



**MODELING BUSINESS OPERATION FOR STONE EXTRACTION WITH
DIAMOND WIRE TECHNOLOGY IN GHANA**

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<p>Abstract</p> <p>This thesis unveiled a state of the art technical model for stone mining with a business environment and financial analysis that will aid a successful transfer of the diamond wire technology in stone mining. The purpose of the project was to bridge the gap between Ghana stone mining industry with the use of traditional methods and the use of modern technologies in the developed world for economic growth.</p> <p>In Africa, mining and construction industry is at its slowest pace due to lack of developing sustainable technologies to revamp the industries in all business sectors to stimulate national economies. Ghana is endowed with significant deposits of natural stones that are extensively used for architectural purposes around the world but lack of state of the art technologies and methodologies are hindering this business potential to be realised.</p> <p>It is based on never ending situation of adhering to old traditional systems with no signs of recovery to bridge gaps to newer technologies glint the idea behind this research to transfer a modern technology used in mining stones from Finska Stenindustri AB (Suomen Kiviteollisuus Oy) in Finland. This project aims at modelling a business operation for the technological implementation in Ghana to meet the project goal.</p>			
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PREFACE

This research has been conducted in partial fulfilment of Bachelor of Engineering programme in Industrial Management at Savonia University of Applied Sciences, Finland. The research topic was chosen as a result of personal experience with the technology and a significant impact to the Ghanaian economy as assessed by the writer upon successful implementation.

The work has been carried out with the support of network of technical professionals in the field of using the technology in Finland, Norway, and South Africa under the supervision of Heikki Salkinoja with Jarmo Pyysalo. The contribution of the Ghana Ministry of Natural Resources, the Ghana Mineral Commissions and Ghana Investment Promotion Council was essential in meeting the goals of the research.

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Finally the warmest thanks go to my fiancée Ms. Raneiya Blake, Parents and family members for contributing to who I am today.

DEDICATION

This thesis is dedicated to my grandmother Suzanna Agyeiwaa Ayim, who has always been there to advice, support and informs me about the importance of education in my early childhood. May God give you long life. I love you grandma.

TABLE OF CONTENTS

1 INTRODUCTION	9
Background of the Project	9
1.2 Future contribution of mineral industry	10
1.3 Problem Statement	10
1.4 Aims and objectives	11
1.5 Research Method	12
1.6 Limitations	12
2 BACKGROUND OF GHANA.....	13
2.1 Overview of Ghana	13
2.2 Ghana as an Investment Destination.....	13
2.3 The Economy	14
2.4 Mineral map of Ghana	16
3 THE STONE MINING TECHNOLOGY	18
3.1 Exploration [Stone Deposits]	18
Province Scale – Area Selection.....	18
Regional Scale – Target Generation.....	18
3.2 Operational Planning	19
3.4 Project Progression	21
3.5 Stone mining techniques	22
3.6 Open - Pit Stone Mining	22
3.7 Underground Stone Mining	23
4 STONE MINING TECHNOLOGICAL PROCESS.....	25
4.1 Proposed Operational Model	25
4.2 Drilling.....	26
4.3 Mining machinery for extraction	27
5 DIAMOND WIRE MANAGEMENT	30
5.1 Fixing the diamond wire for extraction and trimming.....	33
5.2 Hydraulic hand press (Crimping Die Cramp).....	34
5.3 Water Supply System.....	35
Water Recovery	35
6 PUSH SLIDING TECHNIQUE	37
6.1 Standardizing the Block.....	38
6.2 Trimming Blocks	39
Solid Based Pull Back System.....	40
Solid Based Press-Down System.....	41
6.3 Quality Inspections	42
6.4 Transportation of Stone Blocks	42
7 MINING REGULATION AND PROGRAMS IN GHANA	44
7.1 Health and Mining Safety	46
7.2 Environmental Effects of Granite Mining	47
7.3 Entering Ghana mining Industry [The Market]	48
7.4 Project PEST Analysis.....	49
8 MANAGEMENT STRATEGIES.....	51
8.1 Mining Project Financing	51

