ST. MARY'S UNIVERSITY

SCHOOL OF GRADUATE STUDIES

ASSESSEMENT OF ENVIRONMENTAL AND SOCIO-ECONOMIC EFFECTS OF QUARRYING AND STONE CRUSHING: THE CASE OF ETHIOPIAN CONSTRUCTION WORKS CORPORATION

BY

SADIK GIZAW

SGS/0015/2010B

JANUARY 2019

ADDIS ABABA, ETHIOPIA

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A THESIS SUBMITTED TO ST. MARY'S UNIVERSITY, SCHOOL OF GRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIRMENTS FOR THE DEGREE OF MASTERS OF ARTS ADMINISTRATION IN PROJECT MANAGEMENT

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ABSTRACT

Adequate and secure livelihoods have become a major concern for both rural and urban residents. Ethiopian Construction Works Corporation is a giant construction company working on construction of road, dam, airfield, bridge, building and maintenance of roads all over the country. Construction of such big infrastructure requires plenty of construction materials production. Aggregates are among the first construction materials that constitute major portion of civil engineering construction works. Quarrying and stone crushing are the major activities which are done in all projects and districts of the company to produce aggregates. The quarrying and stone crushing activities have considerable effects on the environment quality and human health. For these reasons, more attention should be devoted to understanding, researching, and ultimately reducing their environmental impacts. Hence, this research work attempts to addresses the environmental and socioeconomic effects of aggregate production and identified the possible strategies that help to reduce the effects.

A total of 144 respondents were contacted for relevant information through structured questionnaire administration, interviews and field observation. In addition, documented data from published and unpublished articles and reports were used and analyzed. Quantitative methods such as Chi-square, Relative Importance Index, and descriptive statistics were used to interpret the data collected.

As the research result indicated, quarrying has a significant importance on job creation and better income generation to stone workers and the surrounding community to reduce poverty. Regarding to the environment, the quarrying and stone crushing activities together with poor management of quarries resulted land degradation, loss of plantations, air pollution and noise pollution. Furthermore, the health of workers and residents is affected by the quarrying. In view of this, the study recommends effective collaboration among key stakeholders in the sector such as Environmental Protection Agency (EPA), The projects, Local governments bodies, and local communities is needed to enhance the utilization of resources and minimize the effects of *quarrying on the natural environment through awareness creation, proper management and rehabilitation of abounded quarry pits for other functions and sustainable environment.*

Key words: *Quarries, Stone crushing, Environmental and Socio-economic effects, Ethiopian Construction Works Corporation*

CHAPTER ONE

INTRODUCTION

1. 1. Background of the Study

Aggregate resources are vital for our way of life because they are the major raw materials used in construction of roads, rail lines, bridges, hospitals, schools, air ports, factories and homes (Langer, 2004). Agriculture and infrastructural development ensures the growth of the country's economy, thus the importance of the quarry industry.

Quarry and aggregate production is important because of its positive impact on economic development of the country being a source of construction materials, revenue for the government through taxation and royalties and employment especially of the rural population (Divya, 2012). The industry also provides employment opportunities for both skilled and unskilled workers thereby supporting many urban and rural families as it contributes to their livelihood and socio-economic well being.

Rock quarrying and stone crushing is a global phenomenon, and has been one of the causes of concern everywhere in the world, including the developed countries (Lammeed and Ayodele, 2010).

Quarrying of natural stone, including sand, gravel and crushed rock, represents the main source of construction materials used throughout the world. At the global level, production of natural stone products witnessed a substantial increase over the last decade, with an increasing number of countries involved in the production of natural stone. Worldwide the production of natural stone has increased by 30 percent in the last 10 years (World Bank Stone Report, 2006).

However, operations of quarrying whether small- or large-scale, are inherently disruptive to the environment (Makweba & Ndonde, 1996). Mining of stones frequently generates land use conflicts in populated areas due to its negative externalities including loss of vegetation, noise, dust, truck traffic, pollution and visually unpleasant landscapes. It also causes a conflict with competing land uses such as farming, especially in areas where high-value farmland is scarce and where post mining restoration may be infeasible (Willis and Garrod, 1999). According to Ross (2001), environmental problems are further aggravated by lack of adequate mitigation measures by the respective quarry operators. This in turn affects the ecological sustainability which is a threat to the overall economic sustainability. With regards to the prevailing environmental legislation and its enforcement, there is total lack of efforts in monitoring, rehabilitation, restoration or post-mining programs for minimization of adverse environmental impacts.

Environmental impact is any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization activities, products or services. Quarrying is a form of land use method concerned with the extraction of non-fuel and non-metal minerals from rock. Sand, gravels and limestone are obtained from the earth through quarrying for building houses and other civil construction are obtained from quarrying or rocks of the earth's crust.

However, several wastes are generated when rocks are extracted from the earth. Environmental disturbances as a result of mining and processing activities constitute a major threat to public health and environmental quality (Adepoju, 2002).

Environmental degradation accompanies mining operations and remains after they cease, with air pollution, scars on the landscape and threatened surface and underground waters. As a result of this quarrying waste generated alongside could constitute serious environmental problems either at point of production, processing or during extraction.

1. 2. Statement of the Problem

The current concern in the world is sustainable development that integrates environmental concern in sustainable utilization of the natural environment (Mukundi, 2015).

Following the rapid expansion of infrastructure projects under way in all over the country, there is a significant boom in construction material supply. However, the intensive activities of quarrying and stone crushing disregard to the environment impact leads to a series of socio-economic and environmental problems.

Hence, the study area is one of the giant construction companies which has more than 50 quarry sites and 72 stone crushing plant all over the country, which create large job opportunity and supply different construction materials for road construction. It is observed that various environmental problems such as the excavated site is abandoned and left as waste land, the overburden materials are improperly dumped, soil is eroded, land is degraded and the health of workers and the surrounding community is affected. Besides, the quarry sites in the study areas have many problems on the management practice which can be characterized by poor quarrying plan, lack of ecological considerations, inadequate quarrying process and rehabilitation planning, and lack of technical and policy enforcement barriers, aggravate significantly the degradation on the environment and socio-economic development endeavors in the country. Therefore it needs conducting research on the company to identify the degree of impacts and to take remedy measures. It is difficult to take a sustainable mitigation measure without detail investigation of the impacts. Hence, this study seeks to investigate the impacts of stone quarrying on the physical as well as socio economic environment at study areas.

1. 3. Research Questions

I. How do the process of quarrying, crushing, the disposal of effluents and wastes from the activities affect the surrounding environment in the study areas?

II. What is the impact of quarrying on local livelihoods and natural resource use in the research areas?

III. How is the relationship of health status and workers' years of stay in the quarry and crushing sites?

IV. What strategies will be necessary for successful process of quarrying and stone crushing?

1. 4. Objectives of the Study

1.4.1 General Objective

The objective of the study is to assess the current situation with active and abandoned aggregate production quarries and analyze the condition of the environmental effect in and around the study areas, and formulate a conclusion from the result obtained and give recommendations with respect to the environmental mitigation plan.

1.4.2 Specific objectives

I. To assess the quarrying and stone crushing process and how the activities affect the surrounding people and the environment.

II. To assess the biophysical and social-economic impacts of quarrying activities.

III. To evaluate mitigation measures which have been adopted in order to improve the effects of quarrying and stone crushing activities?
IV. To identify and explain development control measures for quarrying and stone crushing activities in ECWC.

1. 5. Significance of the Study

The findings of the study will be useful to stakeholders in a number of ways. They will be used by the government to justify need for additional budgetary allocation for environmental protection and to develop strict standards to the county in general and to improve ways of stone quarrying, develop mitigation plan and, other alternatives in ECWC particular. The findings will be used to convince financial institutions and development partners to release more funding to support stone quarrying hence creating employment opportunities. The study will also bring strategies how stone quarrying and the immediate impact to the environment can be improved for sustainable development.

Finally, the findings informed the relevant ministry in charge of mining, about problems facing implementation of the policy and suggest ways to address those problems in order to improve the policy.

1. 6. Scope and Limitations of the Study

The scope with respect to the subject include environmental and socio-economic issues, extent and patterns of land degradation, impacts on other physical environmental elements as well as impacts on livelihood strategies and economic benefit to the local community and employees.

The study is a descriptive one and will focus on the opinion, thought, experience and observation of the community and employees around quarrying and stone crushing activities but it does not include chemical analysis of soil, air and water test.

The study will also focus on only environmental and socio-economical impact of quarrying and stone crushing activities in the surrounding community and employees but it does not include biodiversity loss, Wild animal loss and underground water pollution.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Literature

2.1.1 Aggregate Deposit and Sources

Limestone, dolomite, and marble - **the carbonate rocks**- are the principal karst-forming rocks. Karst is a type of topography formed by limestone, gypsum, and other rocks by dissolution and characterized by sinkholes, caves, and underground drainage regions. Karst areas constitute about 10 percent of the land surface of the world (Drew, 1999), and there is widespread concern for the effects that human activities have upon the karst environment.

Many human activities can negatively impact karst areas, including deforestation, agricultural practices, urbanization, tourism, military activities, water exploitation, mining, and quarrying (Drew, 1999).

Much of the resource extractions conducted in areas of karst are for the rock itself. Un weathered carbonate rocks provide crushed stone and dimension stone resources. The term "crushed stone" refers to the product resulting from the crushing of rocks such that substantially all faces are created by the crushing operation (ASTM, 2000). The term "dimension stone" is generally applied to masses of stone, either naturally occurring or prepared for use in the form of blocks of specified shapes and sizes that may or may not have one or more mechanically dressed surface (Bowles, 1939: ASTM, 1998).

2.1.2 Quarrying and Aggregate production Process

i. The Exploration Process

Exploration for deposits of natural aggregate involves locating a suitable resource near where it is to be used. Thus, the process may involve interaction between the aggregate producer and the local community (Gunn and Peter, 1987). In an urban area, the maximum economically feasible shipping distance from the market typically defines a crude target area for exploration. The first step in aggregate exploration is a preliminary geologic evaluation. Geologic and topographic maps and geologic and engineering reports aid in locating promising areas or, conversely, aid in ruling out areas for further study. Preliminary investigations may be followed by detailed studies that involve satellite imagery, aerial photography, geophysical studies, and field reconnaissance studies of target areas to define the limits of the potential sources of aggregate more accurately. These field studies focus on natural exposures, such as stream cuts, cliffs, and other natural outcrops, and on artificial exposures, such as highway and railroad cuts and abandoned or active pits and quarries. Field studies commonly are amplified by samples collected using hand-sampling techniques of surface outcrops and various methods of drilling to obtain subsurface samples. Detailed exploration of an identified source of aggregate varies depending on the nature of the potential resource and the intended uses. Backhoes can be used to collect bulk samples, and truck-mounted power augers or drill rigs can be used to collect deeper subsurface samples. In addition, geophysical studies may be used to determine the thickness of overburden (overlying material), to determine gross changes within the deposit (such as changes from gravel to sand or shale to sandstone), and to provide continuity between drill holes. Exploring for natural aggregate resources generally is not disruptive to the environment. The minor environmental disturbances that result from trenching and digging test pits for sand and gravel resources, geophysical surveys, and the drill holes used to evaluate an area for crushed stone reserves are easily remedied and cause virtually no permanent environmental disturbance (Gunn and Peter, 1987).

ii. Aggregate Quarrying

Aggregate quarrying begins with removing the overburden to expose the sand, gravel, or stone. Soil and partially weathered rock can be pushed aside with a bulldozer and removed with conventional loaders and haul trucks. Organic soil commonly is stripped separately from the rest of the overburden and stockpiled for reclamation activities. Overburden may be used to construct mounds, walls or ledges called berms, or it may be stockpiled, or sold. Following overburden removal, berms, haul roads, processing and maintenance facilities, and other plant infrastructure are constructed by using standard building techniques. The methods to quarry aggregate depend on whether the material being excavated is sand and gravel or crushed stone, the natural conditions at the site, the desired final product, and operator preference (Sauro, 1993).

