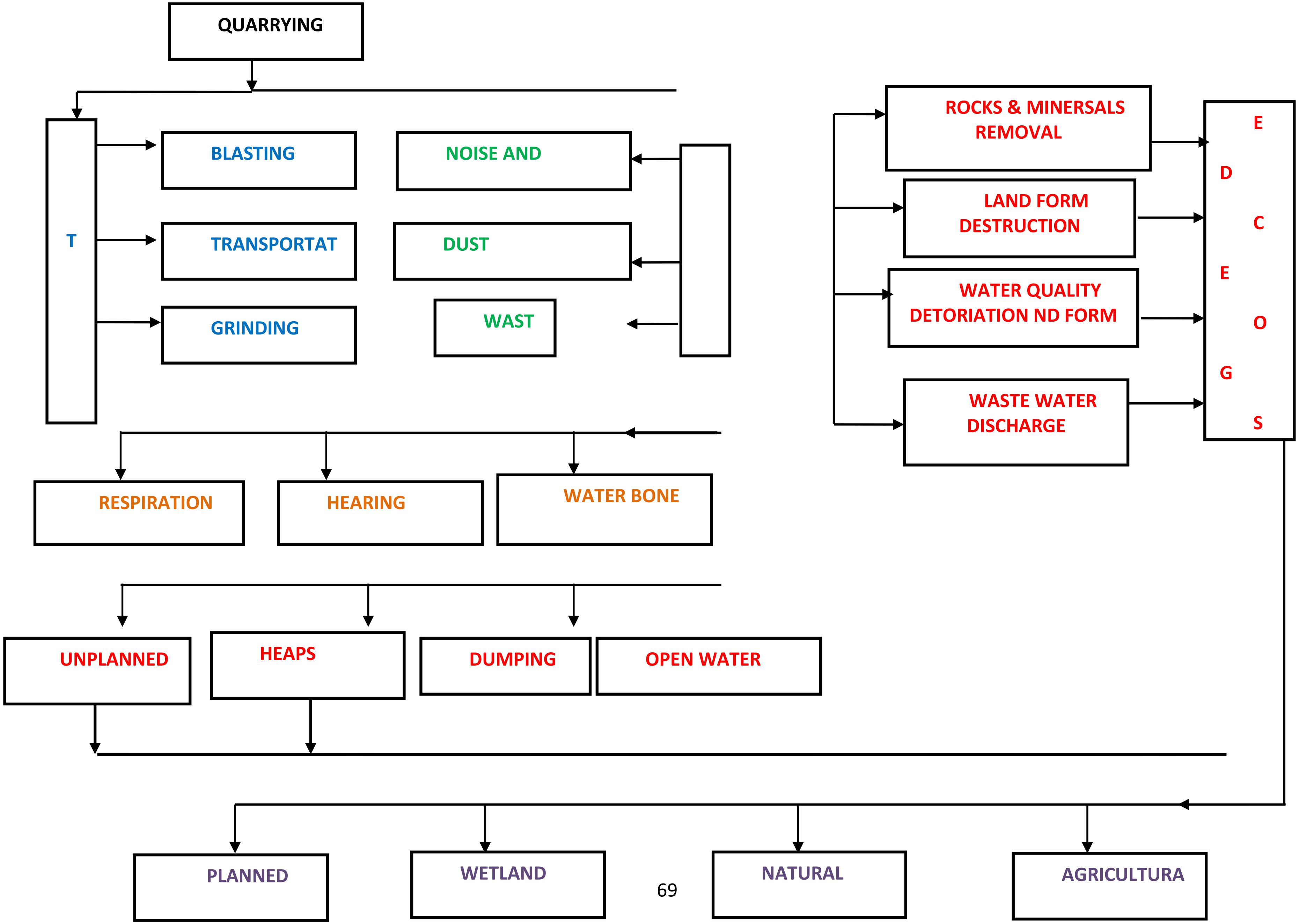
2.12 Conceptual framework

The process of quarrying offers a pre-determined end-state as well as presenting near- pristine state of the environment before the onset of the quarrying process and thus end up offering a completely different and distinct states of the environment as well as presenting the same impacts socially and economically. Along the Ngong river basin, the aftermath of quarrying activities has been abandonment of the previously active quarries thus encouraging unplanned deposition and filling of the quarries with domestic and industrial waste and others becoming open ponds for storm water.

The end of quarrying processes in planned setups results into the establishment of restoration programmes resulting to improved physical environment conditions. When the time comes to restore the quarry, landscaping includes any necessary reshaping of the quarry walls then spreading the overburden and covering it with topsoil. In non-urban sites, native grasses, trees and shrubs are then planted, restoring the appearance of the sites, preventing soil erosion and encouraging birds and animals. In Kenya, an example of this is in Bamburi quarries whose restoration has resulted to the famous Mamba village. This is an example of the global trends in quarrying.

Quarrying processes generate two scenarios: The first is where there is no intervention upon depletion of the resources as shown below and case of intervention as shown by the diagram further below.

Figure 1: Conceptual Framework



The figure above represents the researcher's conceptual frame work of the effects of quarrying to the environment; it shows the relationship between the effects and impacts of quarrying to the residents, environment and land use and their outcome. It shows what is produced that is dust, noise waste and vibration and how these affect the people by causing waterborne diseases, respiratory infection, dumping of waste and shock.

Dust, waste and noise which are produced during the quarrying activities are the independent variable and they determine the occurrence of respiratory diseases, waterborne diseases and dumping which are dependent variables.

Quarrying like most human activities has both negative and positive effects to the environment and the people living closer to the quarry. Source of income to the traders nearby, employment to the quarry workers and production of materials that is use in the construction industry these are some of the positive effects of quarrying on the other hand it leads to production of dust, waste and noise pollution which affect the health of the people (quarry workers and people living near the quarry) by causing respiratory diseases, waterborne diseases and eventually death.

The occurrence of respiratory infections, waterborne diseases and dumping may be determined by the dust production, vibration and noise pollution which are mainly caused by the activities that go on in the quarry but can be controlled by watering or using the proper quarrying procedures that minimizes the effects. For the quarry workers they are involved in different activities within the quarry and the absence of protective gear determines if they are affected provision of protective gear to the quarry workers will improve the welfare of the workers. If the amount of dust and noise produced is reduced, then the occurrence of these infections is also reduced but if they continue going up then the infections also go up.

Nairobi County

The City on Nairobi lies at an altitude of 1,670 meters above sea level and occupies an area of 696 km2. It is divided into nine administrative namely; Embakasi, Makadara, Pumwani, Kamukuji, Kasarani, Westlands, Langata, Njiru and Dagoreti.

The city's population has expanded from an estimated 350,000 people at independence in 1963 to the current 2.7 million people (Census Report 2010). After independence, the population of Nairobi grew rapidly and this growth put pressure on the city's infrastructure. The influx of people into the city from the rural areas in search of livelihood and without corresponding development of urban planning strategies led to a wide variety of environmental problems. Due to economic and political pressures the city has continued to grow without integrating environmental considerations. The resulting poorly managed environment is now a major impediment to economic growth and is already impacting adversely on the health and livelihoods of residents and the long term sustainability of the city's natural resources.

CHAPTER 3 - RESEARCH METHODOLOGY

3.1 STUDY AREA

The study area is concentrated on the Ngong River and limited to the area between the Outering road bridge and the Kangundo road bridge. The Ngong river/outering road bridge is a distance of 9 km from the central business district while the Ngong River/Kangundo road bridge is 18 km from Nairobi's central business district and thus representing a distance of 8 km between the two sections. However, roads and rivers don't always take straight courses and therefore the distance along the winding course of the river is approximately 9 km. Quarrying activities are concentrated on both sides of the Ngong River to an average distance of ½ a km from the banks of the river. Ngong River along this area has steep slopes on the sides, and it is on this steep slope that quarrying takes place.

The riparian vegetation on both sides comprise of sturdy grass, shrubs, as well as farmland resulting from irrigation with open and broken sewers. It's also along this stretch that major way leaves for power and sewer from the main industrial area and the surrounding residential estates pass through. As a result of the availability of key building material resource, the surrounding area is heavily developed with middle and low income high residential developments while another part especially the part closer to the Ngong river/Kangundo road bridge is partially developed due to speculative land ownership. Quarrying activities in Nairobi has been going on since the 1950s when the place was sparsely inhabited. According to NEMA there were twenty-eight quarries located in Nairobi County. Out of this nineteen quarries are located in Embakasi area alone.

Map 1

Map 2

Map 3

Map 4

3.3 Relief and drainage

Nairobi is at 1,795 metres above sea level. The study area which is relatively flat in some area while in some areas is it sloppy. The study area has several streams and rivers for example Ngong River. All the quarries are located along this river that flow through the area.

3.2 Research design

The study used descriptive research design to obtain information concerning the current status of phenomena and used it to draw valid conclusion from the facts discovered. Also the survey aimed at obtaining information which was analyzed, patterns extracted and comparisons made.

3.3 Research population

A research population is a complete set of individuals, cases, or objects under consideration in any field of inquiry and has common observable characteristics that differentiate it from other populations. (Mugenda and Mugenda, 2003). The research populations in this study comprise of all households falling within the study area, all quarry workers in the study area, the owners of all the quarries in operation, the business community and policy institutions.

3.4 Sampling plan

A combination of sampling strategies was used so as to provide representative information in order to address objectives of the study. The study population was stratified into groups that offered useful information for the study. The households were divided according to the existing residential estates in the area, namely: Old Donholm estate, New Donholm, Soweto slums, Kayole, Matopeni, Karagita, Tassia, Kwandege and Baraka estates. From these residential estates further stratification was done based on the distance away from the quarries. From the strata, systematic sampling was done.

The study undertook random sampling for the quarry workers based on the particular quarry each worker is employed. Random sampling was used in accessing data from the quarry owners.

3.5 Sample size

3.5.1 Households

This study used a sample size of 120 households drawn from the, twelve (12) residential estates listed. According to Mugenda and Mugenda (2012) for a population greater than 1000 members 10-30% can be draw to represent a study sample size for the study. In this study 10% of the study population was drawn from a population of 1200 household in the area for the purpose of the study. Selection of the ten households in each estate was based on sampling techniques. The samples were taken from each side of the Ngong river frontage and systematic sampling was done by selecting every 10th household on each row starting from the quarry frontier row for each estate/neighbourhood was interviewed.

3.5.2 Quarry owners

The study applied census method where all companies conducted mining activities were included in the study. Census was considered due to the target population. There were a total of seven (7) active quarries with many others abandoned. All the quarry managers were interviewed.

3.5.3 Quarry workers

Convenience sampling was used to get information from the quarry workers population. This was necessitated by the short time granted by the quarry owners to interview the workers during the working hours. The workers who were positioned proximately were interviewed. The strategy was each of the three interviewers had to interview at least two workers from each of the six active quarries. The other respondents were from two (2) abandoned quarries whereby scavenging of quarry rock by use of hand tools was on-going. A total of 39 quarry workers provided information. This figure was guided by Slovin's formula (1960) whereby, n= N / (1+ N * e^2) Where N: population size, n: sample size, e: significance level, for e.g. (0.05)

$$n=\frac{\mathbf{351}}{\mathbf{1+(351*0.15^2)}}$$

=39.4

3.5.3 Customers

Due to lack of existing customer population, the study employed non-probability sampling technique; to be precise purposive sampling technique was used in recruiting customers to participate in this study. Only the customers who appeared during the interview session were interviewed.

3.5.4 Health facilities

The study used a sample size of five health facilities. The study used census method due to the small number of health institutions. It was noted that many residents more so those in the informal settlements seek healthcare from the dispensing chemists which do not manage data of their customers and thus were not considered for this research.

3.5.5 Public institutions

The study used a sample size of three public institutions. These are responsible for regulation of quarrying namely, the National Environmental Management Authority (NEMA) and Nairobi County. The other public institution considered was the local provincial administration i.e. the chief.

3.6 Data collection methods

Primary data was obtained from ground observations and through research instruments. Secondary data on the background of the study area and the methodology was obtained through library research (published texts, past studies and reports, topographic and registry index maps of the study area) as well as information from government Ministries, and from the internet. A reconnaissance survey of the area was carried out to establish the geographical scope of the study area.

The respondents targeted were adult homestead heads, quarry owners, quarry workers, businessmen/women, health facilities and policy formulators. The respondents were assisted by other resident workers of the selected quarries. Interviews were carried out in either English, Kiswahili and with the help of interpreters from the area. The data collected included demographic, socio-economic, and physical characteristics, nature and occurrence of ailments, wages and other benefits like medical insurance, house allowance, water situation and environmental issues within or affecting the quarry areas, supporting activities, as well as external factors influencing the nature, structure and welfare of the quarry workers and the people living in the neighbourhood.

Questionnaires were developed and used during the field work to collect data from quarry respondents. Key informant interviews were held with officers from environmental, natural resources, administrative offices and the community. The study also included observations, marking of quarry dimensions with GPS and also using photography.

3.7 Data analysis

Data collected from the field was analysed using comparative analysis by coding. Results from the analysis, field studies and literature review have been presented in form of tables, pie-charts, sketches and maps. A report has been prepared detailing the land use and environmental problems, opportunities observed in the study and providing alternative and preferred environmental and land use proposals (models), as well as strategies that would contribute to improved and sustainable exploitation of resources.

CHAPTER 4 – DATA ANALYSIS AND DISCUSSION

4.0. Introduction

This chapter presents the analysis and discussion of the research data; data is presented using frequencies and charts. An attempt has been made to explain the outcome based on the respondents' data. All questionnaires were filled and returned for data analysis. The study collected data based on six target groups; Neighbours, quarry workers, quarry owners, quarry products customers, health care providers and County of Nairobi and NEMA as regulatory bodies. The data is presented based on the research objectives.

Response Rate

The study had a response rate of above 80% for all targeted samples for this study. The sample for customers was approached using purposive sampling technique method; census survey was done for quarry companies, while simple random sampling was done for quarry workers and neighbours. These responses were sufficient for this study.

Categories	Target	n	%
Mining companies	5	4	80.0
Quarry workers	39	30	76.9
Neighbours	120	114	95.0
Health facilities	5	5	100
Customers		36	100.0

Table 1

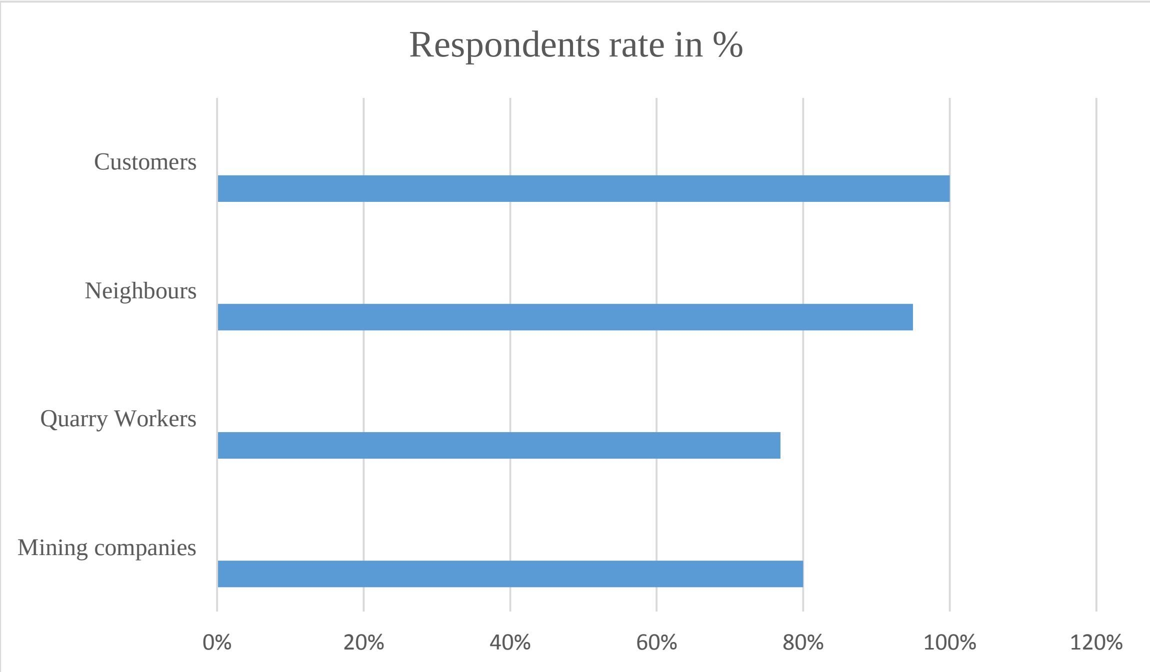


Figure 2: Respondents Rate in %

24.1. Respondent's basic information

This section provides a profile of the respondents who were interviewed in the study. These respondents constituted neighbours of quarries along Ngong River in Embakasi District, quarry workers, customers for quarry products along the river, managers of quarries, health care providers, official from NEMA and City County of Nairobi. This information is presented on a number of basic characteristics, including age group at the time of the study, and level of education. This information offers general understanding about the population under the study. An analysis of these variables provides the socioeconomic context within which other subsequent factors fall.