8.2 Investing In Mining.....	51
8.3 Operations Management	53
8.4 Implementation Plan	54
8.5 Financial plan.....	56
9 FINANCIAL ANALYSIS	57
Project Finance.....	58
9.1 Return on Investment in Capital Assets.....	60
10 CONCLUSIONS.....	62
REFERENCES	63
APPENDIX 1.....	66
APPENDIX 2.....	66
APPENDIX 3.....	68

SYMBOLS AND ABBREVIATIONS

GoG	- Government of Ghana
GDP	- Gross Domestic Product
Know –How	- Professional Experience
MINCOM	- Minerals Commission
GSD	- Geological Survey Department
MLNR	- Ministry of Lands and natural Resources
PMMC	- Precious Minerals
sq	- Square
Mi	- Mile
EC	- European Commission
ERP	- Economic Recovery Programme
Fish trap	- a device in a shape in same way as a fish trap for tracking nylon
Air-pack	- Air seal used to separate the blocks
Water-pack	- Water seal use in separate the block
W τ	- Number of wire turns (clockwise or Anti-clockwise)
Max	-Maximum
L	- Length
GIPC	- Ghana Investment Promotion Council
PNDCL	- Provisional National Defense Council Law
3PL	- Third party logistics
SCR	- Strip Cut Ratio
Aggregate	- Is a mixture of collection of items to form an entity
Coarse	- The roughness or fineness state of particles
Moz	- Million ounces
Sub Chapter S Cooperation	- Business cooperation that meet set government regulations from cooperate tax exemption to shareholders taxation
COGS	- Cost of Goods Sold
PEST	-Political, Economical, Social and Technology
SWOT	-Strength, Weakness, Opportunities and Threats

1 INTRODUCTION

Background of the Project

The cutting edge of new technologies and innovations is ever changing communities and societies, the way people live their lives and how companies are doing business today. *Change* is the only constant faction in business models across the world in recent ages. The effect of *Change* which is transforming into modernization and innovation are expanding national economies faster than could be imagined in stimulating industrial growth.

In the twenty first century where technology is on its rising peak in economies like the America's, Europe and the emerging Asia, Africa is still suffering from modern technological drives lavishing in poverty in spite of its abundance natural resources. A situation which has called for Government of Ghana (GoG) to intervene by launching a new Industrial Policy aimed supporting new entrepreneurs and ensuring that local business can offer high competitive products, to be able to gain access to the global market.

The Government of Ghana (GoG) is on campaign seeking technological transfer in bilateral terms with developed nations and encouraging Ghanaians in Diaspora to return home with acquired knowledge (brain-gain) in setting up businesses to salvage the country's economy. It is upon this call that the country's third trade partner' Sweden, sent Dr. Ewa Bjorling, Trade Minister to Ghana to intensify and broaden bilateral trade relations between the two countries in Mining and Construction and other services.[1]

It is based on these positive indicators that the author has developed interest in converting an abandoned natural resource which is in abundance to money making business by transferring technologies used in extracting stones. It is not amusing to know in these technological ages that hammer and chisel held in hands are still used in some quarrying sites to extract stones. A similar method used by Russians in Finnish territories about a hundred years ago during the construction of St. Petersburg and some Russian state monument.

Stone is natural, stone is solid and stone is beautiful in modern finish. There are thousand types of stone around the globe that have been extracted today and over the centuries. Extraction sites popularly known to be "Quarry sites" are located all around the world. The

vast majority of these precious stones originate from Italy, Spain, Finland, Greece, France, Turkey, China, United States, Canada, Mexico, Taiwan, India and Brazil.

In applying new technologies to extract the commodity in Ghana, the West African nation in large quantities will be a major finding to add up the countries major export like gold, diamond, bauxite, cocoa, timber, nickel and petroleum. This will boost the economy and also create employment opportunities to address the increasing rate of unemployment situation in the county.