iii. Quarrying Crushed Stone

Quarrying crushed stone differs from quarrying sand and gravel because the bedrock, in most situations, must first be drilled and blasted. The technology of blasting rock is highly developed and regulated. Holes are drilled into the rock and are partially filled with explosives. The top portion of the hole is filled with nonexclusive material (usually sand, crushed stone, or a manufactured plug) that is referred as stemming. The explosive in each hole is initiated with detonators that create delay periods between blasts in individual holes. The total blast commonly lasts only a fraction of a second and consists of many smaller individual blasts separated by delays of a few thousandths of a second (Sauro, 1993). Controlled sequential blasting commonly breaks the rock into pieces suitable for crushing. If the rubble is too large, secondary breaking may be required and usually is accomplished with hydraulic hammers, drop balls, or other mechanical devices. The blasted material is dry and can be extracted by using conventional earth-moving equipment, such as bulldozers, front loaders, back hoes, and hydraulic excavators. Rock quarries that do not penetrate the water table and sites where groundwater naturally drains from the quarry commonly are mined dry. Where quarries penetrate the water table, they commonly are dewatered by collecting and pumping the groundwater. The rock is then mined by the same procedures used in a dry quarry (Sauro, 1993).

iv. Processing Aggregates

Aggregate can be processed at remote locations using portable crushing and screening equipment, or can be processed at a plant consisting of a large amount of sophisticated equipment connected by a network of conveyors. Almost all the stationary equipment in a processing plant can be managed by a computer or one person situated in a centrally located control tower. Aggregate processing commonly consists of transporting rock rubble or sand and gravel to a plant, crushing, screening, washing, stockpiling, and load out. Typically, trucks or conveyors move material from the quarrying face to a primary crusher. The crushed material is moved via conveyor to a surge pile. A gate in a tunnel at the bottom of the surge pile releases the sand, gravel, or crushed stone at a constant feed rate via a conveyor to a secondary crusher and screening system where it is further crushed and sorted by size. Rock that is too large is sent back through the crushing and screening process. Depending on the type of material being processed and on the final product, the material may be washed. After screening, sorting, and washing (if necessary) conveyors move the material to bins or stockpiles. And the product is loaded on trucks, railcars, or barges for transport to the final destination (Sauro, 1993).

v. Transporting Aggregates

Aggregate can be transported by truck, train, barge, or freighter. The preferred mode of transporting aggregate depends on a variety of factors including delivery-schedule requirements, distance, volume of material, loading and unloading facilities, and the availability of transportation methods (Sauro, 1993).

Much of aggregate is transported by truck. Trucks can move throughout most areas of an aggregate operation. They can be loaded quickly at points of origin and can dump or drop their loads unassisted at the destination. Trucks can deliver practically anywhere there is a road. From small pickups to rigs that carry 28 tons (25 metric tons), trucks can be matched to requirements and, thus, make cost effective deliveries (Gunn and John, 1993),

Generally, truck traffic is concentrated near an aggregate operation, and many trucks may enter or leave an aggregate operation every day the plant is operating. In rural areas, the trucks may have to navigate narrow, twisting roads to the Construction site. Large trucks of any type, including those transporting aggregate, create the nuisances of noise and diesel exhaust as they pass sub urban dwellings.

2.1.3 Potential Environmental Impacts

Modern technology and scientific investigation methods have made it possible to reduce environmental impacts associated with extraction of carbonate rocks and manage impacts at acceptable levels that do not cause significant harm to the environment. Nevertheless, carbonate rock resources cannot be obtained from the landscape without causing some environmental impacts (Langer, 2001).

2.1. 1. Engineering Impacts

Some of the environmental disturbance created by quarrying is caused directly by engineering activities during aggregate extraction and processing. The most obvious engineering impact of quarrying is a change in geomorphology and conversion of land use, with the associated change in visual scene. This major impact may be accompanied by loss of habitat, noise, dust, vibrations, chemical spills, erosion, sedimentation, and dereliction of the mined site, (Barksdale 1991). Some of the impacts are short-lived and most are easy to predict and easy to observe. Most engineering impacts can be controlled, mitigated, kept at tolerable levels, and restricted to the immediate vicinity of the aggregate operation by employing responsible operational practices that use available engineering techniques and technology (Smith and Collis, 2001).

2.1. 2. Cascading Impacts

In karst environments, aggregate mining may alter sensitive parts of the natural system at or near the site thus creating cascading environmental impacts (Langer and Kolm, 2001). Cascading impacts are initiated by an engineering activity, such as the removal of rock, which alters the natural system. The natural system responds, which causes another impact, which causes yet another response by the system, and on and on. For example, aggregate mining in some karst might lower the water table, which will remove the buoyant support of rock that overlies water-filled caverns or other solution features, which might result in land collapse, which will create a sinkhole. Cascading impacts may be severe and affect areas well beyond the limits of the aggregate operation. Cascading impacts may manifest themselves some time after mining activities have begun and continue well after mining has ceased.

2.1. 3. Geomorphic Impacts

Quarrying has an associated, often dramatic, visual impact. Karst terrain is commonly considered to be of high scenic value, thus compounding the effects of visual impact of quarrying. The principle geomorphic impact of quarrying is the removal of stone, which results in the destruction of habitat including relict and active caves and natural sinkholes, (Gunn and Gagen, 1987). The extent of the geomorphic impact is a function of the size of the quarry, the number of quarries and the location of the quarry, especially with respect to the overall landscape and land forms. The influence of quarry size on environmental impact is obvious: all things being equal, the larger the quarry, the larger the geomorphic impacts. The size of quarries has increased over time, and so has their impact. Great numbers of quarries in a Karst and Region amplifies the geomorphic impact (Sauro, 1993). Stanton (1966) suggested that the disturbance created by numerous smaller quarries is greater than that created by one large quarry and recommend that geomorphic disturbance be minimized by maximizing reserves through deep quarrying.

2.1. 4. Some of the Major Types of Environmental Effects

I. Sound Pollution

Noise is an unwanted sound-produced by a source causing vibrations in the medium around it (Agunwamba, 2001). According to the International Programme on Chemical Safety WHO (1984), an adverse effect of noise is defined as change in the morphology and physiology of an organism that results in impairment of functional, capacity, or an impairment of capacity to compensate for additional stress, or increases the susceptibility of an organism to the harmful effects of other environmental influences. Drilling or shot holes, deposition of rock pieces into the jaw crushes by pail-loaders, grinding action of crushers, power generating sets, vehicular motion and rock blasting with explosives is major source of noise within and around the quarry and Crushing sites. The primary source of noise from extraction of aggregate and dimension stone is from earth-moving equipment, processing equipment, and blasting. The truck traffic that often accompanies aggregate mining can be a significant noise source. Langer (2001), reported that the impacts of noise and highly dependent on 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 noise on the receiver. Exposure to noise pollution arising from industrial machines can induce hearing loss and other pathological changes in the affected worker.

- **Effect of Noise**

a**) Noise Induced Hearing Impairment**

Worldwide, noise-induced impairment is the most prevalent irreversible occupational hazard. Wills reported that in 1995 at the World Health Assembly, it was estimated that there were 120 million persons with disabling hearing difficulties worldwide. It has been shown that men and women are equally at risk of noise-induced impairments (Berglund, and Induall , 1974). Another sensory effect that results from exposure is tinnitus (ringing in the ears). Commonly, tinnitus is referred to as sounds that are emitted by the inner ear itself (physiological tinnitus).

b) Interference with Speech Communication

Noise interference with speech communication results in a large number of personal disabilities, handicaps and behavioral changes. Problem with concentration, fatigue, uncertainty and lack of self-confidence, irritation, misunderstandings, decreased working capacity, problems in human relations, and a number of stress reactions have all been identified (Lazarus, 1998). Environmental noise may also mask many other acoustical signals important for daily life, such as door bells, telephone signals, alarm clocks, fire alarms and other warning signals and music (Edworthy and Adams, 1996).

c) Sleep Disturbance

Uninterrupted sleep is known to be a prerequisite for good physiological and mental function of healthy persons (Hobson, 1989), sleep disturbance on the other hand is considered to be a major environmental noise effect. According to William (1976), from study findings, the general conclusion can be drawn to ensure undisturbed sleep, the maximum sound pressure level should not exceed 45db. The primary physiological effects that can be induced by noise during sleep include increased blood pressure, increased hear beat, changes in respiration, cardiac arrhythmia and an increase in body movement (Berglund and Induall, 1974).

d) Cardiovascular and Physiological Effects

Epidemiological studies involving workers exposed to occupational noise, and general populations (including children) living in noisy areas around airports, industries and noisy streets, indicate that noise may have both permanent and temporary impacts on physiological functions in humans.

e) Mental Health Effects

FEPA (1991) defined mental health as the absence of identifiable psychiatric disorders. According to current norms studies on the diverse effect of environmental noise on mental health cover a variety of symptoms, including anxiety, emotional stress, nervous complaints, nausea, headache, instability, argumentativeness, sexually impotency, change in mood, increase in social conflicts as well as general psychiatric disorders such as neurosis, psychosis and hysteria.

II. Air Pollution

The process of blasting mountains, blasting rocks, loading & unloading crushed stones of various sizes, crushing of stones in primary and secondary crushers continuously generates huge amount of dust in the atmosphere.

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). Dust may occur as fugitive dust from excavation, from haul roads, and from blasting, or can be from point sources, such as drilling, crushing and screening (Langer, 2001).

Site conditions that affect the impact of dust generated during extraction of aggregate and dimension stone include rock properties, moisture, ambient air quality, air currents and prevailing winds, the size of the operation, proximity to population centers, and other nearby sources of dust. Dust concentrations, deposition rates, and potential impacts tend to decrease rapidly away from the source (Howard and Cameron, 1998).

- **Effect of Dust**

a) Effects on Plants

Dust deposits can have significant effect on plant life, though, mainly at high dust loadings (Howard and Cameron, 1998). This includes:

(1) Reduced photosynthesis due to reduced light penetration through the leaves.

(2) Increased incidence of plant pet and diseases. Dust deposits can act as a medium for the growth of fungal disease. In addition, it appears that sucking and dust deposits to any great extent do not affect chewing insects, whereas their natural predators are affected.

(3) Reduced electiveness of pesticides spray due to reduced penetration.

b) Effect on Human beings and Health

The harmful effect of can be found in numerous locations that people choose to spend their leisure time, unknown to the fact that they are breathing in dangerous dust particles that are linked to a barrage of serious respiratory illnesses. There can also be minor health effects such as eye irritation when the dust is airborne. Indirect stress-related health effects could also arise, especially if dust problems are allowed to persist for an unreasonable length to time. For instance, some mineral dusts contain quantities of quartz, which can cause the lung disease known as silicosis when persistent at high concentrations. Exposure of workers to high dust level causes irritation of the respiratory tracts as well as the eyes. According to Langer (2001), these particulate matters penetrate into the respiratory system and induce respiratory diseases such as silicosis.

c) Soiling and Amenity Value Effect

Dust contamination leads to aesthetic degradation caused by both active and abandoned aggregated. The most common areas of concern include the visual soiling of clean surfaces such as cars, window ledges, and household washing. Dust deposits on flower, fruits and vegetable (Howard and Cameron, 1998).

III. Water Pollution

Quarrying can substantially modify the routing of recharge and water quality may be degraded (Gunn and Hobbs, 1999). Commonly the first impact of quarrying is to remove the overlying vegetation and soil. In temperate areas removing vegetation and soil reduces evapo transpiration and increases the effective rainfall. Unless measures are taken to control runoff and sedimentation, deterioration of ground water is likely. In some karst areas the soil overlying the rock normally is a zone of filtration and water purification (Gunn and Hobbs, 1999).

