**ADDIS ABABA INSTITUTE OF TECHNOLOGY**

**DEPARTMENT OF CIVIL ENGINEERING**

# ENVIRONMENTAL IMPACTS OF COARSE AGGREGATE PRODUCTION IN AND AROUND ADDIS ABABA

A thesis submitted to the School of Graduate Studies of Addis Ababa University in Partial fulfillment of the requirements for the Degree of Master of Science in Civil Engineering (Construction Technology and Management)

**By**

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**April 2013**

**Addis Ababa**

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# DEDICATION

To my beloved family: My father Ato Mulatu Bekele, my mother Woizero Atsede H/ Mariam, my elder sister Ajebech Mulatu, my younger brother Eng. Addisu Mulatu, and to all my other family members.

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# ABSTRACT

Population is increasing in this world and it is also true phenomenon in our country. The number of population migrating from rural areas to cities and the high level of birth rate in Ethiopia has substantial contribution for such rapid increase in population. Addis Ababa, being the capital of this country, is one of the cities where rapid growth of population is more significant. Due to this fact, together with the private sector the government is investing huge money for the construction of housing infrastructure in all regions. The 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. Besides, because of their size and profound societal importance, construction activities and processes are among the largest consumers of materials and energy and significant polluters on the global scale. For these reasons, more attention should be devoted to understanding, researching, and ultimately reducing their environmental impacts. Hence, this research work attempt to addresses the environmental impact of aggregate production and identifies the level of aggregate produced in environmentally friendly way in Addis Ababa.

The objective of the research was to make assessment of the current situation of active and abandoned aggregate materials production quarries and the condition of the environmental effect in and around Addis Ababa, and to formulate and give recommendations with respect to the environmental mitigation plan. Therefore, survey of selected active and abandoned quarry sites in and around Addis Ababa has been done. The survey includes observation, on site data collection and conducting interviews. Besides, relevant data were collected from governmental institutions and large construction materials suppliers and producers in and around Addis Ababa were performed. The result indicates that, in and around Addis Ababa, huge area of land has been sacrificed for the production of aggregate (about 2% of the total area of the city). This area should not be considered as minimum as it is even wider than some of the sub cities. On the other hand, the environmental concern provided for this huge land is so small. For instance, only 40 % of the sampled quarry sites have taken some environmental mitigation measures for the protection of surface and ground water pollution. Another conclusion drawn from the research was concrete

aggregate production has relatively good profit (27% the total expenditure). However, the environmental focus given by the producers is very small. Although it is not an easy task to evaluate the monetary value of environmental protection activities performed on quarry sites it can be considered as very negligible. Finally, measurements should be always taken to investigate the impact that the operation in the quarry plant has on the surrounding environment and inhabitants. All concerned parties should work hand in hand for the proper utilization of the scarce resource we had.

**Key words:** coarse aggregate, concrete, environmental impact, mitigation measure, mound, surface and ground water.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| A.A. | Addis Ababa |
| ARDB | Agriculture and Rural Development Bureau |
| Art. | Article |
| EIA | Environmental Impact Assessment |
| EPA | Environmental Protection Authority |
| FDRE | Federal Democratic Republic of Ethiopia |
| MoARD | Ministry of Agriculture and Rural Development |
| MoWR | Ministry of Water Resources |
| SNNPRS | Southern Nations Nationalities Pupils Republic State |

# 1 INTRODUCTION

At the start of the new 2000 Millennium, stone continues to play an important role in shaping our environment. Indeed this is a continuation of a role played for many centuries. Today the extraction, processing and transport of stone is a complex issue. On the one hand it supplies materials to meet many of society's needs and creates employment, but on the other hand it can have significant impact upon the environment and local communities [1].

Population increase in cities is also true in our country. The number of population migrating from rural areas to cities and the high level of birth rate in the country has substantial contribution for such rapid increase in population. This in turn needs the development of plenty of infrastructure in towns. Taking this into consideration, the government is investing huge amount of money on the construction of roads, buildings, dams and condominiums [2].

The construction of such big infrastructure the country also needs plenty of construction materials production. Aggregates are among the first construction materials that constitute major portion of civil engineering construction works [2].

In general, aggregates are produced from materials resulting from the mechanical processing of natural rock. Aggregates are also produced from recycling materials and industrial waste from various origins. Aggregate production in Ethiopia is totally from natural rock and is not produced in a scientific and macro level. Majority of aggregate production is performed by small and micro finance groups [2].

## 1.1 THE NEED FOR CONTINUING QUARRYING ACTIVITIES

It is apparent that quarrying activities do cause environmental damage and ecological imbalances. The question is, should the quarrying activities be stopped? Aggregate form the back bone for any developmental projects, such as road and related systems, irrigation projects, etc. The spurt in the

population growth, developmental programmers and urbanization has necessitated a larger supply of concrete aggregates [2].

Under these circumstances any move to restrict the quarrying activities would severely hamper the developmental programs and projects. The very basic necessities of housing, roads etc. would be affected. The other benefits of quarrying industry are increased employment [2].

## 1.2 CLASSIFICATION OF QUARRIES AND THEIR IMPACT ON ENVIRONMENT

In the present day context quarries for minor minerals can be classified as follows [2].

- Quarries for building stone
- Quarries for sand
- Quarries for brick and clay tile and
- Quarries for ornamental stone.

Quarrying for any minor minerals involves the following [2]

1. Clearance of surface habitats like forest, wild life etc
2. Top soil stripping
3. Creation of excavations and pits that are eventually abandoned
4. Enormous solid waste production which begins from the production to processing stages.

Thus obviously the development of the resources becomes "replacive" in certain cases and predominantly destructive in most cases. The Principal environmental problems arising out of quarrying are [2]:-

- Land degradation
- Deforestation
- Water pollution
- Air pollution
- Socio economic problems caused by land acquisition and influx of outsiders.
- increased demand for amenities

The environmental problems generated by the different classes of quarries are briefly indicated below:

**a) Quarries for Building Stones: -** These quarries are generally located above the ground surface and far away from the villages and towns. The main impact is the disfiguration of the landscape and where the operation is below ground. The result is land damage. It becomes significant when stone crusher's are operating in the area which is normally the case around urban centers [2].

**b) Bricks and Clay Tile Quarries: -** Main impact is land damage [2].

**c) Quarries for Constructional Sand: -** The level of the river bed is affected. However, the excavated portions are normally refilled by sand during flood seasons [2].

**d) Ornamental Stone Quarries: -** The environmental hazards arising out of the ornamental stone quarrying industry are landscape changes, land degradation, dust pollution and noise pollution. The dust and noise pollution are the results of the deployment of machineries and formation of infrastructural facilities [2].

## 1.3 OBJECTIVES

### 1.3.1 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 Addis Ababa, and formulate a conclusion from the result obtained and give recommendations with respect to the environmental mitigation plan.

### 1.3.2 Specific Objectives

With the research, the following specific objectives will be addressed.

- Identify the types of environmental impact of aggregate material production.

- To identify out of the aggregate producers in the study area, how many of them have produced aggregates in environmental friendly way.
- Detail assessment of cost and benefit of aggregate production and the concern provided to the environment compared with the earned benefit.
- Evaluation of how much area of land has been sacrificed for the aggregate producing quarries.
- Explain the mitigation measures taken so far.
- Identify the type of environmental mitigation measures are practiced on the quarry site.

## 1.4 METHODOLOGY

The methods adopted in conducting the research are described as follows

### 1.4.1 Sources and Collection of Data

- Literature survey
- Survey of selected active and abandoned quarry sites in and around Addis Ababa. The survey includes observation, on site data collection and conducting interviews.
- Collecting relevant data from governmental institutions and large construction materials suppliers and producers in and around Addis Ababa.
- Use of internet web sites to find relevant information

### 1.4.2 Processing of Data

- Analyzing information gathered through questionnaires and site quarry visits and observations. Then make a subjective assessment on the current quarrying activities and their negative environmental impacts to the recommended scientific approaches of literatures and also to make a quantitative evaluation of the level of mitigation measures taken to control on the impacts.
- Simple statistical analysis were applied on the out come or on the results obtained.

### 1.4.3 Conclusion

- Formulation of a conclusion from the results obtained.

### 1.4.4 Application of Results

- The importance of this research will be to raise awareness of aggregate producers, employers, contractors, engineers, site workers, institutions, governmental bodies and every single individual regarding environmental effects that have been encountered to now due to the production of aggregate.

- The effectiveness of implementation of waste management and reinstallation of quarries into construction material production quarries will lead to reduction of bad effects towards environment. It is absolutely imperative for the construction industry to adopt ecologically sound planning and construction material production for the purpose of creating a healthy and sustainable built environment.

### 1.4.5 Possible Beneficiaries of the Results

- Parties working on Environment
- Contractors
- Consultants
- Project owners
- The general public
- Educational Institutions
- Professional Associations (Ethiopian Civil Engineers Association, Ethiopian Contractors Association)
- Future studies in construction management and related topics

### 1.4.6 Limitations

In the research, attempt has been done to minimize limitation. However, the under listed limitations were identified:

- Parties involved in replying the questionnaire might not give the correct data as they have a suspicion that data collected might be used for other purpose that might harm their business.
- Due to financial scarcity the numbers of samples taken were limited. However, attempts were considered to take representative samples from small to mechanized aggregate producers and direction wise.
- Although, plenty of attempt have been done to get a reliable data, such as extensively visiting the site, critically observing official documents there is suspicion that small discrepancies are unavoidable.

# 2 AGGREGATE PRODUCTION

## 2.1 AGGREGATE DEPOSITS AND SOURCES

### 2.1.1 Sand and Gravel

Sand and gravel deposits are products of erosion of bedrock and the subsequent transport, abrasion, and deposition of the particles. Water and glacial ice are the principal geologic agents that affect the distribution of deposits of sand and gravel. Consequently, gravel is widely distributed and abundant near present and past rivers and streams, and in previously glaciated areas [3].

Sand and gravel are widely distributed as stream channel and terrace deposits. Bedrock exposed near the surface of the Earth undergoes weathering and is progressively broken into smaller and smaller pieces. The harder, more-resistant minerals remain as fragments that combine with the silt and clay particles and organic materials to form soil [3].

Water moves soil material down from the mountains or other high areas and it accumulates in stream valleys Fig.-2.1. Streams pick up the particles and in the process of transporting them, subject the particles to abrasion and rounding. Eventually, stream-transported material is deposited on floodplains. Stream deposits consisting of sand and gravel may be suitable for aggregate, but deposits of silt and clay are not suitable [3].

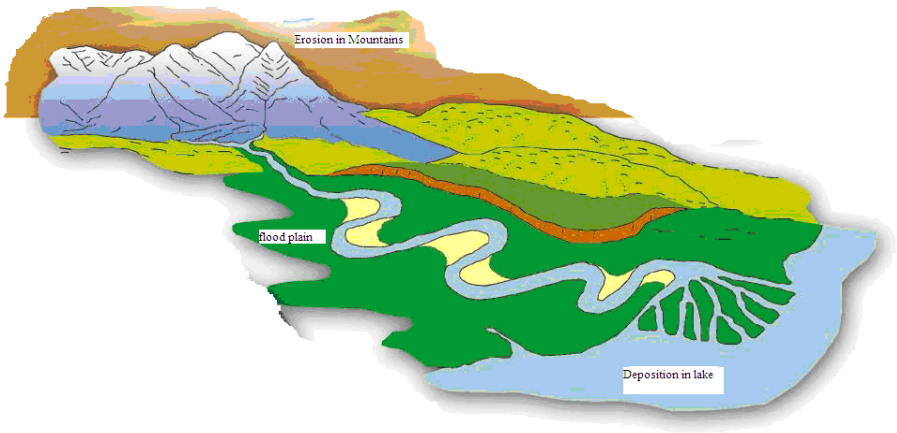


**Fig.-2.1** Sand and gravel are formed by geologic processes [3]

As a river or stream cuts its channel deeper, older channel and floodplain deposits standing above the modern floodplain may be preserved as terraces. Some stream terraces can be sources of sand and gravel. Stream transported material deposited in the oceans and lakes may be dredged for use as aggregate, if it is of the proper size and quality [3].

During floods typical of desert environments, rock fragments are eroded from mountains and are transported down steep-gradient streams to the adjacent basins. When the flood water reaches a basin, it spreads out of the stream channel and deposits sediments in the shape of a fan. These fans, referred to as alluvial fans, contain thick deposits of unconsolidated material including large boulders, cobbles, pebbles, sand, silt, and clay. Some of this material provides useful sources of aggregate. As glacial ice melts, rock particles that had been crushed, abraded, and carried by the ice can be picked up and carried by water melting from the glaciers. The particles carried along in glacial melt water streams, are abraded, rounded, and deposited much like particles carried by non glacial streams. Much of the sand and gravel deposited by glacial melt water streams can be used as aggregate [3].

### 2.1.2 Crushed Stone

Bedrock, the source material for crushed stone, is classified on the basis of origin as sedimentary, igneous, or metamorphic Fig- 2.2. Sedimentary rocks form by consolidation of loose sediment by chemical, biochemical, or mechanical processes. Chemically or biochemicaly deposited carbonate sedimentary rocks, such as hard, dense limestone (calcium carbonate) and dolomite (calcium magnesium carbonate), commonly are referred to as limestone. Generally these rocks make good sources of crushed stone Fig. 2.2, a, however, some are too soft and absorptive, or may contain too much poor quality material to yield high-quality aggregate. Chert, also known as flint, is a tough fine-grained sedimentary rock made of quartz. Chert is used as aggregate but it may react with adverse consequences when used in concrete. Hard, dense sandstone, a mechanically-deposited sedimentary rock, is occasionally used as crushed stone [4].

Many igneous rocks are hard, tough, and dense, and they make excellent crushed stone for construction uses. However, some igneous rocks are chemically reactive when used as aggregate in

concrete. Igneous rocks solidify from naturally occurring molten rock (magma) generated within the Earth, and they are classified further by their origin, composition, and grain size. Hard, coarse-grained rocks form from molten magma that cools slowly deep within the Earth. There rocks commonly are referred as granite in the aggregate industry. Fine-grained volcanic rocks form as molten lava flows onto the Earth's surface and cools and solidifies relatively quickly. These igneous rocks commonly are referred as trap rock in the aggregate industry. Metamorphic rocks form when existing rocks are subjected to heat and pressure within the Earth. Some metamorphic rocks are hard, tough, and dense and can be used as aggregate. These include gneiss (a banded crystalline rock); marble (metamorphosed limestone), and quartzite (metamorphosed sandstone) [4].

## 2.2 AGGREGATE PRODUCERS

In the United States, more than 1,200 companies produce crushed stone from some 3,300 quarries, and 4,000 companies produce sand and gravel from about 6,400 operations. Five companies account for nearly 25 percent of the aggregate production. Even so, more than 5,000 companies are active in the aggregate business, and no single producer dominates the industry. Consequently, acquisitions of companies have become commonplace. One of the major reasons for acquisitions is to obtain new high-quality reserves. Acquisitions are also being used by larger companies to spread the cost of technology over more production, thus achieving higher operating efficiencies [4].

Opening a new aggregate operation is a complicated process that can cost millions of dollars and take many years. Natural aggregate producers expend tremendous amounts of time and money locating potential aggregate resources and determining their quantity and quality. They also spend large amounts of money and effort determining the feasibility of production; identifying potential environmental impacts from production; making certain their operation will conform to the relevant laws; and obtaining the necessary permits to extract, process, and transport the aggregate [4].

## 2.3 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 [3].

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 augmented by samples collected using hand-sampling techniques of surface outcrops and various methods of drilling to obtain subsurface samples [3].

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 [3].

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 [4,3].

## 2.4 AGGREGATE MINING

Aggregate mining 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 mine 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 [5].

## 2.5 MINING CRUSHED STONE

Mining crushed stone differs from mining sand and gravel because the bedrock, in most situations, must first be drilled and blasted (Fig.-2.3). The technology of blasting rock is highly developed and regulated. Holes are drilled into the rock and are partially filled with explosives (Fig.-2.3). 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 [5].

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 Fig.-2.3, 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 Fig.-2.3. 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 [5].

**Fig-2.2** Aggregate mining process [5]

## 2.6 PROCESSING AGGREGATE

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 mining 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. Upon sale, the product is loaded on trucks, railcars, or barges for transport to the final destination [5].

## 2.7 TRANSPORTING AGGREGATE

Aggregate can be transported by truck, train, barge, or freighter (Fig.-2.4). 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 [5].

**Fig-2.3** Aggregate transportation process [5]

The preferred mode of transporting aggregate depends on delivery requirements, distance, volume of material, loading and unloading facilities, and the availability of transportation methods [5].

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 [6].

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. Also, large trucks create a potential danger to motorists on local streets and highways. The environmental impacts and hazards of trucks can be minimized when the trucks are well-maintained and operated, and when automobile drivers yield reasonable space so that truck drivers can maneuver and stop safely. Trucks that haul aggregate are typically equipped with mud flaps and load covers to prevent loose material from being thrown from wheels and off of loads. Loads can be wetted to reduce dust. Paving quarry access roads, limiting the number of quarry entrances and exits, and wheel-washing procedures can minimize the amount of material tracked onto adjacent roads. Acceleration and deceleration lanes can be constructed at the entrance of the pit or quarry to improve the ability of trucks to enter and exit civilian traffic more smoothly, and delivery routes can be designed to minimize interference with neighborhood traffic [6].

Besides, where pits or quarries have railroad access, rail delivery may be more economical than truck delivery. To move aggregate by rail, a plant must have rail access, a means to load the rail cars, a method to unload aggregate at the delivery point, and if the aggregate is not used at the delivery point, a system for further distribution. The choice depends on two principal variables - the tonnage of aggregate to be moved and the distance it must be hauled. Economic advantages of shipping by rail increase as tonnages and distances of transport increase [6].

## 2.8 ENVIRONMENTAL IMPACTS

For thousands of years man has used stone for building, whether it was for monuments, religious buildings or houses. Early on, when Britain was only sparsely populated, man’s use of stone and his primitive quarrying would have had little lasting impact on the environment. Gradually, as time went on, more stone was used in construction. It was a good material with which to build castles, walls, churches, important buildings and roads since it was strong and weather resistant. As the demand for stone grew, so did the demand for quarrying [7].

During the Industrial Revolution demand soared. The Victorians used stone for all their major buildings and with better transport and new technology they were able to meet these increasing demands, probably with little thought as to their impact on the environment [7].

Modern technology and scientific investigation methods have made it possible to reduce environmental impacts associated with extraction of rocks and manage impacts at acceptable levels that do not cause significant harm to the environment. Nevertheless, rock resources cannot be obtained from the landscape without causing some environmental impacts [7].

### 2.8.1 Cascading Impacts

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 regions 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 [8].

Quarrying has an associated, often dramatic, visual impact. The principal geomorphic impact of quarrying is the removal of stone, which results in the destruction of habitat including relict and active caves and natural sinkholes. 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 the local landforms. The influence of quarry size on environmental impact is obvious: all other things being equal, the larger the quarry, the larger the geomorphic impact. Fig2.4 shows the size of quarries increased over time, and so has their impact [8].

**Fig.-2.4** Quarries occupying a significant part of the visual landscape [8]

### 2.8.2 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. 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 [7, 8].

#### 2.8.2.1 Blasting

One of the most frequent complaints the public makes to the crushed stone industry situated near population centers is about blasting noise. Blasting may occur daily or as infrequently as once or twice a year. The blasting techniques used in crushed stone operations are significantly different than those used in dimension stone quarrying. Whereas large amounts of explosives are used in crushed stone operations to produce appropriate-sized rubble. Fig.2.5 shows the dimension stone industry uses only small amounts of explosives to loosen large blocks of stone [9].

**Fig 2.5** Rock is drilled and blasted for use as crushed stone [9].

Geology, topography, and weather affect the impacts of blasting. Blasting noise generally increases with the amount of explosive, with specific atmospheric conditions, and with proximity to a blast. People differ greatly in their response to blasting. The technology of rock blasting is highly developed, and when blasting is properly conducted, most environmental impacts should be negligible. By following widely recognized and well-documented limits on ground motion and air concussion, direct impacts from ground shaking and air concussion can be effectively mitigated [9].