1.2 Future contribution of mineral industry

The expectation of the mining industry is high and even in difficult economics, the demand for mining products are still on appreciable level. With limited exceptions, there isn't any nation that can progress in prosperity without consistent level of supply to feed manufacturing companies. As a result of mining, nations are able to exchange products for money or other services for developmental projects and receiving nations are also supply industries for development. [2]

Scientifically proven data available now projects those mineral reserves that form the future of human race covering only 0.1% of continental areas and thereby placing greater emphasis on metallurgical and mining technologies for new discoveries to sustainable levels. The economical evolutions of societies will continue to rely on minerals in the creation of employment and national wealth. [3]

1.3 Problem Statement

The use of raw manpower is evolving in many sectors, especially the mining and construction industries in Ghana. Manpower use is becoming unpopular in the developed nations as industries starts to move into robotics and automation processes. This situation in Ghana undermines the welfare of the people, economic activities and the private sector which is supposed to be the backbone for engine growth. The Ghanaian laborer cannot afford to survive at the detriment of his/her health. While the developed nations are researching on

new ways to automate the fully mechanized systems and the processes to increase productivity, Africa still suffers with the use of raw manpower.

Inceptive measures and new technological methods need to be adopted to cater for the menace in such working conditions to bridge the gap between the Europeans, Americans and Asians. The use of Diamond Wire Technology in extracting stones when implemented will eliminate the use of chisel and hammer held in hand to extract stone. In the opinion of the writer of this thesis, the situation of raw manpower exists because of lack of technical know-how in the stone industry. However, larger majority of the businesses are centered on the major and well known commodities in Ghana.

1.4 Aims and objectives

The principal goal for this thesis project is to model a technical operation for stone extraction business with diamond wire technology in Ghana. This technological transfer will storm the Mining and Construction industry in the country and also add up to the country's gross domestic products (GDP).

Moreover the second aim is to address a management system and strategies to control the administration and operations of the extraction processes. The management will also reveal Government regulation policies, human resource factors and environmental issues.

Finally, a development of a financial plan will be incorporated for entrepreneurs and investors who wish to enter into this industrial sector of business to ascertain the return on investments.

1.5 Research Method

The research method used in congregating the information for this thesis includes a personal technical experience, stone extraction literature, magazines, and news, journals and user manuals. Finnish major player in the use of diamond wire for extraction were integrated in this project.

In order to get to the bottom of the for specific data from Ghana where this project will be implemented, the major stakeholders in Ghana and government agencies like the Traditional Authorities, Mineral Commission (MC), Geological Survey Department (GSD), Ministry of Lands and Natural Resources (MLNR), Precious Minerals Marketing Company (PMMC) and the Ghana Investment Promotion Council were all consulted to tailored this project to meet the mining regulation.

1.6 Limitations

The major issue that delimits this project is inadequate literature on diamond wire technology. The current location of the researcher will be a factor of hindrances with regards to Finnish language barrier since majority of the available literature are printed in Finnish. Again this is limited to distance since the researcher resides in Finland where this technology transfer originates to be implemented in Ghana.

2 BACKGROUND OF GHANA

This chapter will unveil the potentials of Ghana's background in brief about the economy, location, weather and the available natural resources to investors willing to enter Ghanaian mining sector to share the benefits that awaits them for their decision.

2.1 Overview of Ghana

Ghana, formally known to be Gold Coast when it was first discovered by the Portuguese in 15th century and later colonized by the British in 1874. It is located on the Gulf of Guinea with a small margin degrees north to the Equator. Ghana has considerably warm climate and spans in area of 238,500 km² (92,085 sq mi). Ghana is lower in land marks with exception of the eastern border where there range of hills, flat plains and rivers. Almost half of the country is 150 m – 883 m high above sea level whilst the coastal line is extremely low, sandy shore with plains and scrubs intersected by rivers and streams [4]

There are two main seasons cycle in Ghana as compared to the four seasons of the western world. Ghana has wet and dry season in a year cycle. The northern part experiences its rainy season from March to November whereas the Southern experiences the season April to Mid November.