In aggregate mining, the target limestone, if unsaturated, may also act as a protective cover for the underlying aquifer. If the protective soil cover or unsaturated rock is removed, the hole created by the mining may focus surface water to the ground-water system. If the surface water is contaminated, the ground water can quickly become polluted (Hobbs and Gunn, 1998; Ekmekçi, 1993).

Blasting may cause problems with ground-water quality, but may also be erroneously identified as a cause of problems. Spigner (1978), reported that shock waves from blasting operations loosened clay particles from solution cavities causing “muddying” of the ground water.

Elsewhere, Moore and Hughes (1979) investigated the impact of quarry blasting on ground-water quality and determined there was no relationship between blasting and quality of water in wells in the situation that they studied.

The risk of ground-water pollution may increase if the direction of groundwater flow is modified. New source areas of recharge may be introduced, and those sources may contain contaminated water. This situation can arise because of ground-water pumping (Adamczyk and Sedam, 1988). Ekmekçi (1993), reported that blasting associated with quarrying may close existing karst ground-water passages, or may open up new passage, resulting in a change in direction of ground-water flow.

2.1. 5. Effects of Stone Quarry on Societies

a) Health Effect

According to World Health Organization (WHO), report, almost one-third of the global disease burden can be attributed to environmental risk factors. Environment Protection Agency (EPA) report (2001) affirms that hundreds of stone crushing units are crushing stones round the clock in the vicinities of various cities.

The mining and quarrying sector is traditionally a sector that poses large risks to occupational health and safety. Even in modern quarries and mines, fatal injuries occur regularly (Langer, 2001). The most frequent occupational risks related to stone quarrying include:

- Fatal accidents;
- Physical injuries requiring medical treatment;
- Work-related illnesses: respiratory diseases such as silicosis and tuberculosis due to inhalation of dust.

Work-related illnesses endemic to the natural stone industry include the respiratory diseases silicosis and tuberculosis (or silica-tuberculosis). Large numbers of quarry workers suffer from silicosis or tuberculosis due to prolonged inhalation of silica-dust. According to Langer, (2001), it is estimated that some 4 million people die each year from acute respiratory problems in developing countries, for the most part being aggravated by environmental pollution emanating from quarrying, sandblasting and emission of dangerous chemicals.

b) Job Opportunity

Quarrying activities generate employment and contribute to a country's gross national product, both through production for the local market and for export trade. Kuntala (2000), reported that stone quarrying generate considerable employment opportunities as it is a relatively labor intensive, under-mechanized industry. Even if the availability of accurate data on the sector's contribution to overall employment is difficult, for example in India around 2 million people were employed in the sand stone mining (Kuntala, 2000)

2.1. 6. Minimizing Pollutions

A. Dust Control

The impacts from operations-generated dust commonly can be mitigated through process design and engineering and by the use of dry dust collection or wet suppression systems. Controlling fugitive emissions commonly depends on good housekeeping practices. Measures to reduce dust include the following (Langer and Kolm, 2001).

B. Noise Control

The primary sources of noise from aggregate extraction are blasting, earth-moving equipment, processing equipment, and truck traffic. Sound travels farther in dense, cold air than in warm air, and when there are atmospheric inversions. The impacts of noise depend on the following (Langer and Kolm, 2001).

• Sound source;

• Topography, land use, and ground cover of the surrounding site;

• Climatic conditions; and

• Sensitivity of receivers.

The impacts of noise can be mitigated through various engineering techniques. Means for limiting noise from mobile equipment include the use of mufflers, backup alarms that adjust their volume relative to ambient noise levels, broadband alarms, selecting low-noise plant equipment, such as rubber or urethane screens, flexible equipment mounting systems, and locating noisy equipment in sound-deadening (acoustical) enclosures can help limit noise from stationary equipment. Equipment can be located so that naturally vegetated areas, quarry walls, or topographic barriers shield or absorb noise. Berms, landscaping, and stockpiles can be used to form sound barriers. Conveyors can be used instead of trucks for in-pit movement of materials (Langer and Kolm, 2001).

C. Protecting Water Resources

Potential impacts to water resources, and the techniques to avoid those impacts, vary from site to site, just as the techniques for extracting and producing aggregate vary according to the type of material being produced and the natural site conditions (Kestner, 1994).

I. Surface Water and Stream Channels

If aggregate extraction involves the removal of vegetation and soil cover, standard engineering practices can be followed to control erosion and sedimentation. The amount of ground disturbance for facilities can be limited by making roads, drainage ditches, and work areas fit the site conditions. Disturbed areas can be covered with mulch, vegetation, or other protective cover, and they can be protected from storm water runoff by the use of dikes, diversions, and drainage ways. The amount of disturbance during excavation can be minimized through mine planning and concurrent reclamation. Sediment can be retained on site by using retention ponds and sediment traps. Aggregate mining may change runoff patterns and increase the suspended sediment load of streams. Retaining the runoff in filtration basins and filtering or containing wash water can mitigate these potential impacts. Mining sand and gravel from stream channels has the potential to create cascading environmental impacts (impacts that create secondary impacts). The nature and severity of cascading impacts are highly dependent on the geologic setting and characteristics of a stream (Kestner, 1994).

II. Groundwater

Predicting and controlling environmental impacts to a groundwater system is relatively easy with most sand and gravel deposits and with rocks that have well-defined hydrologic properties and boundaries. However, predicting impacts to a hydrologic system can be extremely difficult in some other settings, particularly bedrock with fracture flow. Groundwater flow in springs, gaining streams, and wells may be impacted by nearby aggregate operations that pump groundwater from the pit or quarry (Kestner, 1994).

D. Minimizing Effects from Blasting

Blasting usually is restricted to quarry operations; generally, it is not used in sand and gravel extraction unless the deposits are heavily cemented. The blasting process is tightly controlled by local, state, and federal regulations and is usually carried out by highly trained blasting professionals. As a rule, quarry operators work closely with blasting specialists to assure that each event is carefully monitored and that any potential impacts are minimized. Ground vibrations, noise, and dust are potential impacts from blasting. Most of the blast vibrations that enter the Earth come to the surface within a few feet of the detonation and travel along the surface in the form of waves, which may cause ground vibrations. The properties of the rock determine the speed at which the vibrations travel, and, although perceptible, ground vibrations decrease rapidly with distance. Rock properties, such as density, bedding planes, joints, cracks, faults, cavities, mud seams, and zones of weak or incompetent rock, also affect the amount of ground shaking. Therefore, the properties of both the rock being blasted and the rock between the quarry and its neighbors should be considered. Limiting the size of the blasts or using time-delay blasting is ways to control ground vibrations (Kestner, 1994).

Because people may feel vibrations at very low levels, they may over-estimate the risk of blasting damaging their homes even if the vibrations are kept within guidelines. Also, low-level vibrations may still be an annoyance. Everyday activities, such as slamming doors, running up and down stairs, and pounding nails, as well as outdoor environmental changes, such as wind and temperature, produce strains on houses greater than legal blasting limits. These activities tend to go unnoticed because they are expected, whereas blast vibrations can be unexpected. This element of surprise can be avoided by using a pre-blast signal to warn nearby residents, blasting at a predetermined time, and scheduling blasting times to coincide with daytime periods of high residential or neighboring activity (Kestner, 1994).

2.2. Empirical literature

The main sources of dust in a quarry operation are drilling, crushing and road haulage. The workers are at risk of inhaling the emitted dust, which is injurious to their health. Inhalation of the dust can cause severe health problems including respiratory and pulmonary problems, while dust deposition causes skin and eye problems (Mengesha & Bekele, 1998).

In a study conducted on pulmonary problems among quarry workers by Nwibo (2012) found out that the workers had various respiratory problems including chest pain, cough, wheezing and shortness of breath. The study found out that up to 98.3% of the workers had no safety measures. Data from the study suggests that chronic exposure to dust from crushing of rocks may increase susceptibility to respiratory problems and impaired lung function with tobacco or cigarette smoking and increased length of service as additional risk factors.

Ugbogu (2009) studied the occurrence of respiratory and skin problems among manual stone workers and found out that up to 85% of the workers had respiratory symptoms while 77% had skin infection. The study also observed that although there was high level of awareness of effect of dust on their health, use of protective clothing and gear was not popular.

In a study by Ilyas (2010) it was established that dust related problems were aggravated by cases of owners of the crushing stone unit not providing appropriate measures to protect the workers. The study also suggested that self medication is the most preferred way of treatment and that health insurance was not at all available to the workers.

Developing countries are more prone to ill health and environmental damages compared to developed countries. This is due to unsatisfactory quality of work environment and health care support in developing countries (Ilyas & Rasheed, 2010). This study also found that due to under privileged livelihood patterns, the health effects of the dust impacts differently in poor working conditions, an increasing trend in respiratory diseases is related to decreasing air quality which is resulting from various types of environmental pollution.

Various studies have shown that rock contains crystalline silica which occurs in different quantities depending on the type of rock. The report on the Geology of the Kajiado Area, records analyses of limestone rock samples indicating varying silica contents, the highest being 11.38% in a sample collected at the Kenya Marble Quarry (Matheson, 1966). However, little research has been conducted on the impact of the limestone quarry dust on the workers' health and therefore the magnitude of the problem has not been documented.

Other studies confirmed that there is a strong body of evidence for causal relationship between exposure to crystalline silica and disease (Rosner & Markowitz, 2006). Other studies by Goldsmith (2006); McDonald (2005); and Steen land (2001), have identified that exposure to crystalline silica can result in psychological changes, disease and death in exposed populations. The exposure caused a range of diseases, which include silicosis, lung cancer, renal disease, kidney cancer, chronic obstructive pulmonary disease (COPD) and rheumatoid arthritis (Bridge, 2009).

Legal Considerations of Quarry Operation

Quarry operations fall under various jurisdictions such as city administration, land management, mining operations, and environmental control. The relevant legal proclamations in Ethiopia, which refer to quarrying activities directly or indirectly, are summarized below.

I. ***Constitution of the Federal Democratic Republic of Ethiopia (Proc. No. 1/1995*)**

In the constitution, environmental rights and objectives have been clearly considered for the implementation of policies and other laws that govern environmental protection activities. The following important points were particularly proclaimed in this constitution.

- The government is to try its level best to secure every citizen with clean and safe living environment; and
- The design or implementation of any development program should not be in a manner to destroy or damage the environment.

II. Environmental Impact Assessment Proclamation (Proc. No. 299/2002)

This proclamation clearly indicates that major development programs, plans and projects of the private or public enterprises shall be subjected to Environmental Impact Assessment study before their approval for implementation. The proclamation also provides a legal base for the effective means of harmonizing and integrating environmental, economic, cultural and social considerations into the planning and decision-making processes thereby promoting sustainable development. These include:

- The application of this proposal at the early stage of project formulation,
- Undertaking the assessment by a neutral consultant,
- The involvement of community members & concerned governmental organs,
- Consideration of the guiding principles and policies on the major issues of significant impacts,
- Identification of appropriate measures for monitoring and managing of the impact, and
- Submission of report to the concerned institution for sound review and decision, etc.

III. Environmental Pollution Control Proclamation (Proc. No. 300/2002)

This proclamation is aimed at eliminating or, when not possible, to mitigate pollution as an undesirable consequence or social and economic development activities. It also stated that the protection of the environment and safeguarding of human health, as well as maintaining biota and the aesthetic value of nature are the duty and responsibility of all citizens. It further considers other important issues in some of its articles, among others:

- Control of pollution,
- Management of hazardous waste, chemical and radioactive substances,
- The importance and need to respect environmental standards, and
- Punitive and incentive measures, etc.