Respondents basic information

	Category	Categories	n	%
Neighbours'	Gender	Male	55	48.2
		Female	59	51.8
		Total	114	100.0
	Religion	Christian	108	94.7
		Muslim	6	5.3
		Total	114	100.0
	Education	Primary	53	47.3
		Secondary	37	33.0
		Tertiary	22	19.6
		Total	112	100.0
Customers'	Gender	Male	6	16.7
		Female	30	83.3
	Religion	Christian	33	94.3
		Muslim	2	5.7
		Total	35	100.0
	Education	Secondary	12	33.3
		Tertiary	18	50.0
		Degree	6	16.7
		Total	36	100.0
Quarry workers	Gender	Male	27	90.0
		Female	3	10.0
		Total	30	100.0
	Education	Primary	19	63.3
		Secondary	6	20.0
		Tertiary	5	16.7
		Total	30	100.0
	Religion	Christian	30	100.0
		Muslim	0	0.0

Table 2

Gender, age and education are very significant socio-demographic factors in a socio-economic study. Female accounting who for 51.8% of the neighbours, 83.3% of the customers interviewed were females while 90% of quarry workers were males

Education is a very important component of one's life. It defines one perception about life thus setting forth the privileges that one enjoys in a community. The study found that only 62.6% of the residents neighbouring the quarries had attained above secondary certificate. On the other hand, customers possessed a minimum of secondary certificate with majority having tertiary (50%) and degree (16.7%) levels. Most of quarry workers had attained a maximum of primary school certificate which accounts for 63.3% of the total respondents.

The most common religion affiliation was Christianity for customers, neighbours and quarry workers where 94.7%, 94.3% and 100.0% were Christian for neighbours, customers and quarry workers respectively.

Age, household and duration lived in the area

Table 3

	n	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**
Neighbour's age	114	22	67	31.52	8.188
Customer's age	36	25.0	60.0	34.50	6.125
Time lived in the area	111	1	40	6.25	9.132
Household size	112	1	10	3.92	1.104
Kids born in the area	75	1	8	1.21	2.105

Consequently, the age determines a number of human factors that range from perception to competitiveness. The group neighbouring the quarries were at their late youthful age with a mean of 31.52 years, a minimum of 22 years and a maximum of 67 of age while customers had a mean of 34.5 years, minimum of 25 years and a maximum of 60 years.

The study found that 95.0% of the families had people aged 21-60 years. This is an age bracket that is strong and capable of the challenging demands of quarry work. The quarry villages are thus labour centred, with the tiny housing per unit restricting family life and hence many quarry workers opting to have their families in rural areas.

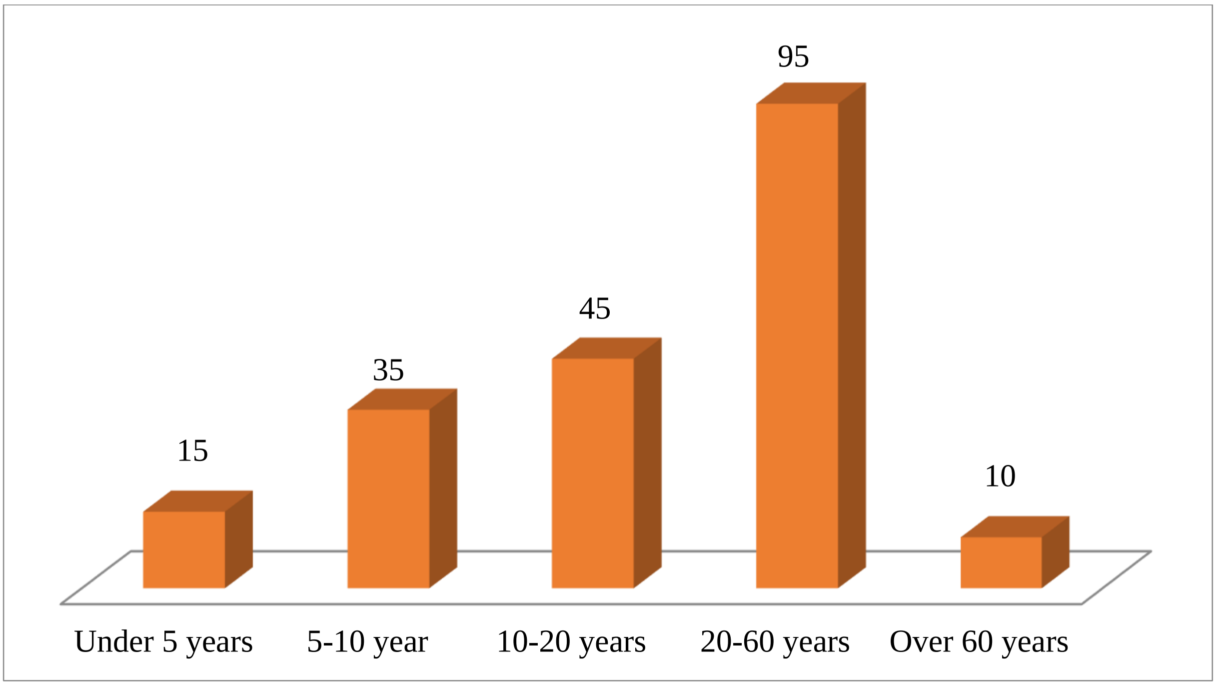


Figure 3: Household age composition

Quarry workers living experience in the area

The study found that nearly 25% of the quarry workers had lived in the study area for 5 years while 75.9% had been in the area for 0-5 years.

Time in years lived by workers in quarry villages	n	%
0-5 years	22	75.9
5-10 years	4	13.8

10-15 years	2	6.9
15-20 years	1	3.4
Above 20 years	0	0.0
Total	29	100.0

Table 4

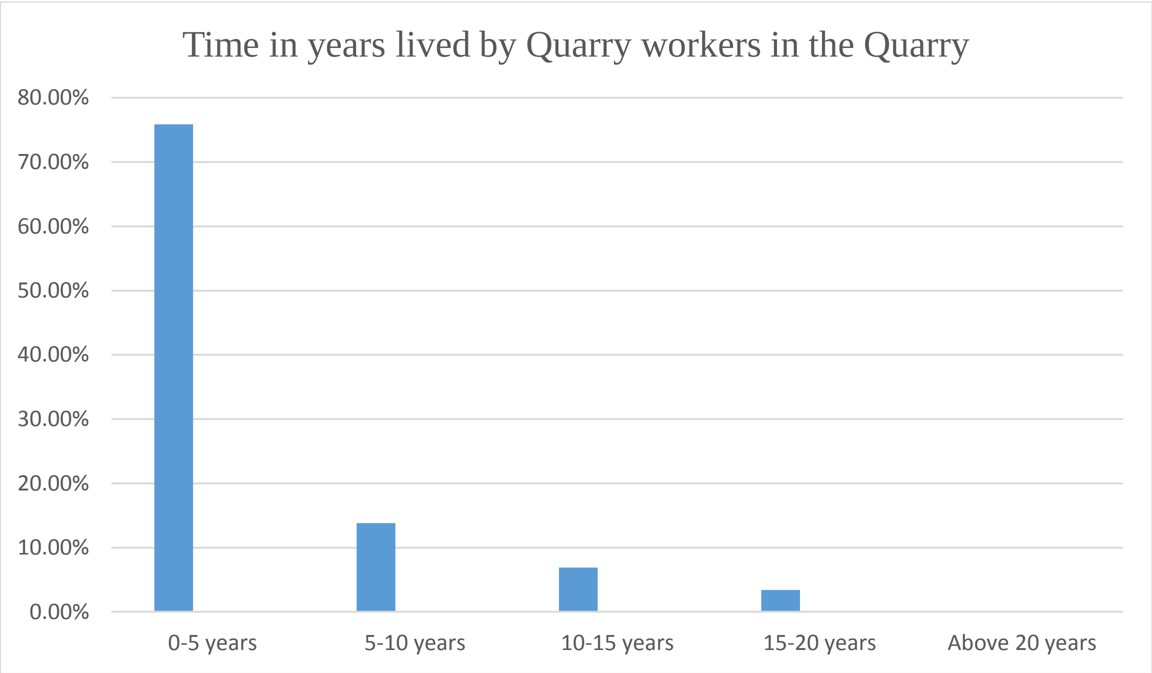


Figure 4

The time spent in an organization informs experience and better understanding of the working environment. Those workers with the least experience are the majority, representing 70%, while those with over 15 years' experience are only 3.4%. The answer to this weigh to the fact that quarry work is largely manual and only those at the prime phase of life can cope with the rigours involved. The harsh environment also acts as a push away from the quarries. As the workers gain more experience, they become more competent and thus attractive to other employers. The quarry environment is the lowest in terms of job attraction and retention.

Factors making the quarry area favourable to the customers

There are various factors that determine the buyer's decisions. The study found that 60% of the customers travelled nearly 5 KM away to acquire the produce from the quarries. This is illustrated in figure 1 below.

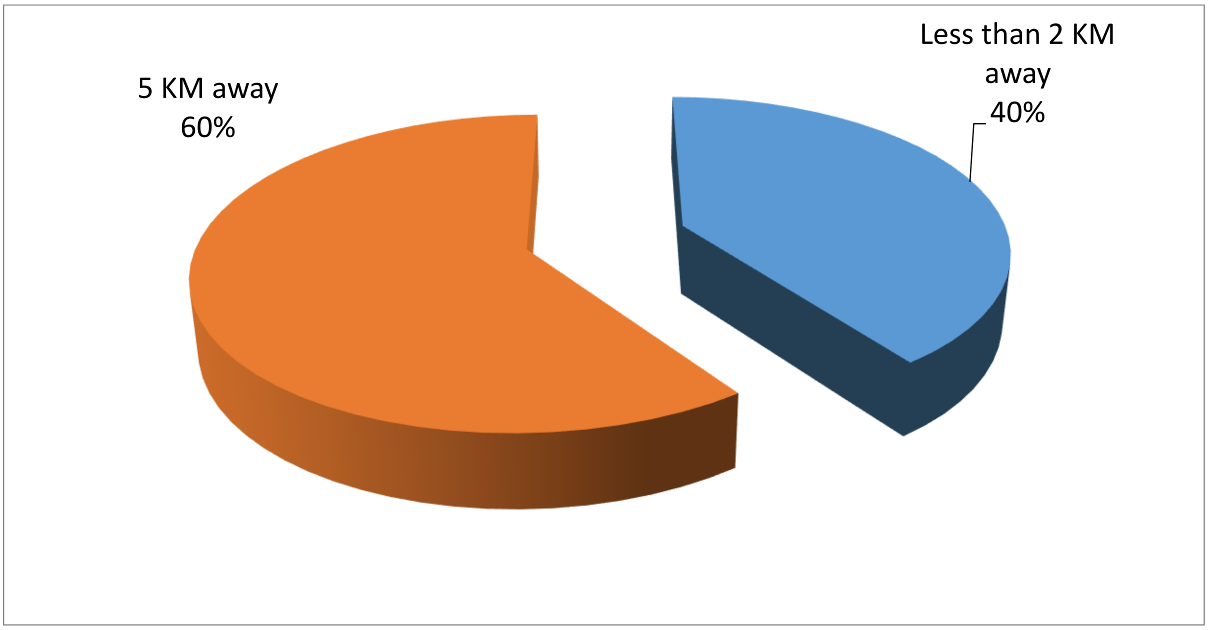


Figure 5: Distance from the market

The source of marketing materials is determined by a number of factors which play a role on buyer's decision making. These include; security, favourable prices, general ease/comfort, batch volume, location and distance, favourable customer relations, quality products and efficiency of services. These factors were ranked in order of their importance. The study found that security was a key factor while the efficiency of services ranked the least in terms of the importance as shown by the mean of 3.00 and 1.33 respectively. The study found that the favourable pricing ranked second general ease third, batch volume, location and distance were also among the leading factors considered by the customers who preferred accessing produce from the area.

Factors that make the area a favourable source of quarry products

	n	Mean	Std. Deviation
Security	35	3.00	1.414
Favourable prices	33	2.50	0.837
General ease/comfort	34	2.33	1.366
Batch volume	31	2.00	0.894
Location and distance	36	1.83	1.602
Favourable customer relation	29	1.50	0.837
Quality products	25	1.33	0.817
Efficiency of services	27	1.33	0.516

Table 5

4.2 Regulation and impact of the quarrying activities in Embakasi zone

The regulatory bodies that are Nairobi City County and NEMA indicated Embakasi Zone river bank as a quarrying site, adding that measures are into place to regulate quarrying activities. Nairobi City County officers reported that quarrying site had been licensed but future licences were not guaranteed, as all the quarries had been advised to relocate to Mlolongo.

The report by the County office indicated that there were guidelines regulating the development of quarries in the neighbourhood. They stated that the size of the riparian reserve was 30 metres.

The decommissioning plan and the life of the quarrying site in the area as observed from interviews with managers of quarries and the Nairobi City County office was not clear. The two institutions however, admitted that they had received complaints from the neighbours concerning environmental issues associated with quarrying activities in the area. The common complains raised by neighbours included noise pollution and dangers caused by open quarries filled with rain water.

4.3 Quarrying activities in Embakasi zone

The study examined the management of quarrying companies. The companies indicated that they engaged in grinding, mining and ballast. They further indicated that their choice of quarries was influenced by the quality of stones. One key benefit of these quarries was the employment opportunities they offered to the locals. They indicated that companies employed between 22 and 40 workers who were mainly casuals. The safety of the employees was ensured by providing safety kits such as helmets and gloves. The study noted that these companies occupied large tracks of land ranging from 10 acres to 22 acres which were either owned by families or companies.

The study showed that neighbours had sought help from the management of the quarries. They indicated that neighbours had severally complained over dust, tremors and noise pollution emanating from quarry sites.

Challenges facing quarry companies

Companies conducting quarrying activities in Embakasi quarries were faced by various challenges ranging emanating from locals, govern and infrastructures. The study found that all companies experienced complaints from the neighbours, land competition challenge, power disruption and poor infrastructure which affected their business operation. Government and other law enforcement organs such as NEMA's harassment were cited as a common occurrence to the companies in the Embakasi mining sites.