Ghana is estimated in population of about 25 million people with over 100 ethnic groups. The country is fully embraced with multi-party democracy and has not seen the kind of conflict that has created a vast majority of the civil wars on the African continent. At least every Ghanaian speaks one local language. However, the official language in Ghana is English. [5]

2.2 Ghana as an Investment Destination

Ghana the West African sub-region nation and the Gateway to Africa on the continent as branded continues to be an enviable destination for investors in due to the political stability and the quest of embracing democracy. The country has achieved remarkable points in the development of the mining sector since the commencement of the Economic Recovery Programme (ERP) in 1984 and the continuous help of the European Commission (EC). After the inception of this programme several macroeconomic policies were initiated to revamp the sector to attract investment into the country. The key mining companies in operation now on

Ghana soil at the moment are AngloGold – [Gold], Gold Fields [Gold], Golden Star Resource [Gold], Newmont [Gold and Bauxite] Great Consolidate Diamond [Diamond] with other multinational companies like BHP-Billiton, Alcan, Rio Into and Alcoa seeking investment opportunities in the bauxite industry in Ghana Respectively.

The operations of mining and its products provide the largest foreign exchange revenue for the country with gold accounting for approximately 90 % shares of this revenue. The statistical data for gold production in 1984 was 282,229 ounces and 2.3 million ounces in 2004. In addition to gold as a natural resource, Ghana is endowed with other mineral deposits like precious stones and Granite which this thesis is emphasizing on to take advantage in converting the neglected commodity into a profitable venture.

The huge deposits of granite and the precious stone are in various types that can be exploited to produce high quality of floor tiles, monuments, ornamental objects when polished, pavements, kerbs, kitchen tops, road and building construction. As the world economic crisis begins to recover, the building industry will also revamp to takes its share in the world economy thereby raising the demand for precious stones and Granite.

2.3 The Economy

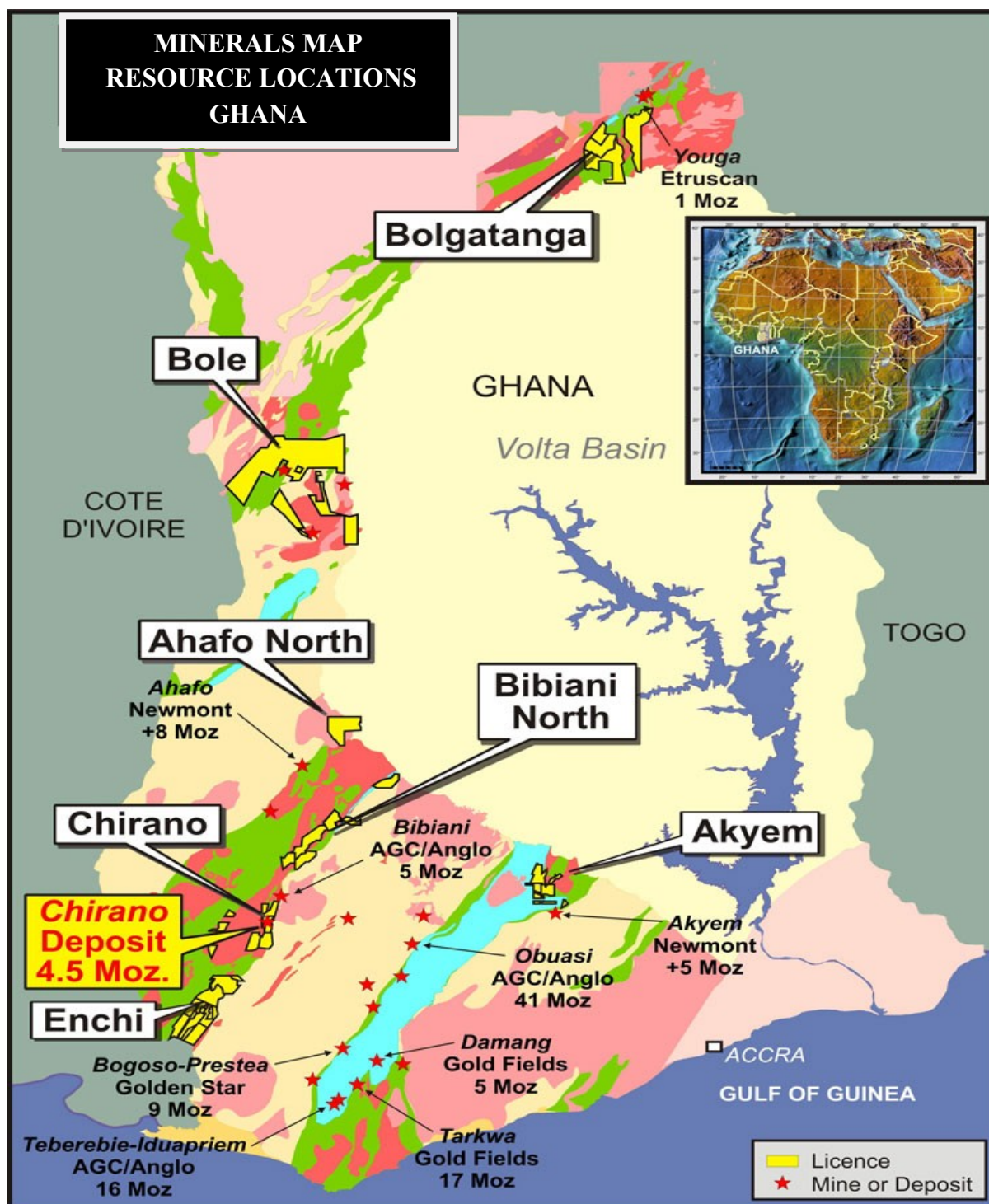
Ghana is considered to be a mixed economy nation driven by the public and private sectors. The total Gross Domestic Products (GDP) is dominated by agriculture (41 %), services industries [46 %] and mining [5 %]. About 46 % of total exports in Ghana are cocoa products and timber which employs 60 % of the countries labor force. Mineral resources exported to other countries are estimated to be 37 % out of total exports and gold exports accounting for over 90 % of the total mineral export. Inflation rate in Ghana fluctuates from 8 % to 25 % per annum.