IV. Mining Operations Proclamation (Proc. No. 678/2010)

Mining operations proclamation No. 678/2010 is proclaimed according to Article 55(1) of the Constitution of the Federal Democratic Republic of Ethiopia. The Constitution of the Federal Democratic Republic of Ethiopia provides that the right to ownership of all natural resources of Ethiopia is exclusively vested in the government and in the people of Ethiopia and that the government is the custodian thereof. Minerals are non-renewable natural resources and that the government shall ensure the conservation and development of these resources to the socio-economic progress of all Ethiopians; it is the obligation of the government to protect the environment for the benefit of present and future generations and to ensure ecologically sustainable development of minerals. The proclamation has nine parts which covered various issues including: General, fundamental principles and general provisions, licenses, certificates, administration, compensation, environment, royalty, income tax and other financial regime and miscellaneous provisions. Mining operation for the extraction of construction materials is one of the licensing areas described in the proclamation including: basalt, ignimbrite, clay, selected material, and aggregates.

The proclamation has the following basic objectives:

- Give effect to the principle of the custodianship of the country's mineral resources by the government;
- Promote socio-economic growth of the country;
- Promote employment and advance the social and economic welfare of all Ethiopians;
- Provide for security of tenure for all investors in respect of exploration and mining operations; and
- Ensure that the country's mineral resources are developed in an orderly and sustainable manner.

The proclamation further proclaimed the requirement and types of licenses applicable in mining operations in Ethiopia. Furthermore, is has indicated on the 'Environment' part of the proclamation the submission of Environmental Impact Assessment study report along with rehabilitation fund for restoring the site at the time of closure. Apart from these the proclamation provided that extraction of construction materials shall be liable with 3% royalty tax during its operation and based on the sales price of the commercial transactions of the minerals produced.

2.3. Synthesis

Environmental impact is any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization activities, products or services. Quarrying is a form of land use method concerned with the extraction of non-fuel and non-metal minerals from rock. Sand, gravels and limestone are obtained from the earth through quarrying for building houses and other civil construction are obtained from quarrying or rocks of the earth's crust. Quarrying is an act of exploring and exploiting stone from rocks. Metal ores are extracted by mining which involves removal of rock from the ground. There is now a great demand for stone especially as limestone in form of crushed rock and it is also an essential constituent of many building and contraction materials. A wide variety of product from mining and crushing of rocks form primary raw materials in many industrial applications. Crushed rocks are used as aggregate in highways or concrete construction; in bituminous mixture and railroad ballast. Quarrying could be done in diverse methods such as hard rock mining, using rock drills, explosion of dynamite and other sophisticated methods. The process could also be open pit or surface method, underground and solution mining. The mining method used depends on the particular mineral, the nature of the deposit and the location of the deposit. Each mining method has its own impact on the environment. However, several wastes are generated when rocks are extracted from the earth. Environmental disturbances as a result of mining and processing activities constitute a major threat to public health and environmental quality. Severity of the environmental problem depends on the characteristics of the mineral being extracted, the methods of mining, waste materials generated and the site characteristics. The effect is manifest in air, land, plants and water associated with mining process. Environmental degradation accompanies mining operations and remains after they cease, with air pollution, scars on the landscape and threatened surface and underground waters.

There is limited information on the level of knowledge and practices as well as the impacts of stone quarrying in Ethiopia. In most cases quarrying is done without considering the impacts to the environment, even there is little done to ensure that there is no overexploitation and collapse of stone quarrying in most regions. If research was well done, there were a lot of opportunities in managing stone quarrying in the area without posing danger to the surrounding community and lives of stone miners and even the related negative impacts to the environment. The government policy and legislation was the most limiting factor in controlling exploitation of stones but there is therefore the need to measure the stone quarrying activities and the immediate impacts to the environment.

Therefore such study is important since it focuses on future environmental conservation in the country and development of the technology in stone quarrying in the regions. Besides, it will address the negative issues of stone quarrying and immediate control measure for sustainable development in vision 2030. The study is important in the areas; since there are pressures in stone quarrying and environmental degradation which need urgent address from both stakeholders and the government. Human encroachment and collapse of quarries which has led to recent conflicts in the areas making the research to be the most appropriate to determine the future sustainable development in the areas. The result will help not only in formation of similar interventions, but also in the design of policies that could be used to address issues on stone quarrying for sustainable development.

The cited conceptual and research literature provided the researchers adequate knowledge and pertinent information about quarrying industry. Most of the information presented are closely related to the present study.

The present study is different from the previous study in terms of the respondents involved in all study areas. With these concepts as reach background, this study will anchor the trust to determine the quarrying industries in Ethiopia. Hence, the researchers strongly believe that quarrying activities can be controlled or regulated if the quarry operators will comply with the laws issued by government. From these inputs from the studies, they can assess that they really add substance to the content of the present study. However despite similarities at some points, it can be said that the present study is not a duplication of any of the aforementioned studies therefore, it has a distinct personality of its own.

CHAPTER THREE

RESEARCH METHODOLOGY

3. 1. Study Areas

The Ethiopian Construction Works Corporation (ECWC) is established as a Federal Government Public Enterprise by Council of Ministers Regulation No 366/2015 on December 18/2015. The Corporation is amended by Council of Ministers Regulation No 390/2016 on September 28/2016.

The Corporation is founded by amalgamation of three former Public Enterprises Namely, Ethiopian Road Construction Corporation (ERCC), Ethiopian Water Works Construction Enterprise (EWWCE) and Prefabricated Building Parts Production Enterprise.

Some of the Corporation's main functions are construction and maintenance of Roads, bridges, Works related to dam, irrigations, hydropower generations, Waters Supply systems, sewerage systems, and drainage. In addition to these, it engages in assembling of construction equipment and machinery and manufacturing of spare parts, provides maintenance services for construction equipment's and machineries, produce construction materials, engages in the rental business of construction equipment, machineries, warehouse and buildings.

These activities are performed by six different sectors of the corporation, namely, Transport Infrastructure Construction Sector, Water Infrastructure Construction Sector, Dam and Irrigation Projects Management Sector, Building Technology & Construction Sector, Construction Equipment & Machineries Management Sector and Corporate Property Management & Service Sector.

Currently the corporation has **8** irrigation and dam projects in Megech, Rib, Kessem, Kuraz, Gidabo, Tendaho, Arjo dedesa, and Welkait, **one** dry port construction project in Mojo, 8 road construction project: kong-begundi, Dimma-rad, Mazoria-Hadero, Adama-Awash, Awash lot 1, Awash lot 3, Awash- Dulecha, and Jinka, **one** airport construction project in shire, **one** bridge construction project in Afar and **10** permanent road maintenance districts in Adigrat, Gonder, Debremarkos, Kombolcha, Jimma, Shashemene, Nekemt, Alemgena, Sodo, and dire dawa. And in addition the corporation has also involved in some building construction in different cities of the country.

In order to fulfill all the required aggregate and sand material for all construction projects, the corporation has more than 50 quarry sites and 72 currently active stone crushing plants. Among the 22,000 permanent and temporary employees, 2192 (10 %) are working around quarry sites, stone crushing plants and material transportation.

Since ECWC has 72 currently active stone crushing plants and more than 50 quarry sites in all over the country, consideration of all sites is very difficult regarding time and financial constraints. Therefore the researcher purposely selected only four nearby quarry sites where there are 11 stone crushing plants associated with the quarries. Four study areas are selected for the study, these are: - 1. Wolenchity quarry site near wolenchity town in Adama – Awash Road overlay project, 2. Geja qore quarry site near Alemgena in Alemgena District, 3.Monopol quarry site near Hawasa in Shashemene District and 4. Mendi quarry site in Jimma District.

1. **Wolenchity quarry site**

This quarry site is located east shewa zone of oromia region with latitude of 8º 40’ N 39º 26’ E and an elevation of 1436 m. This quarry site is located 5 km away from wolenchity town. Farmers are living near the quarry site and 2 stone crushers and one sand making crushers are installed and all of them are working.

2. **Geja qore quarry site**

Located in West Shewa zone of Oromia Region 48 km from Addis Ababa to Butajira road, it has a latitude of 8º 42’9” N 38º 36’30” E. This area has a vast vegetation zone and fertile lands for agriculture productivity. The area also encourages animal husbandry. Two stone crushers are installed but only one crusher is currently active.

3. **Monopol quarry site**

This quarry site is located Wendogenet Wereda in the southern Nation, Nationalities and people of Ethiopia near Awasa town. It is Part of Sidama Zone located in the great rift valley it has a longitude and latitude of 7º 3’ N 38º 30’ E with elevation of 1708 m above sea level. Based on the 2007 census this wereda has a total population of 155,715 of whom 79,664 are men and 14.85% of the population are urban dwellers. The area is rich in stones, which attract investors to carry out stone quarrying. About 10 stone Crushers around the quarry site and tipper trucks load stones from the site to construction sites in and around the area.

4. **Jimma quarry site**

This quarry site is located 5 km away from jimma town on the way to agaro with latitude of 7º 40’ N 36º 50’ E and elevation of 1,780m.Most of the farmers are coffee and chat producers. Only one crusher is installed and currently working but the surrounding people are living very near to the crusher and quarry site.

3. 2. Research Approach and Design

The research design employed for the study is survey research and observational research. The survey method was employed to obtain information from some of the people around and within the operational area on the potential environmental hazards that are concerns to them. Although the major purpose of survey method in research is to tell ‘‘what is”? i.e., to describe the problem or phenomenon, but many surveys go beyond a mere description of the existing situation (Singh, 2006).

The study employed quantitative approach through the use of structured close format. Quantitative approach involves the generation of data in quantitative form which can be subjected to rigorous quantitative analysis in a formal and rigid fashion. This approach can be further sub-classified into inferential, experimental and simulation approaches to research (Kothari, 2004).

This study used inferential approach to research because it is helpful to form a data base from which to infer characteristics or relationships of population. This usually means survey research where a sample of population is studied (questioned or observed) to determine its characteristics, and it is then inferred that the population has the same characteristics (Kothari, 2004).

The observation method employed to support the concerns of the environmental impact from the survey research. The operation of the quarry starting from quarry face preparation, drilling, blasting, transportation, crushing, loading and unloading of materials. This will give the researcher the opportunity to learn at the first hand activities associated with quarrying and stone crushing.

3. 3. Sampling Techniques

Due to the characteristics of the population in the study areas, the population was categorized in to two sample frames, i.e. the quarry and crushing plant employees and the local residence community that they reside for long period in the study areas.

ECWC has 72 currently active stone crushing plants and more than 50 quarry sites in all over the country. The total population of the workers in all crushing plants and quarries are more than 2000. Since the quarry sites and the crushing plants are located in different areas of the country, consideration of all sites is very difficult regarding time and financial constraints. Therefore the researcher purposely selected only four nearby quarry sites where there are 7 stone crushing plants associated with the quarries. The first target population for the study was therefore 352 workers as listed in the table below. The variation in the numbers of workers depended on the size of individual operations and the diversity of the activities (Table 3.1). Concerning the local community, the study only focused on residents who are living near the quarry and crushing site within 1 km radius of the quarry and crushing sites. Based on the information from woreda administrations, there are around 200 households living within 1 km radius of the study areas. Hence in the study areas the size of the population was 352 workers and 197 nearby residents. The study also considered the response of project managers and team leaders in the study areas.