Challenges facing quarry companies	N	%
Complaints from Neighbours	4	100
Harassment by Nema	3	75
Harassment by government law enforcement officers	2	50
Competition for the land	4	100

Power disruption	4	100
Poor infrastructures	4	100

Table 6

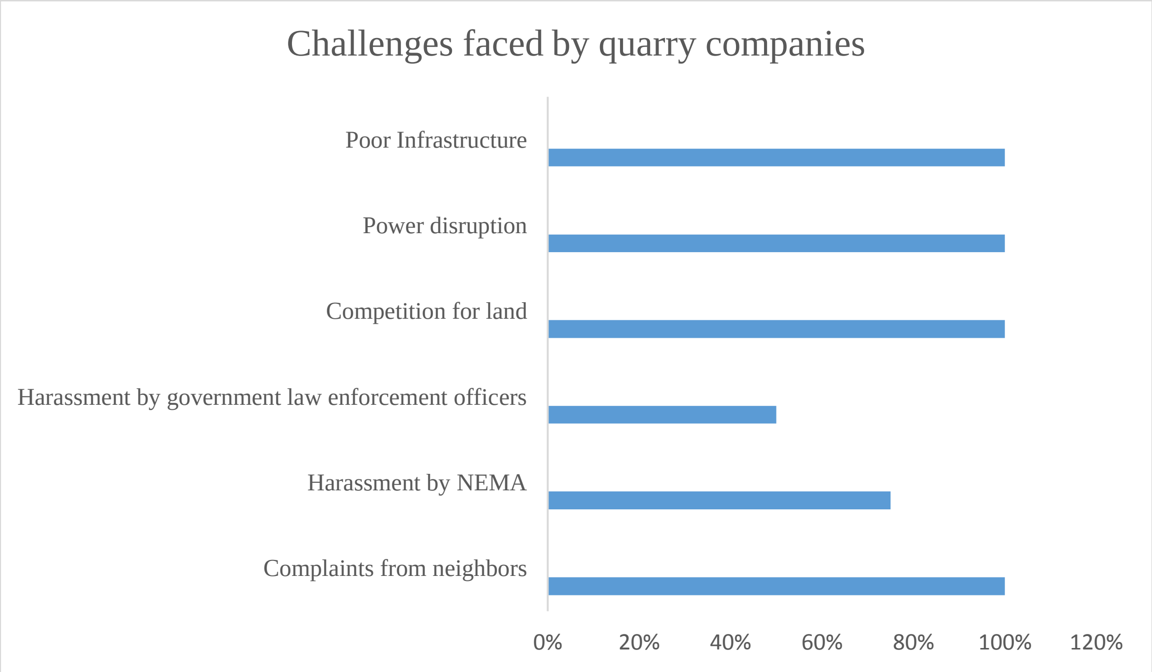


Figure 6

Poor infrastructure, power disruption, competition for land and complaints from neighbours were cited by all the quarry owners and thus representing 100% reporting. Harassment by law enforcement officers is at 50%. The reason for the low reporting is attributable to the location of quarries which is has less ease of access and the dusty environment which is deterrent to many.

Challenges faced by Quarry workers

Work challenges are common phenomena in current working environment. The study found workers were faced with a wide range of challenges that ranged from payment to working conditions. It was noted that workers were poorly remunerated, lacked safety equipment, long working hours, hostile management and had to endure noisy and dusty working conditions.

While these challenges were cited by nearly all, the results indicate that nearly all workers encountered all these challenges.

Challenges faced by workers		n	Case %
	Poor payments	29	96.7
	Lack of safety equipment	21	70.0
	Noise	24	80.0
	Dust	27	90.0

Table 7

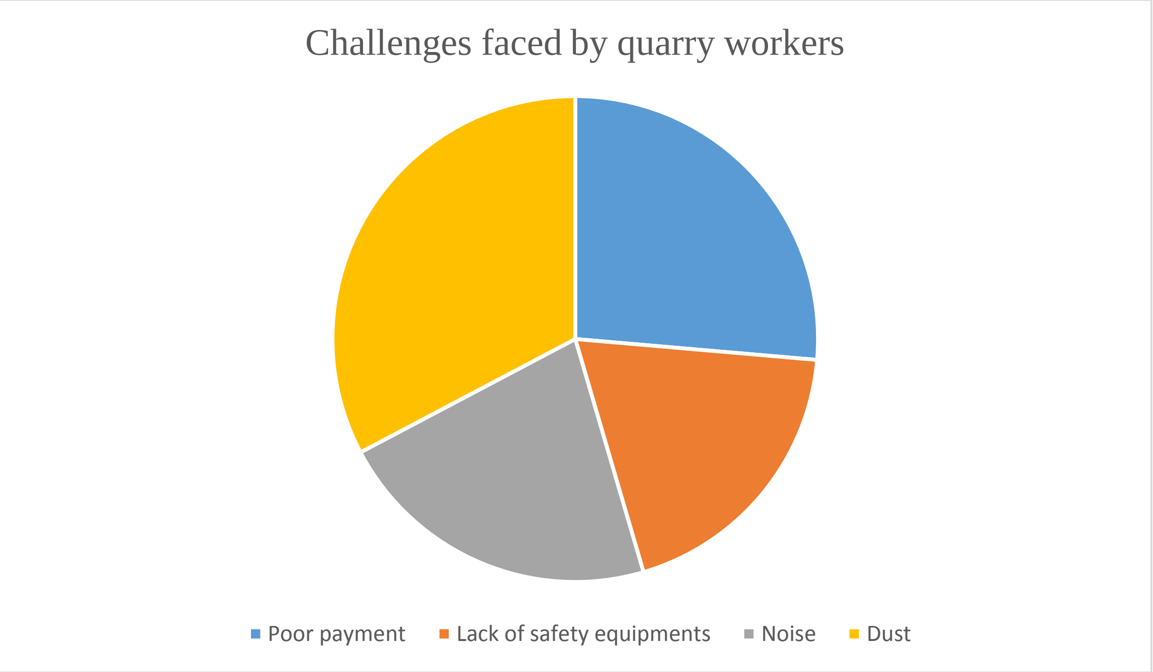


Figure 7

Low pay accounted to over 96% from the respondents. This is because remuneration is the most critical consideration for every employee. Work environment conditions i.e. dust and noise account for 90% and 80% respectively. This two conditions in turn contribute to poor health of the workers.

4.4. Impact of quarrying on health and physical environmental

Quarrying activity has the potential of destroying habitats and the species they support (Mabogunje, 1980). Even if the habitats are not directly removed by excavation, they can be indirectly affected and damaged by environmental impacts such as changes to ground water or surface water that causes some habitats to dry out or others to become flooded. Even noise pollution can have a significant impact on some species and affect their successful reproduction. Nevertheless, with careful planning and management, it is possible to minimize the effect on biodiversity and in fact, quarries can also provide a good opportunity to create new habitats or to restore existing ones (Tanko, 2007).

This study examined with the aim to establish the impact of quarry activities on the environment around Ngong River in Embakasi sub-county. These hazards led to health problems which happen slowly in most cases without the victims' consciousness. The table below presents the health challenges commonly experienced by respondents who are also neighbours to the quarry sites. Among other diseases, the study found that bronchitis, malaria, headache/fever, common cold, allergy, pneumonia, and tuberculosis were common.

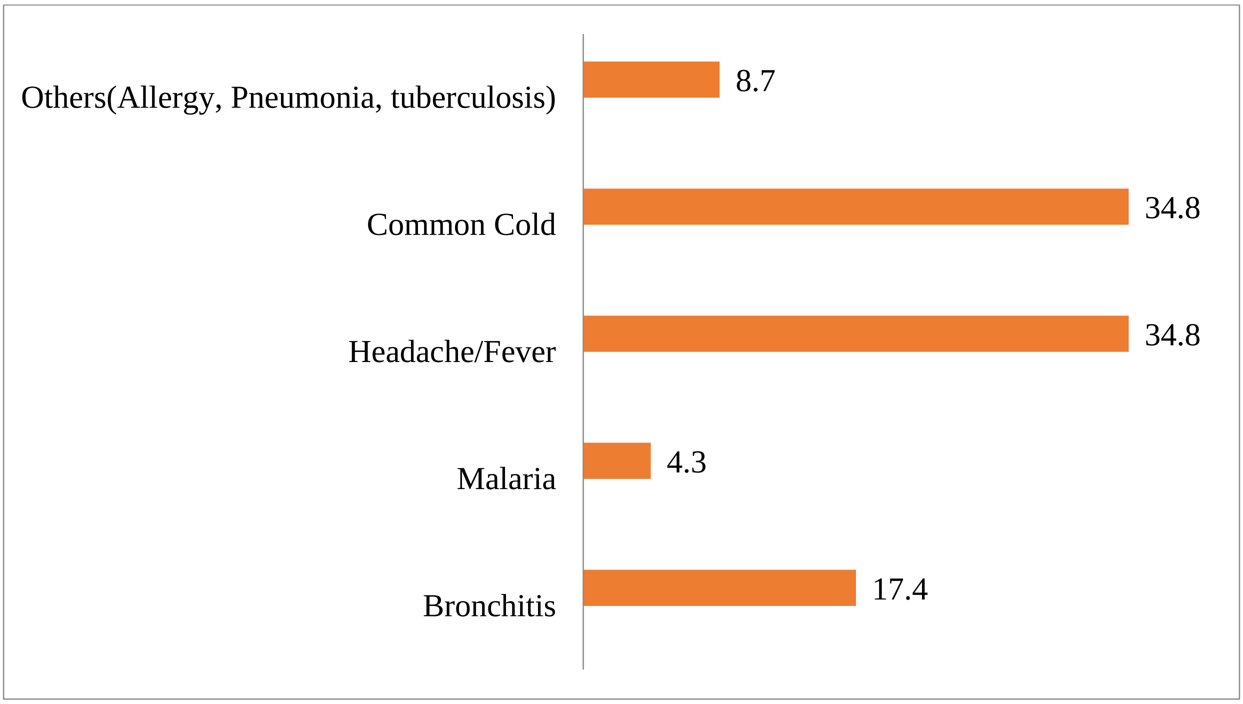


Figure 8: Common diseases affecting quarry neighbours

Common cold and headaches are the common ailments affecting the quarry neighbourhood recording 34.8 % each. Common cold can be associated with allergic reactions resulting from dust from the quarries. Headaches can be associated with the sound vibrations that range from drilling, blasting, trucking and grinding. Bronchitis and other respiratory ailments recorded 17.4% and 8.7% respectively. Malaria had the lowest incidence of 4.3%. This could be attributed to flooded lands as a result of quarrying leading to mosquito breeding in stagnant waters created by the quarrying activities.

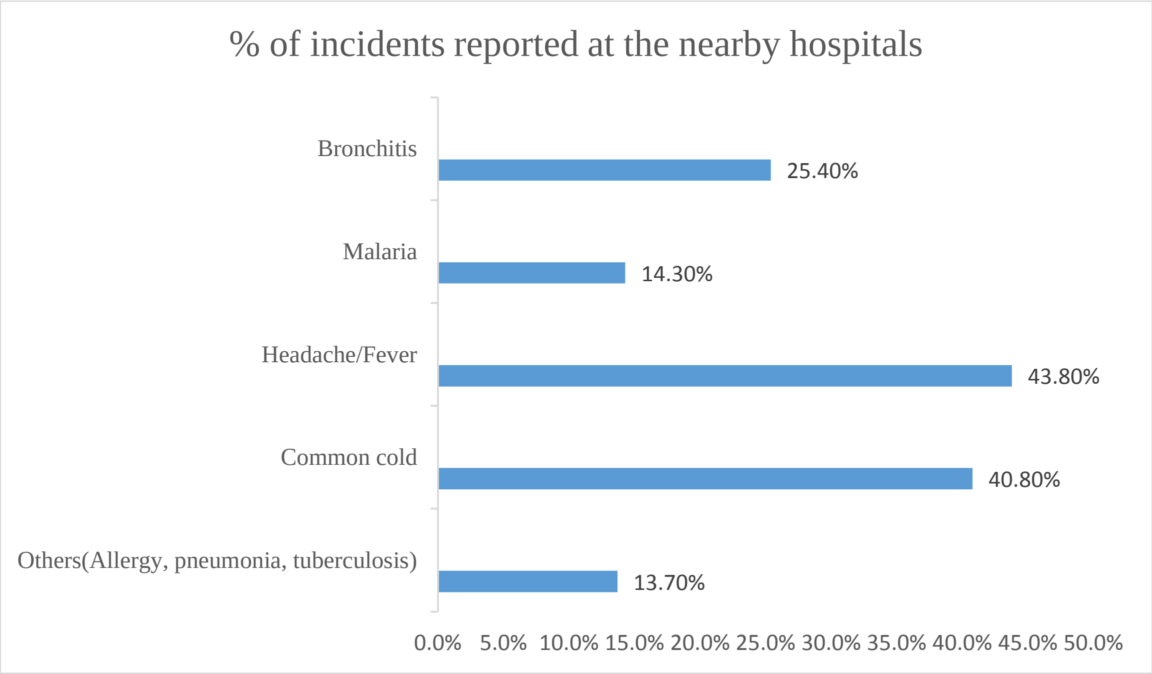


Figure 9

The study also examined the reasons for the people's preference to inhabit the area despite the medical challenges. The study recordedbusiness opportunities, job opportunities, reasonable rent and living standards, family reasons, security, and water as key pull factors. The study found that job opportunities were one of the key factors that led to most (37.8%) people residing in the region. Some reasonable proportion of people considered rent and living standards

(18.8%) while security was the least consideration by the respondents. **Factors making the area favourable for neighbours**

	n	Case %	Response %
Business opportunity	27	22.5	12.2
Job opportunity	84	70.0	37.8
Reasonable rent and livings standards	41	34.2	18.5
Family reasons	35	29.2	15.8
Security	17	14.2	7.7
Water	18	15.0	8.1
Total	222		100

Table 8

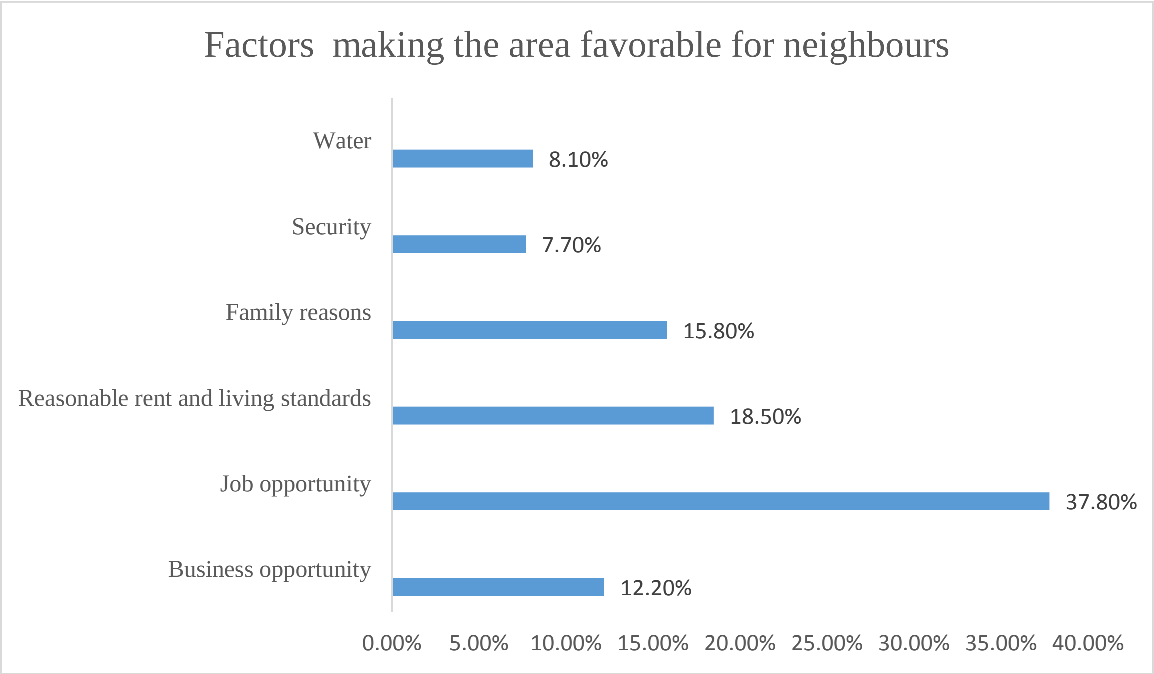


Figure 10

The study found that 47.3% (see table 5) of the residents didn't participate in maintaining environment in anyway. This was manifested by the poor sanitation and hygiene situation in the neighbourhood. Heaps of garbage and foul smell of human waste was a common site in the locality. However, those who considered environmental health important participated in a number of ways; these include, collecting solid waste around the residences (42.9%), advocating against dumping in the neighbourhood and solid waste collection and disposal (9.9%).

Worth noting is the fact that, with a lesser percentage of the population's involvement in environmental awareness and practices, and compounded with the daily generation of waste vis-à-vis once a week of waste attention from a smaller segment of the population, the general environment picture couldn't be brighter.