When an explosive is detonated enormous amounts of energy are released. Most of the energy of a properly designed blast works to displace rock from the quarry face. The remaining energy is released as vibrations through and along the surface of the earth and through the air. Most of the energy that goes through the earth comes to the surface within a few meters of the detonation and travels as surface waves, which may cause ground shaking. A small amount of the energy is transmitted through the rocks as shear waves, which commonly are insignificant [9].

When a blast is detonated, some energy will escape into the atmosphere causing a disturbance in the air. Part of this disturbance is sub audible (air concussion) and part can be heard (noise). Air concussion is most noticeable within a structure, particularly when windows and doors are closed. The air concussion creates a pressure differential between the outside and inside the structure causing it to vibrate [9].

Poorly designed or poorly controlled blasts may cause rocks to be projected long distances from the blast site (fly rock), which can be a serious hazard. Fly rock is not commonly a problem with carefully designed and executed blasting plans, but is a situation that deserves careful attention. Blasting may cause fracturing of quarry walls, increasing permeability and increasing drainage towards quarry face [9].

Blasting-induced fracturing or aperture widening may play a role in initiating flooding events. There is a situation where blasting opened a conduit under the floor of a quarry. The conduit was connected to a nearby river and to a local water storage basin. Extensive grouting was required to stop the inflow of water from those sources [9].

#### 2.8.2.2 Noise

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. The impacts of noise are highly dependent on the sound source, the topography, land use, ground cover of the surrounding site, and climatic conditions. The beat, rhythm, pitch of noise, and distance from the noise source affect the impact of the noise on the receiver. Topographic barriers or vegetated areas can shield or absorb noise. Sound travels farther in cold, dense air than in warm air and travels farther when it is focused by atmospheric inversions than when inversions are not present [9].

An important factor in determining a person's tolerance to a new noise is the ambient (background) noise to which one has adjusted. In general, the more a new noise exceeds the existing background noise level, the less acceptable the new noise will be. In an urban or industrial environment, background noise may mask noise from a quarry operation, whereas the same level of noise in a rural area or quiet, residential neighborhood may be more noticeable to people. Furthermore, ambient noise generally is an accumulation of noises and does not have a single, identifiable source. If the mining noise is identifiable, the perception of noise probably will be great. For example, the noise from a single backup alarm can often be picked out from an equally loud engine noise [9].

Crushed stone operators and dimension stone quarries are responsible for assuring that the noise emitted from the quarry does not exceed levels set by regulations. The impacts of noise can be mitigated through various engineering techniques. Landscaping, berms, and stockpiles can be constructed to form sound barriers. Noisy equipment (such as crushers) can be located away from populated areas and can be enclosed in sound deadening structures Fig. - 2.6. Conveyors can be used instead of trucks for in-pit movement of materials. Noisy operations can be scheduled or limited to certain times of the day. The proper location of access roads, the use of acceleration and deceleration lanes, and careful routing of trucks can help reduce truck noise. Workers can be protected from noise through the use of enclosed, air-conditioned cabs on equipment and, where necessary, the use of hearing protectors. Worker safety may include regular health screening [9].

**Fig - 2.6** Noisy equipment enclosed in sound-deadening structures [9].

#### 2.8.2.3 Dust

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. 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. 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 [9].

A carefully prepared and implemented dust control plan commonly can reduce impacts from dust. Federal, state, and local regulations put strict limits on the amount of airborne material that may be emitted during site preparation and operation. Techniques include the use of water trucks, sweepers, and chemical applications on haul roads, control of vehicle speed, and construction of windbreaks and plantings [9].

## 2.9 CONTROLLING DUST AND NOISE

Although dust and noise are part of aggregate mining, they can be minimized and adverse effects can be avoided. A carefully prepared and implemented operational plan will keep dust and noise within the required regulatory limits [9].

### 2.9.1 Dust Control

The word “dust” is used generically to describe fine particles that are generally less than 75 microns (μm) in diameter and that can be transported in the atmosphere. Dust in the urban environment commonly includes sources from industry, vehicles, coal and wood smoke, and particles from the soil. Typically, the dust associated with aggregate operations consists of particles from exposed soil and rock [9].

The presence of dust sometimes raises concerns that are not directly proportional to its impact on human health and the environment. Dust concentrations, deposition rates, and potential impacts tend to decrease rapidly away from aggregate operations. Federal, state, and local regulations put strict limits on the amount of airborne material that may be released from an aggregate site, especially dust that could be inhaled [9].

Point sources, such as drilling, crushing, screening, and conveying, may also generate dust. Site conditions, including rock properties, moisture, ambient air quality, air currents and prevailing winds, the physical size of the operation, production levels, and other nearby sources of dust, affect the amount of dust generated during aggregate mining [9].

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 [9].

- Controlled blasting;
- Careful location of process equipment and stockpiles;
- Dust collection on drill rigs and stationary process equipment;
- Use of telescopic chutes, dust skirts, and screen covers;
- Reducing drop height of dusty material;
- Water or chemical applications on haul roads and rubble piles;
- Control of vehicle speeds; and
- Construction of windbreaks, buffer zones, and plantings.

The creation of buffer zones and construction of windbreaks and plantings can restrict transport of dust. Dry dust collection systems include the use of enclosures and covers on conveyors, screens, and crushers and the use of vacuum systems and bag houses, which remove dust before the air stream is released to the atmosphere Fig.2.7. Wet dust suppression systems consist of pressurized water (or surfactant treated water) sprays located at dust generating sites, such as conveyors, crushers, and screens. Suppression systems can also be used to wet loads before vehicles leave the plant [9].

**Fig- 2.7** Water trucks minimize dust in and around quarry

### 2.9.2 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 [9].

- 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 [9].

### 2.9.3 Surface Water

Engineering activities associated with quarrying can directly change the course of surface water. Conversely, ground water being pumped from quarries changes streams from gaining streams to loosing streams and can drain other nearby surface water features such as ponds and wetlands. Similarly, blasting can modify groundwater flow, which ultimately can modify surface water flow. Discharging quarry water into nearby streams can increase flood recurrence intervals [10].

### 2.9.4 Ground Water

Overall, quarrying in some areas is likely to result local impacts such as increased runoff, reduced water quality, rerouting of recharge water through the aquifer, and localized reduction in ground-water storage. In areas where the unsaturated zone commonly contains only a small percentage of storage, and where the unsaturated zone is thin, impact on ground-water quantity generally is minimal. However, where a thick, well-developed unsaturated zone is present, in those areas, the unsaturated zone may store significant quantities of water. Following rainfall, water may be collected and temporarily stored in unsaturated zone, until it subsequently joins the ground-water system. The major impact of quarrying in areas of saturated zone relates to quarry dewatering and the associated decline of the water table [10].

## 2.10 PROTECTING THE ENVIRONMENT

Properly designed and operated aggregate production minimizes the impact on landscape, wildlife, surface and groundwater, and surrounding communities. The extraction and processing techniques and the natural site conditions determine which specific impacts may occur, how widespread they will be, and how long they will last. Mining aggregate for building a house, or building a highway all impact the environment [11].

An aggregate operation is a temporary land use, and when mining is completed, the site is likely to be converted into another beneficial use. Consequently, the overall environmental impact of aggregate extraction is usually relatively small over the long term. Aggregates are environmentally inert materials and their processing commonly requires only crushing, screening, and washing. Environmentally sound and safe aggregate operations effectively manage physical disturbance, protect ground and surface waters, control noise and dust, use safe blasting procedures, and have long-term operation and closure plans that recognize habitat and community needs [11].

Modern technology and scientific investigation methods have made it possible to reduce the environmental impacts from aggregate mining and to manage those impacts at acceptable levels.

In addition, a variety of federal, state, and local regulations are designed to limit environmental impacts of industrial operations including aggregate extraction [11].

### 2.10.1 Managing Physical Disturbance

Changing a landscape from undeveloped or agricultural lands to a pit or quarry is an obvious impact of aggregate extraction. A quarry or gravel pit is dramatically different from other types of land use, and it is difficult to discuss the associated visual impacts in absolute terms. Whether or not an aggregate operation is unpleasant to the eye is generally a matter of integrating the operation into the surrounding landscape. The physical impact is predictable and controllable because an aggregate operation is a designed facility, and good design is important [11].

Development of an aggregate operation is accompanied by a change to the landscape as observed from either the site or locations that surround it. The nature of this modification depends on the surface forms, slopes, natural ground cover, and type of operation. Reaction to such changes tends to be subjective, and what is acceptable to some, others may find objectionable. Minimizing unsightly changes to a landscape can be achieved [11].

- Through proper landscape analysis, design, and operations;
- By extracting aggregate from the most suitable deposits; and
- Through creation of super quarries and the use of underground mines, depending on local conditions.

To meet regional needs for aggregate, constructing a single large operation (super quarry Fig 2.8) at an environmentally acceptable site may be preferable to many smaller operations at scattered locations. However, to be economically viable, a large quarry depends on cost-effective, high-volume transport and support from the local residents and government [11].

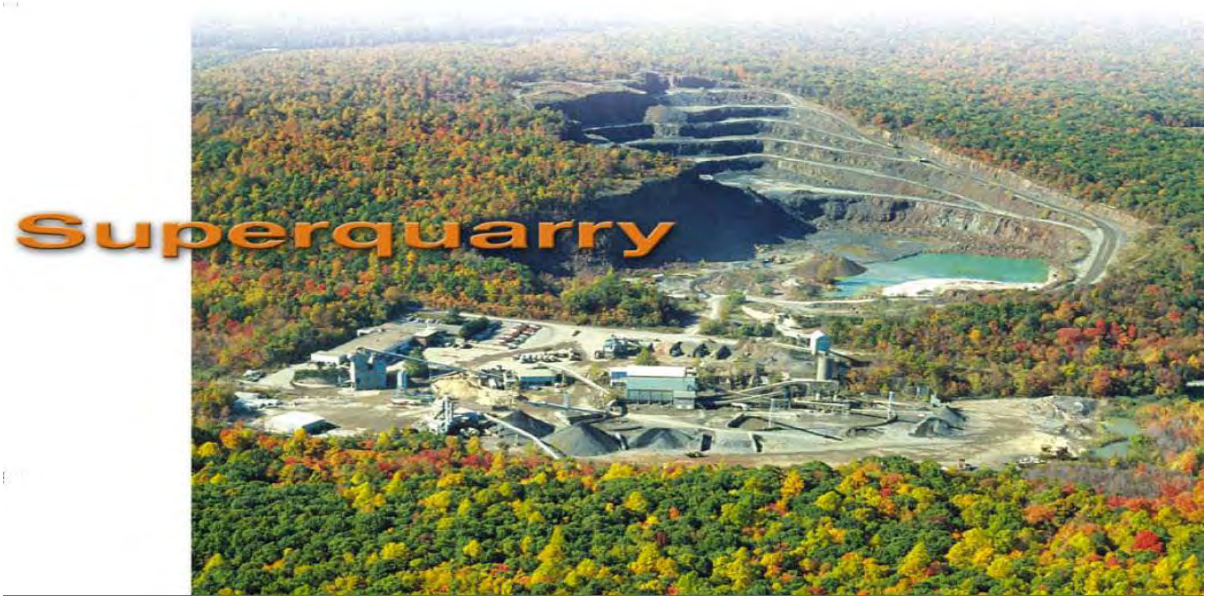


**Fig- 2.8** A super quarry [11]

The use of mining software and geographic information systems makes it possible to predict physical changes to a landscape, and visual impacts can be mitigated through careful design. Designing to minimize visual impacts includes [11]:

- Careful sitting of the operation;
- Limiting active extraction areas;
- Sequential reclamation;
- Buffering, and
- Screening.

Screening includes tree plantings, fencing, or other landscaping techniques. Stockpiled overburden or other material can be designed as elongated rolling hills that mimic the natural landscape. Products can be stockpiled in places located out of view. Good housekeeping practices, such as maintaining equipment, and placing it out of the line-of-sight or in enclosed structures, further improve the appearance of a site [11].

Aggregate extraction results in a temporary loss or modification of wildlife habitat in the mined area. Habitats in river systems and quarry areas are extremely susceptible to cascading environmental impacts. For example, stream erosion from improper aggregate extraction could cause stream bank failure. The bank failure could cause loss of adjacent streamside habitat and shade along stream banks and could result in major changes to aquatic and riparian habitat [11].

Habitat loss can be regulated and controlled. Site inventories before extraction begins can identify rare or endangered species. Buffers can be set aside as wildlife habitat. Animals or plants can be relocated. Creation or improvement of habitat outside the pit or quarry can offset the loss of habitat on site, and sequential reclamation can restore habitat more quickly. In some cases, a site can be reclaimed to function similar to the original habitat. In other areas, new habitat may be created thus increasing biodiversity [11].

### 2.10.2 Minimizing Impacts 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 [11].

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 are ways to control ground vibrations [11].

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 [11].

### 2.10.3 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 [11].

#### 2.10.3.1 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 [11].

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. [11].

### 2.10.3.2 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 [11].

## 2.11 THE GEOLOGIC SETTINGS OF ADDIS ABABA

Geology is one of the most important natural factors that determine the chemistry of natural aggregate materials in the environment. Therefore the geologic setting of Addis Ababa Fig- 2.9 is presented hereunder [12].

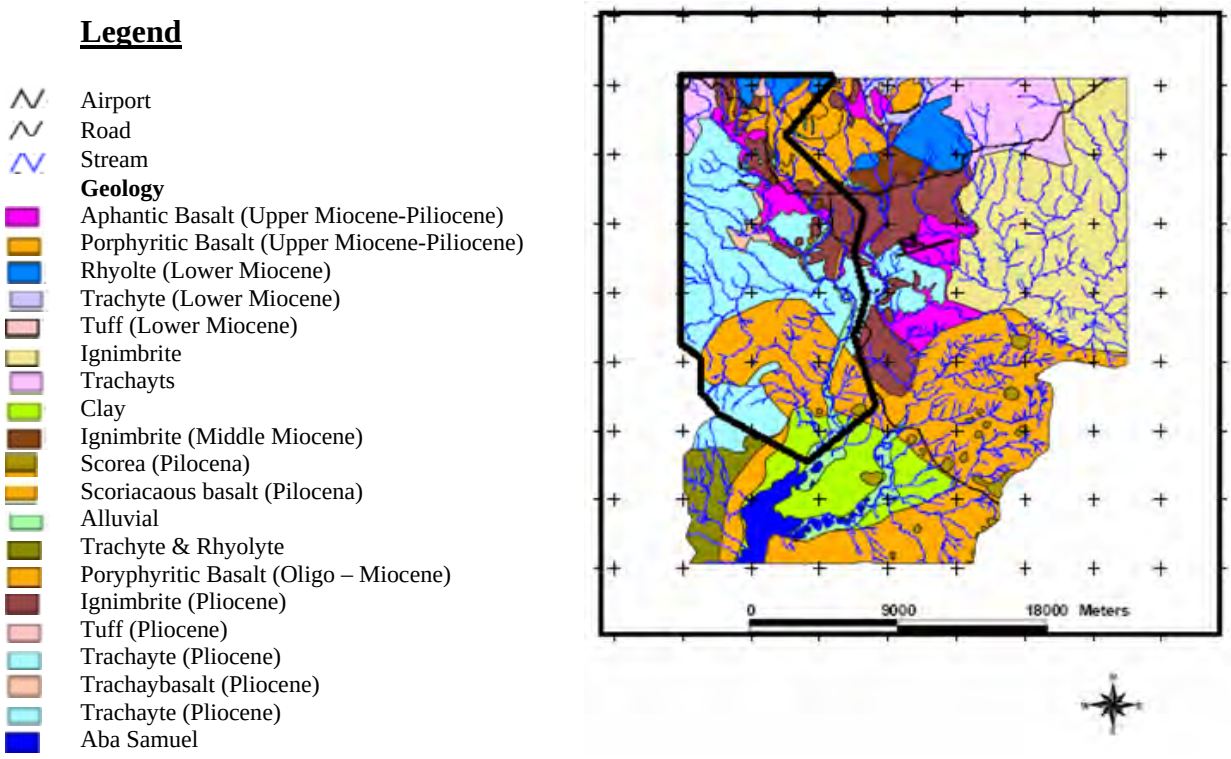


**Fig- 2.9** The geologic map of Addis Ababa (Modified after Tamiru et.al. 2003) [12].

### 2.11.1 The Stratigraphic Sequences

Addis Ababa represents the western escarpment of the main Ethiopian rift system and many researchers systematically proposed its geology and volcanic stratigraphic sequences from bottom to top is [12] :

- Alaji Basalts,
- Entoto Silicics,
- Addis Ababa Basalts,
- Nazareth Group, And
- Bofa Basalts.

#### 2.11.1.1 Alaji Basalts

The Alaji group volcanic rocks (Alaji Rhyolite and Basalt) in this part of the escarpment were outpoured from the end of Oligocene until middle Miocene as stated in. This unit is composed of basalts, which show variation in texture from highly porphyritic to aphanitic. Within this unit there is an intercalation of gray and glassy welded tuff. This unit outcrops at the crest of Entoto-ridge bordering the northern parts of Addis Ababa [12].

#### 2.11.1.2 Entoto Silicics

This early Miocene age silicic volcanic could represent localized terminal episodes to massive Oligocene fissure basalt activity in the Addis Ababa region. The thickness of the flow become maximum on the top of Entoto ridge and thin both towards the plateau and the plain east of Addis Ababa. The Entoto silicics composed of rhyolite and trachyte with minor amount of welded tuff and obsidian. The rhyolitic lava flows outcrop on the top and the foothills of the Entoto ridge, predominantly in the western side. The thickness is quite variable as it frequently forms dome structure [12].

#### 2.11.1.3 Addis Ababa Basalts

These units, which are mainly present in the central part of the town, are underlain by the Entoto silicics and overlain by Lower welded Tuff of the Nazareth group. The ground mass is made of andesine, labradorite, olivine, magnetite and pyroxene. Olivine porphyritic basalts outcrop in the central part of the town that includes Mercato, Teklehaymanote. The distribution of plagioclase porphyritic basalt is almost the same as that of the olivine prophyritic basalt, but only little more northwards. The thickness of the former varies from 1m or less in the foothills of Entoto, Lideta Airfield and Filwoha to greater than 130 meters at Ketchane stream. The Lower Welded Tuff overlies both types of basalt nearby the Building College, and the Kolfe Police School [12].

#### 2.11.1.4 Nazareth Group

The units identified in this group denoted as Lower Welded Tuff, Aphanitic basalt and Upper Welded Tuff. The group is underlain by Addis Ababa basalt and overlain by Bofa basalts. The rocks outcrop mainly south of Filowha fault and extend towards Nazareth [12].

##### 2.11.1.4.1 Lower Welded Tuff

This rock outcrops as small discontinuous body in Filwoha, western parts of Addis Ababa and Sululta. Generally it is overlain by the aphanitic basalt and underlain by the olivine and plagioclase prophyritic basaltsat [12].

##### 2.11.1.4.2 Aphanitic Basalt

This basalt covers the southern part of the town, especially the areas of Lideta Airfield. The rock body shows vertically curved columnar jointing together with sub horizontal sheet jointing. Lenses of Kaolin are present at the contact of this basalt with the younger ignimbrite. Moreover the basalt is overlain by pumeacoues pyroclastic falls and the pyroclastic falls. It consists of: Labradorite, augite, rarely olivine and magnetite. The crystals of plagioclase show marked flow alignments. Trachy-basalt outcrops around Repi and nearby General Wingate School [12].

#### 2.11.1.4.3 Upper Welded Tuff

This rock outcrops all over the southern part of the study area including Nefas Silk; nevertheless it is also present in the central and northern parts of the town. It is gray colored, vertically and horizontally jointed and composed of sandine, an orthoclase, rebekite, quartz, pumice and unidentified volcanic fragments. The welded tuff is underlain by aphanitic basalts and overlain by young olivine basalts [12].

#### 2.11.1.4.4 Young Trachyitic Flow

This rock dominates the southwestern parts from Dama hotel towards Furi and Repi along the hills and foothills of Hana Mariama and Tulu Iyou. It is underlain by the tuff that covers the young ignimbrite and overlain by alternating flows of plagioclase porphyritic basalt and rhyolite especially in the Repi hill [12].

#### 2.11.1.4.5 Young Olivine Porphyritic (Bofa) Basalt

They outcrop southward from Akaki River where they appear in the form of boulders reaching a thickness of 10 meter. They are restricted and dominant in the southeast part of the town i.e. Debre Zeit Road. They contain phencorysts of plagioclase, olivine that is partially and completely altered to iddingisite and agate within a groundmass composed of plagioclase, magnetite, pyroxene and olivine [12].