Table 3.1 Population of the study area

	Projects/districts	Location	No of workers	No. of households in the study areas
1	Alemgena District	Geja qore	96	45
2	Adama-Awash road overlay project	Welenchity town	79	32
3	Shashemene District	Hawasa city	75	73
4	Jimma District	Around Jimma	102	47
	Total No. of workers		**352**	**197**

3.3. 1. Sample Size Determination

There are several methods to determine the sample size of respondents from finite population. Hence in this study to draw representative sample households (n) from the population (N) of each sample frame, I used the formula, which was proofed by (Israel, 1992).

$$n = \frac{N}{1+N(e)^2}$$

Where, n is required sample size, N is total population in the sampling frame e is the precision level with 95% of confidence level i.e. 0.1

Therefore, based on the formula given the sample size in each frame is determined as follows:

a) For employees N= 352

$$n = \frac{352}{1+352(0.1)^2} = 77.88 \approx 78$$

b) For local residence community N= 197

$$n = \frac{197}{1+197(0.1)^2} = 66.3 \approx 66$$

3.3. 2. Sampling Method

1. For employees

The workers are from different work areas and have different exposure level based on their types and nature of work. They are composed of quarry workers, crushing plant operators and assistants, maintenance workers and equipment operators (quarry track, dump truck, loader, excavator, and wagon drill operators). Therefore the study used stratified sampling method.

If a population from which a sample is to be drawn does not constitute a homogeneous group, stratified sampling technique is generally applied in order to obtain a representative sample. Under stratified sampling the population is divided into several sub-populations that are individually more homogeneous than the total population (the different sub-populations are called 'strata') and then we select items from each stratum to constitute a sample (Kothari , 2004).

The workers were then stratified into four in order to capture the different exposure levels; the Quarry workers forming one stratum, those working at the crushing plant forming the second, maintenance workers form the third stratum and Equipment Operators forming the fourth stratum.

The study followed the method of proportional allocation under which the sizes of the samples from the different strata are kept proportional to the sizes of the strata. Regarding sample size allocation from each stratum, we usually follow the method of proportional allocation under which the sizes of the samples from the different strata are kept proportional to the sizes of the strata. That is, if Pi represents the proportion of population included in stratum i, and n represents the total sample size, the number of elements selected from stratum i is $n \times pi$ (Kothari, 2004).

Thus, using proportional allocation, the sample sizes for different strata are 12, 31, 7 and 8 respectively which is in proportion to the sizes of the strata viz., 28: 73: 16: 20.

In respect of the sample selection, the study used simple random sampling for selection of items for the sample from each stratum. The usual method, for selection of items for the sample from each stratum, resorted to is that of simple random sampling (Kothari, 2004).

Table 3.2 sampling method

	Strata	No of workers	Proportion	Sampled
1	Quarry workers	96	0.273	21
2	Crushing plant operators and assistants	153	0.434	34
3	Maintenance workers	57	0.16	13
4	Equipment Operators	46	0.13	10
	Total	**352**	**1**	**78**

2. Household Sampling

The study used purposive sampling to select the samples from the nearby community based on the following criteria:

- Proximity to the quarry/ Crusher site
- Farmers
- Use river water for daily consumption

Based on the above criteria, past experience and personal judgment of the researcher, sampling process was conducted. According to Singh (2006), this method is appropriate when the study places special emphasis upon the control of certain specific variables and to pick out the sample in relation to some criterion.

3. 4. Data Collection Techniques and Procedures

For the purpose of this research both primary and secondary sources of data were utilized.

3.4. 1. Primary Data

The primary data were gathered from the cross-sectional survey through questionnaire, interviews and observation.

a) Questionnaires

Data was collected from the local residence community and quarry employees using open and close-ended questions. Open-ended question enable respondents to freely express their options and view without prejudices, and hence obtain adequate information in relation to the objectives set for this study. However, the close-ended questions, apart from reducing time consumption, made it easier for data analysis and processing of factual information. Questionnaire was administered to these groups of respondents to get their views and perception on the impact of stone quarrying on individual employment status, income as well as health issues and on the physical environmental condition of the locality. The questionnaire method will be chosen for use because it is easy to administer and provide stimulus to all the subjects (Casley and Kumar, 1988). Further it allows an individual to give information independently without any influence from the researcher (Emerton, 1994).

b) Interview

Structured interview was conducted with people from different offices with different responsibility, and expertise knowledge as well as experience to collect data related to quarry impact and livelihood of the community, management problems, land vulnerabilities occurred, major challenges to quarry program, the deriving factors to the change of natural environment and possible suggestions in the view of communities and quarry owners to handle the challenges of sustainable development. Interviewers are advantageous in that they allow the researcher to explain clearly to the respondent the subject of discussion. They also allow both the literate and illiterate persons to respond to questions (Casley and Kumar, 1988).

c) Observation

Observation was conducted because it provides background information about the environment where the study is going to be conducted. Therefore, an extensive personal observation was undertaken in order to support the primary data that gathered and be able to gain richer understanding about the phenomena in natural setting and qualify the nature of the problem. The merit of this approach is that the investigator gets an inside picture of the study. It can also reveal information people are not directly aware of (Emerton, 1994).

3.4. 2. Secondary Data

Relevant secondary data were collected from different sources for this research particularly, from government organization, ECWC plan report documents, mining operation legal frameworks (policy, proclamation and regulations of mining activity), and also different books on environmental impact of quarrying and stone crushing and empirical studies. Moreover extensive use of internet browsing and literature reviewing of best practices were also conducted.

3. 5. Data Analysis Techniques

Data analysis was performed using Chi-square tests for significantly difference ($p<0.05$) in Statistical Package for Social Sciences (SPSS). The below chi square formula was used to determine variable relationship;

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

Where O = observed and E = expected

The Chi-square test is one of the most useful statistics for testing hypotheses when the variables are nominal. Unlike most statistics, the Chi-square ($\chi 2$) can provide information not only on the significance of any observed differences, but also provides detailed information on exactly which categories account for any differences found (Mary and McHugh, 2013). Thus, the amount and detail of information this statistic can provide rendered it the most useful tool in this research.

The different types of environmental impacts and their possible mitigation were examined and the ranking of the attributes in terms of their criticality as perceived by the respondents was done by use of Relative Importance Index (RII) which was computed using equation (1).

$$\mathrm{RII} = \frac{\sum \mathrm{W}}{\mathrm{A} \times \mathrm{N}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where: W – is the weight given to each factor by the respondents and ranges from 1 to 5, (where "1" is "strongly disagree" and "5" is "strongly agree"); A – is the highest weight (i.e. 5 in this case) and; N – is the total number of respondents.

Relative Importance Index or weight is a type of relative importance analyses.RII was used for the analysis because it best fits the purpose of this study. According to Johnson and LeBreton (2004), RII aids in finding the contribution a particular variable makes to the prediction of a criterion variable both by itself and in combination with other predictor variables.

The collected quantitative data was cleaned, edited for accuracy and analyzed using descriptive statistics in order to give numerical summaries. Descriptive statistics are used to describe the basic features of the data in a study. They provide simple summaries about the sample and the measures. Together with simple graphics analysis, they form the basis of virtually every quantitative analysis of data (William, 2008).

3.3. 3. Validity of Instruments

According to Straight (1993), validity refers to the extent an instrument measures what is supposed to measure. The research instrument was validated through application of content validity by seeking expert judgment from the advisor while developing research instruments.

To check for internal consistency in the content of the study instrument, splint half- test reliability was carried out. The relevant instrument analyzed for this purpose was administered on three surrounding communities and so workers in the quarry. Scares of even numbered items were correlated against those of odd numbered items.

3.3. 4. Reliability of Instruments

Fraekel & Wallen (1993) referred reliability as consistency if an instrument to yield the same results at different times. Bell (1993) noted that piloting is one way of checking the reliability of instrument. The researcher having identified pilot area in the district then visited the quarry area to test the reliability of the instruments by issuing the instrument to the respondents. After they have responded, the researcher collected the instrument and split it into half and analyzed the results using the spearman’s rank-order coefficient of correlation. After analysis the researcher paused for a week and went back and issued the same format of instrument and followed the same procedure. Since there was a consistency of responses from respondents, it is possible to conclude that the instrument is reliable.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Questionnaire Return Rate

144 questionnaire were allotted for the study and from which 140 were returned but after data cleaning only 120 were suitable for the analysis of which 73 employees and 47 local residents .

4.2. Demographic features of respondents

The age structure of the respondents show that 5% of the sampled populations are under 20 years of age, 23.3 % are between 20-30 years, 20 % are between 30-40 years while 32.5 % accounted for 40-50 years, the remaining 19.2 % are above 50 years of age. This age structure shows majority of the respondents are adults between the age of 20 and 50. These set of people are the active proportion of the population who are likely to bear the burden of the quarry threat. Any adverse impact of quarry on this set of people will surely have serious effects on the social and economic life of general population.

Table 4.1 demographic features of respondents

Characteristics	Numbers of workers	Percentage
Gender		
Male	99	82.5
Female	21	17.5
Marital Status		
Single	89	74.2
Married	31	25.8
Level of Education		
Non	13	10.8
Primary	41	34.2
Secondary	44	36.7
Post secondary	22	18.3

Occupational status of respondents		
Quarry workers	69	57.5
Farmers	35	29.2
Civil servants	5	4.2
Merchants	7	5.8
Other	4	3.3

The educational level of respondents shows that majority of the respondents can read and write, as can be seen in the table where 34.2 % completed or some primary education, 36.7 % secondary or some secondary and 18.3 % of the respondents are into the post secondary education. This implies that majority of the respondents understand the issue of environmental impact of quarry in the study area.

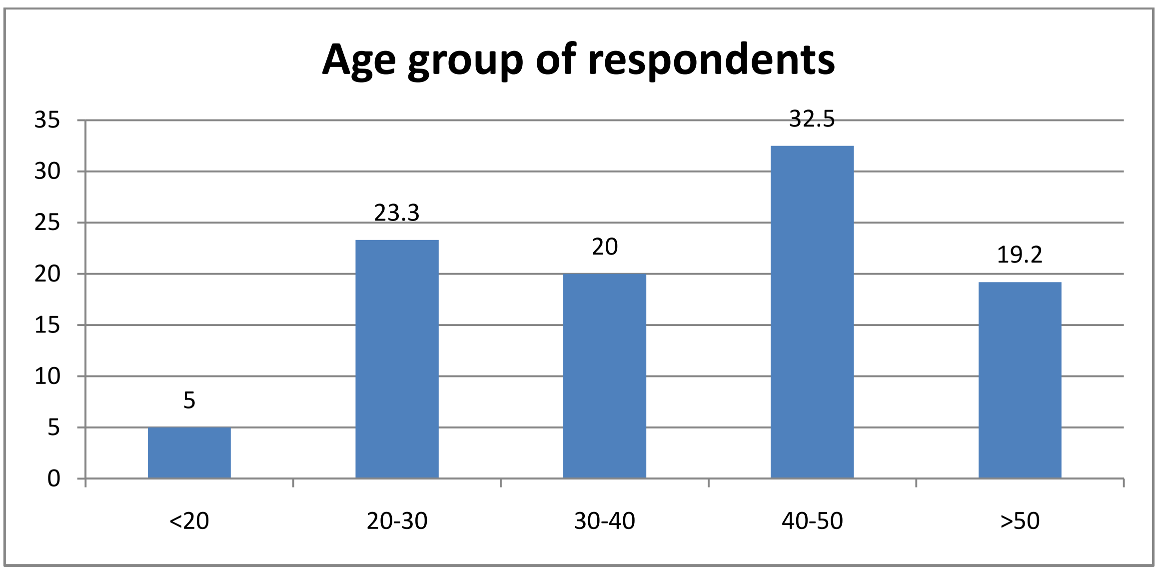

Fig.4.1 Age group of respondents

The work experience of the workers in the quarry and crushing plants, as seen in the table below, shows that most of workers, 75 %, have more than 5 years of experience. This shows that they have detail knowledge about how quarrying is taking place and understanding of the working environment. Therefore their response can be taken as seriously and relevant. There are some studies confirmed that workers stayed longer in the quarry areas and their exposure to different health problems has direct relation (Azandandet , 2006, Jethro , Ogbodo , Peter E.A., 2018).