Community involvement in environmental awareness

	n	**%**
Collecting solid waste from residence	39	42.9
No participation	43	47.3
Protecting against dumping around this place, solid waste collection and disposal	9	9.9
Total	91	100.0

Table 9

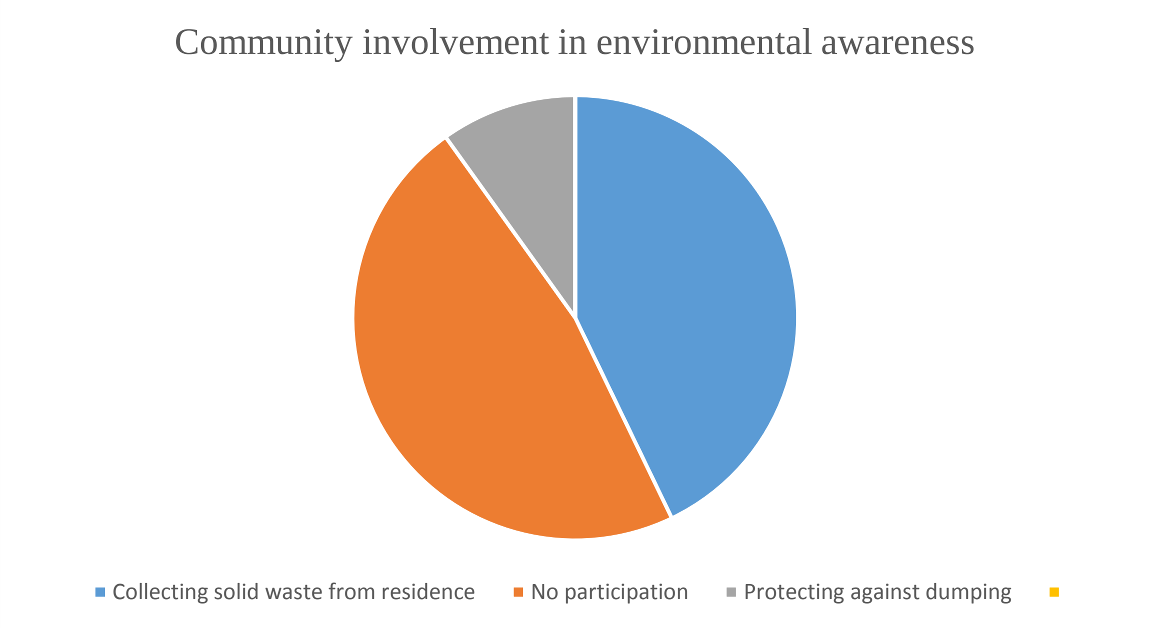


Figure 11

Quarrying like many other man-made activities cause a significant impact on the environment. It is often necessary to blast rocks with explosives in order to extract material for processing but this method of extraction gives rise to noise pollution, air pollution, damage to biodiversity and habitat destruction. Considering that quarrying undergoes various processes such as prospecting an area to locate an ore which may lead to relocation of people. The study found noise, smoke and dust pollution from quarry accounted for 53.4% (see table 6) of the main environmental challenges for the people living in Embakasi. Other related, but not entirely, was sewage polluted water (10.1%) and dumping of garbage near residence (36.5%) which formed part of potential environmental hazards.

Environmental challenges caused by quarrying activities

	n	**Case %**	**Response %**
Noise, smoke and dust from quarry	111	97.4	53.4
River pollution	21	18.4	10.1
Dumping of garbage	76	66.7	36.5

Total	208	100.0

Table 10Key

Red- Ngong river and some quarries

Blue- JKIA runway

Black- International Mine Action Centre

Plate 15: Image showing the noise emitters in the study region

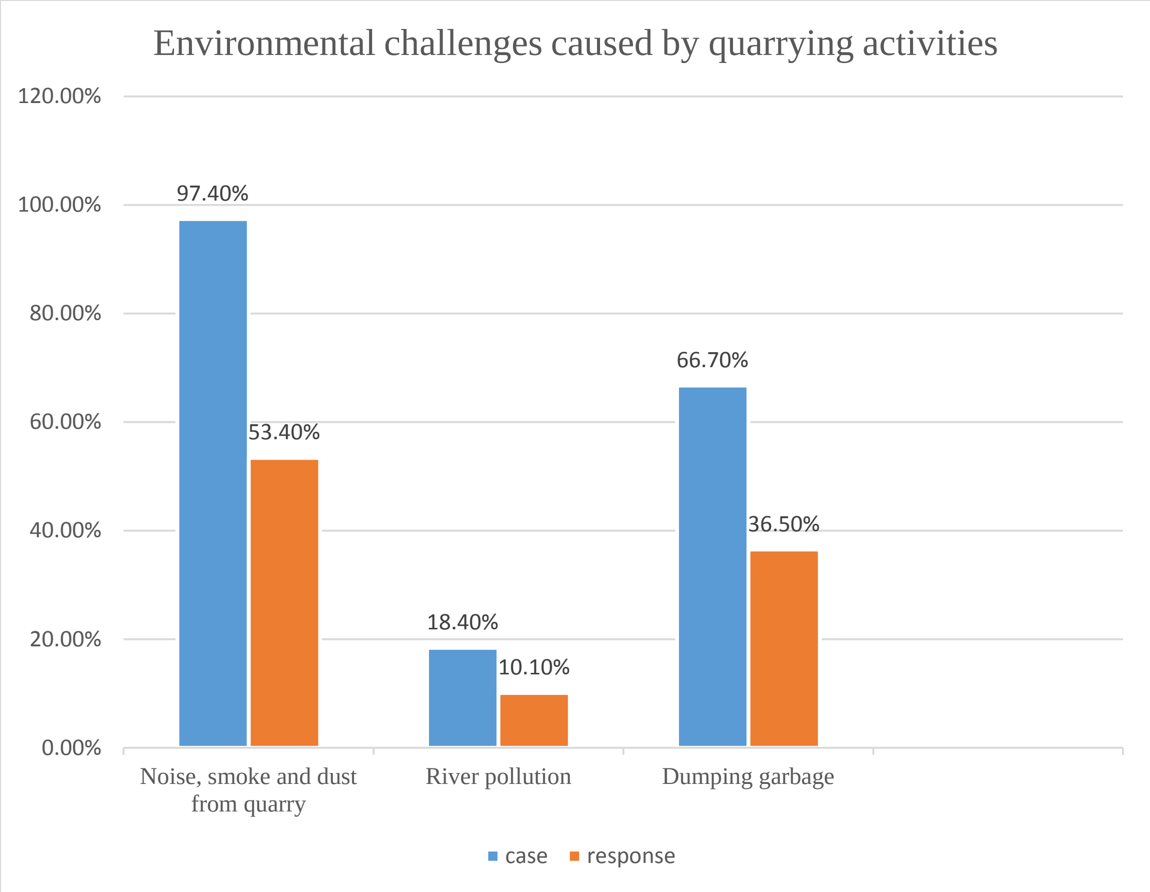


Figure 12

Embakasi area easily passes as the "bang" zone within Nairobi. Loud noise in the area is experienced from the three loud noise emitting zones i.e. the quarries themselves, the airport and the military installations in the vicinity and specifically theInternational Mine Action Training Centrelocated within the Embakasi barracks grounds. The sound produced by a landing or departing Boeing 787 airliner, the detonation of mines from the international mine action training centre and that from a quarry blast have nearly the same impact to the resident of Soweto slums.

Development of quarries causes physical displacement of homes or economic displacement of land of beneficial use to local communities, including areas used by individuals or communities for cultivation, grazing, hunting, forest products, water supply, street vendors and other purposes. Therefore, involvement of the communities affected is crucial. Nevertheless, in most cases communities involved seem not to be interested completely in the said environmental problems affecting them. The study found that 61% of the respondents were not engaged in the environmental activities affecting them. The high response level that characterises the neglect of the local environment by the neighbours can be attributed to low education levels. Highly educated people have a higher regard for their surroundings as compared to those with minimal education. 47% of the respondents had not gone past primary stage. This is an indicator of poor education standard for any urban environment. The work schedules in the quarries also contributes to the poor attitude towards the environment as majority of workers engage themselves in overtime schedules as a way of making up for the low pay thus leaving them with little or no time to engage in other activities.

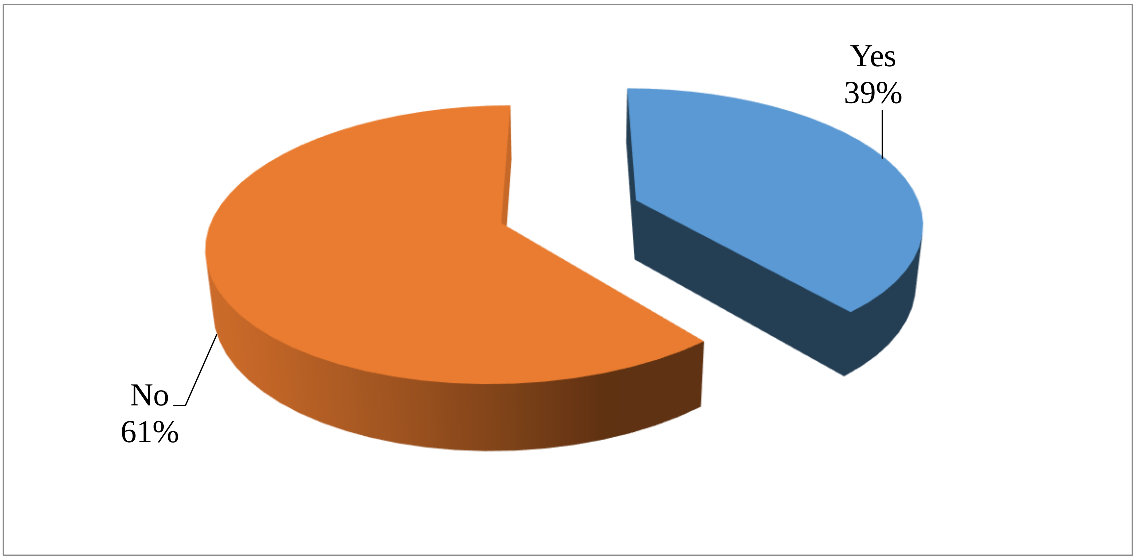


Figure 13: Respondent engagement on environmental activities

The study further noted that the proportions that were slightly involved on weekly basis (72%). While 28% were engaged on daily (14%) and monthly basis (14%) as shown in the Figure 4 below.

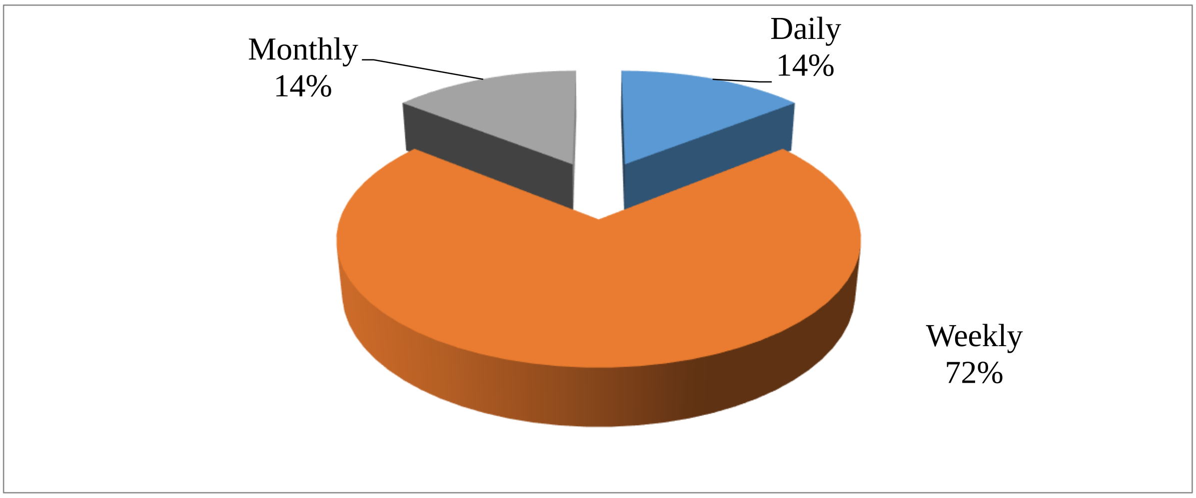


Figure 14: Frequency of engagement

The study also examined if the respondents were satisfied with the state of environment around Embakasi region. The study found that majority were not satisfied with state of environment in Embakasi region as shown in the table below.

Respondents satisfaction with the environmental status

		n	%
Satisfaction with state of environment	Yes	41	37.3
	No	**69**	**62.7**
	Total	**110**	**100.0**

Table 11

The study further examined how the respondents addressed dissatisfaction with environmental status of Embakasi region where 37.3% indicated that they had taken steps to address the dissatisfaction.

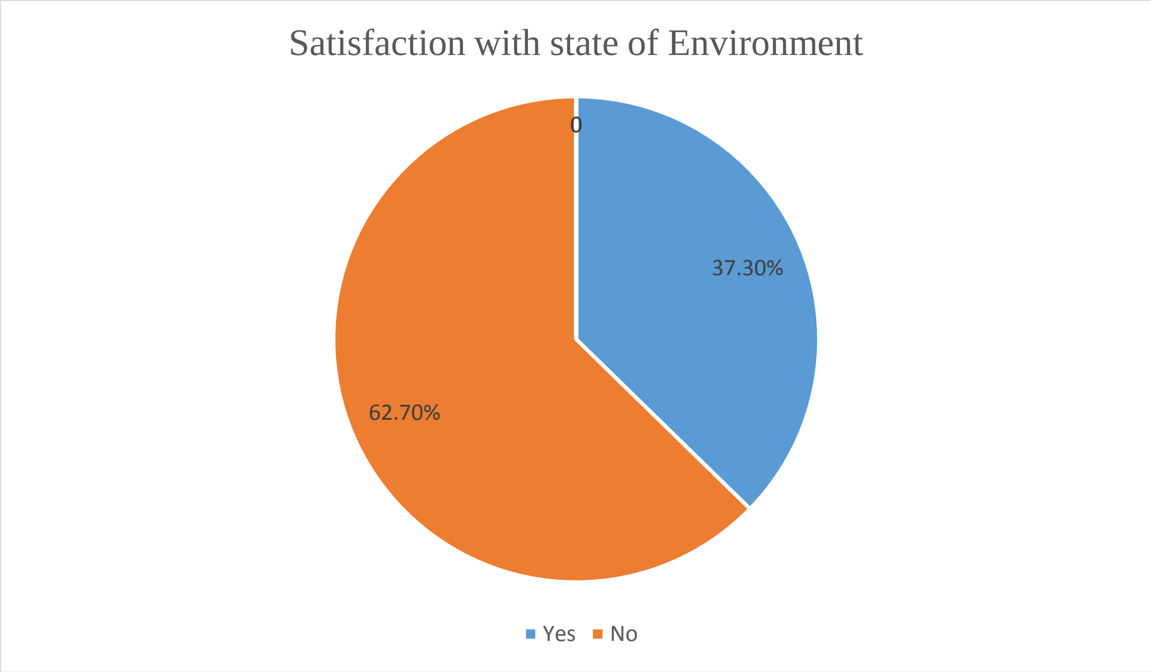


Figure 15

Steps undertaken to address dissatisfaction by respondents

		n	%
Steps of addressing dissatisfaction	Yes	35	41.7
	No	49	58.3
	Total	84	100.0

Table 12

The study found that some of the ways adopted by neighbours to address dissatisfaction were covering food kiosks from dust using polythene, ensuring that waste is collected and taken to a central place for burning, have raised complains to City Council and NEMA about smoke and dust. They have also raised complains to the authorities of quarry mines.