The severity of Ghana economic decline in 1983 called on government intervention to Institute an Economic Recovery Plan (ERP) with the aim of deregulating prices in order to boost production in the country. This policy has been revised over the year to make it suitable and attractive for foreign direct investors. The government over the years has been focusing on designing new systems to promote the mining industry on a win-win situation in the fiscal regimes and laws.

There has been an explosive growth in the Mining Industry since 1986 through 1996 and 2005 with respect to production increase. This indication depicts the results achieved with the initiation of the Economic Recovery Plan (ERP). Stone production accounts less than one percent share of the growth in the industry in spite of the abundant availability of the natural resource. As greater outputs were achieved, Minerals Commission was set up to be an all in one investment package center for the mining industry. The complimentary investment climate created by the Government of Ghana (GoG) is raffled as fairly well known minerals endowment which has attracted over 150 local and foreign companies into minerals explorations in Ghana. It is by these positive indications that the author has developed a keen interest in modeling a business operation for stone extraction. [6]

2.4 Mineral map of Ghana

The map below depicts the mineral rich areas in Ghana certified by the mineral commission. Stone deposits across the nation differentiate from one region to the other. The northern part of the country has only one kind of rock whereas the southern part carries varieties of stone deposit.



Source: Ghana Minerals Commission

Figure 2.1 Ghana Mineral Maps

The table 2.1 below explains the various types of deposits available and documented. According Geological Survey Department (GSD) and the Mineral Commission of Ghana, there can be more types of deposits which are not known yet to the nation due to unavailable resources to cover all regions in Ghana for the purpose of exploration. The commission is still committed in exploring new area and seeking foreign direct investors with exploration potentials.