## 2.12 MODE OF PRODUCTION AND PROPERTIES OF AGGREGATE

### 2.12.1 Available Aggregates In and Around Addis Ababa.

The most commonly available local coarse aggregates are obtained from normal weight crushed basaltic stone and lightweight volcanic ash, which are a member of a family of igneous rock (scoria or pumice) [13].

#### 2.12.1.1 Basalt

Basalts are dark colored, fine-grained extrusive rock. The mineral grains are so fine that they are impossible to distinguish with the naked eye or even with a magnifying glass. They are the most widespread of all the igneous rocks. Most basalt is volcanic in origin and was formed by the rapid cooling and hardening of the lava flows. Fig 2.10 some basalt is intrusive having cooled inside the Earth's interior [13].

**Fig-2.10** Basalt Rock Quarry Site at Killinto , around Kality,

#### 2.12.1.2 Pumice

Pumice is a very light, porous igneous rock that is formed during volcanic eruptions. It is an excessively cellular, glassy lava, usually rhyolite or dacite in composition. It is usually white-gray to yellow in color, but may be red, brown or sometimes black according to the mineral oxides or impurities it contains. Pumice is bubble rich and therefore has very low density. Due to this low density, pumice is very light and can even float in water. It has a bulk density of 500-900kg/m. The varieties of pumice, which are not too weak structurally, make a satisfactory concrete with a density

of 700 to 1400kg/m and with good insulating characteristics, but high absorption and high shrinkage characteristics [14-16].

#### 2.12.1.3 Scoria

Scoria is a volcanic cinder which generally has a rough surface and high porous nature, with its pores chiefly in the form of vesicles instead of the more tube like, interconnected pores of the pumice. Scoria varies in color often within the same cone and may be black, red, gray or brown in color. The black color is mostly due to its high iron content while the red color is caused by oxidation of iron in the scoria, which might have happened because of rainfall during the eruption. Scoria aggregate is found extensively in Ethiopia especially in the Great Rift Valley, which crosses the Northeastern part of the country. It is mainly used as a base coarse material in road construction and as an aggregate in the manufacturing of masonry blocks [14, 16].

### 2.12.2 Engineering Geological Map of Addis Ababa

The geological formation of Addis Ababa soils is dominantly igneous rock. This is due to the volcanic activity the area undergone in geological times. The most abundant rock types are basalt and trachite. The red ash, which is found in the near vicinity of the city, is just an oxidized form of the basalt during eruptions. The different quarries in Addis Ababa produce crushed aggregates, red ash, stones, clay and selected materials. Basalt stone is used for the production of aggregates on major quarries. The stone is crushed into different aggregate sizes. It is mainly mined around big Akaki and Kilento rivers, Bole Bulbula and Keranyo which are the areas producing the majority of the city's demand. Red ash (scoria) is mainly used for block making. It is mainly mined around Tullu Dimtu. A reasonable amount of aggregate is also brought from the areas in the vicinity. Scoria and crushed gravel is also brought from Debrezeit area. The area of study was focused to in and around Addis Ababa and is shown with Fig. 2.11 [16].

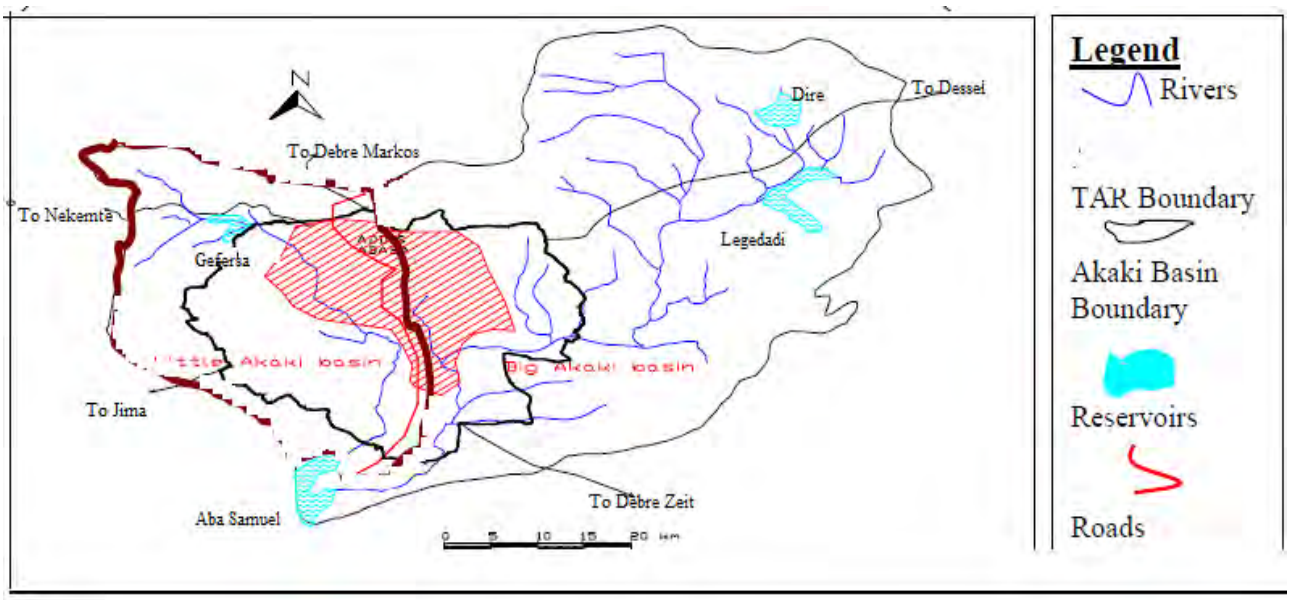


**Fig - 2.11** Shows study area (Map of Addis Ababa) [12]

### 2.12.3 Mode of Production in and Around Addis Ababa.

It is a known fact that concrete making aggregates are the major building materials in Ethiopia. Most structures, including domestic houses, roads, bridges and Hydro power dams, which are necessary for the development of the country, are built with these materials. Huge amount of resource is invested in these structures and infrastructure [17].

### 2.12.4 Course Aggregate Demand in Addis Ababa

Studies so far have shown that the ever increasing demand for quarry output, the continuous increase in budget allocated to the construction sector and the new economic policy etc are providing more favorable condition especially for the quarry operation sector [17].

However, obtaining accurate statistical information concerning the demand of the city is very difficult. Hence an attempt was made to estimate the demand of gravel of Addis Ababa in 2003 and it was found to be 855,300.07 m3. Taking the annual population growth rate of demand as 3.1% (IMF data base) and the demand for 10 years is projected. In addition the annual production

capacity of ten existing quarries was calculated and the supply for 10 years is projected and the supply demand gap was calculated in Table-2.1 [17].

**Table -2.1** Project supply and demand condition of Addis Ababa [17]

| **Year E.C** | **Demand ($m^3$)** (3.1% growth rate) | **Supply ($m^3$)** (1% growth rate) | **Excess Demand ($m^3$)** |
|---|---|---|---|
| 2003 | 855,300.07 | 412,235.04 | 443,065.03 |
| 2004 | 881,814.38 | 425,014.33 | 456,800.05 |
| 2005 | 909,150.62 | 438,189.77 | 470,960.85 |
| 2006 | 937,334.29 | 451,773.65 | 485,560.64 |
| 2007 | 966,391.65 | 465,778.64 | 500,613.02 |
| 2008 | 996,349.79 | 480,217.77 | 516,132.02 |
| 2009 | 1,027,236.64 | 495,104.53 | 532,132.11 |
| 2010 | 1,059,080.97 | 510,452.77 | 548,628.21 |
| 2011 | 1,091,912.48 | 526,276.80 | 565,635.68 |
| 2012 | 1,125,761.77 | 542,591.38 | 583,170.39 |
| 2013 | 1,474,747.92 | 596,850.52 | 877,897.40 |
| 2014 | 1,933,919.77 | 656,535.57 | 1,275,384.2 |
| 2015 | 2,530,814.90 | 722,189.13 | 1,808,625.78 |

As indicated in the above table, the forecasted – supply demand gap indicated that, there will be a shortage of about 4 million $m^3$ of unsatisfied demand within the coming three consecutive years [17].

### 2.12.5 Aggregate Production In and Around Addis Ababa.

Addis Ababa city is growing from time to time rapidly. Its area which is 54,000 Hectare is being covered by buildings, bridges, roads, etc. This shows the high demand of construction materials, which include lacks for the production of aggregate. The supply-demand gap of aggregate is still

imposing negative impact influence to the existing construction activity in the city. The majority of coarse aggregate sources in Addis Ababa are located around rivers within the city, with the exceptions of sources of scoria. The big riverbanks of Akaki river and Matahara river (around bole air port) are the main suppliers of aggregates to the city of Addis Ababa. Scoria is mined from big mountains in areas of flat or rolling terrain. Quarry sites are established at the outskirts of the city on the areas. One of the quarry site established for the production of scoria is shown with Fig-2.12 [18].

**Fig- 2.12** Scoria Source, Tullu Dimtu , around Debregelan

### 2.12.6 Course Aggregate Production in and Around Addis Ababa

The two dominantly produced aggregates, lightweight (namely pumice and scoria) and the normal weight (basalt), do have different modes of productions. The lightweight aggregate is produced from quarries by simple digging or bulldozing as it is a soft material and the different sizes produced mainly depend on digging or bull dozing [18].

#### 2.12.6.1 Production Method

Course aggregate in and around Addis is produced using Aggregate crusher and by manually using human labor and small hand tools. In this paper visit was made to different large and small scale course aggregate production plants in and around Addis Ababa. Then summary is shown below.

##### 2.12.6.1.1 Crushing by human labor and tools

***A) Steps***

1. boulders are collected
2. Very big boulders are broken down using hummer& wedge in to smaller units.

3. Very strong boulders are broken down after they are burnt for hours with high temperature using worn out vehicle tires.
4. The broken relatively smaller boulders are then further broken down by hand/human/ labor.

***B) Problems /draw backs/***

1. Production is by human labor which results high degree of non uniformity and inconsistent product, especially, the gradation and shape of aggregate produced will certainly be poor.
2. It is not up to the standard.
3. It has environmental Impact.
    - Carbon dioxide from smoke
    - Risky working environment to the workers due to flying stones
4. Has problems associated with the production process.

    - production is too little
    - not convenient to quality control
    - difficult to rely on the quality and quantity produced by this process

Typical traditional aggregate production around Addis Ababa is shown with Fig-2.13 which is taken at Kilinto villege, about 6 Km south east of Addis.

**Fig-2.13** Typical Traditional Aggregate Production around Killinto

#### 2.12.6.1.2 Low scale mechanized crushing

***A) Steps***

1. boulders are collected/quarried as shown with Fig-2.14
2. Very big one are broken down, using sledge hammer and wedge in to smaller units.
3. Very strong boulders are broken down after they are burnt for hours with high temperature using worn out vehicle tire as shown with Fig – 2.15
4. The relatively smaller boulders are fed in to the crusher and are crushed in to smaller sizes as shown with Fig – 2.16

***B) Problems /draw backs/***

1. Production is relatively law.
2. The row crushed stone is prepared by human labor which results high degree of non uniformity and inconsistency of the product. Especially the gradation and shape of the aggregate produced is poor. Flaky aggregate particles results from this mode of aggregate production. It is not also feasible in places where relatively smaller boulders are not readily available.

3. The boulders they usually use for production are so week that the resulting product becomes of low quality. In addition it is not convenient to quality control.
4. It is not up to the standard.
5. It has environmental impact as there is emission of carbon dioxide from the smoke & the working environment is risky to the workers due to flying stones.
6. Production is relatively small and it is not reliable both in terms of quality and quantity.

**Fig- 2.14** Typical Quarrying Process Akaki River Basin, Killinto around Kality

**Fig- 2.15** Used Tire for Heating of Strong Boulders Killinto Crusher Site around Kality

**Fig-2.16** Typical Low Scale Mechanized Crushing Activity Killinto Crusher Site, around Kality

On the other hand, the modern way of aggregate production requires aggregate crushing machines so that the quarry is either drilled, blasted or dug with special mechanisms, fed to crushers, crushed, sieved and separated according to their sizes. The different sizes commonly known as 01, 02, 03 and 04 are stockpiled separately. Size 02 means aggregates having a maximum aggregate size of 20mm, while 01, 03, 04 has a maximum aggregate size of 10, 30 and 40 mm respectively. This method enables to classify aggregates based on their maximum aggregate sizes and enable engineers to suggest unique mix proportion to arrive at the required concrete quality production. The dust content over the surface of the aggregate, however, is not given adequate emphasis by the producers while creating serious problems during concrete production.

#### 2.12.6.1.3 Medium to large scale crushing plants

These types of crushing techniques use open pit quarrying method of aggregate production. They have the following characteristics. A typical Medium to Large Scale Crushing Plants is shown on Fig-2.17.

***A) Steps***

1. Have big plots of land and are usually established after some geological investigation is carried out on the availability extent and quality of the parent rock.

2. At the begging of the production process, the over burden is removed and the area is made ready for drilling before the actual process of blasting started.
3. Usually boulders are produced from the existing big bed rock by a process of blasting.
4. Blasting is usually carried out by explosives such as ammonium nitrate or gelatin 30.
5. The resulting crushed rock is there further crushed using dozers. The crushed rock is them sent to the crushing site by dump truck and stoked pile.
6. The stock piled crushed rock is then fed to the crusher and will farther be crushed in to rather different sizes.
7. Using separators, which are usually three or more, the crushed rock is stoked piled and becomes ready for use. The usual ranges of production capacities of crusher plants in Addis Ababa is about 95m3/hr for Jaw crusher to 71m3/hr Cone crusher.
8. Finally it is loaded to dump trucks and is then transported to actual sites or market places.

***B) Comparison with the other method of production***

1. There is a controlled production system.
2. The gradation of the resulting aggregate is relatively good and is convenient for quality control.
3. Carried out by relatively trained personnel.
4. It has reliable supply.
5. High production capacity per day.
6. Has high environmental impact.
7. Convenient for production of standardized product.

**Fig- 2.17** Typical Medium to Large Scale Crushing Plants

## 2.13 LEGAL FRAMEWORK FOR ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

### 2.13.1 The FDRE Constitution

Being a supreme law of a land, a constitution provides the basic framework on which detailed laws shall be developed for various sectors. The 1995 Constitution of the Federal Democratic Republic of Ethiopia contains provisions that support the enactment of EIA legislation. In this regard, it stipulates that the design and implementation of development programs and projects in the country should not damage or destroy the environment; and recognizes the right of the people to be consulted and express their views on the planning and implementation of environmental policies and projects that affect them. In addition, the constitution recognizes the right of citizens to live in a clean environment, and, where they are displaced or their livelihood has been adversely affected by the development projects undertaken by the government, the rights to get commensurate monetary or Overview of EIA in Ethiopia alternative compensation, including relocation with adequate state assistance. These provisions provide a perfect constitutional basis for the development and implementation of an effective EIA process [19].

### 2.13.2 Environmental Impact Assessment Law

Following the provisions of the environment policy, the Ethiopian government introduced the Environmental Impact Assessment Proclamation. The proclamation requires an EIA process for any planned development project or public policy which is likely to have a negative impact on the environment. With regard to development projects, the proclamation stipulates that no person shall commence implementation of a proposed project identified by directive as requiring EIA without first passing through environmental impact assessment process and obtaining authorization from the competent environmental agency. In line with this, project proponents must undertake EIA and submit the report to the concerned environmental body, and, when implementing the project, fulfill the terms and conditions of the EIA authorization given to them [19].

Moreover, the proclamation allows for the imposition of a fine between fifty-thousand and one hundred thousand birr on any project owner who commences implementation of a project without obtaining authorization from environmental agencies or who makes false presentation in the

environmental impact assessment study report. Furthermore, the proclamation obliges licensing institutions, prior to issuing investment permits or operation license to projects, to ensure that the relevant environmental bodies have authorized the implementation of the projects. In addition, it requires such licensing institutions to suspend or cancel the permit or license they have issued for projects where the concerned environmental body suspends or cancels the authorization given for implementation of the project. These provisions are important to ensure that project owners comply with the EIA requirement [19].

The proclamation also provides for public participation in the environmental impact assessment process. It requires environmental bodies to ensure that the comments made by the public (in particular the comments by the communities likely to be affected by the implementation of a project) are incorporated into the EIA study report as well as into its evaluation. To this end, it requires environmental bodies to make any EIA study report accessible to the public and to solicit comments thereon. The proclamation also requires public instruments, which are identified by directive as requiring EIA, to pass through environmental impact assessment process prior to their approval. In line with this, it obliges government organs to ensure that their policies have passed through EIA process prior to their submission for approval. Having provided the basic framework of EIA, the proclamation envisages the issuance of specific directives and guidelines that further specify implementation of the EIA process. Particularly, it requires the Environmental Protection Authority (EPA) to develop a directive identifying categories of projects likely to have negative impact and thus require EIA. It also requires EPA to issue of guidelines that determine the elements necessary to prepare and evaluate EIA study report [20].

### 2.13.3 Sectoral Laws Relevant To EIA

It has been recognized that activities in the various economic sectors have the greatest impact on natural resources in particular and the environment in general. Accordingly, integrating EIA into the laws, regulations and decision-making process in such sectors is crucial. The following section describes the sector specific laws and regulations in the country into which EIA should be integrated [21].

### 2.13.4 Land law

The legal framework governing how land is allocated for investment presents other possibilities for the incorporation of EIA. Regarding the utilization of land for investment, Ethiopia's 1995 Constitution provides for the right of investors to obtain land for investment purpose on lease in accordance with conditions to be specified by subsidiary laws. In line with this, the Rural Land Administration recognizes the right of investors to obtain and use rural land, provided that priority is given to peasants and pastoralists. Once land has been allocated, the proclamation obliges landholders to sustainably use and manage the property. Land users thus face the threat of losing their right to the land in the case that the holding is damaged due to misuse and mismanagement, in accordance with details to be specified by regional land laws. Having provided the guiding rules, the Rural Land Administration leaves the particulars to be legislated by regional states [21].

Accordingly, regions have issued their regional rural land laws in recognition of the rights of investors to obtain and use rural land. The Rural Land Administration and Utilization Proclamation recognize the rights of private investors to obtain rural land for investment, with priority given to peasants and pastoralists if any. Further stipulate that the development plan submitted by investors seeking land must not lead to the degradation of the land or surrounding environment). In addition, it obliges investors to sustainably manage their holding, including any and all natural resources therein [22].

### 2.13.5 Mining law

The Mining Proclamation and the Mining Operations Regulation regulate the mining of mineral resources in the country. These mining laws contain provisions aimed at ensuring that mining activities are carried out in a way and manner that shall not cause significant damage to the environment. In this respect, the mining laws determine the rules on the utilization of water and timber resources in a mining area. While the mining law allows a miner to use water and timber found in the leased area for the mining operation, it requires at the same time that the use of water should not result in substantial reduction of the quantity of quality of the water needed by other users. It also stipulates that one cannot construct dam or divert watercourses without the prior

approval of the appropriate government body. With the exception of the clause on pollution, the mining law does not strictly prohibit uses of water by miners that may cause other environmental problems, such as damage the ecosystem, reduce biodiversity or degrade water resources. Holders of a mining license may log and use timber as dictated by other applicable laws and must submit a restoration plan. Moreover, the mining law obliges a licensee to conduct the operation in a manner that minimizes damage or pollution to the environment. It also requires a licensee to immediately notify the licensing authority of anything likely to jeopardize the property or the environment and to immediately take the necessary steps to mitigate the impacts [22].

### 2.13.6 The Institutional Framework of EIA

The current system of government in Ethiopia is organized into a federal structure, comprised of a federal government and nine regional states. Government administration of EIA in Ethiopia is thus shared between the federal government and regional states. This section provides an overview of the institutions responsible for, and relevant to, the administration of EIA in the country [23].

### 2.13.7 Environmental Protection Organs

The Environmental Protection Organs Establishment Proclamation established the institutions responsible for regulation of EIA; these include the Environmental Protection Authority, Regional Environmental Agencies and the Sectoral Environmental Units [23].