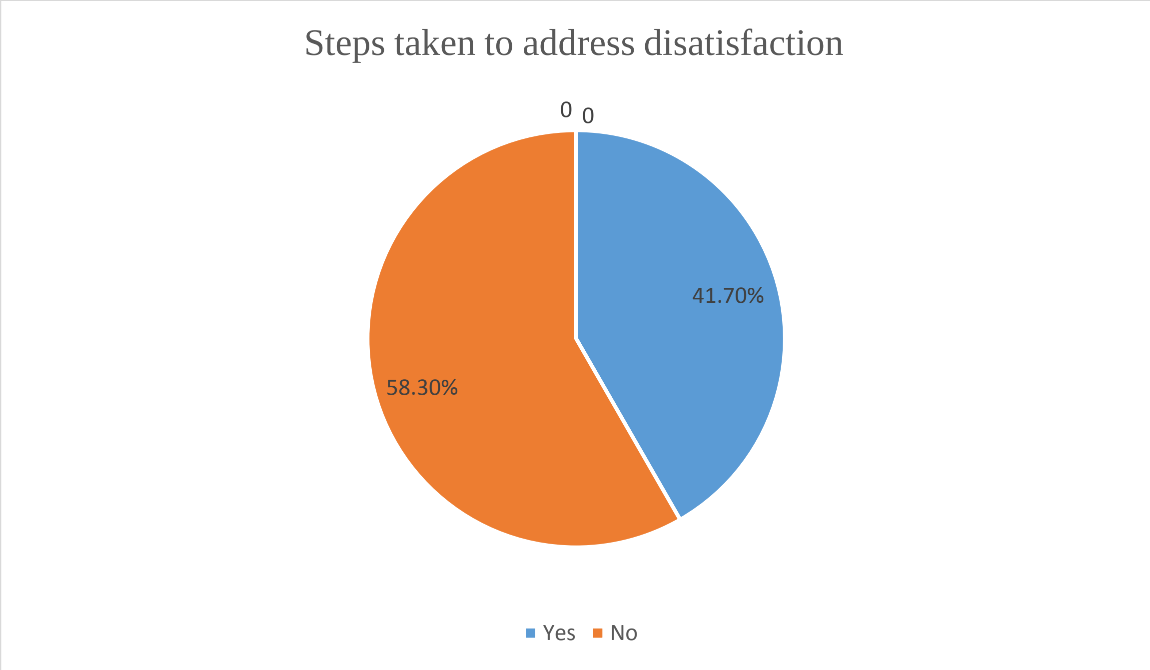


Figure 16

Proposed environmental impact mitigations

The study through interviews conducted from NEMA and County officers outlined the following possible ways of addressing environmental challenges occurring as a result of mining activities in Embakasi quarrying sites. The study found that there are possible ways of addressing environmental impacts which are recommended to the mining companies. These includes; planting trees around the quarry, installation of dust trappers, application of noise dumping technology, scheduling of blasting hours, watering quarries before blasting hours and adoption of appropriate land reclamation procedures.

CHAPTER FIVE: SUMMARY OF THE FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY

5.1.1. Respondent's demographic information

The respondents for this study constituted neighbours of quarries along Ngong River in Embakasi sub-county, customers for products along Ngong river, managers of quarries, NEMA officers and City County of Nairobi. The neighbours and customers were selected based on a number of basic information which include; gender, age and religion.

5.1.2. Quarrying activities in Embakasi Zone

Quarrying activities in Embakasi Zone were found to be controlled by individual families and companies. The main activities noted included grinding, mining and ballast production. These activities were carried out in huge tracks of land ranging from 10 acres to 22 acres. One factor that might have led to settlement despite the observed complains raised by neighbours to all concerned is employment and business opportunities as a result of these companies. It was observed that most people preferred settling in the area because of business and employment opportunities. Most of them worked as casuals and business people in the quarry companies and the neighbourhood.

5.1.3. Regulations and impact of the quarrying activities in Embakasi Zone

There is lack of clear and specific regulations to guide quarrying activities and as a result there is poor site management, use of illegal explosives, inadequate inspection and enforcement regulation to guide quarry activities. Most of the quarry owners do not consider the welfare of their workers and the impact that the quarries have on the health of the people living next to them.

The two main organizations involved in regulatory services that were targeted in this study were NEMA and the County Government of Nairobi. The study found that the quarrying sites were on transition to cease operations in the area. The two regulatory agencies indicated that they have been receiving complaints from the public. However, nothing much has been done about it. According to interviews with quarry managers, the decommissioning plan was not clear. The two however, admitted that they had received claims from neighbours concerning environmental problems associated with quarrying activities in the area.

5.2 Land use impacts

5.2.1 Unplanned settlements

The increase in urban population in Kenya, resulting from natural increases in population as well as migratory trends coupled with urban poverty has led to the proliferation of many unplanned settlements in many urban areas in the country. The value of urban land in Kenya on the other hand has spiralled in recent years thus becoming unaffordable to a majority of urban dwellers especially the low income groups. This has made it harder for the low income earners to own land in the urban centres.

The National housing demand has been pegged at 150,000 annually, majority of which is in the low income areas. The government, together with institutional and private developers have not been responsive to this problem and have extended much of their efforts in supplying housing units to the middle and upper class segments of the population and thereby condemning majority of the urban population to the unplanned informal settlements.

The unplanned settlements are not initiated or commissioned but spring up on any idle and contested spaces in urban areas. Worth noting is the fact that any idle land in any densely populated urban area will be the contested spaces, unutilised public land, the areas prone to flooding and other waste lands like dumpsites and filled up or abandoned quarries.

The quarries along the Ngong river basin having been zoned and established before the start of any residential development in the surrounding area, meant that the quarry managers had to organize for accommodation of staff by way of developing cost effective workers' quarters in the form of one roomed units constructed mainly by the workers themselves and using materials from the quarries.

The provision of accommodation preceded the organization of other support services like recreation and basic commercial services like shopping, domestic repair services like cobblers and tailors, barbers etc. These essential services were demanded constantly and had to be provided at close quarters. The providers of these essential services were at first the dependants of the quarry workers and their relatives from afar who by staying close hoped for jobs like their employed benefactors. As they waited for the lucky day, they would ‘’ keep themselves busy’’ by rendering some of these services and thus the beginning of activities linked to the quarries but not under the quarry management. The expansion of these services together with the increase in population of the quarry activities contributed to the emergence of unplanned settlements in the quarries vicinity.

There are several unplanned settlements in the study area that arose as a result of quarry activities. These include: Vumilia, Moola, Riverside and Matopeni as indicated below.

Vumilia slums -Started next to a quarry that is now abandoned and fronts the Ngong river on one side. This slum has a resident population of 500 households.

Moola– Stands between KarsanMurji quarries and Donholm phase 5 and fronts the Ngong river on one side. This informal settlement started in 1958 and has a resident population of over 600 households. There are many Slum lords in this informal settlement. Distillation of illegal brews is prevalent in this settlement capitalizing on the waters of Ngong river for the illegal practice.

Riverside - Started next to the Garuda quarries and fronts the Ngong river on the eastern side. Unique to the other quarry supported informal settlements in the study area, this informal settlement started after the decline in activity of this particular quarry in 2010 and therefore the most recent informal settlement along the Ngong River basin.

Matopeni – Started near Bhimji and Kenya builders' quarries. This is the biggest informal settlement in the entire study region. With a population of over 1,000 households, this informal settlement has grown over the years and is rapidly undergoing renewal in that it's not entirely dependent on quarrying. The presence of basic social and infrastructure services has led to the development of high-rise residential units and thus morphing in form and character with the nearby Kayole estate.

Plate 16: Moola informal settlement

5.2.2 Low property values

Land is a commodity whose value depends on the interplay of several factors that include; the level of services accessible to the property, the particular land use of the property – for instance agricultural land use attracts lesser values as compared to commercial and residential land use.

Agricultural land use in turn depends on the climate patterns, the type of soils, the favourable crops for the area etc. Urban land values have determinants that range from the particular land use; whether commercial or residential, the infrastructure services available, the neighbourhood development characteristics and most important and particular to the study region, the condition and state of the environment.

The proximity to a serene environment for example urban greenery has an incremental effect on the value of residential land use. On the other hand, the proximity to a noisy, dusty and geologically unstable environment impacts negatively on land value. The quarries in the study area have therefore contributed to a hostile residential environment leading to comparatively lower land values in the quarries neighbourhood.

Low land values in turn attract low income development and the subsequent low income earners. The low income earners and the segment of the lower middle class comprise of high population in many urban areas of the world. This is thus the case of the neighbourhoods in the quarry areas. The pull by these residential estates to the low income and lower middle class segments of the population further contributes to increased residential development activity as more and more people seek tenancy in these areas. The estate developers' response to the demand for housing results to flouting of the Council regulations and guidelines on zonal policies as well as the building regulations leading to unplanned re-development in the neighbourhood estates.

Plate 17: Part of the redevelopment of Donholm estate from single residential development to flats

5.2.3 Increased residential development

The residential estates surrounding the quarries in the study area have witnessed some of the highest development and redevelopment in recent years. Notable of this is Donholm, Tena and Tassia II estates that are also closest to the quarries. As per the City County of Nairobi records, the following development applications were received in the noted estates in 2013.

Cluster A

RESIDENTIAL ESTATE	NO. OF DEVELOPMENT APPLICATIONS
DONHOLM	58
TENA	31
TASSIA	63

Cluster B

RESIDENTIAL ESTATE	NO.OF DEVELOPMENT APPLICATIONS
KASARANI	20
NGUMBA	22

Compared to Kasarani, Komarock and Ngumba which are located almost the same distance from Nairobi central business district, almost same property values and appealing to the same economic class of residents, the residential estates neighbouring the quarries in the study area attract more development than the later cluster of examples - The environmental hostility of the area notwithstanding.

However, the number of development applications from any residential zone depends greatly on the prevailing development policy guidelines for the particular area as spelt out by the local authority and the spatial size of the particular estate. The estates in cluster A have development density of: plot coverage of 35% and plot ratios of 1.0% as compared to estates in cluster B which have development densities of: plot coverage of 50% and plot ratios of 2.0%. Ideally, this suggests that estates in cluster B would attract more development than those in cluster A as a result of the more favourable development densities and their expansive spatial size notwithstanding.

Consistent to the high development applications in the study area, is the high levels of impunity with regard to flouting building regulations. The development density of plot ratio of 1.0 with plot coverage of 50% implies that, no residential development ought to scale over three levels. However, the situation on the ground is rather different as residential blocks of six (6) levels are observable within the study area.

One of the reasons to this inequality in development between the two sets of clusters is the relative ease of accessing ballast in the area as compared to the estates in cluster B**.** This is in the form of reduced transportation cost and general availability. The importance of ballast as compared to other bulk construction ingredients i.e. natural building stones, sand and hard core is explained by the on-site prices of the four materials as at January 2013.

Cost of construction materials per tonne as at January 2013

Ballast Ksh 200/tonne

Sand Ksh 1500/tonne

Hard-core Ksh 1200/tonne

From the above prices, ballast is the key determinant to total construction material cost when it comes to the pricing of the bulk building materials, and would thus influence the location and site of physical development. As compared to sand, which is harvested from rivers without processing and hard-core which is a by-product of stone quarrying, ballast is technologically produced and therefore does not only depend on the presence of the natural raw material. This means that other factors like the working state of the crushing plant, the machinery to feed the ballast to lorries and the reliability of electricity to drive the motors of the crushing plant contribute to the difference in pricing per tonne.

The practise of quarrying in the study area has a serious impact on the state and establishment of other land uses. This is because the organization of particular activities depends on the presence or absence of other activities. For example, the siting of institutions like hospitals and schools require the presence of an enabling atmosphere that facilitates a conducive working environment. Other institutions have requisite environmental requirements for their establishment. Quarrying practices in the study area have greatly negated the establishment of many such public institutions despite the presence of a large and needy population.

5.2.4 Land degradation

Land degradation is a process in which the value of the biophysical environment is affected by combination of human-induced processes acting upon the land. **(**Journal of environmental quality 26:581-589,1997) The degradation is the result of gradual destruction or reduction of the quality and quantity of human activities, animals' activities or natural means either by natural or by human induced processes.

Quarrying activities are some of the greatest man induced land degradation agents known. This is borne by the fact that the inception of quarrying destabilizes the natural environment which in most cases is at its pristine state. The first steps in quarrying involve the clearing of natural vegetation which also acts as the natural habitat of various life forms. This first step is not drastic compared to the massive destabilization of the physical environment that follows in the form of excavation that exposes the target granite rock. This is followed by deposition/ dumping of the top soil some distance away from the quarry site and thus creating further destabilization of the natural environment.

The period of active quarrying represents the phase of the worst land degradation. Inside the quarry itself, intense degradation takes place as volumes of earth matter comprising of the hard granite rock is blasted and hauled to the surface for crushing into ballast. The aftermath of this is man –made craters that expose the rock strata on the steep cliffs.

Plate 18: Land degradation by excavation at Karsan Murji quarry

The product of crushing the granite stone is ballast while the by-product of the same process is fine dust. The fine dust is of less market demand as compared to ballast yet it is continually produced. The result of this is heaps and mounds of the fine dust which further degrades the environment. Just like degradation by excavation, this latter form of degradation also alienates the existing life-forms from their natural habitats as well as altering the landscape of the area. This form of degradation by deposition is the opposite of degradation by excavation which takes place at the start of quarrying. The extent of waste material deposition is characterized by the depth of the quarries, the propensity of the quarry operators to use the quarry dust to make other products. For instance, at KarsanMurji quarry, effort has been directed towards the making of concrete blocks, culverts, balustrades and other construction accessories as a way of reducing the mountains of quarry dust and thereby increasing efficiency and profitability.

Plate 19: Degradation by deposition at Nyoro construction company quarry

Land degradation is also realized at the closure stage of the quarry. There is no evidence of efforts towards total restoration of quarries within the study area. Once the quarry is depleted the quarries are leased to construction companies as sites to dump the unwanted black cotton soils that are prevalent in many areas within Nairobi. The deposition of the waste soils without a pre-conceived end –state only leads to further land degradation

.5.2.5 Solid waste dumping

Waste refers to lack of value and is a by-product of human activity(White.et al,1999). Solid waste can be from domestic, commercial, agricultural or industrial sources. The generation of solid waste is a factor of human population size, the consumption patterns as well as their values and integrity. The higher the population size, the higher the amount of generated waste.

Populations with higher consumption levels contribute to higher levels of waste generation as compared to populations with marginal incomes to whom consumption is basic, and which in turn contributes to low waste generation. Increased waste mobility achieved through the use of garbage trucks results to long distance transportation of waste to the most convenient dumpsites. This means that, the communities residing around the abandoned quarries now serving as dumpsites are therefore not the exclusive generators of the waste.

Solid waste contracted companies contribute to the greatest degradation through solid waste dumping. The abandoned quarries provide alternative dumping sites to the well-known Dandora dumping site. This method of dumping is cheap and requires little or no planning. These dumpsites become the breeding ground of rats, mosquitoes and flies. It also accommodates urban livestock farming especially those venturing to pig rearing.

The informal settlements in the study area also contribute to land degradation attested by their handling of domestic waste. As population in this informal settlements increase, so does the waste generated. The handling of waste in all the informal settlements neighbouring the quarries is wanting. Most of the solid waste is disposed in the open and ends up attracting marabou storks and other scavenging birds. The only waste disposal method employed is pig feeding the solid waste at the Vumilia informal settlement, an aspect that poses a great health hazard to the residents.

Plate 20: Humans, pigs and dogs competing for the same resource at a dumpsite next to Vumilia informal settlement in the background

The totality of land degradation resulting from quarrying activities underpins the assertion that, the best way to preserve and save land is by reducing the land mass under quarries or doing away with them.

5.2.6 Land use conflict

As a result of the increase in urban population, quarries cannot exist in isolation as earlier envisaged by the planning authorities, who being aware of the challenges of the co-existence of quarries and residential settlements had zoned the quarries to hitherto fringes of the town and with the cattle and sisal ranches of Tassia, Donholm and Kayole providing buffer between the two land uses. For years these was maintained, but as the city population grew, the three ranches ceded to of subdivision and the subsequent residential development came into being. This change was guided by the 1973 Nairobi Master plan that recommended and directed the future growth of the city to the eastern side of Nairobi. In place of the three ranches now stands; Kayole, Donholm, Tassia,Umoja, Komarock, Tena, Greenfields, Baraka, Greenspan, Jacaranda among other small gated communities and a near equal number of informal settlements.