Table 2.1 *Types of Stone Deposits*

REGION	LIMESTONE DEPOSITS / OCCURENCES
NORTHERN	Buipe, Bongo-Da, Daboya
EASTERN	Oterkpolu, Anyabone, Dedeso, Asubone, Mem
WESTERN	Nauli
VOLTA	Fo River
ASHANTI	Ejura Scarp, Akubi
BRONG AHAFO	Kintampo, Prang
	DOLOMITE DEPOSIT
NORTHERN	Buipe, Baka
COMODITY	DEPOSIT
JASPER	Kwamekrom
GARNITEFEROUS GNEISS	Shai Hills
GRANITOIDS	Bongo, Tongo, Kongo, Shai Hills, Gomoa Nkroranza
SLATES	Achimota, Ayi Mensah Tarkwa,

Source: Ghana mining portal

3 THE STONE MINING TECHNOLOGY

In this chapter, the initial procedure of the Diamond wire technology as the extraction tool for the project will be explained. Mining a commodity like Stone is very technical and converting natural land states consist of numerous distinct procedures.

3.1 Exploration [Stone Deposits]

In writer's opinion, *Mining Exploration* can be defined as the investigation of plain land ascertains, the earth stratum. The purpose of this is to discover the resource, location and related data by geophysical data or remote sensing in estimating the extent of viable concentration of the stone deposit during feasibility studies. The data collected during exploration are used mathematically for the resource calculation to determine the size in deposits. Getting data in exploration stage before the commencement of the work gives a solid stance to determine the hypothetical economics of the stone deposits.

Exploration also aids as a risk determinant instrument to advice an investor with all indicators for the purpose of investment level. In most cases feasibility studies are done in conjunction the exploration. The exploration of mineral (stone) varies from one process to the other in context of its size in area, capacity and the obtained information. The process stage can be categorized into two scales. [7]

Province Scale – Area Selection

This process is critical in professional mineral (stone) exploration. The proper selection of the potential sample field and geological terrain will support in making the initiative in finding stone deposits as quickly and cheaply as possible.

Regional Scale – Target Generation

This process is done by investigating the geology via mapping; geophysics that is sophisticated geophysical testing of the surface and subsurface for the project. In certain cases, in place where topsoil has covered the stones, drilling will be executed directly as an instrument in generating targets.

3.2 Operational Planning

Success in any human endeavor has an attribute to planning. The mining industry and stone extraction business is not just smaller enterprise to overlook planning with respect to huge sums of capital investment. Planning is imperative to project management and time management techniques that serve as a framework to embody series of sequential activities in an orderly manner. Stone mining and its management have sequential processes and needs action steps to achieve main goals. Putting resources, processes and set-ups properly in the right way reduces much the necessary time and effort of achieving the company's strategic goal.

According to Pareto Law (80/20 Rule), it clearly establishes that for unstructured activities, roughly 80 percent of total effort gives less than 20 percent of the precious outcome. This in real life situation means that much time will be spent on deciding the subsequent activity after every task as a result of distorted mindset, non orderly arrangement of layouts, taking many redundant, distracted and inefficient measures. This in long term visionary undermines administration and productivity of total operations. [8]

The interpretation of Pareto Law shows how crucial planning is for organization in meeting the needs during each action step with respect to time, money and all available resources. When strategies and plans are set in place, it is very easy to predict or foresee possible bottlenecks which are likely to hinder laid down systems. As a rule of logic, it is easier to adjust plan to circumvent foreseen crisis, rather than to compact with the crisis when it bumps suddenly. [9]

In reference to Pareto Law as stated above to accommodate planning for the Stone extraction business, much emphasis has to be placed on the following factors:

- | | |
|----------------------------|----------------------|
| ▪ Administration | ▪ Road accessibility |
| ▪ Organizational Structure | ▪ Transportation |
| ▪ Factory Layout | ▪ Materials planning |
| ▪ Electricity | ▪ Human Resources |
| ▪ Water source | |

Infrastructure and the needed logistical systems have to be set in place for smooth operation. These factors concurrently inter-relate each other in the process chain. Thereby this calls for necessary consideration in eliminating possible bottlenecks without interrupting other activities. The plan is like a map. When guided by a plan you will always identify the extent of progress en route for project goal. Realizing status of project is essential for making good decisions on subsequent line of action. [10]

The location of infrastructure set-ups and layout mining industry has great economical impact on logistics, human ergonomics and capital investment. For example, access of water pipes, electricity, roads, services with long bridging distance will means huge cost to the investor and has to be plan in spacious area within the proximity of the site. Putting these measures in place for smooth operations has great capital investment benefits which are crucial to resource management, finance and the wellbeing of the engineers on site.