#### a) Environmental protection authority

The Environmental Protection Authority (EPA) is the lead federal environmental organ with the objective of formulating policies, strategies, laws and standards to ensure social and economic development activities in the country sustainably enhance human welfare and the safety of the environment. The regulation of EIA is one of the key responsibilities entrusted to the EPA. In this respect, EPA is responsible for establishing a system for undertaking EIA on public and private projects as well as on social and economic policies, strategies, laws and programs. Specifically, it is responsible for developing a directive that identifies categories of projects likely to have negative impact and thus require EIA, and for issuing guidelines that direct the preparation and evaluation of

EIA study reports. In addition, EPA is responsible for evaluating the EIA study reports on projects subject to federal licensing, execution or suspension and on projects likely to create inter-regional impacts. The EPA is also responsible for auditing and regulating the implementation of such projects. Moreover, EPA is responsible for giving technical support pertaining to environmental management and protection to regional states and sectoral institutions [23].

**b) Regional environmental agencies**

The Environmental Protection Organs Establishment Proclamation requires regional states to establish or designate their own regional environmental agencies. The regional environmental agencies are responsible for coordinating the formulation, implementation, review and revision of regional conservation strategies; and for environmental monitoring, protection and regulation [23].

Relating to EIA specifically, the Environmental Impact Assessment Proclamation gives regional environmental agencies the responsibility to evaluate the EIA study reports on projects that are licensed, executed or supervised by regional states and that are not likely to entail inter-regional impacts. Regional environmental agencies are also responsible for auditing and regulating the implementation of such projects. The institutional standing of regional environmental agencies varies from region to region. In some regions, they are established as separate institutions, while in others they are constituted within other institutions. For instance, in the Oromiya Regional State, an Environmental Protection Office is established as separate institution, while in the Southern Nations Nationalities and Peoples Regional State, the regional environmental organ is situated within the Bureau of Agriculture and Rural development as an Environmental Impact Assessment and Pollution Control Team [23].

**c) Sector environmental units**

The other environmental organs created by the Environmental Protection Organs Establishment Proclamation are the “Sector Environmental Units,” which are mandated to be established at every competent agency with the responsibility of coordinating and following up activities in harmony with environmental protection laws and requirements. Such sector environmental units can play

important role in ensuring that EIA is carried on development projects and public instruments initiated by government institutions. However, sector environmental units have not been established as yet in most of the relevant federal institutions, except at the Ethiopian Roads Authority, Ethiopian Electric Power Corporation and the Ministry of Water Resources [23].

### 2.13.8 Sector Institutions Relevant To EIA

#### 2.13.8.1 Licensing institutions

**a) Ministry/Bureau of Trade and Industry**

Business activities are regulated at the federal level by the federal Ministry of Trade and Industry, and by the Bureaus of Trade, Industry and Transport the Trade at regional levels. These institutions have the power to issue business licenses for most commercial activities and the obligation to see that they are operated in accordance with the law. There are some commercial activities, however, which because of their technical nature are licensed by other institutions [24].

**b) Investment institutions**

The Ethiopian Investment Agency is the federal institution responsible for promoting, coordinating and facilitating foreign investment in the country. In particular, the Investment Agency is vested with the power to approve and issue investment permits, trade registrations and operating licenses to foreign investors; and to facilitate acquisition of land by foreign investors. Investment licenses for domestic investors are issued by regional investment commissions. Regional investment commissions are responsible for facilitating and promoting investment activities in the regions [23].

***c)*** **Ministry/Agency of Mines and Energy**

The Ministry of Mines and Energy is responsible for the development and proper utilization of mineral resources in the country. In relation to this, the ministry has the responsibility to, among other things, prepare laws on the utilization of natural resources, issue licenses to private investors engaged in large-scale mining activities and supervise their operations. Regional Agencies of Mines

and Energy are responsible for regulating the utilization of mineral resources at regional levels. In this regard, they have the responsibility to, *inter alia*, study the mineral resources in the regions and prepare directives and manuals on the utilization of mineral resources in the region, issue license for producers of construction minerals and for small-scale mineral producers and supervise the operations the producers [24].

#### 2.13.8.2 Natural resources management institutions

**a) Ministry/Bureau of Agriculture and Rural Development**

The Ministry of Agriculture and Rural Development (MoARD) has both development and natural resource management responsibilities. Relating to natural resources management, MoARD has the responsibility to prepare policy on land use and draft legislation on forestry and wildlife. The Agriculture and Rural Development Bureau (ARDB) is the key natural resource management institution at regional level. It is responsible for the management of land, forest, wildlife and biodiversity resources. Relating to the wider land use domain, ARDB is expected to, allocate rural land for agricultural investment; provide assistance to investors engaged in the sectors; and issue and implement directives that enable protect natural resources and the environment from pollution [24].

**b) Ministry/ Bureau of Water and Energy**

The Ministry of Water Resources (MoWR) is the lead federal institution responsible for the conservation, utilization and development of water resources in the country. Specifically, MoWR has the responsibility, inter alia, to formulate legislation on the conservation and utilization of water resources; develop plans on the proper utilization of the country's water resources for development, and, upon approval, supervise their implementation; and determine water quality standards for various uses. In addition, MoWR is responsible for determining the conditions and methods for the optimum allocation and utilization of water resources that occupy more than one regional state among various uses and users; and to undertake studies on the utilization of trans-national rivers. The Water Resources Bureau (WRB) is a regional institution responsible for the management and use of water resources. Particularly, WRB has the responsibility to, among other things, study the

quantity and distribution of water resource of the region and prepare water utilization directives and manuals; ensure balanced and fair sharing and utilization of water resource in the basins; and issue license to, and supervise, investors engaged in irrigation development [24].

#### *2.13.8.3* Financial institutions

Financial institutions should also incorporate EIA into their procedures. By incorporating EIA authorization into their loan policies, financial institutions can help ensure that development projects comply with the EIA requirement. There are a number of private and state-owned banking institutions operating in the country. Nevertheless, only the Development Bank of Ethiopia, the major long-term development loan provider in the country, has incorporated environmental impact into its loan policy. The Development Bank of Ethiopia thus requires loan applicants to present EIA authorization from environmental agencies as a requirement for obtaining loan [24].

# 3 NEGATIVE ENVIRONMENTAL IMPACTS OF AGGREGATE PRODUCTION PLANTS IN AND AROUND ADDIS ABABA

## 3.1 ACTIVE QUARRIES

Quarries are opened for production of construction material such as selected materials for roads construction, dimension stones for buildings, gravel for aggregates and ceramic and cement raw materials, etc. However, quarry operations have impact on the surrounding environment. Especially, the environmental impacts of aggregate production plants which are located in and around cities cannot be underestimated. Aggregate production plants in and around Addis Ababa are good examples. The discussion made in this section concentrates on the situation of aggregate production and its environmental impact in and around Addis Ababa.

### 3.1.1 Degradation of Land

Quarrying involves activities such as stripping, excavating and damping of the overburden soil, as well as drilling and blasting of the rocks are the serious causes of soil erosion, frequent soil creeps, siltation of down steams, formation of pits, borehole, surface ragging or cliff. Besides, agriculture productivity redaction, losses of the natural aesthetic of the area as well as the bio diversity are created because of the land degradation is shown with Fig- 3.1.

**Fig 3.1** Degradation of quarries in Addis Ababa, Midrck Quarry, around Debre- Gelan

### 3.1.2 Noise Pollution

Even though the noise created by crushers and drilling machines may not exceed the tolerable limit/ permissible limit/ of human ear, the repetition and long duration of the sound could be potential source of unpleasant feeling. Fig -3.2 shows source of noise pollution by the crusher at MIDROC quarry.

**Fig 3.2** Sources of Noise pollution in Addis Ababa around Akaki Kella

### 3.1.3 Air Pollution

The formation and release of dust and dust particles in quarry and mining operation are the expected phenomenon. All the crushing activities, excavation of the over burden, transportation or mobility of the product are the potential causes for the release of dust particles. Usually the surrounding and the site in particular are concentrated with these particles. Once again the same to noise effect, the repetition and the exposure of the workers repeatedly makes potential causes for the air born diseases, respiratory infection, etc. The other cross boundary effect of the dust particle are shading of the leaves of the plants, trees or other crops which effect the normal photosynthesis activities Fig – 3.3.The exhaust gases such as carbon dioxide discharged from diesel crusher,

driller, generators, or trucks also have adverse effect on the health of the workers and the atmosphere.

**Fig 3.3** Dust Produced By a Process of Aggregate Production in One Aggregate Production Plants in Addis Ababa, Blue Nile, around Debre Gelan

### 3.1.4 Water and Soil Pollution

Solid and liquid waste discharged such as, scraps of metal, machinery parts discharges of fuel, lubricant or oil from heavy duty machines, vehicles during maintenance. There are also items such as packagings are the main source of water and soil pollution. Fig-3.4 shows a polluted seasonal river containing lubricant and oil.

**Fig 3.4** Water pollution by liquid waste discharge from one of the biggest Quarry of Midroc

### 3.1.5 Disturbing River Eco-System

Disturbance of river eco-system as a result of striping and excavation of the river bank. This is resulted in loss of bio-diversity and changing the natural river course, at the same time aggravates soil erosion. The Akaki River is susceptible for such effect. Fig– 3.5 shows the disturbed catchments area of Akaki River.

**Fig 3.5** Quarries Distributed in Wider Area, Around Akaki River

### 3.1.6 Increase Traffic

Due to the opening of the quarry additional vehicles and earth moving equipment will come to the area. This will increase the amount of traffic in the quarry area. The effect of increased of traffic means more accident as a result of vehicle movement is shown with Fig – 3.6. This is especially severed due to the fact that the people living in the area are not acquainted with traffic safety. Children and women will be vulnerable.

**Fig 3.6** Opening of quarry increases additional vehicles and earth moving Equipment, Addis Ababa around Akaki Asmagibi

## 3.2 ABANDONED QUARRIES

Most of the materials used in the building of cities have natural origin. In obtaining these materials there are a number of active and abandoned quarries which change the natural topography in Addis Ababa. Abandoned quarries are left open and some of them becoming ponds, or domestic waste is dumped to them which become favorable place for flies and other insects breeding. Unless old quarries are filled and planted with trees it would be difficult to avoid their hazardous consequences. The distribution and location of abandoned quarries in and around Addis Ababa is shown with Fig- 3.7.

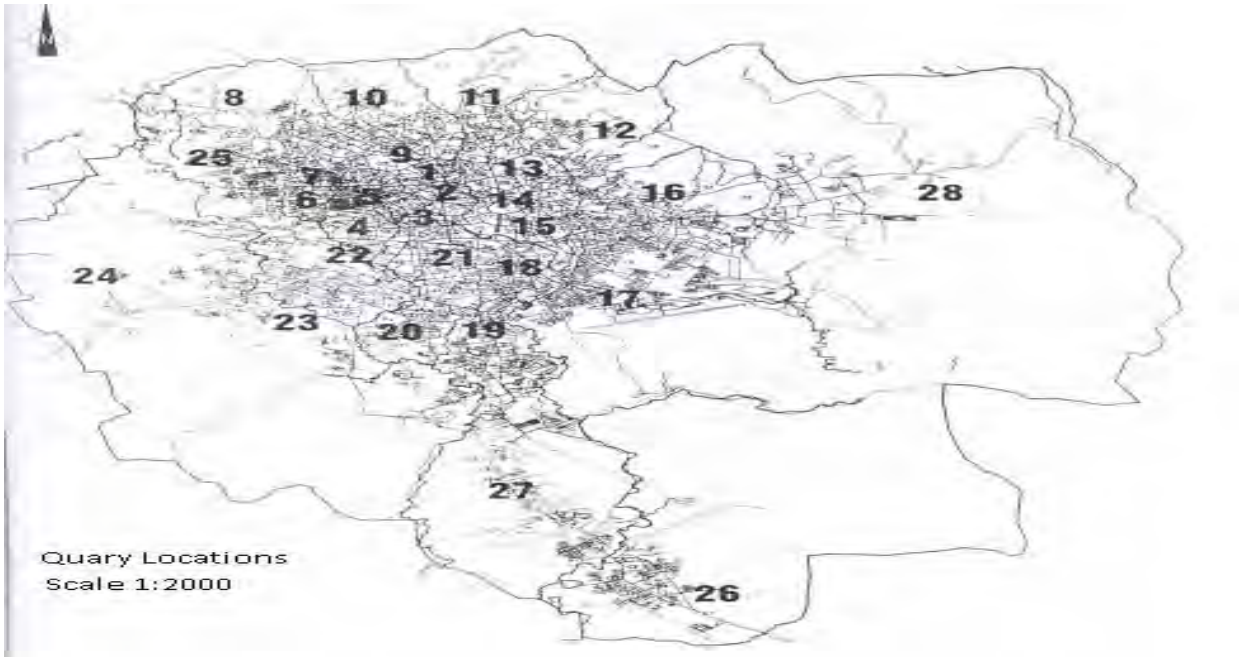


**Fig 3.7** Locations of abandoned quarries in Addis Ababa Source: Mines and Energy Department, 2000 [12].

In one of the quarry there is a cliff that has a height of more than 25 meters and it is possible to observe the houses located on top it and how it is susceptible for risk is shown with Fig- 3.8.

**Fig 3.8** Impact of coarse aggregate production on the environment (The Addis Ababa City Administration Construction Materials Production Plant, Scoria)

Coarse aggregate crushing plants have effect on nearby inhabitants, schools, hospitals, condos, factories etc. Especially proper consideration should be provided when constructing infrastructure such as condominiums. In one of condominium site, Gelan, a quarry is still functional with at most 60m distance from the building is shown with Fig- 3.9.This has an impact both on the structures and the dwellers around the vicinity.

**Fig 3.9** Coarse aggregate crushing plants have effect on nearby inhabitants, schools, around Gelan condominium)

Abandoned coarse Aggregate production quarry have unsightly views and it is risky for the nearby inhabitants .In one of abandoned quarry site, Gelan, a quarry is still not rehabilitated thought the depth of the quarry is more that 40m is shown with Fig 3.9.

**Fig 3.10** Abandoned coarse aggregate production quarry around Kality, Sallo

# 4 RESULTS AND DISCUSSIONS

## 4.1 SUPPLY OF AGGREGATE PRODUCTS

According to the information from the Environmental Protection Authority mines and land use controlling team and personal investigations, over 350 quarries of different capacities are claimed to exist in Addis Ababa and the surroundings. Similarly, more that 250 licensed organizations are assigned in the extraction of ignimbrite rocks for the production of dimension stone for Addis Ababa market. These production centers are supplying necessary types of crushed stone aggregates at their capacity for the on-going construction of housing sector, small to large level complex business buildings, public infrastructure extensions, upgrading and rehabilitation works, NGO activities and other related works.To investigate how much area of Addis Ababa has been utilized for the production of aggregate, dimensional area of licensed quarries were collected from quarry owners and Addis Ababa Environmental Protection Authority.

The number, size and the sub city of quarries in the research have been shown Appendix A. The grand total of area scarified for quarry is presented through Table 4.1 and the total area of the sub cities through Table 4.2, and finally comparison is made between the two areas and presented by Fig. 4.1.

**Table 4.1** Grand total area of land for quarries in Addis Ababa [21]

| No. | Sub - City | Licenced Area (Sq.m) |
|---|---|---|
| 1 | Gulele and Kirkos Sub City | 56,322.00 |
| 2 | Yeka Sub City | 963,412.50 |
| 3 | Bole Sub City | 4,087,078.00 |
| 4 | Nifas Silk Lafto Sub City | 583,955.35 |
| 5 | Akaki Kality Sub City | 5,136,443.91 |
| **Total Area** | | **10,827,211.76** |

**Table 4.2** Area of land occupied by each sub cities [21]

| Sub City | Area (Sq.KM) |
|---|---|
| Addis Ketema | 7.42 |
| Arada | 9.54 |
| Akaki Kality | 124.7 |
| Bole | 119.7 |
| Gullele | 31.34 |
| Kircos | 14.72 |
| Kolfe Keraniyo | 63.25 |
| Nefas Silk Lafto | 58.51 |
| Lideta | 11 |
| Yeka | 81.9 |

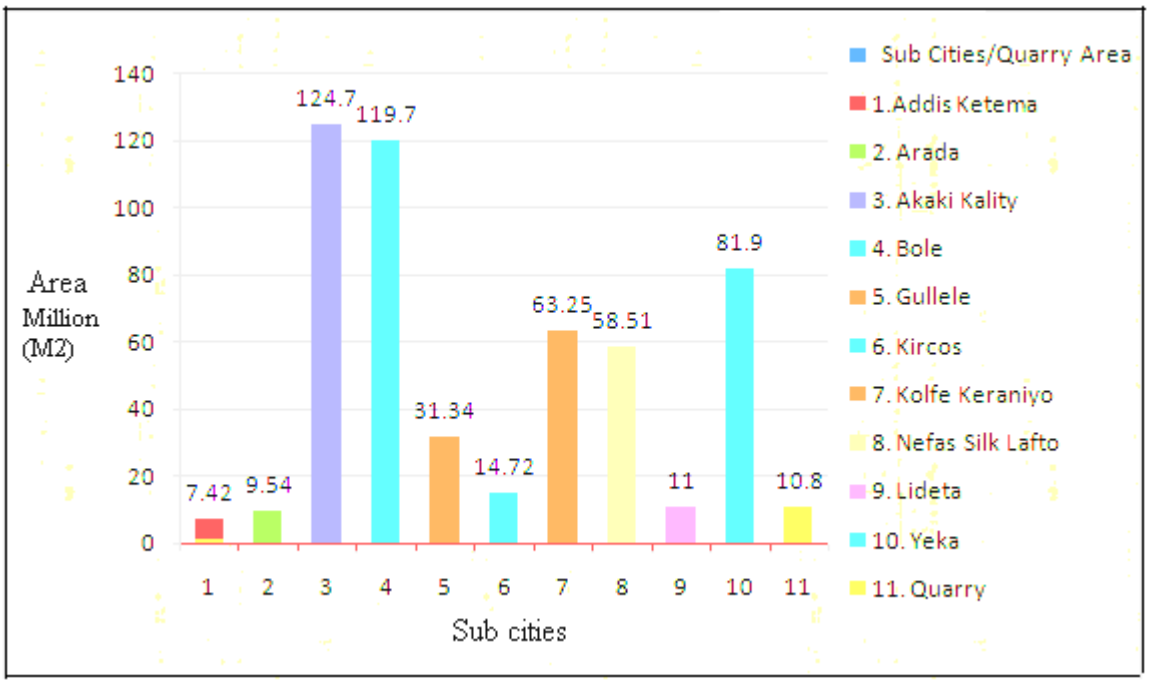


**Fig. 4.1** Comparison of Areas of Sub cities Verses Quarry Area

## 4.2 LANDSCAPE IMPACT

The primary information shows that according to the current trend, the existing supply - demand gap will reach to 4 million $m^3$ in the next four years. This shows the importance of identification of potential resources and future planning. Besides, under any circumstances any move to restrict the quarrying activities would severely hamper currently booming construction industry. The very basic necessities of housing, roads etc. development would be affected in Ethiopia. The other benefits of quarrying industry are increasing employment. Currently, significant numbers of employees are involved directly or indirectly in the quarrying industry.

Despite this, as we can observe on table 4.1 About 11 (Sq.KM) area of the land of Addis Ababa has sacrificed for production of concrete aggregate. This area is considerably high. Especially, it is comparatively higher than the area of some of our sub cities like Addis Ketema and Arada. The area that has been sacrificed for the production of aggregate is equivalent to Lideta sub city. Hence, clearly saying, the area that can be used for the habitation of the increasing population is used for quarrying industry that can harm the environment.

Obviously, the effectiveness of implementation of waste management and reinstallation of quarries into construction material production quarries will lead to reduction of bad effects towards environment. It is absolutely imperative for the construction industry to adopt ecologically sound planning and construction material production for the purpose of creating a healthy and sustainable built environment.

## 4.3 ENVIRONMENTAL MITIGATION AND MONETARY CONCERN

In addition to estimate the total area of land sacrificed for concrete aggregate production, an attempt is done to investigate the allocation of fund for environmental protection and mitigation activities that shall be performed by aggregate producers. To perform this:

- Detail production cost break down was collected from concrete aggregate producers through site visit and interview.
- The market price of different sizes of aggregate was also collected and an attempt was done to calculate the profit earned and the monetary value given for environmental mitigation measures.
- Table 4.2-4.6 shows detailed costs breakdown for different phases of aggregate production.
- The cost of pre- operational activities were considered from different aggregate mining proposals and found as 2.5% of the profit. The cost of the under listed pre – operational activities were considered.
    - Land lease,
    - Feasibility study (Field reconnaissance, Aerial photos, and sometimes test boreholes),
    - Licensing fee.
- Royalty is considered as 3% the gross sale revenue.
- Profit tax of 35% is considered.