Table 4.2 Workers' years of stay in the quarry in the quarry and crushing areas

Range of years	Frequency	%
0-5	18	24.6
5-10	15	20.5
10-15	17	23.5
15-20	11	15
Above 20	12	16.4
Total	73	100

4.3 Socio-ecological impacts of quarrying and stone Crushing

Mining has often a negative impact on the environment by the pollution it causes. The impact of mining on the environment affects different aspects. The deforestation and generally the environmental degradation have indeed important implications for the environment concerned, particularly on agriculture, which is often the main economic activity. Air pollution, noise pollution and land degradations in the study sites and their surroundings are the major environmental problems that need to be addressed. It has contributed to human health problems, destruction of vegetation and eventual loss of fertility of farm lands. People living in household close to the quarry share their opinion on environmental effect caused by the existence of quarry and crushing sites. Their views are presented in the Table.

a. Negative Impact

Table 4.3 ranking of negative socio economic impact of quarrying

Impacts	RII	Rank
Dust pollution	0.912	1
Erosion/loss of vegetation/fertility	0.871	2
Source of breeding grounds for mosquitoes and spread of diseases	0.855	3
Reduction of farm lands and grazing lands	0.841	4
Noise pollution	0.840	5
Destruction of landscape and beauty	0.839	6
Loss of biodiversity	0.826	7
Pollution of underground water	0.819	8
Building collapses or cracks	0.789	9
Other	0.772	10

Ranking of problems shown in Table above indicates the local peoples' perceptions on the problems experienced in the community, which reveals that the most pressing problems are dust, erosion/loss of vegetation/fertility, open pits which hold water in the rainy season and becomes source of breeding grounds for mosquitoes and spread of diseases, Reduction of farm lands and grazing lands and noise pollution are the top five problems.

Fig. 4.2 Stone crushing plant in Jimma quarry site

Dust pollution affects human, vegetation, and plants. The degree of proximity to the quarry sites are direct linkage with the extremes of effects on the victims. The dust emitted is first from shot holes by use of power driven drills. Then blasting, Crushing and material transportation are the main sources of air pollution. Dust is one of the most visible, invasive, and potentially the most irritating impact associated with quarrying (Howard and Cameron, 1998).

Fig. 4.3 drilling activity in Wollenchity quarry site

The cutting down of important trees and the destruction of the vegetative cover have led to ecological imbalance in the quarry areas. Closely related to the above impact is the destruction of fertile land. According to some respondents, their lands were very fertile for agricultural productivity. However, due to the quarry activities some land within the community can no longer support effective agricultural productivity. Farmlands that previously supported agriculture have been destroyed and others used as quarrying sites.

Noise pollution is common in all quarry sites. This takes place from the first stage of drilling to crushing. However, the blasting stage produces the highest level of noise pollution. The effect of noise pollution from blasting affects human, animals and the surrounding buildings. Excessive noise is a pervasive occupational hazard with many adverse effects, including elevated blood pressure, reduced performance, sleeping difficulty, annoying and stress (Deborah, 2005).

Fig. 4.4 blasting in geja qore quarry site

b. Positive Impact

Table 4.4 ranking of positive socio economic impact of quarrying

Impacts	RII	Rank
Provides employment to mine workers	0.882	1
Business opportunities like housing rent, restaurants, etc	0.723	2
Infrastructural developments such as road , housing, health facilities, schools, etc	0.587	3
Provides income for landowners	0.564	4
No positive impact	0.493	5
Others	0.321	6

Respondents from each of the study areas indicated positive impacts of mining as providing employment to mine workers, business opportunities like housing rent, restaurants, etc , enhancing infrastructural developments such as road and housing and, as well as providing income for landowners.

The quarry and crushing sites have played a vital role in improving the socio-economic status and life style of the local people. The plants guarantee direct employment to the local people from nearby villages. Further generates indirect employment for several persons in different associated activities like local trading, house construction, transportation, loading of materials etc.

4.4 Occupational health assessment

Stone crushing causes severe air pollution problems in active mining and crushing sites, workers are persistently exposed to large concentrations of dust, gaseous pollutants, high level of noise and accidents which constantly pose a severe threat to workers life and communities in close proximity to operations. The data on various health effects obtained from the current survey among the stone crushing workers and the population inhabiting in and around mining sites is exhibited by Fig. 4.2.

The overall observations showed that the quarry and crushing activities cause serious health problem which accounts respiratory (45.8%), eye (33.4%), skin (15%) and hearing problem (5.8%).

Table 4.5 Occupational health assessment of respondents

Health Challenge	Frequency	Percent
Respiratory problem	55	45.8
Eye problem	40	33.4
Skin problem	18	15
Hearing problem	7	5.8
None	0	0
Total	120	100

The respiratory problems observed in present study were coughing, shortness of breath, chest pain, asthma, bronchitis etc. Skin problems include dryness and roughness of skin. The activities such as digging, blasting, unloading, crushing, loading release dust particles of variable sizes into immediate atmosphere. The workers are encountered with substantial exposure to dust and noise which may lead to manifestation of various occupational diseases in long term. The most prevalent occupational diseases among the stone crusher workers and the surrounding communities are: respiratory, hearing, eye, skin, fever, silicosis, blood pressure problems and accidents (Singh and Pal, 2010). The distribution of these problems the study areas is shown below.

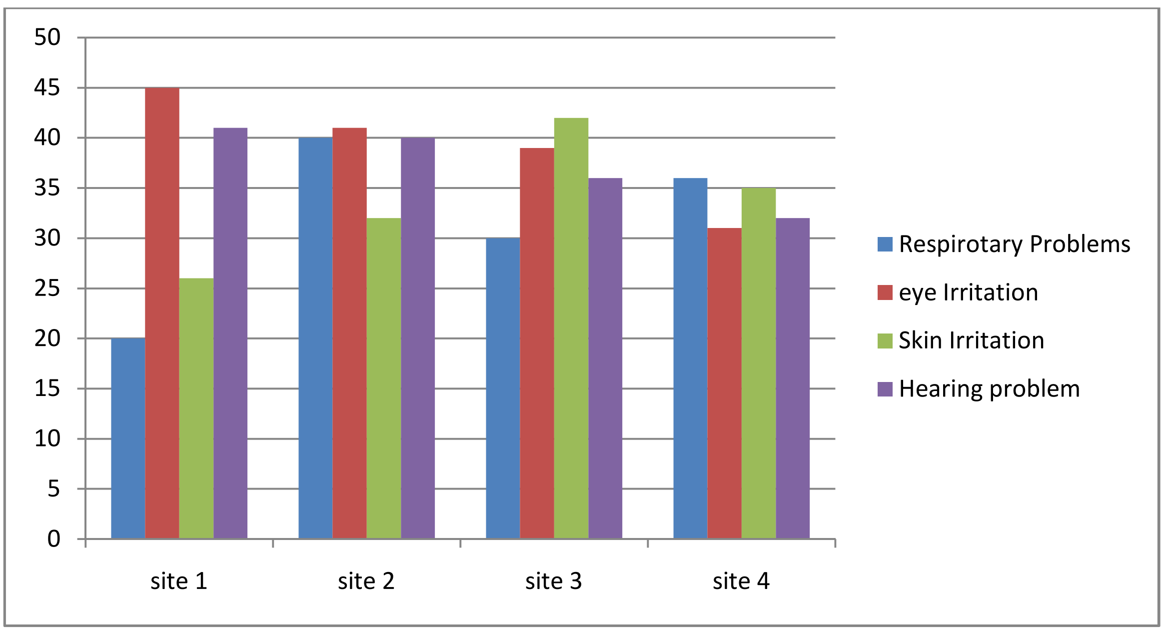

Fig.4.5 Human health problems at crushing and residential areas.

Table 4.6 Ailments exhibited in relation to work type

Common Health problem / Respondents	Respiratory Problem	Eye problem	Skin problem	Hearing problem	None	Row sum
Quarry workers	10	6	2	15	0	33
Crusher operators and laborers	28	7	5	11	0	51
Equipment operators	8	7	1	3	0	19
Maintenance technicians	12	5	1	2	0	20
The surrounding community	41	21	4	10	0	76
Column sum	99	46	13	41	0	199

The above table relates type of works and type of diseases in which the respondents are facing. The sum of the entire cells in this table is 199 (more than 120) as we have taken into account all the disease a respondent is facing with. Our sample shows that respiratory, eye and hearing problems were the most common illnesses found. Among workers, the crusher operators and labours working around were the most facing respiratory problem because high concentration of dust is always found around the crushing areas. Quarry workers were more exposed for hearing problem. This might be because of high blasting noise around the quarry workers. The surrounding communities were facing respiratory and eye problems more than other diseases. This might be related with their living areas which are very close the crushing areas.

The relationship of number of years staying in the quarry & crushing sites and workers' health situation.

The study also tried to find out the relationship of workers' year of stay in the quarry and crushing sites and their health experience related to one of respiratory, hearing, eye and skin or combination of them. It is evident that those who have stayed relatively longer period with in the quarry and crushing site experienced one or more of ailments than those who have stayed for relatively shorter period.

Table 7 Chi square test displays the relationship of year of stay and health condition

H_o: There is no connection b/n the ailment of workers and their years of stay in quarry and crushing sites.

H1: There is connection b/n the ailment of workers and their years of stay in quarry and crushing sites.

Table 4.7 Opinion of respondents about their health condition

Workers' years of stay in the quarry and crushing sites	Experience of workers for one or more of ailments related to quarrying and crushing			Total	Chi square value calculated	Degree of freedom (df)	Probability value
	yes	**No**	**No idea**				
0-5	12	5	1	18			
6-10	10	3	2	15			
11-15	12	5	0	17			
16-20	9	1	1	11			
> 20 years	12	0	0	12			
Total	55	14	4	73	10.94	4	0.005

At 95% of certainty index, x^2 (3, N=73) =10.94, P=0.005. Because $P < 0.05$, there is a critical connection b/n health status and duration of stay in the crushing and quarrying sites. Therefore the study rejects the null hypothesis and accepts the alternative hypothesis.

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

Chen (2012) confirmed that long term dust exposure caused heightened death of Chinese workers. Also Ohakwe (2009) and Nwibo (2009) ascribed respiratory inconveniences to micro-particles.

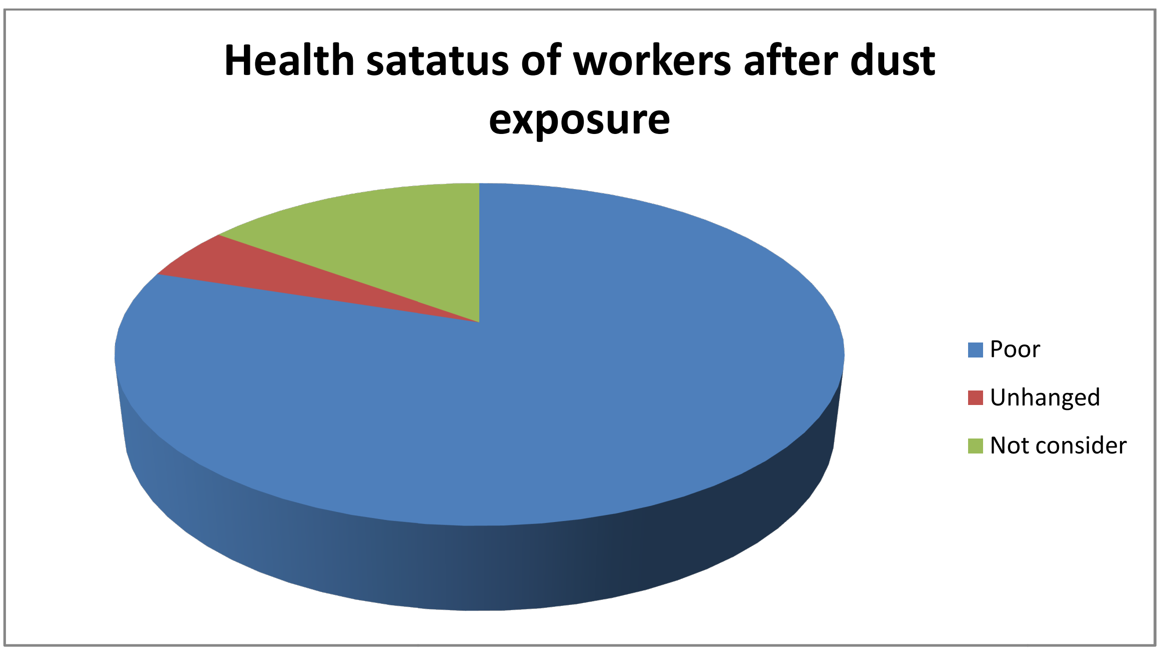

Fig.4.6 Respondents health condition after dust exposure

4.5 How residents and workers deal with effects of the pollution

The study also tried to find how residents and workers cope with the pollution they have suffered. From the questionnaire 43 of the respondents, representing 35.8% of the total respondents prefer to live with the effects of the pollution. It might likely be due to economic reasons and psychological attachment to their area in spite of pollution or lack of awareness about how bad the pollution is. 42 of the respondents representing 35% of the total respondents would prefer to protest the company. During interview of key informants, local community protest against the quarry and crushing site has been increasing in recent years. This might be related with the current political instability of the country or previously they were afraid of government bodies to protest.22 respondents representing 18.3 % protect themselves by using protective devices but all of them are workers either in the quarry or crushing site. Since workers constitute 60% of the total respondents, only 18.3% of them are properly using protective devices while all workers are provided with necessary devices regularly. 11 of the respondents representing 11.7% of the total respondents would prefer to complain to kebele or wereda.