3.3 SWOT Analysis of the project

In every project or organization there are internal and external forces that affect its management. SWOT analysis is a planning tool that aims at evaluating project strength, weakness, opportunities and threats of a prospective project to abreast with situations that exist and may be encountered in its progress. The strength and weakness probe the internal capabilities of project performance while the opportunities and the threats probe the external factors that will affect the project operations.

The internal factors pertains issues such as experience, resources, customer service, infrastructure, efficiency, originality, quality and competitive advantage. The external forces factors are centered at business alliances, services, divestiture, government policies, industrial image, employment and technology.

Reflecting the SWOT analysis, representing business environment with Ghana as a target destination, each sector under the analysis has its own challenges and success. The following chart signifies the summary of the project plan SWOT analysis:

SWOT ANALYSIS	
STRENGTHS	WEAKNESSES
<ul style="list-style-type: none"> - Modern technology application - Profitable business - Stable political system in Ghana - Adequate infrastructure - Mining industry with proven records - Enabling environment - Direct access to university of mines experienced graduates -Diversified products to local market - No competition in Ghana stone mining sector 	<ul style="list-style-type: none"> - Ghana mining sector is over regulated - Inadequate infrastructure in the northern region - Limited access to capital - Inexperienced stone miners - Foreign manufactures are threat to local suppliers
OPPORTUNITIES	THREATS
<ul style="list-style-type: none"> -Diversification of Ghana's mineral resource -Market leader project -Flexible terms and conditions from regulators -3 years tax waive in free zones -Increase investment and innovations -New export and foreign exchange -Technology consultancy -Duty free on imported equipment 	<ul style="list-style-type: none"> - Technology leakage - Foreign investors may flood the market - Global competition - Slow land acquisition process - Heavy tax, royalties and compensations may discourage investment - Licenses and permits complexity - Severe environmental protection laws - Foreign sales raise red flags about purchasing power abuse -Lack of well trained stone engineers

Figure 3.1 *SWOT Analysis*

3.4 Project Progression

Careful consideration of the situation analysis that embodies findings from SWOT and PEST is essential to the success of the project. The feasibility of the project as analysed in the in above and PEST planning tools demonstrate the strength and bottleneck of the project that need sound strategy for progress. The government of Ghana through its agencies has committed policies and programs to help investors.

The uncovered issues as analysed in the planning tools demand effective utilizations and approach for the development of stone mining business to create opportunities for mining sector diversification.

3.5 Stone mining techniques

There are several techniques widely adopted in worldwide in the mining industry for mining practices. In order to apply the diamond wire technology in extracting stone, there are two categories.

- Open - Pit Mining
- Underground Mining

3.6 Open - Pit Stone Mining

This is a form of mining whereby the topsoil is been uncovered to expose the stone deposits for extraction from the earth. In certain cases the stone deposits are exposed and removal of topsoil becomes inapplicable. This technique in mining is also known as the Open Cast mining. This method of extracting is used basically in mining mineral deposits in commercial quantities when found exposed.

This method of mining is commonly used around the globe; about 85% of mineral extraction processes in the United States are clench to the use of this system [11]. The minerals are excavated from the surface deep down the earth by adopting a strategic plan. This system can engage the restructuring of the earth after extracting the stones to a depth as much as 1000 ft below ground level. [12]

To succeed in open - pit system of mining the site is normally evaluated by consigning the deposits into adequately large geometric blocks. Applying the right sequential methodologies of diamond wire technological system in the extraction is followed to achieve the overall pit limits and the gross sequence of exploitation.