**Table 4.3** Basic assumptions considered during cost break down

| | | |
|---|---|---|
| Capacity | **14.00** | **$m^3$** |
| Average Distance | **3.00** | **km** |
| Average Speed | **35.00** | **km/hr** |
| Loading And Unloading Time | **8.00** | **min** |
| No. of Dump Trucks Required for a Loader | **5** | **No.** |

**Table 4.4** Detail cost break down of concrete aggregate material production – (Phase -I quarry rock production)

| No | Description | | Labor | | | | | Material | | | | | Equipment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Description | No. | UF | Indexed Hrly Cost (ETB) | Total Cost per Unit (ETB) | Description | Unit | Unit Qtty | Unit Price (ETB) | Total Cost per Unit (ETB) | Description | No. | UF | Hrly Rate (ETB) | Total Cost per Unit (ETB) |
| **I** | **Quarry Rock Production** | | | | | | | | | | | | | | | | |
| | Unit | m3 | Quarry Foreman | 1.00 | 1.00 | 9.38 | 0.13 | Power Gel | kg | 0.10 | 55.00 | 5.50 | Dozer (D8R) | 1.00 | 1.00 | 1,100.00 | 14.67 |
| | Hourly Production Rate | 75.00 | Dozer Operator | 1.00 | 1.00 | 12.00 | 0.16 | ANFO | kg | 0.25 | 40.10 | 10.03 | Wagon Drill | 1.00 | 1.00 | 300.00 | 4.00 |
| | Quantity | 1.00 | Stationary Equipment Operator | 5.00 | 1.00 | 6.25 | 0.08 | Detonator | no | 0.15 | 24.23 | 3.63 | Compressor | 1.00 | 1.00 | 480.00 | 6.40 |
| | Indirect Cost Factor | 0.20 | Blasting Foreman | 1.00 | 1.00 | 18.00 | 0.24 | Drill Bits_ Rods etc. | no | 0.15 | 9.00 | 1.35 | Jack Hammer | 3.00 | 1.00 | 8.10 | 0.32 |
| | | | Laborer | 10.00 | 1.00 | 4.38 | 0.06 | | | | | | Hand Tools | 10.00 | 0.50 | 0.30 | 0.02 |
| | Direct Cost per Unit (ETB) | 46.59 | | | | | 0.67 | | | | | 20.51 | | | | | 25.41 |
| | ***Total Unit Price (ETB)*** | **55.90** | | | | | **0.80** | | | | | **24.61** | | | | | **30.49** |

**Table 4.5** Detail cost break down of concrete aggregate material production – (Phase -II quarry rock crushing)

| No | Description | | Labour | | | | | Material | | | | | Equipment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Description | No. | UF | Indexed Hrly Cost (ETB) | Total Cost per Unit (ETB) | Description | Unit | Unit Qtty | Unit Price (ETB) | Total Cost per Unit (ETB) | Description | No. | UF | Hrly Rate (ETB) | Total Cost per Unit (ETB) |
| **II** | **Quarry Rock Crushing, Concrete Aggregate** | | | | | | | | | | | | | | | | |
| | Unit | m3 | Quarry Foreman | 1.00 | 1.00 | 9.38 | 0.13 | | | | | | Crusher Plant | 1.00 | 1.00 | 3,000.00 | 42.86 |
| | Hourly Production Rate | 70.00 | Stationary Equipment Operator | 1.00 | 1.00 | 6.25 | 0.09 | | | | | | Wheel Loader | 1.00 | 0.60 | 600.00 | 8.57 |
| | Quantity | 1.00 | Loader Operator | 1.00 | 0.60 | 14.00 | 0.20 | | | | | | | | | | |
| | Indirect Cost Factor | 0.20 | Helper | 2.00 | 1.00 | 5.00 | 0.07 | | | | | | | | | | |
| | | | Laborer | 10.00 | 1.00 | 4.38 | 0.63 | | | | | | | | | | |
| | Direct Cost per Unit (ETB) | 52.55 | | | | | 1.12 | | | | | | | | | | 51.43 |
| | ***Total Unit Price (ETB)*** | **63.06** | | | | | **1.34** | | | | | | | | | | **61.71** |

**Table 4.6** Detail cost break down of concrete aggregate material production – (Phase –III quarry rock hauling to crusher)

| No | Description | | Labour | | | | | Material | | | | | Equipment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Description | No. | UF | Indexed Hrly Cost (ETB) | Total Cost per Unit (ETB) | Description | Unit | Unit Qtty | Unit Price (ETB) | Total Cost per Unit (ETB) | Description | No. | UF | Hrly Rate (ETB) | Total Cost per Unit (ETB) |
| **III** | **Quarry Rock Hauling to Crusher** | | | | | | | | | | | | | | | | |
| | Unit | m3 | Truck Driver | 5.00 | 1.00 | 11.00 | 0.25 | | | | | | Chain Loader | 1.00 | 1.00 | 1,500.00 | 6.70 |
| | Hourly Production Rate | 224.00 | Loader Operator | 1.00 | 1.00 | 14.00 | 0.06 | | | | | | Dump Truck (14m3) | 5.00 | 1.00 | 550.00 | 12.28 |
| | Quantity | 1.00 | | | | | | | | | | | | | | | |
| | Indirect Cost Factor | 0.30 | | | | | | | | | | | | | | | |
| | Direct Cost per Unit (ETB) | 19.28 | | | | | 0.31 | | | | | 0.00 | | | | | 18.97 |
| | ***Total Unit Price (ETB)*** | **23.14** | | | | | **0.37** | | | | | **0.00** | | | | | **22.77** |
| | Grand Total of Direct Cost per Unit (ETB) | 142.06 | | | | | 2.88 | | | | | 20.51 | | | | | 137.96 |
| | ***Grand Total of Total Unit Price (ETB)*** | **170.47** | | | | | 3.45146 | | | | | 24.6114 | | | | | 165.5464 |

**Table-4.7** Aggregate price comparison between the three methods of production of aggregate [interview of aggregate producers and National Construction Magazine]

| Type of Aggregate | Price (Birr per $m^3$) | | |
|---|---|---|---|
| | **Crushing by human labor and tools** | **Low scale mechanized crushing** | **Medium to large scale crushing plants** |
| Agg.00(Fino) | - | 208.00 | 215.00 |
| Agg. 01 | - | 95.95 | 114.35 |
| Agg. 02 | 170 | 265.00 | 295.00 |

Price of aggregate is excluding VAT

- Aggregate -02 is sold at the quarries within the range of ETB 265 – 395 Table 4.7.
  The average price is ETB $\frac{265 + 295}{2}$ = (approx. 280) per $m^3$
- Royalty which is 3% (approx. 280) per $m^3$ = (approx. 8.4 ETB) per $m^3$
- Production costs per $m^3$ of aggregate is ETB (approx. 170) from Table 4.6.
- The gross revenue to the quarry owner is therefore approximately ETB (280 – 8.4 -170) = ETB (approx. 101.6).
- Out of the gross revenue, 3% is the pre- operational cost, ETB (approx. 3.04 )
- Out of the gross revenue, 35% is profit tax, which is ETB ( approx 37.1)
- Hence, the net profit is (101.6 – 3.04 – 37.1) = ETB ( approx. 61.4)

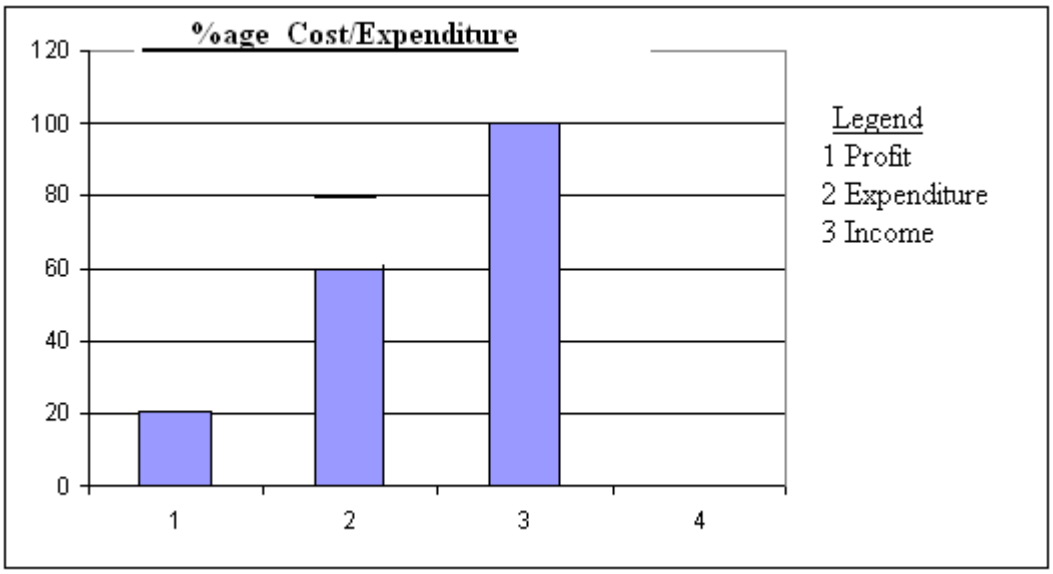


**Fig. 4.2** Comparison of total cost of production of aggregate-02 to earned profit

- On the other side, 1 $m^3$ of ordinary soil excavated as wastage from construction project area or other source cost within the range of (ETB 0.00 – ETB 300) per 9 m3 dump truck.
- Considering the average price ETB 0 + ETB 300 = (aprox. ETB 150) per 9 $m^3$ dump truck, which is ETB 16.6 per $m^3$. 2
- Hence, we can see any party who wont to make a quarrying business will earn ETB 61 and will invest about 16.6 to fill the quarry per unit.

## 4.4 ENVIRONMENTAL COST CONCERN

Detail assessment of cost and benefit of aggregate production and the concern provided to the environment compared with the earned benefit were analyzed in the above section. Prices quotations were collected from more than ten projects solicited from private, governmental and associations and a detailed cost break down were calculated.

As we can learn from the Table 4.6 and 4.7, the net revenue to the quarry owner is approximately ETB (approx. 61) per $m^3$. This money is relatively high income. Beside, the figure shows that the quarrying industry is an optimistic business approach for investment.

On the other hand, as we can learn from the above figure, about ETB 16.6 per $m^3$ is required for filling of the abandoned quarry. For quarry owners, investing about ETB 220 per $m^3$ and earning ETB 60 per $m^3$ is huge money. Owners should not hesitate to invest at least 26 % (16/61) of their profit for reclaiming of such a valuable natural resource on the environment. This amount of money should get the Government focus and there has to be some mechanism that portion of the profit can be used for the purpose of implementing environmental mitigation measures on the quarry sites.

## 4.5 ENVIRONMENTAL IMPACT VERSUS MITIGATION MEASURES

On the other hand there is a wide range of potential environmental effects caused by quarries which concerned authorities need to consider when dealing with proposals for new development, or for significant expansion.

In order to study what kind of negative environmental impacts are happening in and around Addis Ababa a questionnaire have been developed and detail site visit has been performed on 22 concrete aggregate producing quarry sites. Besides, a detailed field investigation has been carried out simultaneously with the questionnaire.

Attempt was made to select representative samples with respect to:

- Ownership – Quarries owned by Government, Private organizations, and Associations, were considered in the sample.
- Location –With respect to the Sub cities, samples were taken from all sub cities.
- Scale – Quarry size scale from medium to large scale crushing plants were considered in the sample.

On the questionnaire a detailed possible negative environmental impacts together with the possible mitigation measures and practices were incorporated. Finally, an attempt is done to identify the number of companies which undertake the mitigation measures and further analysis were also performed.

Just for the study presentation purpose, English alphabets were used as a replacement of company names and the assignment of the alphabets to the company's name were presented in Table 4.8.

**Table 4.8** Company codes for the development of the questionnaire

| ***Company Code*** | ***Company Name*** |
|---|---|
| **A** | Ato Daniel Admasu |
| **B** | Mendelo Aggregate and Cement Pro. PLC |
| **C** | Blue Nile |
| **D** | Midroc Construction |
| **E** | Awash Construction |
| **F** | W/ro Angatu PLC |
| **G** | SANA Aggro ENG.PLC |
| **H** | W/ro Meaza Alemayehu |
| **I** | A.A Roads Athority |
| **J** | Adugna Egigu |
| **k** | A.AHowsing Development |
| **L** | Gorge Nikola |
| **M** | Homa Construction |
| **N** | Ato Niguse Tulu |
| **O** | B.H Trading |
| **P** | A.A.CRBC |
| **Q** | Ato Samuel Tadese |
| **R** | Alfa International |
| **S** | Berta Construction |
| **T** | G and T Plc |
| **U** | Vera International |

**Table 4.9** Result obtained through the Questionnaire developed

| *No* | *Possible Negative Environmental Impact* | *Possible Mitigation Measures and Practices* | *Company Code* | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **M** | **N** | **O** | **P** | **Q** | **R** | **S** | **T** | **U** |
| **1** | **Noise and Vibration** | Earth mounds around the site | | X | | | | | | | | | | X | | | | X | X | | | | X |
| | | Housing of conveyers and belts | | | | | | | | | | | | | | | | | | | | | |
| | | Professional control of blasting | X | X | X | X | | | | | X | | | X | | X | X | | X | | | X | |
| | | Other | | | | | | | | | | | | | | | | | | | | | |
| **2** | **Dust Deposition/Air Quality** | Water spraying | X | | | | | | | | | | | X | | | X | | X | | X | | |
| | | Wheel washing of cars leaving the site | | | | | | | X | | | | | | | | | | | | | | |
| | | Mounds and plantations around the site | | X | X | X | | X | X | X | X | | | X | X | X | | X | X | | | | X |
| | | Other | | | | | | | | | | | | | | | | | | | | | |
| **3** | **Surface and Ground Water** | Surface and ground water base line test | | | | | | | | | | | | | | | | | | | | | |
| | | Making of hydrological tests while excavating below water table | | | | | | | | | | | | | | | | | | | | | |
| | | Rapidly vegetating areas to protect erosion | | | | | X | | | X | | | X | | | | | | | | | | |
| | | Provision of appropriate drainage system | | X | | X | | X | | | | | | | X | X | | | | | X | | X |
| | | Other | | | | | | | | | | | | | | | | | | | | | |
| **4** | **Landscape Impact** | landscape mounds constructed to screen unsightly excavation | | X | | | | | | | X | | | X | | | | | | | | | |
| | | Planting of native species | | | | | | | X | | | X | | | | | | | | | | | |
| | | Removing of all accommodation (warehouse, internal roads etc...)after excavations | | X | X | X | | X | | X | | X | X | X | | | | | | | | | |
| | | Other | | | | | | | | | | | | | | | | | | | | | |
| **5** | **Traffic Impact** | Strengthening / widening of local roads | | | | | | | | | | | | | | | | | | | | | |
| | | Limiting high speed | | X | | | | | | | | | | X | X | X | X | | | X | | | X |
| | | Provision of foot path/pedestrian | X | | X | X | | | | | | | X | | | | | | | | | | |
| | | Other | | | | | | | | | | | | | | | | | | | | | |
| **6** | **Waste Management** | Re usage of unsuitable materials like clay, silt for other purpose | | X | | | X | | | | | | | X | | | | X | X | | | | |
| | | Collection of waste (batteries, metal chips etc)in appropriate way | X | X | X | X | | | | | | | X | | X | | | | X | X | X | X | X |
| | | Other | | | | | | | | | | | | | | | | | | | | | |
| **7** | **Natural Heritage** | Provision of ecological base line study | | | | | | | | | | | | | | | | | | | | | |
| | | Provision of buffer zone and protection of habitats | | | | | | | | | | | | | | | | | | | | | |
| | | Other | | | | | | | | | | | | | | | | | | | | | |

A simple mathematical analysis like counting the number of company ( horizontal counting on table 4.8) show which possible negative environmental impact mitigation have got the highest and which have the lowest concern to perform environmental mitigation measure.

**Table 4.10** Comparison of the number of companies to the negative environmental impact

| ***Possible Negative Environmental Impact*** | ***Summation*** | ***Percentage of the Total*** |
|---|---|---|
| Noise and Vibration | 12 | 55% |
| Dust Deposition/Air Quality | 16 | 73% |
| Surface and Ground Water | 9 | 41% |
| Landscape Impact | 10 | 45% |
| Traffic Impact | 11 | 50% |
| Waste Management | 14 | 64% |
| Natural Heritage | 0 | 0% |

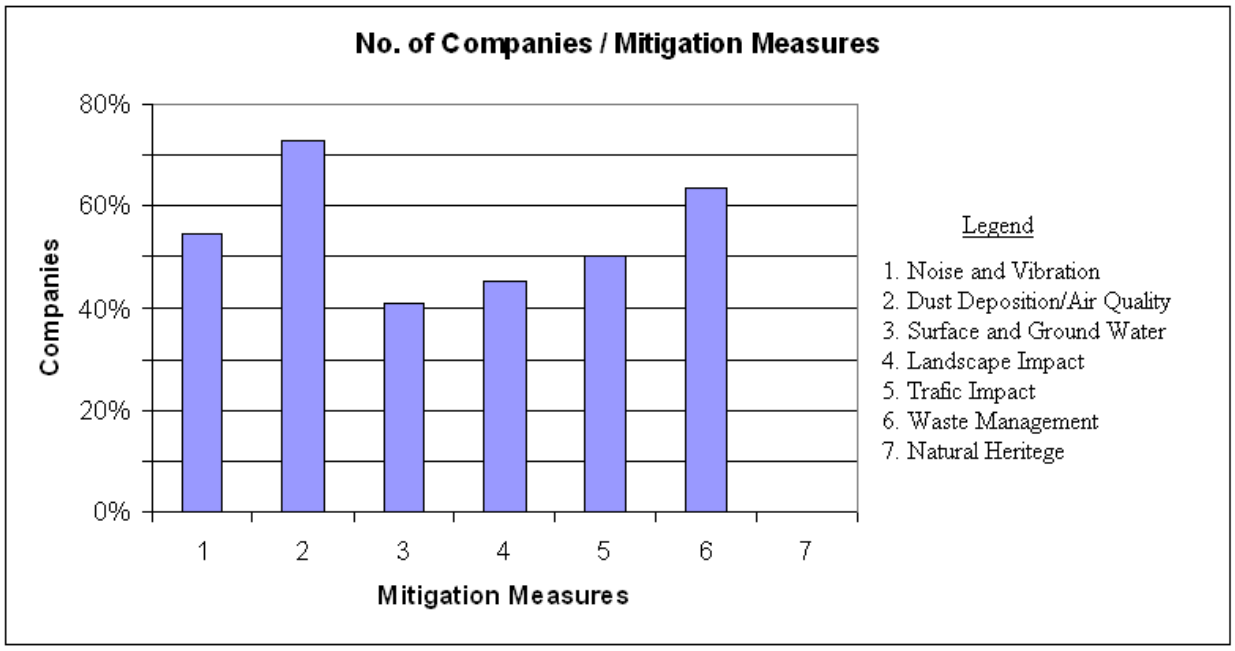


**Fig. 4.3** Comparison of number of companies Vs environmental mitigation measure

Besides, a simple mathematical analysis (counting on Table- 4.7) is performed to observe out of the sampled quarry sites which type of environmental mitigation measure and practice are performed by the quarrying companies.