The land use conflict in the study area is espoused in the form of quarry (industrial) and the residential aspect. Numerous complaints have been channelled through the offices of the provincial administration, the local District environmental offices, the National environmental management authority office (NEMA), and the local public health offices regarding the effects of quarrying to the neighbouring residential communities. These challenges centre on the stability of buildings, respiratory infections, cardiovascular problems, skin infections, loss of hearing etc. The cause of these health and structural problems is underpinned by the closeness of the residential development to the quarry sites. The buffer of several kilometres between the residential developments has now been reduced to zero. In all the abandoned and existing quarries, the only buffer existing is the public access roads which in some areas are as low as 9 metres.

The close proximity of human settlements and the quarries implies that the neighbouring residential developments bears the heaviest blunt of the quarry effects. These effects include; vibratory shocks to buildings and humans, dust, excessive noise etc.

In an attempt to address the serious concerns, the government, the City County of Nairobi, and NEMA have leaned on the side of the residents. As a result of this the quarries have been issued with restraining orders to cease their operations. The government has gone ahead to support the quarries on this initiative by making land accessible to the quarries in Mavoko. However, this has been met with opposition by the quarry operators. The standing argument as forwarded by the quarry operators is that, the residents themselves are the once to relocate as they migrated to the area long after the quarries had been in operation. Despite the stand-off, many of the quarries are planning to cease operating from this area while some have already ceased to operate in the area.

Plate 21: Tassia II residential estate next to water- filled KarsanMurji quarry site

Land use conflict also takes the dimension of informal settlement and institutional land. Quarrying, being a predominant land user in the study area has ensured the alienation of a big spatial area from human settlement resulting to land pressure from the high population in the area. Neighbouring the quarries is vast institutional land held by the Department of defence. Sections of this land has also been quarried and therefore being accessible to the general public. This has led to occasional invasion by the neighbouring communities. The present Tassia II estate is another example of land use conflict in the area. The land where the estate rests was institutional land held by the National Social Security Fund but ended up in the hands of land invaders. Land use conflict is also manifested by the encroachment of the quarries to the riparian reserves. The stipulated reserve in this case is 30m. However, this is not the case from many of the quarries along the Ngong river.

5.2.7 Destruction of physical infrastructure

The demand for construction materials has been highest in the country in recent years, leading to what has been referred to as the construction boom. The construction boom has made significant contribution to national development by way of creating jobs and leading to general wealth creation. This growth in the construction sector has been highest in the City of Nairobi. One of the implications of this growth is that quarries have operated optimally with some engaging in overtime and double –shift operations as a way of meeting the high demand of ballast which is a key material ingredient in the construction industry.

Material transporters have responded to the above demand by increasing their capacities through addition of high tonnage lorries to their fleet as well as employing the unscrupulous methods of overloading. The effect of this on the existing road network leading to the quarries has been deplorable. The quarry operators' despite being the cause of the bad road situation have not responded in arresting the situation, notwithstanding being in possession of tonnes of ballast that can be used in improving the road surface. The poor state of the road network leading to the quarries has not escaped the attention of the resident's in the neighbourhood as they point fingers to the quarry operators for the poor state of the roads. This scenario has not made better the relationship between the residents whose plight is already worsened by the noise, dust and vibrations from the quarries.

The Ngong River that traverses through this area has to be crossed so as to access some of the quarries. Example of this is the Garuda quarry when accessed from Donholm. The existing culvert bridge is very simple in nature yet it has to support the overloaded high tonnage lorries. This has led to constant collapse of the bridge. The Garuda quarry owners in a way that exposes irresponsibility have resulted to levelling the river bed so that only the big lorries and tractors can drive through. The destruction of infrastructure by the heavy traffic to quarry sites is not limited to roads but also affects water pipes and drainage channels along quarry routes.

Plate 22: A section of road leading to KarsanMurji quarry on the right. On the left is residential development that is accessed from the same road.

5.2.8 Survival of slums upon quarry closure

The continuity of life in the quarry dependent settlements even after the closure of quarrying activity implies that settlements don't die but are only transformed. Quarrying is a technical activity. It is this technical skill that is imparted to those dependent on quarries – and residing in the nearby informal settlements. The resident population in many of these informal settlements can be referred to as mono-skilled residential workforce. It is this skill that they continue to depend on after the closure of a quarry. This is done by the use of hand tools. The use of hand tools is a popular emerging method of material extraction in this area. This is evident in many inactive quarries whereby the populations neighbouring the quarries and especially the women folk together with former quarry employees result to scavenging livelihoods by scouring the quarry cliffs for the granite rocks and then hammering them into ballast by use of hand methods. The implication of this scavenging for resource contributes to the survival of the informal settlements even after main quarrying has stopped.

Plate 23: Activities that sustains the informal settlement at Bhimji quarry upon cessation of quarrying activities. The precarious nature of the quarry cliffs is not enough deterrent.

Plate 24:Activities that sustains the informal settlement at Bhimji quarry upon cessation of quarrying activities. The precarious nature of the quarry cliffs is not enough deterrent.

The demand for land was very minimal in the study area at the start of quarrying activities within the study region. This meant that quarries were leased sizeable tracts of land. Some of the quarries and for instance Nyoro Construction Company rests on over 60 acres of land, some of which may not be conducive for quarrying. Thus upon cessation of quarrying and without closure procedures being followed, the resident population, with the assistance of unscrupulous officers of the provincial administration takes over ownership of the land. This is followed by subdivision of the land into tiny parcels. The ex-quarries workers hence turn to slumlords while some of the parcels are sold to the non-resident population. The effect of this is that there is a corresponding increase in the population of the informal settlements upon cessation of quarrying.

5.3Environmental impacts

The environment is composed of the atmosphere, earth, water, and space. It remains simple and clean and becomes complex when industrial activities grow. The interactions by man through activities like mining, quarrying, construction, transportation and industrialization alters this natural balance leading to generation and release of objectionable materials into the environment thus rendering life miserable and uncomfortable. (Khopkar, 2005). The key environmental impacts identified included air pollution, dust, noise, stagnant water, land degradation and dumping of waste.

5.3.1 Air pollution

As earlier noted from various studies on quarrying activities; for example, Simon (1992) observed that the destruction of the land resources, with soils blighted and water fouled, needs to be accounted against the expediency of economic short term gain. Air pollution affects humans, vegetation and plants. The degree of proximity to the quarries has a direct linkage to the extremes of effect on victims. Unlike stone quarries that emit minimal dust, ballast crushing quarries emit vast amounts of dust throughout the working life of a quarry. The dust emitted is first from the drilling of shot holes by use of power driven drills that drill down to the level to be blasted. In some cases, this can be 100 feet. Dust is one of the most visible, invasive, and potentially irritating impacts associated with quarrying, and its visibility often raises concerns that are not directly proportional to its impact on human health and the environment (Howard and Cameron, 1998)

Blasting by explosives destroys the natural hold of the hard earth material accompanied by disintegration of the rock to boulders. This stage also produces dust from the depth of the quarry to the atmosphere. The amount of dust produced depends on the span blasted as well as the weather conditions. Blasting during prolonged dry weather spells leads to more air pollution as more dust is released to the atmosphere from the dry earth surface. Blasting during the wet season offers the best time for blasting operations, however this is rarely achievable since rain water often collects at the bottom of the quarry and has to be pumped out before quarrying restarts at the onset of the dry season.

The material crushing stage is the biggest contributor to air pollution in the entire quarrying process. Dust is emitted in large volumes as the boulders are crushed and reduced to smaller sizes. More dust is released to the atmosphere when the smaller stones are crushed into ballast and when the ballast is released from the elevated conveyor belt. More dust is further released to the atmosphere when the ballast is loaded to the cargo lorries.

Plate 25: Dust billowing from the crushing site at Bhimji quarries

5.3.2 Effect of dust on the environment

According to (Banez, 2010), potential health impacts are almost exclusively linked to the presence of airborne dusts, in particular respirable particles, i.e. those that are less than 10 µm in diameter, have the potential to affect human health, including effects on the respiratory and cardiovascular systems. The study found that challenges such as respiratory diseases which are related to dust were common among the people who living in the area.

Dust on quarry floors clog pores in the ground and the surrounding surfaces, thus altering ground-water recharge. The fine quarry dust binds itself to form a strong layer on the surface. Naturally the top soil, has the highest content of organic matter and thus the most porous. This aspect enhances soil capillarity and permeability at the top levels of the soil structure. The fine quarry dust on the surface negates this characteristic leading to little water percolating to the lower surfaces of the ground as more water runs-off the ground and thus affecting ground water recharge and leading to ground-water withdrawal and diversion of surface water causing aboveground and underground hydrologic systems to dry up with adverse consequences for aquatic bio-diversity.

The effect of air pollution is spread out within the entire study area and beyond. The plant life around the quarries and in the close vicinity suffers immensely from the emitted dust. Plants make food for their growth through the process of photosynthesis. This process depends on light, the presence of carbon dioxide in the air and the chlorophyll- the green matter on the leaves surface. The extent of dust deposition on plants depends on the morphology structure and arrangement of leaves. Smooth and flexible leaves like Millingtoniahortensis, Azadiractaindica, Meliarubia do not hold dust to the same degree compared to horizontally arranged leaves of Grevillea robusta, (Pattanayak, 1994,).

The pores (stomata's) through which plants perspire are also clogged by the blowing dust. The absence of either of this, despite the presence of rich soils and water inhibits the manufacture of plant food leading to stagnation in growth. The effect of dust thus leads to poor plant growth. This problem is only overcome when strong winds blow the dust off their surface or during the rainy season when all the dust is washed off the surface. Dust particulates remain in air for varying lengths of time and get settled out on various parts of plant, especially on leaf surface, which affects the vegetation of the area. The extent of impact depends on the amount of dust deposited on the surface. More dust is blown and deposited to the neighbouring environment during hot and windy weather. The natural vegetation and agricultural crops suffer a great deal from the thick deposits of quarry dust. Cases of diseased plants, stunted growth, reduced leaf area, low chlorophyll content and low crop yield are prevalent on the neighbourhood of active quarries and can all be attributed to the deposition of quarry dust.

Dust blowing from the quarries also settles on the nearby buildings on the quarry site as well as those in the neighbourhood. Dust collecting on buildings has adverse effect on them as it dazes their spark rendering them to deteriorate faster and thus increasing the maintenance cost. Inside the buildings, the occupants are faced by the challenge of a dirty environment as the billowing fine dust from the quarries permeates through the small orifices in the buildings to every part of the building including the kitchen- to the stored food and water. This poses a big health hazard to the residents. It is thus a difficult task of maintaining hygiene in the quarry neighbourhood.

The occupants of the houses in this area together with the quarry workers are most affected by the dust emanating from the quarries. From the field study, it emerged that respiratory ailments, eye infections and allergies –all attributable to the dust from the quarries affect a sizeable number of the population within the neighbourhood. The result of this is a high tenant turn-over as tenants seek alternative places of residence. To the developers, this is a constraint as it affects the flow of revenues which in-turn impacts the return on investment.

5.3.3 Noise pollution and blasting

Sound is a form of energy which requires material medium for propagation (Khopkar, 2005). Sound is propagated through material medium that may either be solid, liquid or gas, but not through vacuum. Noise pollution is prevalent in all quarry operations. This takes place from the inception stages of drilling to crushing. However, the blasting stage produces the highest levels of noise pollution. This is occasioned by sound vibratory sound akin to detonation of bombs or other forms of explosives. When an explosive is detonated enormous amounts of energy are released. Most of the energy of a properly designed blast works to displace rock from the quarry face. The remaining energy is released as vibrations through and along the surface of the earth and through the air.

The effect of the noise pollution from blasting affects humans, animals and buildings as well. Excessive noise is a pervasive occupational hazard with many adverse effects, including elevated blood pressure, reduced performance, sleeping difficulties, annoyance and stress, tinnitus, noise-induced hearing loss (NIHL) and temporary threshold shift. (Deborah, et al, 2005). The hazardous effects of noise depend on its intensity (loudness in decibels), duration, and frequency (high or low). High and low pitch has more serious implications than middle frequencies, and white noise covering the entire frequency spectrum is less harmful than noise of a specific pitch (Lusk, et al, 2004).

Loud and abrupt sound poses great risk to the eardrum while sustained sounds at lower volume pose risk to the middle ear (Havas,2006). Noise disrupts sleep and communication. Stress, high blood pressure, anger and frustration are symptoms of exposure to high noise levels Noise can also disturb wildlife feeding and breeding. Damage to properties range from external deterioration to structural damage and failure resulting from vibrations brought about by sound waves. This leads to economic detriment in the form of constant repair and the resulting low property values. The primary source of noise from the extraction of aggregates is from blasting, drilling, earth moving equipment and processing equipment.

The impacts of noise are highly dependent on the sound source, the topography, land use, ground cover of the surrounding site, and climatic conditions. The beat, rhythm, pitch of noise, and distance from the noise source affect the impact of the noise on the receiver (Langer, 2001). Reduced hearing ability is most common among the quarry workers, their housed families and those in the immediate neighbourhood. Cases of hypertension and trauma from shocks are experienced in the areas surrounding the quarries. Expectant women receive the biggest blunt from the explosions. Incidences of miscarriage, defective births resulting from shocks and low birth weight in new-borns are common phenomena in the area. The impact of the blasting to the workers is remarkably minimal as many of the quarry workers result to applying ear plugs to their ears whenever blasting is carried out. The hoisting of a red flag as a warning sign to eminent blasting is not effective enough due to limited visibility and the fact that neighbours have task and chores to undertake and cannot be expected to always keep an eye onto the quarry front all the time.

The levels of noise produced by the constant drilling and crushing of the quarry stones has less impacts to the neighbouring population as compared to blasting. The noise levels from these operations are comparable to a busy construction site or a diesel powered electricity generating plant. The noise levels have almost the same frequency and therefore not very hazardous as would be in the case of fluctuating vibrations. The noise levels are only a spectacle to the visitor and are hence tolerable. Noise can adversely affect wildlife especially birds by interfering with communication and masking the sounds of predators and prey, and in the extreme, result in temporary or permanent hearing loss.

Blasting of the quarry stone has significant effects to buildings in the quarry neighbourhood as compared to any other stage of the quarrying process. The closer to the quarry site the more hazardous it is to the structural stability of the building. Residential buildings should be sited in safe distances of not less than 500m from quarry sites (Fletcher and Busnel, 1978). The span to be blasted, the amount of explosives applied and depth of the quarry have a bearing to the vibration. However, the structural strength of the building and the building materials used also contribute to the extent of damage arising from blasting.

Noise has detrimental effects upon children's performance at school, including reduced memory, motivation, and reading ability. External noise has significant negative impact upon performance, the effect being greater for the young children. The environmental noise emanating from the quarries has negative effects on all the schools in the Ngong river neighbourhood. The dust billowing from the quarries also finds way to the classrooms of neighbouring schools and this also affects learning.

Plate 26: The map shows a distance of 75.59 between one active quarry pit in Garuda quarries

The map shows a distance of 75.59 between one active quarry pit in Garuda quarries and the neighbouring Moola informal settlement. The noise experienced during drilling and grinding is loud enough to impede hearing between two people having a conversation. The level of noise generated by moving trucks is discernible even on an audio-active day within the informal settlement. The noise impact generated during blasting is loud enough to shake all the shanties in this informal settlement. One of the research assistants hand held phone dropped down when a blast coincided with the field day. Dust from the quarry activities easily settles on the shanties and surrounding vegetation even on a calm day.

When drilling, grinding and transportation of material is done at night, the effect on the neighbourhood is even much more. This is because noise vibrations are transmitted more at night. This ends up destructing the sleep and other night activities within the informal settlement.

Plate 27: The photo above shows another end of Garudi quarries and the neighbouring Riverside informal settlement.

The photo above shows another end of Garudi quarries and the neighbouring Riverside informal settlement. The separation distance between one quarry pit and the settlement being a mere 35.47m. This neighbouring part of the settlement is impacted more than any other settlement within the Ngong river.

Plate 28: 175.53m is the linear distance between one quarry pit at KarsanMurji quarry

175.53m is the linear distance between one quarry pit at KarsanMurji quarry and the main Tassia estate. The sound from drilling and blasting is discernible throughout the day. Billowing dust from the quarries settles on the buildings and surrounding vegetation even on calm days. Noise from blasting reverberates through the estate. The impact of noise, dust and blasting is even more intense in the few informal settlements developing on the buffer between the Tassia estate and the Ngong river.