Table 4.8 Assessment of how residents and workers deal with the pollution

Effects of pollution	Frequency	Percentage
Nothing done just accept as it is	43	35.8
Protest the company	42	35
Use protective devices	22	18.3
Complain to the kebele/ wereda	11	9.2
Others	2	1.7
Total	120	100

4.6 Use of Protective Clothing and Equipment

In ECWC the labour union and management collective agreement clearly put all the necessary devices that workers should be provided based on their work areas. And safety shoes, overall, dust mask and ear plug are provided to workers once in a year but hell mate and eye goggle are provided once in two years .But the study result showed that few workers protected themselves from the harms of quarrying and crushing. Safety shoes and overall were common by almost all workers, 91% and 85% respectively but using the other devices were not common practices by most workers. During observation welders are the only one who used eye goggle and hell mate was mostly practiced by crusher operators and laborers working around the plants.

And during interview some managers gave important information that some workers sell the protective devices to outside people but enforcement of workers to use these devices and disciplinary measures on those who do not use these devices are not common practice.

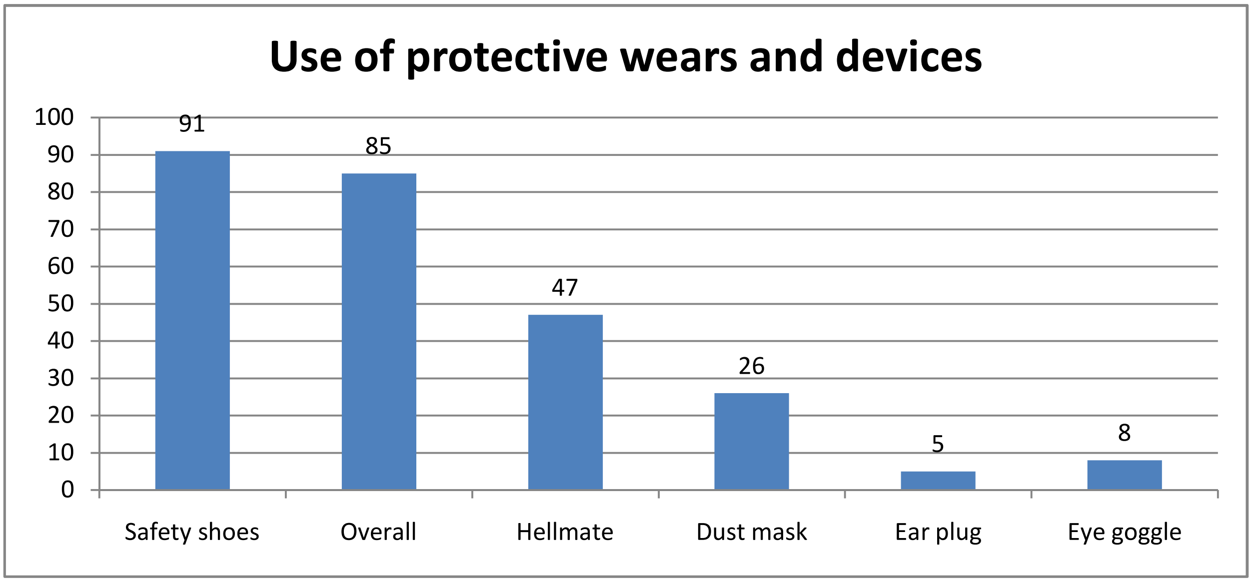

Fig.4.7 workers' use protective devices

4.7 Community development efforts of the company to mitigate or compensate for the damage

The study reveals that 56 respondents, constitutes 37.3 %, believed that the company constructs road to the local community even if the main aim of the roads construction are to facilitate company's material transportation but water and electric power supply are not common benefits they are provided because the company uses diesel generator for electric power source and some respondents 16 % represented that they have water supply from the company but all of them are live very near to the quarry sites and at least one of their families are working either in the quarry or crushing sites. In addition 37 respondents, constitutes 24.7 %, presented that they have at least one experience in payment compensation even if they were not satisfied with the amount and distribution of the compensation payment and during interview of key informants, the researcher understood that payment compensation covered very few members of communities specially those who are living very near to the quarry sites and those who displaced from their farm land for the quarry. Therefore protest and collision with local community is common in all sites. On the other hand 33 respondents, constitutes 22 %, provided their opinion that nothing will ever be done to compensate them for the pollution. These respondents further presented that they do not want to see the company to exercise quarrying activities around.

Table 4.9 Respondents opinion about company's effort of mitigation and compensation

Mitigation and compensation effort	Frequency	Percentage
Frequent mitigation activities like showering the dusty roads, watering of the material during crushing in the crushers, etc	28	18.7
Provide safety devises	45	30
Providing electricity	0	0
Payment compensation	37	24.7
Providing good roads	56	37.3
Providing water supply	24	16
Nothing will ever compensate	33	22
Total	223	148.7

4.8 Suggestions of respondents on how the company is going to continue around

The community development effort analysis revealed that almost all respondents, representing 85 % of the total respondents, have strong opinion that company shall be forced to provide/increase compensation or strong environmental protection standards should be implemented and the company must be forced to follow. Only 15 % respondents that do not want to see the quarry & crushing site around. This may be connected with the economic benefits they are gaining from the company.

Table 4.10: Respondents opinion about how the company is going to continue

Community dev. Effort	Frequency	Percentage
I do not want to see the quarry & crushing site around	7	15
The company shall be forced to provide or increase compensation	23	49
Strong environmental protection standards should be implemented	17	36
Total	47	100

4.9 Pollution Reduction Activity Practices

The under listed mitigation activities taken from literatures were given to the respondents to assess how the effect of quarrying and stone crushing could be reduced. Most workers have strong opinion that the company should take strict measures on quarry workers who do not use necessary protective wears but most of the respondents from local community believed that regular watering and showering of dusty roads, precautionary measures and rehabilitation of abandoned quarry sites are the most appropriate pollution reduction activities that must be taken to reduce the impact.

Table-11: Respondents opinion of the possible pollution reduction activities

Statement	RII	Rank
Dust barriers/traps should be erected around the quarry sites	0.891	1
Dusty roads should be watered regularly to reduce dust	0.811	2
Quarry workers should be provided with necessary protective wears	0.755	3
With respect to safety at blast sites, precautionary measures such as appropriate safety and protective gears, blast warning signs and signals and the proper control and management of blast sites are extremely important.	0.741	4
Strict measures must be taken to rehabilitate abandoned quarry sites	0.730	5
Speed of the vehicles should be maintained within the prescribed limits.	0.639	6
Restrict drilling, blasting and noisier activities to normal working hours	0.626	7
If removal is necessary, a garden center or buffer should be established for the maintenance and propagation of the endemic species and other naturally occurring plants.	0.619	8
Rock fall protection methods such as rock berms, wire/net mesh and catch fences should be employed as direct physical/structural mitigation measures.	0.589	9

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

The overall purpose of this study was to assess the impacts of stone quarrying on environment and livelihood of local community in quarry and stone crushing areas in ECWC Projects and Districts. Specifically, it aimed at; assessing and identifying significantly affected elements of the natural environment and socio-economic activities associated with livelihood of the community. The study also explored perceptions of respondents in line with the impact of quarrying activities on the environment, household income and local community health and safety.

As findings revealed the quarrying activity in the areas affect the natural environment through changing the land use, land cover and the landscape. Quarry extraction in the area involves bulk excavation of rocks and disposing of overburden rock wastes, which caused loose of agricultural land. Negative landscape effects due to presence of abandoned quarry pits and heaps of quarry wastes together with lack of quarry pit restoration plan and/or after-use plans degraded the land.

The study also fined out quarrying serve as an alternative job opportunity and created large amount of employment at the study areas.

The health and safety of workers and the nearby communities are at risk from a variety of factors, ranging from the inhalation of dust, poor safety procedures and water contamination to unprotected pits and cliffs. The workers' awareness levels of the health risks they are exposed to at the quarry were high but use of protective clothing while at work was poor. The exposure of workers to the high concentrations and the poor use of protective clothing and devices dispose them to respiratory, skin and eye ailments and ere ailments.

The findings of this research further corroborate other related works. For instance, Gale and Groat (2001) argue that stone quarrying contributes to noise pollution, vibration, chemical spills, erosion and sedimentation. Although the study did not conduct any chemical analysis in the quarry sites, similar pollutions were experienced by the respondents. In addition, there is absence of water pollution as there are no rivers in the study areas. Furthermore, contrary to Ilyas et al., (2010)'s view that dust related problems were associated with cases of owners of the crushing stone unit not providing appropriate protective devices to protect the workers. The case of ECWC is different as the workers are provided with all the necessary protective devices but the problems still existed because the culture of using these devices is very poor. Therefore providing protective devices are not the only solution to protect workers from the pollution but continuous monitoring, awareness creation and disciplinary measures on workers who do not use protective devices will be more appropriate measures to protect them.

Unlike similar studies, this study tried to investigate the opinion of respondents weather they are interested if the company quit quarrying and stone crushing in their environments or not. And most respondents do not want the company to quit quarrying and stone crushing activities but they want the company to provide appropriate compensation and should follow all the necessary standards to protect the environment. This may be related with the economic benefits they gained or their level of awareness about the impact of the activities on the environment.

5.2 CONCLUSIONS

The purpose of this study was to examine the impact of stone quarrying on the environment and the livelihood of communities in the projects and districts of Ethiopian Construction Works Corporation (ECWC). The survey method was used as a guideline for answering this objective. It can be concluded that there is potential that stone quarrying may contribute significantly on the economic improvement but the pollutions affect the health of workers and the people living very close to the site thereby making live difficult. It was discovered that majority of all that are residing within jurisdiction of less than 1km of the quarry and crushing plant areas are vulnerable to different types of pollution such as, Noise, Air (Dust), Water and Land pollution.

The Stone Quarries with crusher plants of ECWC are beneficial for the development of the nearby villages. Some environmental aspects like dust emission, noise, siltation due to surface run-off, etc. have to be controlled within the permissible norms to avoid impacts on the surrounding environment. Necessary pollution control equipment like water sprinkling, plantation, personal protective equipments, etc., have to be regular practice in all the projects. Additional pollution control measures and environmental conservation measures must be adopted to control or minimize impacts on the environment and socioeconomic environment of the areas. Measures like development of thick green belt and plantation within mine lease areas and along transport roads will be implemented.