**Table 4.11** Show comparison of the number of companies to the possible mitigation measures and practices

| ***Possible Mitigation Measures and Practices*** | ***Summation*** | ***Percentage of the Total*** |
|---|---|---|
| Earth mounds around the site | 5 | 23% |
| Professional control of blasting | 10 | 45% |
| Water spraying | 5 | 23% |
| Wheel washing of cars leaving the site | 1 | 5% |
| Mounds and plantations around the site | 13 | 59% |
| Rapidly vegetating areas to protect erosion | 3 | 14% |
| Provision of appropriate drainage system | 7 | 32% |
| landscape mounds constructed to screen unsightly excavation | 2 | 9% |
| Planting of native species | 2 | 9% |
| Removing of all accommodation (warehouse, internal roads etc...)after excavations | 8 | 36% |
| Limiting high speed | 8 | 36% |
| provision of foot path/pedestrian | 4 | 18% |
| Re usage of unsuitable materials like clay, silt for other purpose | 5 | 23% |
| Collection of waste (batteries, metal chips etc)in appropriate way | 11 | 50% |
| Others | 0 | 0% |

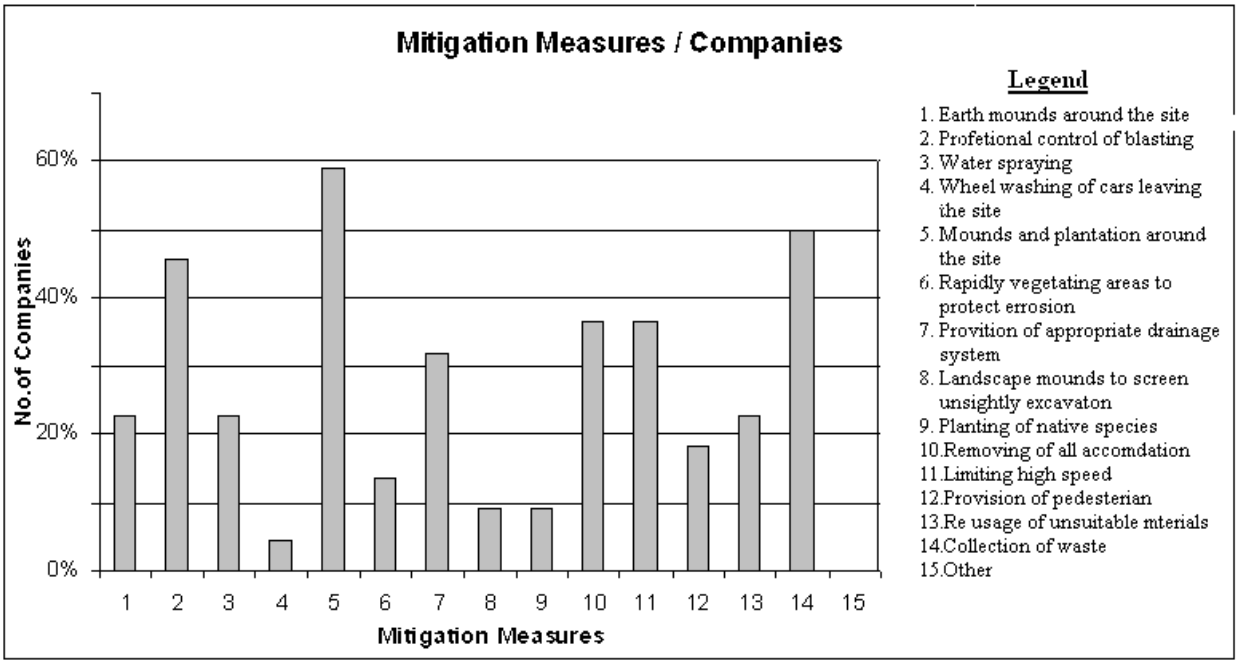


**Fig. 4.4** comparison of number of companies Vs possible mitigation measures and practice

In order to mitigate the negative environmental impacts, noise and vibration, out of the total 22 sampled companies 12 (55%) of the companies have taken environmental mitigation measures Fig- 4.4. Out of this 55 % of the total companies 5 (41.6%) companies have constructed earth mounds around the site, 10 (83.3%) the companies have controlled the blasting by professionals and any of the companies have made housing on conveyers and belts or used other mitigation measures to mitigate noise and vibration.

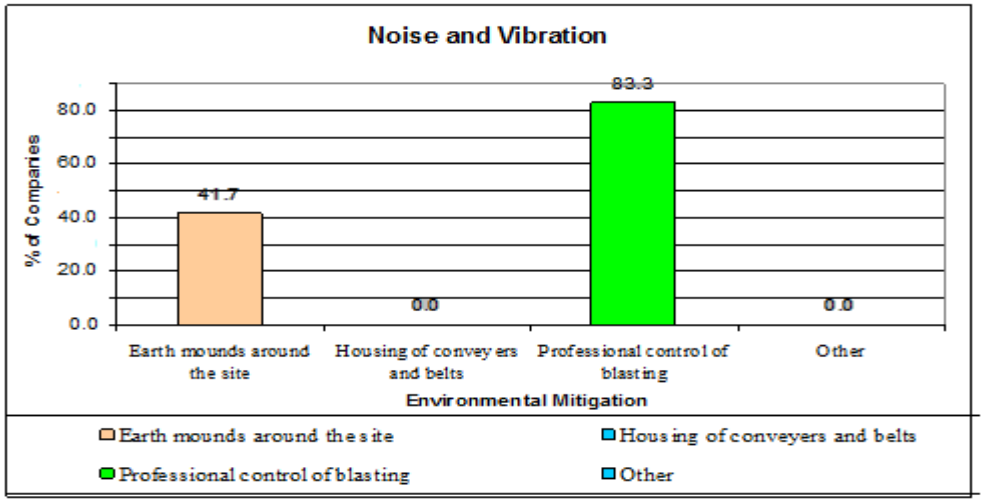


**Fig. 4.5** Noise and vibration versus environmental mitigation measures

In order to mitigate the negative environmental impact of dust deposition, out of the total 22 companies 16 (73%) of the companies have taken environmental mitigation measures. Out of this 73 % of the total companies 5 (31.3%) have sprayed water on quarry site, 1 (6.3%) company have washed cars leaving the site and 13( 81.3%) companies have constructed earth mounds and plantation around the quarry, and any of the companies have used other mitigation measures to mitigate noise and vibration. The proportion is shown with Fig 4.6.

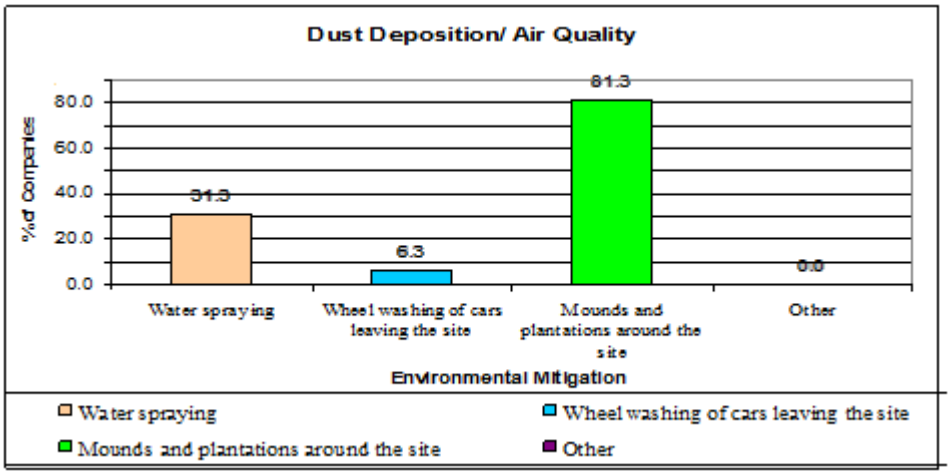


**Fig. 4.6** Dust deposition versus environmental mitigation measures

In order to mitigate the negative environmental impacts on surface and ground water, out of the total 22 companies 9 (41%) of the companies have taken environmental mitigation measures. Out of this 41 % of the total companies 3(33.3%) companies have tried to vegetate areas to protect erosion, 7 (77.8%) the companies have provided appropriate drainage system and any of the companies have made surface and ground water base line test or hydrological test or any other mitigation measures to reduce impact on surface and ground water The proportion is shown with Fig 4.7.

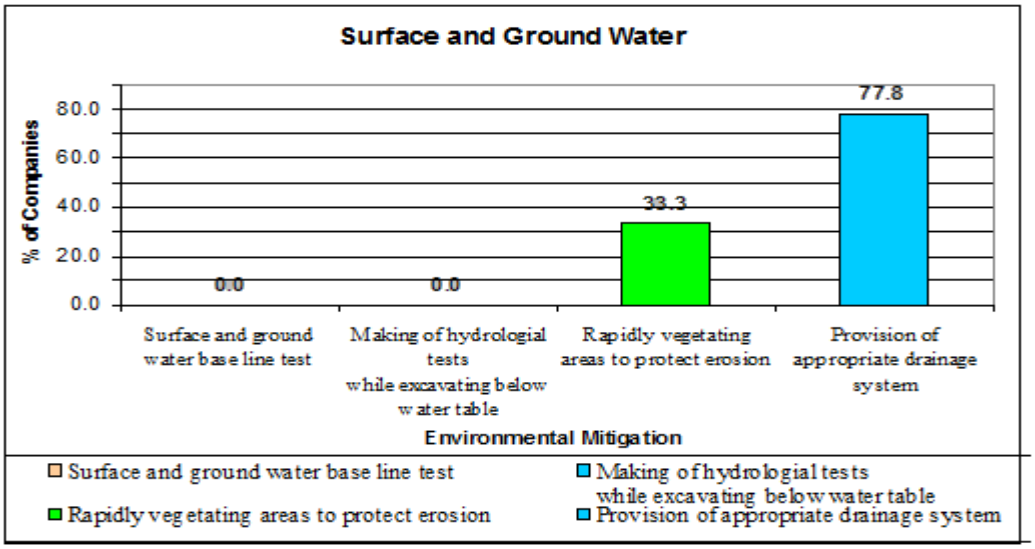


**Fig. 4.7** Surface and ground water versus environmental mitigation measures

Besides, in order to mitigate the negative environmental impacts on landscape out of the total 22 companies 10 (45%) of the companies have taken environmental mitigation measures. Out of this 45 % of the total companies 2 (20%) companies have constructed landscape mounds, 2 (20%) the companies have planted native species, 8 (80%) of the companies have removed all accommodations such as warehouse after excavation and any company has made other mitigation measures to reduce impact on landscape. The proportion is shown with Fig 4.8.

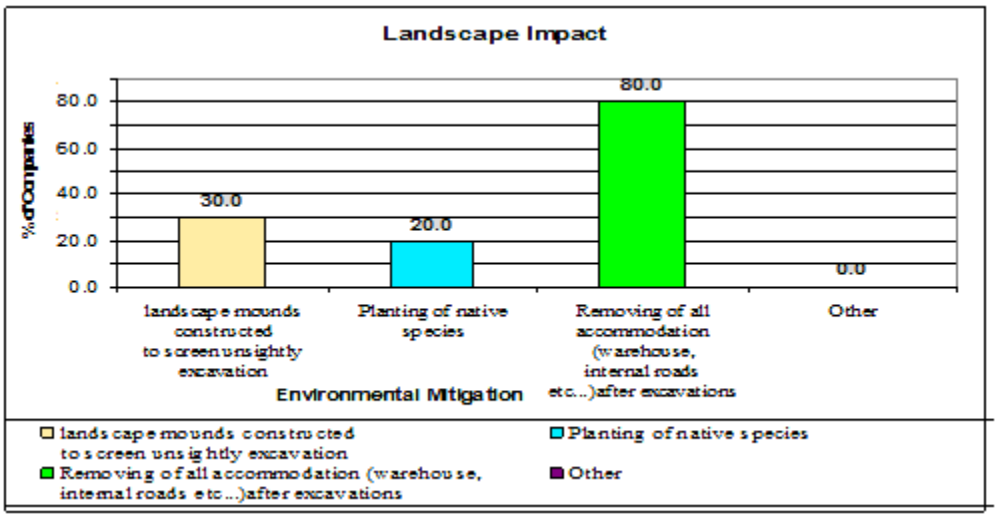


**Fig. 4.8** Landscape impact versus environmental mitigation measures

In order to mitigate the traffic impact, out of the total 22 companies 11 (50%) of the companies have taken environmental mitigation measures. Out of this 50 % of the total companies 7 (63.6%) companies have limited the speed of cars, 4 (36.6%) the companies have provided footpath and any of the companies have strengthen or widened the local roads or used any other mitigation measures to mitigate the traffic impact. The proportion is shown with Fig 4.9.

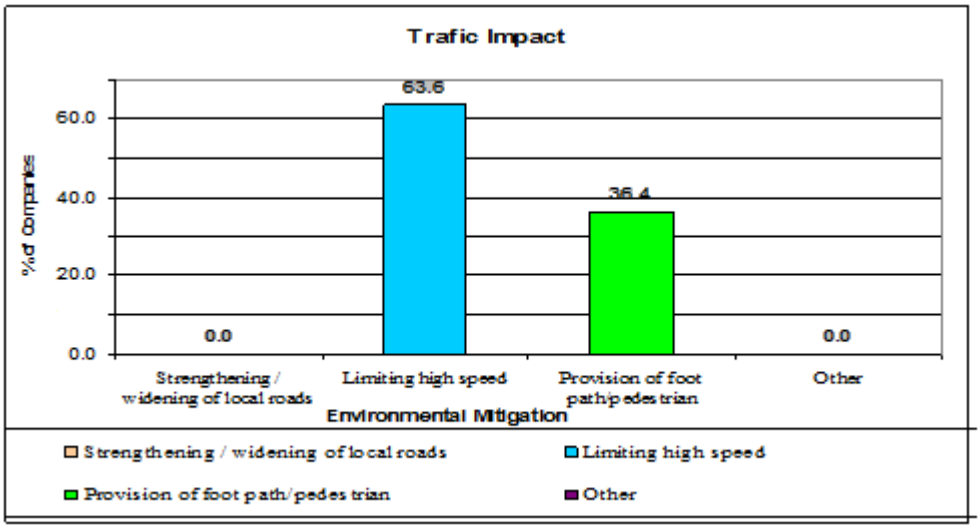


**Fig. 4.9** Traffic impact versus environmental mitigation measures

In order to mitigate the negative environmental impacts by waste out of the total 22 companies 14 (64%) of the companies have taken environmental mitigation measures. Out of this 64% of the total companies 5 (35.7%) companies have reused unsuitable materials like clay, silt for other purpose, 11(78.6%) the companies have collected waste in appropriate way and any company has made other mitigation measures to mitigate impact poor waste management. The proportion is shown with Fig 4.10.

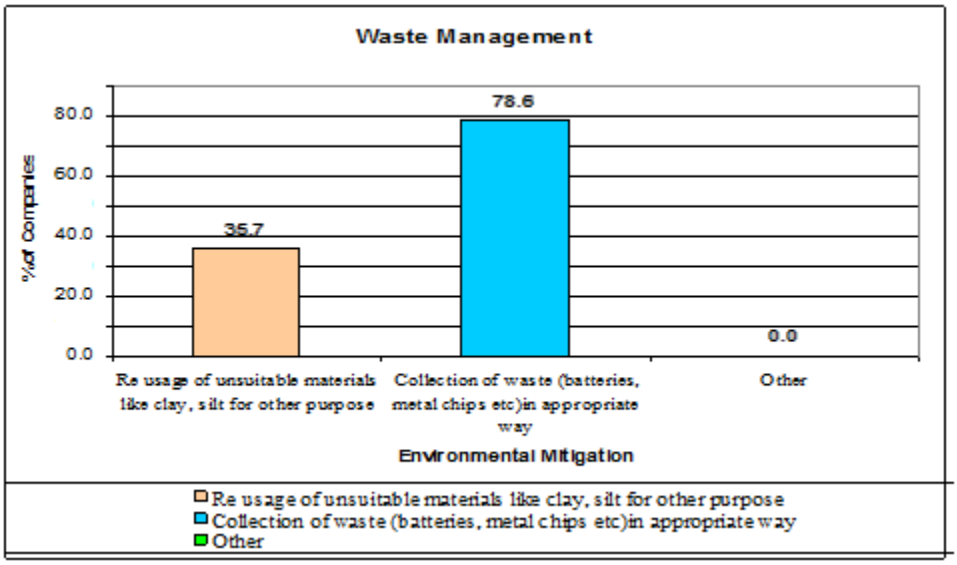


**Fig. 4.10** Waste management versus environmental mitigation measures

On the other hand, in order to mitigate the environmental impact of the natural heritage, no company has performed mitigation measures such as provision of ecological base line study, provision of buffer zone and protection of habitats or any other mitigation measure.

# 5 CONCLUSIONS AND RECOMMENDATIONS

## 5.1 CONCLUSIONS

In and around Addis Ababa, huge area of land has been sacrificed for the production of aggregate (about 2% of the total area of the city). This area should not be considered as minimum as it is even wider than some of the sub cities. On the other side, the environmental consideration given to this huge land is small.

Environmental impacts such as noise pollution, dust deposition, surface and ground water pollution, impact on the natural heritage, landscape impact and traffic impact were identified as the negative environmental impacts of the quarrying industry.

Considering the environmental protection measures, only dust deposition has been given a better emphasis and possible mitigation measures and practices such as construction of mounds and plantation around the quarry (59% of the sampled companies) and collection of solid waste (50% of the sampled companies) were the common activities so far done on the quarry site. Adequate mitigation measures should be considered as an integral part of the aggregate production process.

These environmental mitigation measures and practices were relatively common on the quarry sites as the cost of such practices were negligible and even collection of waste have a salvage value for the quarry owners. On the other side environmental mitigation measure for surface and ground water pollution should get much focus in the coming quarrying practices. Only 40 % of the sampled quarry sites have taken some environmental mitigation measures for the protection of surface and ground water pollution.

For quarry owners, investing about ETB 220 per $m^3$ and earning ETB 61 per $m^3$, which is (27%) of the total expenditure is substantial money. Although it is not an easy task to evaluate the monetary value of environmental protection activities performed on quarry sites, it can be considered as insignificant when it is compared to the earned profit. On the other hand, as we can

learn from the above analysis, about ETB 16.6 per $m^3$ is required for filling of the abandoned quarry and ETB 61 per $m^3$of earned profit.

Only environmental mitigation practices such as planting of trees and collection of waste are the common practices. These activities are common as the mitigation measures (planting of trees and collection of waste) have future scrap values.

Quarry restoration can not only replace, but may even add to, the diversity of plants and wildlife. There are many options for restoration that enable land to be returned to an attractive and useful form.

## 5.2 RECOMMENDATIONS

### 5.2.1 ENVIRONMENTAL ASPECT

1. Quarrying investors should be aware that quarry sites within the city and among settlements could be detrimental to people's well being and health and hence to look for other areas that could not cause much harm.
2. If there is environmental, social impact on the surrounding area, technical advice should be given to enable limitation of number of bore holes, stripping lines and extent of depth, amount of explosive material use etc. to make the development environmentally friendly.
3. City Administration should ensure that the quarrying activity would not adversely affect the environment and society through the introduction of sustainable urban development.
4. Governmental bodies should take urgent appropriate legal actions to safeguard the environment from inappropriate land management.
5. Investors should install their plant on relatively far from nearby inhabitants, quarry sites need to be surrounded by vegetation that the impact of dust pollution is minimized.
6. Environmental regulatory bodies should take measurements and be always ready to investigate the impact that the operation in the quarry plant has on the surrounding environment and inhabitants. For instance, measurements of the extent of vibration to a certain distance from the quarry plant should be carried out whenever there is blasting operation in the plant.
7. Site-specific restoration options should be evaluated as part of a site restoration plan.
8. In line with the approved restoration plan by the regulatory bodies, quarry investors should restore both the active and abandoned quarry sites.
9. With respect to each negative environmental impact, the following best practices/possible mitigation measure shall be implemented and properly monitored with all the stakeholders in the aggregate quarrying industry.

**A. Best practice/possible mitigation measures for noise pollution**

Hence, quarry shall be implemented far from cities as much as possible. The nearer a site to noise-sensitive properties or areas, the more stringent should be the controls on noise emissions.

**B. Best practice/possible mitigation measures for dust pollution**

The first step is to try to prevent dust creation at source. Where practicable, earth stripping or moving should not be carried out in periods of dry and windy weather unless suitable mitigation measures are implemented, and dust should be prevented from escaping from enclosed equipment by means of filters or other appropriate means.

**C. Best practice/possible mitigation measures for surface groundwater resources**

The key objectives are to protect existing surface watercourses and groundwater resources, and to optimize the requirements for water abstraction through best water management practice. The relevant local authority should be consulted about any likely alterations to existing surface watercourses, nearby river corridors, and any discharges/abstractions. All operators must comply with the requirements of the Water Pollution Acts, and discharge licenses obtained if necessary.

**D. Best practice/possible mitigation measures for natural heritage**

An ecological baseline study should be carried out for every new extraction site, and for major extensions to existing sites. Ecologists should be involved in recommending appropriate mitigation measures for all phases of site development and operation, including restoration and after-care.