Plate 29: From the photo above, 80.29m is the distance between part of Soweto slums

From the photo above, 80.29m is the distance between part of Soweto slums and the abandonedMugoya quarries that lie inside the Embakasi barracks land in Embakasi. From 80m, mosquitoes will breed and infect the surrounding population with malaria. Having been abandoned in the immediate past, the close distance means that there were intense impacts from quarrying activities to this side of the slum. Being the biggest informal settlement along the Ngong river, the adverse effects of quarrying impacts more on the large population than on any other settlement.However, unlike Karsanmurji and Garudi quarries that are surrounded by settlements, this quarry's impacts are on Soweto side only as the other side fronts the defence facilities that got a wide buffer and thus minimal impacts.

Plate 30: The photo above shows a distance of 93m as the distance between on active pit at Sharma quarry and Kayole estate.

The photo above shows a distance of 93m as the distance between on active pit at Sharma quarry and Kayole estate. This is one of the oldest quarries along the Ngong river and has the most intense levels of land degradation both by deposition and erosion. Like the Mugoya quarry, it borders only one settlement as one side fronts the Embakasi garrison. Unlike the other quarries that neighbour mabati walled shanties, this quarry neighbours Kayole estate that has permanent buidings. Cracks on the masonry walls are clearly evident on almost all the structures on the front row of the Ngong river within this estate.

It is also within Kayole estate that public institutions like schools and hospitals are located along the Ngong river neighbourhood. The impact of noise, dust and cracks emanating from Sharma quarry are therefore more pronounced.

Plate 31: 40m is the measured distance between an active pit in Kenya builders quarry

40m is the measured distance between an active pit in Kenya builders quarry and Matopeni informal settlement. The effects of noise and dust from this quarry is thus comparable to that of Garudi quarry on its neighbourhood. Like Mugoya and Sharma quarries, this quarry also borders the Embakasi garrison on one front.

Plate 32: Nyoro construction quarry

The photo above shows a distance of 162m between Nyoro construction quarry and the neighbouring Mihang'o residential settlement. This is the widest buffer along the entire Ngong river and which is still below the international standard of 500m. One advantage the neighbours derive from this quarry is that it is not a building material trading venture but strictly operates a source of material for the parent company i.e. Nyoro construction company. However, there is an emerging threat of encroachment from squatters on the vast land on the opposite side of the Ngong river and this has the potential of reducing the buffer area on the neighbouring side.

5.3.4 Water pollution

Naturally, rain water collects in natural water masses such as lakes, swamps or oceans. The characteristic of this water bodies is that they are based on low attitudes compared to the areas that form the sources of the flowing water. Quarries, whether abandoned or active are natural collection points for rainwater and surface water run-off owing to the lack of drainage outlets. The natural drainage methods of seepage and evaporation are slow, much more compared to the volume of water involved. The stagnant water resulting from surface water run-offs becomes the breeding grounds for disease through organisms like mosquitoes which cause malaria. The result of this to the neighbouring population is high incidences of malaria.

Malaria and fever have mainly originated from open quarry filled with water. Other common problems noted were bronchitis at 17.4% and common cold 34.8%. Generally, the apparently poor health status of the people based on the range of infections and their frequency could be attributed to the high concentration of particulate matter (dust) generated from the quarries, drinking of unclean rain water and perhaps status of the residents before and after the inception of the quarrying activities.

The stagnant water sometimes runs several metres deep and thus provides the problem of providing a quick solution to those bent on taking their own lives by committing suicide. Suicidal cases are minimal but with an average of one case every two years. The increase in socio-economic problems especially among the lower economic segments of the population – who are the majority in the quarry neighbourhood increases the viability of the stagnant pools of water as the preferred suicide spots.

Plate 33: Improvisational facilities for swimming pools

The presence of the stagnant pools of water coupled with the lack of adequate recreational facilities in the area presents improvisational facilities for swimming pools which is a beloved sport to a majority of the young people as witnessed during the field survey. Majority of those venturing into these swimming grounds are the young school going children without the sufficient skills to manoeuvre in such water fields. This is further complicated by the rugged rocky nature of the quarry bottom as well as the quarry sides which are then covered by water. These pools of water further pose the problem of uniformity in depth as compared to conventional swimming pools which have shallow ends – for beginners and the deep ends for the seasoned swimmers. This complicity of their innovation quite often ends up in tragedy, but the lure of a cool good time keeps many of the young, in the quarry neighbourhoods in full adventure.

River water pollution arising from quarry activities is a constant feature along the entire Ngong river. The appetite for aggregates has attracted all the quarries to quarrying on the riparian reserve leading to pollution of the river water by fine dust from the quarry pits.

Plate 34: Showing the encroachment of the riparian by quarrying along the Ngong river

5.3.5 Destruction of the natural environment

Like other human activities, quarrying disrupts the existing natural environment. The natural environment consists of natural vegetation, life-forms residing in their natural habitats, rivers, atmosphere and life cycles. In this environment organisms are continually engaged in a highly interrelated set of relationships with every other element constituting the environment in which they exist. This is usually what exists in many places before the onset of quarrying activities since quarrying is often centred on the pristine environment. Quarrying therefore alters the existing balance of interrelationships that is hard to restore even after the restoration efforts have been employed.

5.3.6 Dumping of waste

For many years, landfills were the most convenient waste disposal sites in many parts of the city of Nairobi. This was a replication of the domestic waste pit that was hygienically advocated for by public health and sanitation department of the ministry of health. The biggest landfill dump in Nairobi and in Kenya is found in Dandora estate in Nairobi. This dumpsite is a former quarry site. The lack of quarry restoration procedures after the decommissioning of quarries has ensured that the quarries in the study region become alternatives for the disposal of domestic and industrial waste. The waste is not just from the neighbourhood but is ferried from industrial area, Embakasi and some of the populous Eastlands residential estates of Nairobi. In doing so, environmental challenges akin to the Dandora dumpsite experience become expected scenarios.

The prevailing solid waste handling challenges in the City of Nairobi is finally transferred to the study area. Very little of separation of waste takes place in Nairobi, and thus all the solid waste is lumped together. The result of this unfortunate circumstance is that, industrial, commercial, residential, plastics, the biodegradable and the non-biodegradable, the toxic and non-toxic waste is ferried together and lumped together. This confusion in waste handling creates a den of opportunity in the dumpsites as scores of those who earn livelihoods from them scramble for what is meaningful to them.

Unique to the landfill dumpsites in the study region, and of greater environmental risk is the closeness to the natural but polluted Ngong River - a tributary of Athi River that passes through the marginal agricultural areas of Ukambani. The dumpsites, being recipients of both unsorted industrial and domestic waste contributes to the leaching and flow of the waste chemicals that include heavy metals like lead flowing to the river that sustains thousands of humans and animals downstream.

5.4 Contribution of quarries to the study area

5.4.1 Employment creation

The state of un-employment in Kenya is presently alarming. Majority of the young people cannot find jobs while many of those already in employment are not gainfully employed. Employment creation is a clarion call by the government and all those with the intent of witnessing a reversal to this situation.

Quarrying activities are hugely physical and involve the use of manpower and machines. Compared to other industrial concerns, quarries have a higher demand for land and machinery. The output in volume and noise generation also out-runs many industrial concerns. However, the human labour demand remains lower than other industries of the same capital investment. The manpower levels in many quarries are three, i.e. the management, skilled, and the unskilled.

The management of all the quarries is family based. Many of the quarries are owned by Asians and the family networks through kin and few kindred are tightly organized. The management structure in many of the quarries is therefore very informal, whereby the manager and director is held by one individual and who in many cases is the family patriarch. The sons work below the family patriarch in positions such as technical director/ manager in charge of all the plant and machinery. The human resource manager/director is in charge of payroll and recruitment of the few labourers whenever need arises. The financial manager/director is in charge of all revenues while the store manager is in charge of securing all the consumables in the quarry, namely explosives, fuel, lubricants etc.

The skilled manpower comprises of the clerks, drivers, mechanics, electricians, blasters and plant operators. Drivers are usually the majority as one quarry can have as many as seven (7) drivers as in the case of KarsanMurji quarry. The number of mechanics and blasters is less than the number of drivers in all quarries. The aspect of multi-skilled workforce is highly emphasized in many quarries and therefore many drivers are equally skilled as mechanics and this then contributes to reduced payroll costs. This manpower category is also sometimes infiltrated by the quarry owners' families and therefore less of employment benefits trickle to the surrounding area as all the quarry managers and their families live away from the study area.

The unskilled workforce is predominantly from the study area, with many of them residing in the surrounding informal settlements. The work force in this category is employed as cooks for the management, guards, loaders and general duty workmen. The gender equation is heavily biased towards males as many quarries have not employed a single woman.

The contribution of quarries with regard to direct employment remains marginal to the study area. It's the indirect employment generated that has a higher significance to the study area. The indirect employment creation lies in the transportation sector, construction sector as well as other indirect jobs created by the quarries. Examples of indirect job creation is the flourishing industry of manufacturing culverts, building blocks, paving blocks by youth groups from the study area. The youth groups buy the crushed ballast from the quarries, mix with cement and other aggregates to make their products.

5.4.2 Supply of building materials

The construction industry cannot thrive without quarries. All the construction aggregates namely: ballast, stones and cement are quarried products. Sand, the only exemption of the bulky construction ingredients is in some instance quarried, though more of it is harvested from rivers. The supply chain of quarry products to the construction industry is through direct consumers with ongoing real estate developments, to middle men who buy in bulk for distribution to consumers or to industrialists with interests in the manufacture of pre-cast building materials. However, some quarries in the study region are owned by road construction companies and other general contractors. These groups of quarries do not sell their products externally but have been established to meet their own ballast demand. Example of such quarry is Nyoro Construction Company, which is a leading local construction company.

5.4.3 Opening of the study area for development

For many years in the 1980's and before, the spatial area east of Outerring road was largely undeveloped. This area was under beef ranching and sisal farming going by the names such as Kayole sisal estate, Tassia estate, Donholm estate etc. With the decline in sisal market and the pressure of africanisation of the economy in the 1960's and early '70's, many of the former white ranchers gave in, and sold the land to the able non-white Kenyans. Many of the new owners had no long term intentions of running the farms and thus went on to a subdivision mode. Tassia estate was largely sold to the National Social Security Fund to which Nyayo estate and Tassia estate stand. Kayole estate was acquired by the then City Council of Nairobi. It was later subdivided into subplots and allocated to private individuals for residential development. Donholm estate was sold to private developers who developed it to the Donholm estate as known today.

Man is by nature a social animal. Wherever he chooses to settle, he draws communion from the surroundings and thus deriving a sense of satisfaction. The closest inhabitant is the neighbour in spite of the distance between them, and not the many wild animals that inhabit close to him. The earliest settlers in the study area derived this sense of communion from the quarries no matter the spatial extent between them. During that state of underdevelopment, direction and description of once abode was quarry based i.e. which direction and what extent from this or that quarry.

The only means of access to the above estates then, was principally the roads leading to the quarry estates. All other roads that were developed later were accessed from the roads accessing the quarries. Without any means of transportation, the early inhabitants relied on the Lorries destined to the quarries for building material supply for their daily movement. Power supply to the residential development was extended from the high voltage lines supplying power to the quarries thus underlying the role of the quarries in opening up of the study area for development.

5.4.4 Provision of opportunities for waste soils

The construction industry in Kenya has been growing by over 10% in the last decade (Kenya Economic Survey, 2013). The cause of this growth has been fuelled by the government, private developers as well as institutional actors in the construction industry. A high proportion of this development has taken place in Nairobi and therefore great a bigger impact of this growth has been in Nairobi.

All types of construction involve a series of steps that begin with laying the proper foundation for the proposed structure. Often, the bigger the structure, the more pronounced is the foundation. The state of topography and the soil type also impact on the nature and type of foundation selected for particular structures.

The eastern part of Nairobi whereby, the study area is situated comprise mostly of black cotton soils that by nature are very poor bases for any structural foundation. This therefore means that, these soils have to be excavated and be removed from the building site and be dumped at officially designated sites. It is the building contractor’s duty to comply with the Nairobi County’s laws on dumping of waste soils. The depleted quarry sites are some of the designated dumping grounds and hence the depleted quarry sites within the study area come in handy.

5.4.5 Provision of markets for construction plant

The growth of the construction industry in Kenya in the last decade has had a ripple effect of the associated sectors. The increased demand for quarry materials implies that quarries have to operate optimally at all times. Thus bigger plants and machinery have been commissioned while those wearing out call for scheduled servicing so as to continue operating optimally or replacement. This has resulted to regular business in terms of sales from plant and machinery companies and dealers like Atlas Copco, Mantrak Kenya etc.

5.5. Conclusion

The study concludes that quarrying activities in Embakasi Zone along Ngong River have affected the land use and physical facilities due to environmental issues accompanying mining activities. Dust originating from the quarrying site affected plants while tremors have potential to cause cracks in buildings.

This study also concludes that impact assessment and audits conducted mainly by NEMA has not been fruitful in addressing environmental challenges caused by quarrying activities in Embakasi Zone. Finally, the study concludes that quarrying activities are potential environmental hazards which riggers health issues to neighbouring people. Diseases such as headaches, fever and pneumonia which are associated with dust were found to affect people neighbouring the quarrying sites.

5.6. RECOMMENDATIONS

Land filling is the only waste disposal method that can deal with all materials in the solid waste stream. It's the simplest and cheapest disposal method and works very well for bulk waste that may be problematic for other disposal methods. Waste disposal procedures should be adopted at the dump sites being a culmination of waste handling from the source. With the rapidly increasing population of Nairobi, there is need for proper planning of reclaiming the abandoned quarries by turning them to useful landfills rather than leave them to turn to dams and swamps. The ever increasing City population increases the need for more housing. The geology of the City of Nairobi, especially the Eastlands area is composed of black cotton soils. This type of soil has no construction relevance and thus has to be cleared before commencement of construction. Large disposal areas therefore have to be created for their disposal and the quarry sites are a favourable solution to this problem. The oldest design approach around is nature itself. Given enough geologic time, a suitable small site scale, and stable adjacent ecosystems, disturbed areas may recover without mankind's input.

1. The County government should take charge of the operations of the landfilling so as to regulate the contracted solid waste collectors and gangsterism that results from the unregulated practices. Waste classification should be adhered to and measures towards recycling adopted.
2. Proper planning and implementation of such plans should be pursued throughout the quarry operations. To control the growth of unplanned settlements upon cessation of quarrying activities, the County government should adopt a closure mechanism of all quarries along the Ngong River. The closure plan should detail the land use of choice that the closed quarries should be changed to. A better way is for the land to be gazetted as reverting to the government for a stipulated but short period to undertake reclamation and thereafter a change of land use be sought.
3. Land use conflicts are a major challenge in many quarrying environments. This is mainly manifested by the spatial interactions between residential and quarrying – industrial. The main cause of this is the rapid increase in population especially in the urban areas. The increase in urban population has resulted in land subdivisions and eventual development of parcels that are less than 30 m from the quarries. Many of these residential developments are permanent and claimed ownership by the middle class in Nairobi. Proper land use zoning that ensures the provision of buffer zones from quarrying and other activities deemed as hazardous to humans.
4. Degradation of the environment through massive deposition of the by-products of ballast crushing which results to mountains of quarry dust can be mitigated by encouraging all quarry owners to add value to this by-product by producing concrete products like paving blocks, culverts, construction blocks etc. This approach to the

crushing by-product will not only lead to increased revenue stream but also contribute to increased employment opportunities. Environmentally, this manufacturing addition will clear the mountains of the crushing dust from the quarries.