Moreover the government, the industry and the community should be encouraged to be partners in progress. They can jointly be involved in monitoring environmental resources depletion, especially the compliance level of the plant to minimum standards for sustainable and pollution free society.

5.3 RECOMMENDATIONS

The study has tried to establish the negative consequences of quarry activities on the environment. The study reveals that though there have been efforts on the part of the projects and districts to reduce their pollution impact, more still needs to be done especially in the area of environmental monitoring.

I. Air pollution

During stone extraction and crushing, it is anticipated that the surrounding air might be polluted by the dust emitted during crushing. For this it would be important to constantly water the site so as to reduce the amount of dust emitted in the air. Also appropriate machines should be used for crushing as well as the appropriate stones i.e. the hard ones which produce less dust. During the rainy season, rain water harvesting will be maximized which will reduce the cost of buying water. Storage tanks will be required to store water during the dry season.

The following measures will be taken to mitigate the fugitive dust from different operations.

- Watering of haul roads and other roads at regular intervals
- Spraying of water on permanent transport roads at required frequencies.
- Provision of dust filters / mask to workers working at highly dust prone and affected areas.
- Provision of green belt by vegetation for trapping dust.
- Greenbelt development along the haul roads and along the boundaries of the lease area.

II. Safety Management

A qualified and experienced safety officer shall be appointed. The responsibilities of the safety officer include identification of the hazardous conditions and unsafe acts of workers and advice on corrective actions, conduct safety audit, organize training programs and provide professional expert advice on various issues related to occupational safety and health. He is also responsible to ensure compliance of Safety Rules/ legal Provisions.

The extracted material should be transported from the quarry to the crusher by adopting following measures so as to minimize dust emissions.

- Water sprinkling should be done prior and after loading into the trucks.
- Speed of the vehicles should be maintained within the prescribed limits.
- Trucks should not be over loaded and should be maintained to the body level.

III. Noise Pollution Management

The major noise generating source from the quarry and crushing activities are: blasting, drilling, crushing, excavation, loading, unloading and plying of vehicles. The following control measures are to be undertaken to bring down the noise levels.

- Use of personal protective devices i.e., earmuffs and earplugs by workers, working in high noise areas.
- Proper maintenance and tuning of Vehicles would be ensured.
- The greenbelt with species of rich canopy around the noisy area and along the roads will further attenuate the noise levels.
- Conducting periodical medical checkup of all workers for any noise related health problems
- Proper training to personnel to create awareness about adverse noise level effects.
- Planned noise monitoring at suitable locations in the plant and outside location for proper effective remedial actions.

IV. Socioeconomic

The following measures will be taken up to improve the socioeconomic conditions of the area:

- Local people will be employed on priority basis as per their skills
- Direct & indirect development of the society.
- As a part of Corporate Social Responsibility the project proponent agrees to provide free of cost boulders and sand for social projects as, schools, clinics in the area.
- Medical facilities to the workers employed at site

5.4 Area for Further studies

The study found that the workers exhibited respiratory, skin and eye ailments and therefore there is need to carry out further research in these areas. Another study should be carried out to find out why despite the high levels of awareness of the workers' they do not use protective gear and clothing. A study with chemical analysis should also be carried out on the quarries to find out the presence of silica because various studies have shown that rock contains crystalline silica, which occurs in different quantities, depending on the types of rock. Other studies confirmed that there is a strong body of evidence for causal relationship between exposure to crystalline silica and disease (Rosner & Markowitz, 2006).

Appendices

Appendix I: Questionnaire for local community in the quarry and crushing sites

Dear Respondents,

I am a student in St. Marry University, undertaking an investigative study as a prerequisite for the award of master's degree of project management. This survey is to assess the impact of quarrying and stone crushing in your environment. Thank you for accepting to take part in this study. Your answers are very important to us. We would like you to be honest and truthful. Your name will not be included in this questionnaire. Your answers will be kept confidential. Your answers will not be shared with anybody outside the study. Your answers will not be used against you in any way. We will ask you questions about yourself, the environment and your health in relation to the quarries and stone crushing. Please mark the right box.

PART I: DEMOGRAPHIC DATA

1. **Gender**

   Male ☐ Female ☐

2. **Age**

   Below 18 ☐ 18 -25 ☐ 26 - 35 ☐

   36 - 45 ☐ Over 45 ☐

3. **Formal education**

   None ☐ Primary ☐ Secondary ☐ Tertiary ☐

4. **Marital status**

   Single ☐ Married ☐ Divorced ☐ Widowed ☐

PARTII: WORK AND HEALTH RELATED DATA

5. Do you often suffer from any of the following ailments?

Headache ☐ Chest pain ☐ Cold ☐

Chest tightness ☐ Eye irritation ☐ Skin irritation ☐

Other (specify)……………………………………………………

6. Do you know that exposure to dust in the quarry environment can affect your health negatively?

Yes ☐ No ☐

7. Show how you agree with the following statements using the responses listed below by ticking the appropriate one.

Strongly agree b. Agree c. somewhat agree d. Not agree e. Strongly disagree

Negative Impacts	Strongly agree	Agree	Somewhat agree	Not agree	Strongly disagree
Reduction of farm lands and grazing lands					
Source of breeding grounds for mosquitoes and spread of diseases					
Erosion/loss of vegetation/fertility					
Loss of biodiversity					
Destruction of landscape and beauty					
Dust pollution					
Pollution of underground water					
Noise pollution					
Building collapses or cracks					

8. Which one of the following positive impact you agree with from quarrying and stone crushing in your environment? (you can tick more than one)

Positive Impacts	Yes
Infrastructural developments such as road , housing	
Provides employment to mine workers	
Provides income for landowners	
Business opportunities like housing rent, restaurants, etc	

9. How many years you have stayed in surrounding? (For local Community only)

<5 ☐ 6-10 ☐ 11-15 ☐ 16-20 ☐ >20 ☐

10. What is your economic activity? (For local Community only)

Civil servant ☐ subsistent farming ☐ livestock rearing ☐

Related to quarrying/stone crushing ☐ petty business student ☐

Other (specify)……………………………………………………….

11. Do you believe the activities of stone quarrying contribute to scarcity of agricultural land? (For local Community only)

a) Strongly agree ☐ b) agree ☐ c) strongly disagree ☐

d) Disagree ☐ e) no certain ☐

12. Have there been any conflicts between quarries and local community members in the past? (For local Community only)

a) Yes ☐ b) no ☐

If yes, what was the cause of the conflict? …………………………………………………...
………..………………………………………………………………………………………
…… ……………………………………

13. Does the quarrying activity affect the environment? (For local Community only)

Yes ☐ No ☐ No idea ☐

14. The impact of quarrying on the environment (For local Community only)

Degradation of land and vegetation ☐ Water pollution ☐

Air pollution ☐ Noise pollution ☐ Building Cracks ☐

15. How do you cope with the pollution? (you can tick more than one)

Effects of pollution	Yes
Use protective equipment	
Nothing done just accept as it is	
Complain to the kebele/ wereda	
Protest the company	
Others	

16. Which one of the following mitigation efforts you ever noticed from the company to compensate the impact because of quarrying and stone crushing in your environment? (you can tick more than one)

Mitigation and compensation effort	Yes
Frequent mitigation activities like showering the dusty roads, watering of the material during crushing in the crushers, etc	
Provide safety devises	
Providing electricity	
Payment compensation	
Providing good roads	

Providing water supply	
Nothing will ever compensate	

17. What is your opinion on how the company is going to continue quarrying and stone around?

Respondents opinion	Yes
I do not want to see the quarry & crushing site around	
The company shall be forced to provide or increase compensation	
Strong environmental protection standards should be implemented	

18. What is the relationship between quarries and local residents in the area? (For local Community only)

a) Very good ☐ b) good ☐ c) bad ☐

d) Very bad ☐ e) No certain ☐

19. Show how you agree with the following statements using the responses listed below by ticking the appropriate one.

Extremely helpful b. Very helpful c. Somewhat helpful d. Not so helpful e. Not at all helpful

Statement	Extremely helpful	Very helpful	Somewhat helpful	Not so helpful	Not at all elpful
Dust barriers/traps should be erected around the quarry sites					
Dusty roads should be watered regularly to					

reduce dust					
Quarry workers should be provided with necessary protective wears					
With respect to safety at blast sites, precautionary measures such as appropriate safety and protective gears, blast warning signs and signals and the proper control and management of blast sites are extremely important.					
Strict measures must be taken to rehabilitate abandoned quarry sites					
Speed of the vehicles should be maintained within the prescribed limits.					
Restrict drilling, blasting and noisier activities to normal working hours					
If removal is necessary, a garden center or buffer should be established for the maintenance and propagation of the endemic species and other naturally occurring plants.					
Rock fall protection methods such as rock berms, wire/net mesh and catch fences should be employed as direct physical/structural mitigation measures.					

Appendix II: Questionnaire for employees in the quarry and crushing sites

PART I: DEMOGRAPHIC DATA

1. **Gender**

Male ☐ Female ☐

2. **Age**

Below 18 ☐ 18 -25 ☐ 26 - 35 ☐

36 - 45 ☐ Over 45 ☐

3. **Formal education**

None ☐ Primary ☐ Secondary ☐ Tertiary ☐

4. **Marital status**

Single ☐ Married ☐ Divorced ☐ Widowed ☐

5. **Job specification**

Loader Operator ☐ Truck Driver ☐ Stone breaker ☐

Mechanic ☐ Driller ☐ Blaster ☐

Crushing plant operator ☐

6. **Terms of employment**

Permanent ☐ Contract ☐ Temporary ☐

7. **Period worked for**

<1 year ☐ 1 – 5 years ☐ 6 – 10 years ☐ 11- 15 years ☐

☐ ☐

16 – 20 years > 20 years

8. Working area

Do you often suffer from any of the following ailments?

Respiratory problems ☐ Hearing problem ☐ Malaria ☐

Chest tightness ☐ Eye irritation ☐ Skin irritation ☐

Other (specify)………………………………………………………

9. Do you usually cough or clear your throat in the morning?

Yes ☐ No ☐

10. Do you have a cough for 3 months or more in total during a year?

Yes ☐ No ☐

11. Do you have phlegm when coughing?

Yes ☐ No ☐

12. Are you breathless when you walk and ascend a hill at an ordinary pace?

Yes ☐ No ☐

13. Do you wheeze in your chest?

Yes ☐ No ☐

14. Do you have any skin infection?

Yes ☐ No ☐

15. Have you noticed any skin infection/rash you feel is related to your work?

Yes ☐ No ☐

16. Which of the following protective clothing/gear do you wear while at work? (for employees only)

Gloves ☐ Helmet ☐ Boots ☐

Overalls ☐ Dust Mask ☐ Dustcoat ☐

Earplugs ☐ Goggles ☐

None (why)………………………………………………………….

Other (specify)……………………………………………………….

17. Do you know that exposure to dust in the quarry environment can affect your health negatively?

Yes ☐ No ☐

Appendix III: Key informants interview guide

Thank you for accepting to take part in this study. Your answers are very important to us. We would like you to be honest and truthful. Your name will not be included in this questionnaire. Your answers will be kept confidential. Your answers will not be shared with anybody outside the study. Your answers will not be used against you in any way. Please mark the right box.

Respondent position …………………………………

How many employees related to quarry and stone crushing in your project? And what is the nature of employment?

What do you provide toward the safety of your employees?

Are there any environmental implications caused by the quarrying process?

What measures your project has undertaken to protect the environment?

Do you have any complaints from the residential neighborhood?

Do you have any post closure strategy on quarried areas?

Is your project socially responsible to the neighboring community?

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