**E. Best practice/possible mitigation measures for landscape**

The method of extraction, together with proposed restoration schemes, where properly planned and implemented, can minimize potential adverse impacts. Besides, Closure planning needs to take place before extraction starts.

**F. Best practice/possible mitigation measures for traffic impact**

Some related mitigation measures (e.g. in relation to noise and dust) have been outlined above. Specifically traffic-related measures such as the improvement of sightlines at the site entrance, the strengthening/widening of local roads.

**G. Best practice/possible mitigation measures for Cultural heritage**

The employment of a project archaeologist who will work with the developer during site selection and project design, with a view to minimizing the impact on known archaeological sites or areas of established significant archaeological potential.

**H. Best practice/possible mitigation measures for waste**

Unsuitable materials, such as clay/silt materials from settlement ponds, should be re-used and recycled as far as possible. Quarry operators should ensure, by securing their site entrance and boundaries that illegal fly-tipping and disposal of waste by third parties does not occur. Besides it should be noted that waste disposal shall be in accordance of Waste Management Acts.

### 5.2.4 ALTERNATIVE MATERIAL ASPECTS

1. The crude forecasts of future demand, which have resulted in large areas of the city being devoured by development, should be abandoned. Instead, more efficient and considered use of aggregates is needed, based on the principles of 'plan, monitor and manage'. That means using less primary aggregates overall, and adopting a new approach based on the ability of the environment to absorb minerals extraction. Only with such an approach will the Government start to reduce our reliance on quarrying and the damaging impact it has on the beauty and diversity of the city.
2. We need a more intelligent approach to sourcing our construction material. This should aim to increase the use of secondary or recycled aggregates and the use of alternative materials.

### 5.2.6 SUGGESTIONS FOR FUTURE WORK

For future research work, the following suggestions are forwarded

1 Assessment of concrete aggregate wastage in the Ethiopian quarrying industry.

2 Assessment of artificial aggregate those are available in Ethiopia for production of concrete.

3 Forecasting future depletion of aggregate materials the land that will be sacrificed, using surveying software.

4 Introduction of more economically feasible subsurface quarrying technology.

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# ANNEXES

## ANNEX A

**A1** Total area of land for quarries in Gulele and Kirkos Sub-city [21]

| Gulele and Kirkos Sub City | | |
|---|---|---|
| **No.** | **Owner** | **Licenced Area (Sq.m)** |
| 1 | Gorge Nikola | 10,092.00 |
| 2 | Gulele Former Militery Association | 8,000.00 |
| 3 | Ato Mesfin Aseged | 38,230.00 |
| **Total Area** | | **56,322.00** |

**A2** Total area of land for quarries in Bole Sub-city [21]

| Bole Sub City | | | | | |
|---|---|---|---|---|---|
| **No.** | **Owner** | **Licenced Area(Sq.m)** | **No.** | **Owner** | **Licenced Area(Sq.m)** |
| 1 | Addis Ababa Roads Authority | 94,796.00 | 42 | Mebrat Degene | 225,681.00 |
| 2 | Addis Ababa Roads Authority | 106,484.00 | 43 | Shbiru Tefera | 57,320.00 |
| 3 | Asefa Gemeda | 1,436.00 | 44 | W/ro Hanan Yasin | 28,510.00 |
| 4 | Mesfin Abera | 2,323.00 | 45 | Bulbula Plc | 195,741.00 |
| 5 | Getachew Worku | 3,660.00 | 46 | Bahiru Bireda | 80,000.00 |
| 6 | Tasew Minda | 2,314.50 | 47 | W/ro Aster Siyum | 15,712.54 |
| 7 | Chmdesa Gudisa | 5,025.00 | 48 | Elmi Olindo Plc | 82,066.00 |
| 8 | Wude | 3,800.00 | 49 | Amsalu Birhanu | 7,760.60 |
| 9 | Homa Construction | 49,991.51 | 50 | Eskindre Getachew | 30,490.74 |

| | | | | | |
|---|---|---|---|---|---|
| 10 | Getachew Habte | 82,066.00 | 51 | Kiya Manufacturing Plc | 35,744.00 |
| 11 | Yonas Worku | 17,952.12 | 52 | Dawit Melese | 45,958.00 |
| 12 | Wendesen Tesfaye | 10,578.26 | 53 | Gize Stone Crusher Company | 22,170.00 |
| 13 | I.K. General Treding | 30,334.00 | 54 | Gisla Zewde and Girma Abebe | 56,819.00 |
| 14 | Fikadu Maru | 18,425.50 | 55 | Tsegaye T/Mariam | 77,628.00 |
| 15 | Magercon Plc | 22,537.21 | 56 | Etenesh Melese | 39,186.00 |
| 16 | A.AHowsing Development | 155,285.00 | 57 | Shbru Tefera | 22,968.00 |
| 17 | A.A Howsing Development | 200,892.00 | 58 | Bole Kotebe Con. Mterials Plc | 240,390.00 |
| 18 | Enyi Construction | 23,285.00 | 59 | W/ro Birchko Tarekegn | 87,745.00 |
| 19 | Alemu Denekew | 24,795.00 | 60 | Triangle G.Con. Bussiness Plc | 24,130.00 |
| 20 | W/ro Zibad Tamiru | 5,796.00 | 61 | Norinko Lalibela Engineering Con. | 82,184.74 |
| 21 | Daniel Tedla | 23,965.00 | 62 | Gutu Aggregete Production Plc | 36,918.00 |
| 22 | Engineer Asrat Gashaw | 8,186.78 | 63 | Tsegaye T/ Mariam | 24,905.16 |
| 23 | Ato Girma Geleta | 14,103.02 | 64 | Mesfin Gebre | 31,731.00 |
| 24 | Gemetri Lewege Varnero | 26,745.00 | 65 | Endalkachew Arage | 15,023.00 |
| 25 | W/ro Esrael Yegata | 103,200.00 | 66 | Building Materials Production Ent. | 72,553.00 |
| 26 | A.A Howsing Development | 120,000.00 | 67 | Selemon Yirgashewa | 26,034.00 |

| | | | | | |
|---|---|---|---|---|---|
| 27 | Bole Kotebe Con. Materials | 4,500.00 | 68 | Firilanders Construction Plc | 36,848.50 |
| 28 | Bole Kotebe Con. Materials | 78,557.00 | 69 | Shbre W/ Mariam | 30,734.00 |
| 29 | Degene Desalegn | 31,253.50 | 70 | Yenkomad Construction | 236,651.00 |
| 30 | A.A Howsing Development | 63,522.00 | 71 | Derege Belete | 70,000.00 |
| 31 | Ture Plc | 60,000.00 | 72 | Hayle Fenta | 8,527.00 |
| 32 | Aklilu Kalekristos | 58,505.50 | 73 | Hayle Fenta | 22,175.50 |
| 33 | K/Berihun G/ Hiwot & W/ Mariam | 7,540.00 | 74 | Enyi Construction | 73,992.00 |
| 34 | Esayas Eyesuswerk | 18,786.40 | 75 | 3 M Engineering and Con. Plc3 | 19,538.00 |
| 35 | Trakon Treding Plc | 74,250.00 | 76 | Gebresilase Hadis | 5,000.00 |
| 36 | Asmako General Treding Plc | 13,000.00 | 77 | Gemal Mehamed | 14,807.00 |
| 37 | Abebe H/ Mariam | 23,282.00 | 78 | W/ro Alem Yimer | 5,062.00 |
| 38 | Minase Aklilu | 19,765.00 | 79 | Eston Ehtiopia Plc | 6,987.81 |
| 39 | Giyon Construction Plc | 29,719.11 | 80 | Teklehaymanot Asgedom | 3,000.00 |
| 40 | Luwis Construction Plc | 14,780.00 | 81 | Areaya Yemane | 2,945.00 |
| 41 | Bole Bulbula Construction Plc | 225,681.00 | 82 | Andinet Aggregate Producing Plc | 4,324.00 |
| **Total Area 4,087,078.00** | | | | | |

**A3** Total area of land for quarries in Nifas Silk Lafto Sub-city [21]

| Nifas Silk Lafto Sub City | | | | | |
|---|---|---|---|---|---|
| **No.** | **Owner** | **Licenced Area(Sq.m)** | **No.** | **Owner** | **Licenced Area(Sq.m)** |
| 1 | Hagere Selam | 5,239.00 | 35 | Ato Asefa W/Silase | 4,088.00 |
| 2 | Engineer Yewubdar | 41,440.00 | 36 | Ato Dagne Sime | 10,335.00 |
| 3 | Adugna Egigu | 45,750.00 | 37 | Ato Tefera Teshome | 4,230.00 |
| 4 | Ato Zewdu and Meseret | 10,417.50 | 38 | Ato Getachew Tefera | 9,664.00 |
| 5 | W/ro Tewabech | 8,352.00 | 39 | Ato Alemayehu Kedida | 5,406.00 |
| 6 | Ato Azezachew Wase | 3,650.00 | 40 | Ato Efa Shume | 4,549.00 |
| 7 | Ato Aschalew Tilahun | 3,052.00 | 41 | Ato Asefa Belhu | 7,344.00 |
| 8 | Ato Tesfaye Debebe | 3,444.00 | 42 | Adis Raey Plc | 3,793.00 |
| 9 | Tidenekiyalesh Salehu | 2,450.00 | 43 | Addis Abeba Roads Athority | 98,338.00 |
| 10 | Ato Mamo Gari | 3,486.00 | 44 | Ababu Abte | 3,727.00 |
| 11 | W/ro Simegn Tadese | 4,758.00 | 45 | Ethuma Haile | 4,851.00 |
| 12 | Ato Mengistu Shume | 5,232.00 | 46 | Etaferahu Tadese | 5,730.50 |
| 13 | Ato Niguse Tulu | 3,051.00 | 47 | Dr. Aberash Hailu | 9,554.16 |
| 14 | Ato Adinew Tadese | 3,523.50 | 48 | Mered Gizaw | 52,295.00 |
| 15 | Ato Tilahun W/ Michael | 12,836.00 | 49 | Ato Getachew Tulu | 7,897.00 |
| 16 | W/ro Birknesh Tilahun | 2,321.00 | 50 | Tadese Belhu | 9,169.00 |
| 17 | Ato Seyfu Tadese | 6,155.89 | 51 | Gosa Asefa | 4,976.20 |
| 18 | Ato Zewdu Wendimu | 3,500.00 | 52 | Getenesh Eticha | 3,257.00 |

| | | | | | |
|---|---|---|---|---|---|
| 19 | Ato Birhanu G/Aregay | 15,860.00 | 53 | Getachew Tufa | 6,648.00 |
| 20 | W/ro Abeba W/ Gebriel | 4,822.00 | 54 | Yemane Birhan Arage | 5,000.00 |
| 21 | Hamsalu Wuleta and K/Tilahun | 3,458.00 | 55 | Girma Belhu | 3,000.00 |
| 22 | Ato Tdese Teshome | 10,561.00 | 56 | Biru Kiflu | 2,000.00 |
| 23 | Ato Belete Kasaye | 6,500.00 | 57 | Derege Negash | 2,500.00 |
| 24 | Ato Ayalew Dires | 3,214.10 | 58 | Beshada Shume | 4,302.00 |
| 25 | Ato Abebe Gebre | 3,096.00 | 59 | Kebede Beyene | 5,110.00 |
| 26 | W/ro Werknesh kebede | 1,573.00 | 60 | Negash Shume | 7,237.20 |
| 27 | Ato Gashaw Bogale | 2,078.00 | 61 | W/ro Almaz Getahun | 8,591.00 |
| 28 | Ato Alemu Bedane | 2,500.00 | 62 | Hayle Mariam Alemu | 3,214.00 |
| 29 | Ato H/Michael Dagne | 10,335.00 | 63 | Yalem Work H/Giworgis | 3,000.00 |
| 30 | Ato Selemeon G/Kidan | 6,155.89 | 64 | Genet Shume | 8,014.50 |
| 31 | Ato Niguse Balcha | 3,000.00 | 65 | Mekbib Mengesha | 2,288.00 |
| 32 | Ato Taye Abebaw | 1,508.00 | 66 | W/ro Meseret Kibru | 2,100.00 |
| 33 | Ato Tewedros Erke | 3,499.00 | 67 | Ato Alemayehu G/Mariam | 19,390.00 |
| 34 | Ato Getachew Balcha | 5,538.91 | | | |
| **Total Area 583,955.35** | | | | | |

**A4** Total area of land for quarries in Akaki Kality Sub-city [21]

| Akaki Kality Sub City | | | | | |
|---|---|---|---|---|---|
| **No.** | **Owner** | **Licenced Area (Sq.m)** | **No.** | **Owner** | **Licenced Area (Sq.m)** |
| 1 | Norinko Lalibela | 8,967.00 | 92 | Amera General Treading | 18,700.00 |
| 2 | Lalibela Engineering | 6,548.00 | 93 | Enyi Construction | 96,217.00 |
| 3 | Partenol Plc | 58,878.00 | 94 | Hercul Construction | 20,100.00 |
| 4 | Tahir Plc | 5,327.00 | 95 | Ato Araya Yehualashet | 105,730.00 |
| 5 | Ato Abate Gelan | 25,128.00 | 96 | Ato Niguse Mekonen | 7,712.00 |
| 6 | Sostu Wendimamachoch | 26,212.00 | 97 | Ato Daniel Admasu | 27,632.50 |
| 7 | Ato Meles Dilnesahu | 20,000.00 | 98 | Boren Realstet | 41,722.72 |
| 8 | G.l.G.Ha Plc | 42,839.00 | 99 | Ato Zewdu Wolde | 24,360.00 |
| 9 | A.L.Gu.D | 45,000.00 | 100 | A.A Roads Athority | 133,706.50 |
| 10 | Ato Meles Dilnesahu | 10,000.00 | 101 | Moreshi Plc. | 145,000.00 |
| 11 | Yamu Plc | 6,665.00 | 102 | Ahmed Yasin | 40,153.00 |
| 12 | Tesfaye Kebede,, | 5,280.00 | 103 | Ato Yemane Asfaw/ Yerer | 25,638.00 |
| 13 | Asnakew Zelelew | 2,000.00 | 104 | Andualem Yirdaw & his Family | 100,000.00 |
| 14 | W/ro Sitra Kemal | 6,723.00 | 105 | Ato Zerihun Marefia | 26,795.00 |
| 15 | Tibeb Construction | 12,900.00 | 106 | Ato Zenebe Asfaw | 33,858.32 |
| 16 | Negashi Aderna Adisu Wubishet | 8,348.58 | 107 | Nana Construction | 45,991.00 |
| 17 | Ato Samuel Tadese | 41,444.40 | 108 | Fikadu Bogale Aggregate Pro. | 10,000.00 |
| 18 | Ato Kebede Belema | 8,805.40 | 109 | Melkasheno Plc | 32,993.00 |

| | | | | | |
|---|---|---|---|---|---|
| 19 | Ato Wendesen Hailu | 21,215.34 | 110 | Ene Zewde Gebre | 3,219.63 |
| 20 | Ato Abiy Bisrat | 6,030.00 | 111 | Ato Abera Wube | 12,489.00 |
| 21 | Daniel G/Michael | 34,936.00 | 112 | Ene Weyzero Gete Alemu | 9,214.00 |
| 22 | Daniel G/Michael | 63,091.00 | 113 | Tadese Flate Plc | 36,059.00 |
| 23 | Kasa Getahun | 1,810.00 | 114 | Astucon.Plc | 15,560.00 |
| 24 | W/ro Masresha Tekola | 3,940.00 | 115 | Ato Boga Zerfu | 4,787.10 |
| 25 | Haile Juru | 12,369.50 | 116 | Voronica and Dedeli | 9,650.00 |
| 26 | Ato Teklebirhan Haron | 8,736.00 | 117 | Cor.Teshome Adnew & his Familu | 19,412.00 |
| 27 | Ato Abate Akalu | 5,000.00 | 118 | Mehamed Hagi Berhe | 91,768.00 |
| 28 | Ato Alemayehu Kentiba | 8,863.00 | 119 | Ato Meles Bisrat | 61,480.00 |
| 29 | Ato Dawit Hailemariam | 5,000.00 | 120 | Ato Meles Bisrat | 43,484.00 |
| 30 | Hywot Biloket Am.Hulegeb | 1,726.00 | 121 | Ato EmkidimAlem Tadese | 17,300.00 |
| 31 | Ababo Beera | 6,996.50 | 122 | Ethio Beton | 20,759.00 |
| 32 | Ato Lema Gima | 3,581.00 | 123 | Ato Geremew Azmach | 19,736.00 |
| 33 | Cement Products Enterprize | 11,159.00 | 124 | Haylemelekot Kasa/W/ro Zeyte/ | 16,896.00 |
| 34 | Se.De. Plc | 11,159.00 | 125 | Hagi Yimam Muzeyin | 27,207.00 |
| 35 | Bifa Roresa and Abebe Tekalign | 8,052.00 | 126 | Yechayna Longo Mila | 98,568.00 |
| 36 | Tulu Dimtu No.1 Red Ash | 17,525.00 | 127 | A.A Ho. Agency /Prefabricated/ | 112,881.50 |
| 37 | Tulu Dimtu Red Ash | 15,925.07 | 128 | Ato Tewedros Shiferaw | 60,895.00 |
| 38 | Addis Abeba Roads Athority | 3,300.00 | 129 | Shewit G/Agazi | 52,995.00 |
| 39 | W/ro Etabezahu | 5,068.00 | 130 | Ato Asefa Abebe | 18,109.00 |

| | | | | | |
|---|---|---|---|---|---|
| | Selemon | | | | |
| 40 | W/ro Tigist Mersha | 5,343.32 | 131 | Asefa Abebe and Tolere | 36,541.00 |
| 41 | Bifa Rorisa and Abebe Tekalign | 8,052.00 | 132 | Sana Agro Eng.Plc | 19,349.00 |
| 42 | Ene Addisu Tesfaye | 4,079.70 | 133 | Leaba TilesPlc | 82,135.00 |
| 43 | Ato Habib Sirage | 10,000.00 | 134 | Piramid Construction | 34,290.00 |
| 44 | Ato Meles Dilnesahu | 17,000.00 | 135 | Ato Said Husen/Demis Tila/ | 34,859.00 |
| 45 | Salo Giworgis Red Ash Ass. | 44,251.00 | 136 | Ato Nahusenay Getachew | 8,054.00 |
| 46 | Co.Mat.Mate. Producers | 39,234.00 | 137 | Ato Biruk Tamirat | 14,960.00 |
| 47 | B.H Trading | 53,340.00 | 138 | Ato Fikru Degene | 8,141.00 |
| 48 | B.H Trading | 26,032.00 | 139 | Ato Degene Egersa | 7,047.50 |
| 49 | Ato Addis Gelaw Blg. Cont. | 84,657.05 | 140 | Vera Enternational | 98,152.50 |
| 50 | Ato Hagi Yimam | 8,391.69 | 141 | Ene Ato Chala Tadese | 36,390.00 |
| 51 | Ato Hagi Yimam | 36,496.00 | 142 | Mamushet Alemu and Elyas | 9,092.90 |
| 52 | Ato Hagi Yimam | 13,566.50 | 143 | W/ro Seble Mamo | 59,364.00 |
| 53 | Ato Hagi Yimam | 27,207.00 | 144 | Ato Michael G/Mariam | 48,936.00 |
| 54 | Egel Conc. Aggregate Producers | 28,012.50 | 145 | W/ro Meaza Alemayehu | 39,549.00 |
| 55 | Ato Abdela Mehamed | 116,557.00 | 146 | Ato Seyfu Begashaw | 30,757.00 |
| 56 | Alfa Enternational | 69,628.00 | 147 | Ato Sirak Weldu | 30,377.00 |
| 57 | M.WAZ Plc | 99,600.00 | 148 | Ato Million Yitbarek | 42,877.00 |
| 58 | Berhe Hagos Plc | 85,098.50 | 149 | L.General Treading | 32,192.00 |
| 59 | Aklisiyana Arayana Nahusenay | 53,300.00 | 150 | Ato Habtamu Yitbarek | 84,226.00 |