5. The destruction of infrastructure mainly roads, drains and culverts by heavy transportation trucks ferrying construction materials from quarries is widespread in the study area. A transportation ban is not good as a way of protecting the laid down infrastructure. However, a form of cess can be levied to all trucks ferrying building materials from the quarries. The collected levy can be used to maintain the physical infrastructure that is prone to the heavy truck loads.
6. Air pollution resulting from billowing dust can be overcome through the introduction of both natural and man-made measures to curb the spread of dust to the neighbourhood. Planting of fast growing trees with dense foliage around the quarries and in all reserved land held by the quarries can help in ameliorating the damage to the environment by the dust from the quarries. The proposed buffer zone should also be densified with the same fast growing trees with dense foliage. Air pollution resulting from billowing dust can be overcome through the introduction of both natural and man-made measures to curb the spread of dust to the neighbourhood. rather than the corrugated sheets nailed on the sides of crushing plants in some quarries.
7. Noise pollution can be controlled through reduction at the source, interruption of transmission paths, or protection of the receiver. The use of ultra – modern machines that encompass noise damping should be employed. The use of outdated drilling machines that vibrate loudly should be replaced with modern drills. The timing of the use of the noisiest machines is another way of reducing noise levels. Quarries that are proximate i.e less than 200 m to residential developments should not be allowed to operate at night – since sound vibrates more when the environment is cool.

8. Quarry personnel should be provided with ear plugs to help minimize the impact of noise from the machines. The use of noise barriers and enclosing the locations of highest noise emission should be adopted.
9. The health risks posed by stagnant water can be ameliorated by mandating the quarry owners to erect perimeter fencing round the quarries. Counter measures should also be employed in controlling surface run-off from draining into the quarry. Regular pumping out of water from the quarry should also be enforced so as to always have dry quarry beds.
10. Regular environmental audits should be conducted on all the quarries in the study area. This refers to the systematic examination of the quarries interaction with the environment as a way of assessing the success of its conservation or anti- pollution programme.
11. Regulations should also be enforced making clear boundaries between residential and mining sites in municipality areas.
12. Health awareness campaigns to enlighten people of potential threats of unhealthy environments should also be carried out on regular basis.
13. The County government should enforce regular health assessment studies to help them improve citizens' health status.
14. Flood control sites need to be developed along the Ngong river. The quarry pits can easily be utilised for this function.
15. Quarries should be barred from opening new sites within their land before restoring the previous sites.
16. All quarries like many other organizations and processing industries should be compelled to come up with a vision and mission that guide towards restorative

quarrying and reclamation. This mission statement if ingrained to the daily practises will work towards the end state.

Areas of further study

Reclamation of quarries is an important area in furthering the research. With the increasing demand for housing, quarries cannot be resisted. More affordable means of reclamation need to be researched since the cost of reclamation is almost equivalent to the real value of an equivalent parcel of unquarried land.

Further research need to be done on the best models to utilise the restored quarry areas.

Further research need to be done on the total cost of quarrying i.e. to the environment and land use so as to determine the cost and benefits balance of quarrying on different spectra of environment.

APPENDICES

APPENDIX 1: QUESTIONNAIRE FOR NEIGHBOURS TO THE QUARRY SITES

Section 1

NAME OF RESPONDENT…………………………………………………………………

PLOT NO…………………………………………………………………………………

Social and economic characteristics of the respondents

a) Sex: Male…………………………………………………………………………….

Female……………………………………………………………………………….

b) Religion: Christian……. Muslim…… ……………………………………………

Others………………………………………………………………………………

c) Age (years)……………………………………………………………………......

d) Highest level of education…………………………………………………………. …..

e) How long have you lived in this area?...

f) What is your reason for choosing to live here?

i) …………………………………………………………………………

ii) …………………………………………………………………………

iii) …………………………………………………………………………

iv) …………………………………………………………………………

g) What is the size of your house hold?........…………………………………..

(i) Males?..

(ii) Females?...

h) What is the age category of the members of your household?...

i. Under 5 years…………………………………………………………….........

ii. 5-10 years…………………………………………………………………

iii. 10-20 years………………………………………………………………

iv. 20-60 years………………………………………………………………

v. Over 60 years……………………………………………………………

i) How many of your children were born in this neighbourhood? ……………………..

j) What are the common ailments that afflict members of your household? ....

k) (i)……………………………………………………………………………(i

i)...……………………………………………………………………………(iii

)……………………………………………………………………………

l) Are you affected in any way by the neighbouring quarries? Yes…. No………………

m) If yes to (k) above, how are you affected?

…………………………………………………………………………………

…………………………………………………………………………………

n) Have you sought redress from any institution? Yes…. No...

Section 2. Environmental issues

a) What comes to your mind when the term environment is mentioned?

....

....

b) How do you participate in environmental matters in this area?

c) What environmental concerns do you have in this area?..

…………………………………………........……………………………………

d) Do you engage yourself in environmental activities –Yes…? No……………………...

e) If yes, how often do you engage in environmental activities?

i) Daily…………………………………………………………………………...

ii) Weekly…………………………………………………………………......

iii) Monthly……………………………………………………………….…...

iv) During holidays………………………………………………………………

v) When on leave…………………………………………………………......

f) Do you feel satisfied with the state of the environment in this area? Yes…...? No……….

g) If no, have you taken any step to address your dissatisfaction? Yes…. No……………….

h) If yes which steps have you taken?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

APPENDIX II QUESTIONNAIRE FOR QUARRY OWNERS/MANAGERS

NAME OF RESPONDENT…………………………………………………………………..

RESPONDENT POSITION …………………………………………………………....

a) Name of company…………………………………………………………………..

b) When was the Quarry started?...

c) What activities take place in your quarry? ....

d) Why did you choose to quarry here? ……………………………………………….

e) How many employees do you have?………………………………………………..

f) What's the nature of employment? ……………………………………………......

g) What do you provide towards the safety of your employees?

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

h) What is the development trend of your company?

i) Downward …………………………………………………………………………

ii) Stagnant……………………………………………………………………………

iii) Upward……………………………………………………………………………

i) What is the acreage of your land?…………………………………………………

j) Nature of ownership

i) Individual ownership ………………………………………………..

ii) Family ownership…………………………………………………

iii) Company owned………………………………………………......

k) What regulatory institutions have you complied with?

(i)……………………………………………………………………………………(i

i)……………………………………………………………………………………(ii

i)……………………………………………………………………………………

l) Are there any environmental implications posed by the quarries? Yes….. No…...........

m) If yes, what are the implications?

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

n) What measures have you undertaken to protect the environment?

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

o) Do you have any complaints from the residential neighbourhood? Yes …. No ……….

p) If yes, what are the common complaints?

(i)..

(ii)...

q) What is the anticipated life span of the quarry? ………………………………………..

r) Do you have any post closure strategy on the quarried area? Yes…… No……………

s) If yes, what are those measures?

(i)……………………………………………………………………………………(i

i)……………………………………………………………………………………

(iii)……………………………………………………………………………………

t) Are you in any way socially responsible to the neighbouring community?

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

(i)……………………………………………………………………………………..

………………………………………………………………………………………….

……………………………………………………………………………………..

APPENDIX III QUESTIONNAIRE FOR CUSTOMERS

NAME OF RESPONDENT…………………………………………………………..................

a) Sex: Male……. Female……………………………………………………………

b) Religion: Christian……. Muslim…. Others…………………………………………

c) Age…………………………………………………………………………………

d) Highest level of education…………………………………………………………….

e) How far is your market?

   i) Less than 1 km away………………………………………..................

   ii) Less than 2 km away…………………………………………………

   iii) Less than 5 km away……..

   iv) More than 5 km away……………………………………………….

f) Why do you purchase from you here?

Customers	1	2	3	4	5	6	7
Favourable prices							
Favourable customer relations							
Quality products							
Batch volume							
Efficiency of service							
Security							
Location and distance							
General ease/comfort							

APPENDIX IV: HEALTH FACILITIES

NAME OF RESPONDENT…………………………………………………………………...

RESPONDENT POSITION IN THE FACILITY…………………………………………...

How long have the facility been running within this area………………………………………

How long have you been attending to patients in the area……………………………………?

What are the major health issues/ complaints in the

area………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………?

How do the complaints compare with other places you have worked

before……………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………?

If high what can be attributed to the high number of

cases……………………………………………………………………………………………

…………………………………………………………………………………………………

Have there been any interventions to mitigate the incidences…………………………………

Are all the cases encountered handled successfully within the facility……………………….?

If no, which referral facility do you advice……………………………………………………

Are there any emergency cases you have ever dealt with……………………………………?

Have you and your staff been victims of poor health attributable to the state of the

environment……………………………………………………………………………………?

If yes, which ones ……………………………………………………………………………..?

APPENDIX V: POLICY INSTITUTIONS

QUESTIONNAIRE FOR NATIONAL ENVIRONMENTAL MANAGEMENT AUTHORITY

NAME OF RESPONDENT…………………………………….................……………...

RESPONDENT POSITION IN THE ORGANIZATION…………………………………...

i) National Environment Management Authority

   a. Is NEMA aware of quarrying along Ngong River in Embakasi? Yes …. No….

   b. Have you received any complaints from the quarry neighbours nearby?

      Yes…………………………………………………………………………………

      No………………..

   c. If yes, from whom do you receive the complaints?

      …………………………………………………………………………………

      …………………………………………………………………………………

   d. How many quarries are you aware of their existence…………………………?

   e. How many are licensed to operate……………………………………………..

   f. Do they submit the decommissioning/ closure plan Yes…? No……………….

   g. What is the compliance rate %

   h. Which body(s) is mandated with rehabilitation of quarries?

      …………………………………………………………………………………

      …………………………………………………………………………………

      …………………………………………………………………………………

   i. What's the imposed penalty on those operating without a licence?

      …………………………………………………………………………………

      …………………………………………………………………………………

   j. What is the imposed penalty on those operating without license……………...?

QUESTIONNAIRE FOR CITY COUNCIL OF NAIROBI

NAME OF RESPONDENT……………………………………………………………..….......

RESPONDENT POSITION IN THE ORGANIZATION………………………………........

a) Is the Ngong river basin in Embakasi zoned for quarrying? Yes…… No……………

b) Are there planning regulations that guide quarrying in this area? Yes…... No………

c) If yes, are the quarries approved? Yes…… Some……... No……. Not aware……….

d) If yes to (c) above, what's the level of enforcement?

   Adequate………...

   ....

e) Are there regulations guiding development in the quarries neighbourhood? Yes…

   No……………………………………………………………………………….....

f) What is the size of the width of riparian reserve along the Ngong river in

   Embakasi…………………………………………………………………………

   …………………………………………………………………………………………

g) Are there existing post decommissioning plans for the quarries? Yes…. No………..

h) Has there been complains on the existence of quarries from the neighbourhood?

   Yes… No………………………………………………………………………………

i) If yes to (h) above, what are the common complaints

   (i)………………………………………………………………………………..

   (ii)……………………………………………………………………………….

   (iii)………………………………………………………………………………

   (iv)………………………………………………………………………………

REFERENCE

Abdallah, C. (2007). Assessment of remote sensing and geographic information. Angers, France.

Ayodele, E.O. (2010): Bribery and Corruption – Threats to the Nigeria construction industry economy. International Journal of Engineering. India, 4 (2), 257 – 262

Abi Saleh B, Nasser N, Rami H, Safi S, Tohme H. (1996). Environmental impact of quarries on natural resources in Lebanon, Pnue, Lebanon.

Bailey, D. Gunn J (1991). Landform replication as an approach to the reclamation of limestone quarries.

Bishop, P. (2008). Urban tactics, temporal interventions and long term planning, London

Bonnie, T. M., Sandra, J.O., Mark, C.S., George, H., and Michael,W. (2002). Economic systems, New York, U.S.A

Cullingworth, J.B., Barry, C., Nadin, V., Trevor H., Pendlebury, J. and Townshend, T. (2015). Town and County planning in the U.K. Routledge, London.

Darlow, E. (2007). Health and safety in quarries, Oxford

Dharwish, T. (2004). Assessing soil degradation by land use cover change in coastal Lebanon Lebanese Science Journal, Vol. 5, No. 1, 2004. 46.Science journal.1,45-59

Dharwish, T, Faour G. (2008). Rangeland degradation in two watersheds of Lebanon. Lebanese Science Journal 9: 71–80.

Diab, L. (2016). Illegal quarries in Lebanon Hayat chaif. Beirut, Lebanon.

Gunn, J., Bailey, D., and Gagen, P. (1992). Landform replication as a technique for the reclamation of limestone quarries. London.

Hagerty, D.J. (1973). Solid waste management, London

Hartmann, H.F. (1972). Nature in the balance, Taplinger, New York

Holmes, J.R. (1984). Managing soil wastes in developing Countries, Wiley

Kenworthy, J. R. (1996). "The land use transport connection: An overview." Land Use Policy 13(1): 1-22.

Khawlie, M. (1998). An environmental perspective on quarries for the construction industry in Lebanon. Applied vegetation science.2, 199-204.

Khater, C., Darwish, T. M., Stehouwer, R., Miller, D., Sloan, J., Jomaa, I., and Hamzee, M. (2010) Assessment of abandoned quarries for revegetation and water harvesting in Lebanon.

Khopkar, S.M. (2004). Environmental pollution Monitoring and Control.: New Age International. New Dehli.

Lambin, E.F. (2011). Global land use change, economic globalization, and the looming land scarcity.Rockville Pike, Bethesda, USA.

Lameed, G.A and Ayodele, A.E. (2010). "Effect of Quarry Activity on Biodiversity: Case Study of Ogere Site, Ogun State Nigeria", *African Journal of Science and Technology,* 4(11): 740-750, 2010

Lusk, S.L, Sallyet, G. B., Hagerty, B. M, Ziemba, R. A. (2004). Acute effects of noise on blood pressure and heart U.S. National Library of Medicine8600 Rockville Pike, BethesdaMD, 20894USA.

Mabogunje, A.L. (1980). The Debt to Posterity: Reflection on a National Policy on environmental Management management of Quarrying activities in Kenya March 2010.

Milburn, E, (2001). Sand and gravel production. Michigan Havas Valerie, Noise! The invisible pollution Ministry of Environment and Mineral Resource

Murray, C.J.L, et al, (1996). Global Health Statistics: a compendium of Mwashighadi S. M., (1989). Quarry stone as a building material: a case study of National Environmental Management Authority: Provincial Environmental Action plan 2007 – 2011 Nairobi Province.

Mwashighadi, S. M (1989). Quarry stone as a building material: a case study of Taveta, University of Nairobi.

Musyoka, P.J. (1997) The impact of resource exploitation on the environment and landuse, the case of stone quarrying in kangundo division. University of Nairobi e-repository.
Njuguna, G. N., (2004). Environmental planning and management, Kijabe printing press.

Okafor, F. C. (2006). Rural Development and the Environmental Degradation versus Protection: In P. O. Sada and T.Odemerho (ed.). Environmental Issues and Management in Nigerian Development.

Power, (1996). Urban air pollution Earthscan: London.

Ramcharan, E.K and Dey, P.K. (2005). The role of environmental factors in industrial site selection activities: a case of limestone quarry expansion in Barbados, West Indies.

Ramphele, M. (1991). Restoring the land,Panos institute London.

Robinson, G. M. (2011). Land-use change in the 'edgelands': Policies and pressures in London's rural–urban fringe: Journal land use policy Volume 28 Issue 1 Pages 266-279 Pergamon, London.

Rao, C.S. (2006) Environmental Pollution Control Engineering

Royston, G.M. (1979). Pollution prevention pays, Pergamum, London

Russel, C.A. (1994). The earth, Humanity and God, UCL London

Samant, R.J and Samant J.S. (2013).Environmental and social impacts of stone quarrying-a case study of Kolhapur District.

Stanier, P. (2009). Quarries and quarrying. Shire

Stanton, W. (1990). Hard limestone Too valuable to quarry: Minerals Planning, v. 43, pp. 3-9.

Talen, E. (1996). Do Plans Get Implemented? A Review of Evaluation in Planning, Regional Research Institute, West Virginia University.

Tanko, A. (2007). "Environmental concerns, assessment and protection procedures for Nigeria's oil industry" Centre for Development studies and the school of Geography,Geol. Environ. Sci., BUK, Nigeria.

Toke, P. and Veie, K. L. (2013). Landscape and urban planning. Elsevier, Denmark

Wathern, P. (1995). Environmental impact assessment Routledge, London

Watkins, S. (2007). Environmental Management, Philadelphia.

Wilson, C. D., (1981) Waste management, New York: Oxford University press

Vediya, S. (2014). Dust pollution monitoring by higher groups of plants near stone quarrying industry – a case study in vadagam, arravali district, Gujarat. Life sciences, Modasa.