| | | | | | |
|---|---|---|---|---|---|
| 60 | W/ro Mintiwab Abebe | 26,426.00 | 151 | W/ro Bihan Ahmed | 11,975.00 |
| 61 | Ato Bayisa Fufa | 68,854.00 | 152 | Jambo.Construction Plc | 5,340.00 |
| 62 | W/ro Mulumebet Getahun | 20,413.00 | 153 | G and T Plc | 27,283.00 |
| 63 | W/ro Rumiya Yesuf | 30,000.00 | 154 | Ato Biruk Zewdu | 21,666.00 |
| 64 | Gafat Plc. | 10,000.00 | 155 | Alek Terzzo Producer Plc | 9,220.00 |
| 65 | Ato Elyas Mehamed,, | 30,570.00 | 156 | Ato Daniel G/Michael | 18,000.00 |
| 66 | W/ro Sefina Ayenew Kase | 24,889.00 | 157 | W/ro Angatu Haile | 98,170.00 |
| 67 | Addis Precition | 38,435.00 | 158 | Ato Ermiyas | 2,453.00 |
| 68 | A.A Roads Athority | 22,935.26 | 159 | Milhab Plc | 55,533.50 |
| 69 | A.A Roads Athority | 4,594.50 | 160 | Ato Birhanu Hayle | 3,209.50 |
| 70 | A.A.CRBC | 22,935.26 | 161 | Ato Girma Gulma | 4,974.00 |
| 71 | A.A.CRBC | 13,566.50 | 162 | Ato DD Adamu | 5,786.00 |
| 72 | Ato Eyob Akber | 13,566.50 | 163 | Desta Gurmu and Abebe Mulugeta | 1,530.00 |
| 73 | B.H. Treading | 53,340.00 | 164 | Ato Adamu Bikila | 7,325.00 |
| 74 | W/ro Abebech | 14,000.00 | 165 | Ato Adamu Bikila | 3,381.00 |
| 75 | Fikadu Bogale Conc. Agg. Pro. | 18,779.68 | 166 | Mekonen Haylena Shimels Chala | 6,181.00 |
| 76 | Eniy contraction W/ro Tigist | 31,000.00 | 167 | Ato Zerihun Abebe | 4,286.00 |
| 77 | Ato Mekuriya Abebe | 28,000.00 | 168 | Ato Aklilu Zena | 2,275.00 |
| 78 | Ato Mekuriya Abebe | 8,000.00 | 169 | Ene M/A Wedago Bulti | 14,658.00 |
| 79 | Kabriyan Plc | 27,000.00 | 170 | Ato Kebede Belema | 4,691.00 |
| 80 | E.M. Treading Plc | 11,675.00 | 171 | Ato Jafar Kasim | 20,306.10 |
| 81 | Berta Construction | 53,640.00 | 172 | Ato Gafar Kasim | 49,033.50 |
| 82 | Ato Sileshi Aboye | 10,094.89 | 173 | Ato Jafar Kasim | 6,527.00 |

| | | | | | |
|---|---|---|---|---|---|
| 83 | Ato Girma Balesiyum | 15,729.00 | 174 | Ato Getachew Tekalgn | 14,662.00 |
| 84 | Nazcom Pl | 11,719.00 | 175 | Addis Tub Producing Plc . | 10,910.00 |
| 85 | Ato Asegid Getachew | 2,328.00 | 176 | Ato Alemu Mamo | 26,479.00 |
| 86 | W/ro Etemanch Hailu | 1,543.00 | 177 | Engineer Yewubdar Gebeyehu | 3,300.00 |
| 87 | W/ro Desita Gurmu and Abebe | 1,530.00 | 178 | Sira Behbret Red Ash Producers | 5,481.00 |
| 88 | Ato Demsis Wudmetas | 50,400.00 | 179 | W/ro Tsehay Sitotaw | 16,531.00 |
| 89 | Ato Million Temesgen | 21,706.50 | 180 | Edget Besira Red Ash Producers | 26,590.00 |
| 90 | Ato Million Temesgen | 7,050.00 | 181 | Ethio Beton Plc. | 12,593.00 |
| 91 | Ato Yilma Mulugeta | 37,132.00 | 182 | Wekil International | 31,780.00 |
| **Total Area 5,136,443.91** | | | | | |

## ANNEX B

**B1** Views of abandoned quarry site in and around Addis Ababa

**B2** Views of active quarry site in and around Addis Ababa

**B3** Views of explosive arrangement at quarry sites in and around Addis Ababa

**B4** Views of deforested quarry site in and around Addis Ababa

## ANNEX C

**C1** Questionnaire developed and data collected from the quarry site

| *No* | *Possible Negative Environmental Impact* | *Possible Mitigation Measures and Practices* | *Company Code* | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **M** | **N** | **O** | **P** | **Q** | **R** | **S** | **T** | **U** |
| **1** | **Noise and Vibration** | Earth mounds around the site | | X | | | | | | | | | | X | | | | X | X | | | | X |
| | | Housing of conveyers and belts | | | | | | | | | | | | | | | | | | | | | |
| | | Professional control of blasting | X | X | X | X | | | | | X | | | X | | X | X | | X | | | X | |
| | | Other | | | | | | | | | | | | | | | | | | | | | |
| **2** | **Dust Deposition/Air Quality** | Water spraying | X | | | | | | | | | | | X | | | X | | X | | X | | |
| | | Wheel washing of cars leaving the site | | | | | | | X | | | | | | | | | | | | | | |
| | | Mounds and plantations around the site | | X | X | X | | X | X | X | X | | | X | X | X | | X | X | | | | X |
| | | Other | | | | | | | | | | | | | | | | | | | | | |
| **3** | **Surface and Ground Water** | Surface and ground water base line test | | | | | | | | | | | | | | | | | | | | | |
| | | Making of hydrological tests while excavating below water table | | | | | | | | | | | | | | | | | | | | | |
| | | Rapidly vegetating areas to protect erosion | | | | | X | | | X | | | X | | | | | | | | | | |
| | | Provision of appropriate drainage system | | X | | X | | X | | | | | | | X | X | | | | | X | X | |
| | | Other | | | | | | | | | | | | | | | | | | | | | |
| **4** | **Landscape Impact** | landscape mounds constructed to screen unsightly excavation | | X | | | | | | | | | | X | | | | | | | | | |
| | | Planting of native species | | | | | | | X | | | X | | | | | | | | | | | |
| | | Removing of all accommodation (warehouse, internal roads etc...)after excavations | | X | X | X | | X | | X | | X | X | X | | | | | | | | | |
| | | Other | | | | | | | | | | | | | | | | | | | | | |
| **5** | **Traffic Impact** | Strengthening / widening of local roads | | | | | | | | | | | | | | | | | | | | | |
| | | Limiting high speed | | X | | | | | | | | | | X | X | X | X | | X | X | | | X |
| | | provision of foot path/pedestrian | X | | X | X | | | | | | | X | | | | | | | | | | |
| | | Other | | | | | | | | | | | | | | | | | | | | | |
| **6** | **Waste Management** | Re usage of unsuitable materials like clay, silt for other purpose | | X | | | X | | | | | | | X | | | | X | X | | | | |
| | | Collection of waste (batteries, metal chips etc)in appropriate way | X | X | X | X | | | | | | | X | | X | | | | X | X | X | X | X |
| | | Other | | | | | | | | | | | | | | | | | | | | | |
| **7** | **Natural Heritage** | Provision of ecological base line study | | | | | | | | | | | | | | | | | | | | | |
| | | Provision of buffer zone and protection of habitats | | | | | | | | | | | | | | | | | | | | | |
| | | Other | | | | | | | | | | | | | | | | | | | | | |

**ANNEX D**

**D1** Labor Cost Data Collected

| **Monthly Cost – ETB ( Salary)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Quarry Forman | Dozer Operator | Stationary Equipment Operator | Blasting Foreman | Labor | Loader Operator | Helper | Truck Driver |
| **Company Name** | **Phase-I & II** | **Phase-I** | **Phase-I & II** | **Phase-I** | **Phase-II** | **Phase-II & III** | **Phase-II** | **Phase-II** |
| Ato Daniel Admasu | 1,750.00 | 2,140.00 | 980.00 | 3,225.00 | 775.00 | 2,650.00 | 910.00 | 2,100.00 |
| Mendelo Aggregate and Cement Pro. PLC | 1,665.00 | 2,175.00 | 1,050.00 | 3,200.00 | 745.00 | 2,595.00 | 880.00 | 1,990.00 |
| Blue Nile | 1,560.00 | 2,100.00 | 1,135.00 | 3,100.00 | 780.00 | 2,620.00 | 970.00 | 1,895.00 |
| Midrock Plc | 1,840.00 | 2,240.00 | 1,160.00 | 3,000.00 | 850.00 | 2,580.00 | 980.00 | 2,175.00 |
| Awash Construction | 1,460.00 | 2,125.00 | 1,135.00 | 3,200.00 | 790.00 | 2,578.00 | 870.00 | 1,789.00 |
| W/ro Angatu PLC | 1,570.00 | | 970.00 | | 670.00 | 2,448.00 | 855.00 | 1,860.00 |
| SANA Aggro ENG.PLC | 1,650.00 | 2,215.00 | 1,150.00 | 3,100.00 | 790.00 | 2,360.00 | 880.00 | 1,935.00 |
| W/ro Meaza Alemayehu | 1,565.00 | | 1,040.00 | | 690.00 | 2,356.00 | 795.00 | 1,960.00 |
| A.A Roads Athority | 1,440.00 | 2,100.00 | 1,170.00 | 3,200.00 | 750.00 | 2,300.00 | 865.00 | 1,995.00 |
| Adugna Egigu | 1,560.00 | | 980.00 | | 735.00 | 2,260.00 | 815.00 | 1,786.00 |
| Homa Construction | 1,785.00 | 2,165.00 | 1,145.00 | 3,275.00 | 790.00 | 2,382.00 | 868.00 | 1,866.00 |
| I.K. General Treding | 1,790.00 | 2,150.00 | 1,180.00 | 3,100.00 | 810.00 | 2,345.00 | 863.00 | 2,095.00 |
| Bole Kotebe Con. Materials | 1,580.00 | 1,710.00 | 1,160.00 | 3,150.00 | 828.00 | 2,380.00 | 892.00 | 1,980.00 |
| Shbiru Tefera | 1,640.00 | | 1,160.00 | | 768.00 | 2,395.00 | 875.00 | 1,796.00 |
| B.H Trading | 1,784.00 | | 1,060.00 | 3,290.00 | 790.00 | 2,590.00 | 870.00 | 1,766.00 |
| A.L.Gu.D | 1,775.00 | | 1,125.00 | 3,176.00 | 773.00 | 2,585.00 | 892.00 | 1,988.00 |
| **Average** | **1,650.88** | **2,112.00** | **1,100.00** | **3,168.00** | **770.88** | **2,464.00** | **880.00** | **1,936.00** |

**D2** Equipment Cost Data Collected

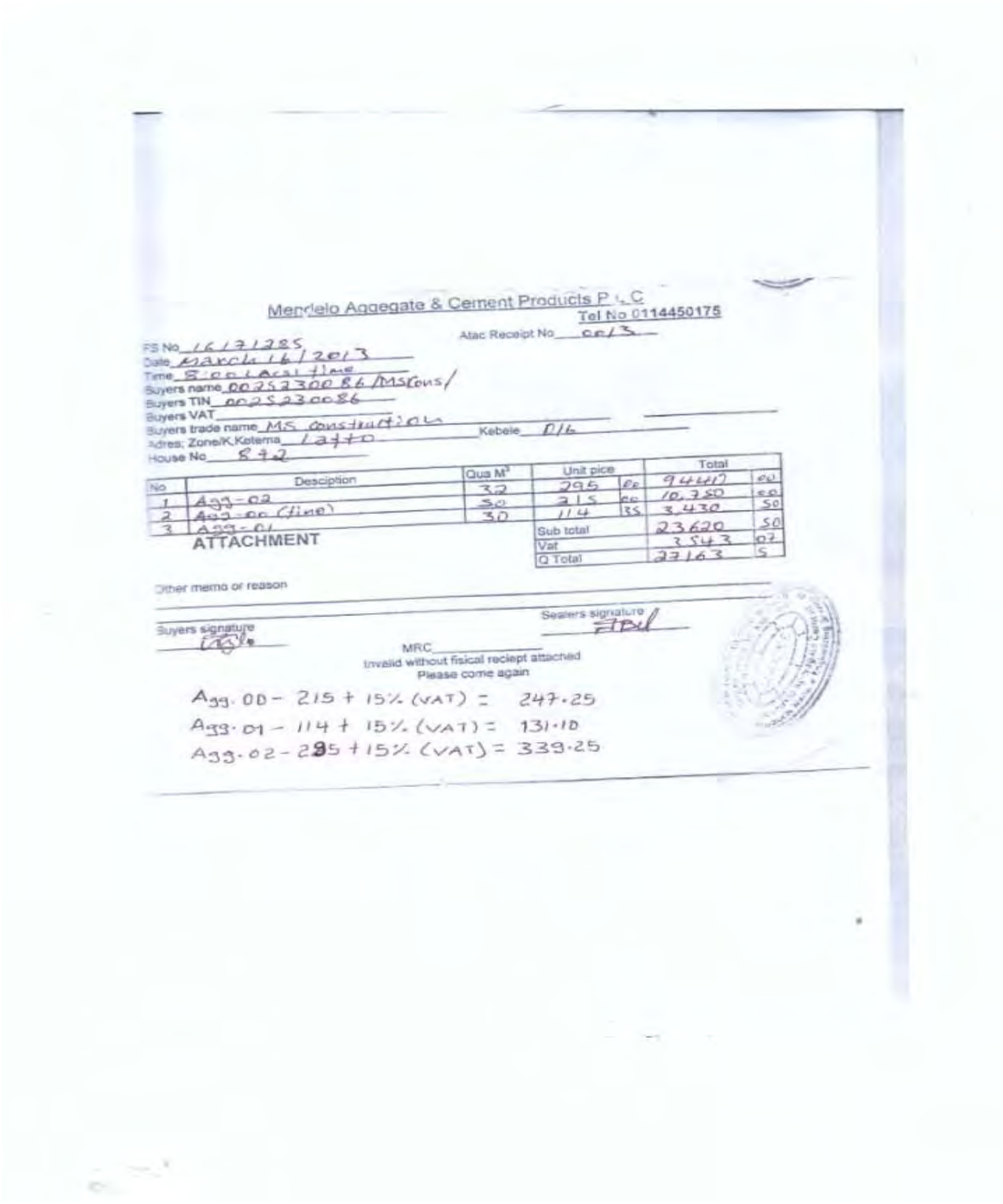
| **Indexed Hourly Cost - ETB** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Company Name** | Dozer (D8R) | Wagon Drill | Compressor | Jack Hammer | Hand Tools | Crusher Plant | Wheal Loader | Chain Loader | Dump Truck (14m3) |
| Ato Daniel Admasu | 1100.00 | 320.00 | 520.00 | 9.20 | 0.25 | 3,250.00 | 650.00 | 1,460.00 | 560.00 |
| Mendelo Aggregate and Cement Pro. PLC | 1090.00 | 325.00 | 490.00 | 8.80 | 0.25 | 3,260.00 | 640.00 | 1,520.00 | 570.00 |
| Blue Nile | 1075.00 | 310.00 | 480.00 | 9.30 | 0.30 | 3,150.00 | 600.00 | 1,400.00 | 615.00 |
| Midrock Plc | 1160.00 | 360.00 | 520.00 | 8.00 | 0.35 | 3,270.00 | 660.00 | 1,620.00 | 620.00 |
| Awash Construction | 1150.00 | 250.00 | 450.00 | 7.80 | 0.40 | 3,250.00 | 590.00 | 1,470.00 | 585.00 |
| W/ro Angatu PLC | | 280.00 | 435.00 | 6.50 | 0.40 | 2,840.00 | 530.00 | | 600.00 |
| SANA Aggro ENG.PLC | 1120.00 | 290.00 | 430.00 | 8.20 | 0.25 | 2,900.00 | 580.00 | 1,480.00 | 590.00 |
| W/ro Meaza Alemayehu | 1000.00 | 285.00 | 465.00 | 8.50 | 0.35 | 2,700.00 | 570.00 | | 560.00 |
| A.A Roads Athority | 1100.00 | 280.00 | 460.00 | 9.40 | 0.25 | 3,000.00 | 580.00 | 1,450.00 | 585.00 |
| Adugna Egigu | | 360.00 | 465.00 | 6.50 | 0.25 | 2,860.00 | 540.00 | | |
| Homa Construction | 1100.00 | 340.00 | 525.00 | 8.00 | 0.25 | 2,800.00 | 610.00 | 1,520.00 | 600.00 |
| I.K. General Treding | 1175.00 | 290.00 | 475.00 | 8.30 | 0.25 | 3,000.00 | 630.00 | 1,500.00 | 575.00 |
| Bole Kotebe Con. Materials | | 280.00 | 495.00 | 8.30 | 0.20 | 3,050.00 | 640.00 | 1,530.00 | 565.00 |
| Shbiru Tefera | 1070.00 | 260.00 | 495.00 | 7.65 | 0.35 | 2,700.00 | 560.00 | | 595.00 |
| B.H Trading | 1050.00 | 250.00 | 490.00 | 7.50 | 0.40 | 3,020.00 | 620.00 | 1,540.00 | 550.00 |
| A.L.Gu.D | 1110.00 | 320.00 | 485.00 | 7.65 | 0.35 | 2,950.00 | 600.00 | 1,510.00 | 630.00 |
| **Average** | **1100.00** | **300.00** | **480.00** | **8.10** | **0.30** | **3,000.00** | **600.00** | **1,500.00** | **550.00** |

**D3** Material Cost Data Collected

| **Unit Price -ETB** | | | |
|---|---|---|---|
| **Company Name** | **ANFO (Kg)** | **Detonator** | **Drill Bits_ Rods etc.** |
| Ato Daniel Admasu | 130.00 | 130.00 | 70.00 |
| Mendelo Aggregate and Cement Pro. PLC | 159.00 | 159.00 | 72.00 |
| Blue Nile | | | |
| Midrock Plc | 180.00 | 180.00 | 84.50 |
| Awash Construction | 172.00 | 178.00 | 66.00 |
| W/ro Angatu PLC | | | |
| SANA Aggro ENG.PLC | 147.00 | 147.00 | 52.00 |
| W/ro Meaza Alemayehu | 160.00 | 160.00 | 69.00 |
| A.A Roads Athority | | | |
| Adugna Egigu | | | |
| Homa Construction | 179.50 | 189.50 | 49.00 |
| I.K. General Treding | 155.00 | 155.50 | 42.50 |
| Bole Kotebe Con. Materials | 180.00 | 180.00 | 42.00 |
| Shbiru Tefera | | | |
| B.H Trading | 155.00 | 155.00 | 53.00 |
| A.L.Gu.D | 142.50 | 142.50 | 60.00 |
| **Average** | **160.00** | **161.50** | **60.00** |

## ANNEX E

**E1** Market Price of Aggregate



Mendelo Aggegate & Cement Products P L C
Tel No 0114450175

Atac Receipt No 003

FS No 16171285
Date March 16/2013
Time 8:00 Actual time
Buyers name 0025230086/MSCons/
Buyers TIN 0025230086
Buyers VAT
Buyers trade name MS construction
Adres: Zone/K.Ketema Latto Kebele 016
House No 842

| No | Desciption | Qua M³ | Unit pice | | Total | |
|---|---|---|---|---|---|---|
| 1 | A33-02 | 32 | 295 | 00 | 94417 | 00 |
| 2 | A33-00 (fine) | 50 | 215 | 00 | 10,750 | 00 |
| 3 | A33-01 | 30 | 114 | 35 | 3,430 | 50 |
| | ATTACHMENT | | Sub total | | 23620 | 50 |
| | | | Vat | | 3543 | 07 |
| | | | Q Total | | 27163 | 5 |

Other memo or reason

Buyers signature

Sellers signature

MRC
Invalid without fisical reciept attached
Please come again

A33.00 - 215 + 15% (VAT) = 247.25
A33.01 - 114 + 15% (VAT) = 131.10
A33.02 - 295 + 15% (VAT) = 339.25

## DECLARATION

I, the undersigned, declare that this thesis is my original and has not been presented for a degree in any other university, and that all sources of materials used for the thesis have been duly acknowledged.

| | |
|---|---|
| Name | Semere Mulatu |
| Signature | _____ |
| Place | Addis Ababa University,<br>Addis Ababa Institute of Technology |
| Date of submission | April 2013 |