The economic calculation of the maximum allowable “Strip Cut Ratio” (SCR) is used to determine the pit limit. In establishing the ratio solely by economics it declares the critical boundary of the pit in the existence breakeven that is when the profit margin becomes zero. Scientifically resolving [13]:

$$\text{Strip Cut Ratio (Max)} = \frac{\text{Value of Stone Deposit} - \text{Production Cost}}{\text{Strip Cut}} \quad (1)$$



Figure 3.2 Open Pit Mining [14]

This system applied when stone or mineral are exposed on the mountain or on a slope side of mountain. It makes it easier and cheaper to mine

3.7 Underground Stone Mining

Underground mining is process of mining precious minerals deeply below ground level. Stone and any other mineral can be buried deeply below ground level thereby making the application of open- pit or open cast mining impossible or uneconomical to apply. This system of mining is technical in nature and requires experience and planning for a successful operation. There is greater risk in underground mining as compared to open pit mining.

To facilitate the stone extraction from the underground, the operations are planned with a large underground room to work in. In carrying out this the best feasibility has to be done and measures put in place to prevent possible collapse. In carrying this out, the applicable

company or project manager has to adopt the preeminent realistic system to get the minerals extracted out. Continuous mining mechanism can be useful in extracting the stone with diamond wire technology. The application of continuous mining system reduces explosives, blasting, drilling and utilizes fewer workforces down in the mine. It is safer to ply this system with the diamond wire technology. [15]

Continuous mining technicians operate in a room and mining pillar system underground with the pillars supported by 6ft long steel bolt inserted in the roof and brace the pillar. Although very secure and acceptable safely method, underground mining sill posses risk to mining technicians. Today robotic continuous miners are now being innovated to automate the process of underground mining operations. Advanced intelligent system machines, computers and sensors that will reveal all operations and positions of all items with cameras and controlled system will be used in the future. A robotic miner will have a navigation system that can be controlled and monitored from earth surface. These will be emerging technologies in the next few years to take the mining industry. [16]

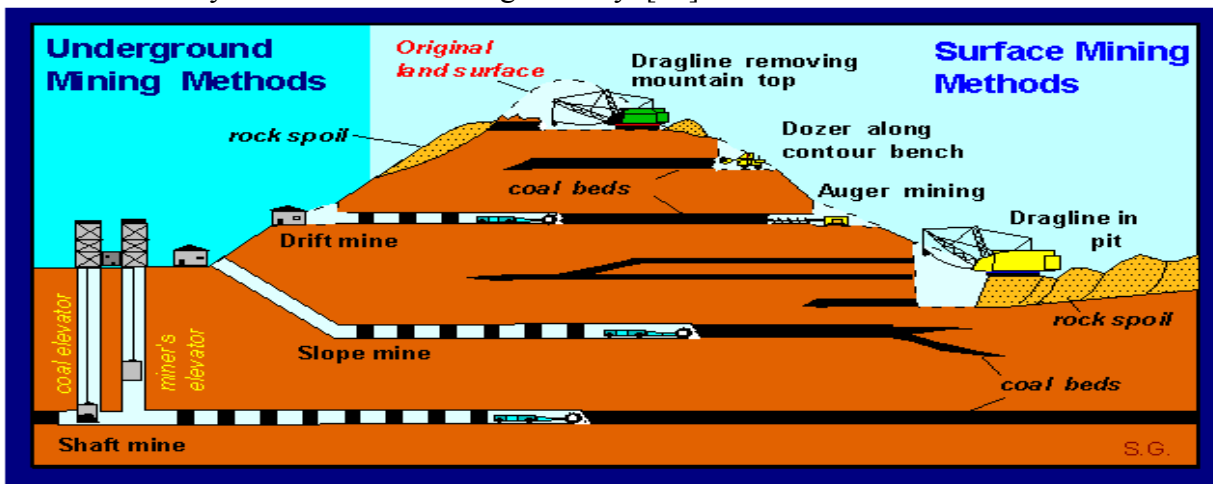


Figure 3.3 Underground and surface mining method [17]



Figure 3.4 Underground mining

Source: Google Images

4 STONE MINING TECHNOLOGICAL PROCESS

This section will unveil the process, technology and the principal focus within the model that has been developed for the benefit of this research work to meet its intended goals. This will include the graphical diagram representations of the proposed model with key elements to meet the demands at all levels.

4.1 Proposed Operational Model

The model below shows the technical operational procedures for site preparation to the final stone blocks. The mining process developed to facilitate project model goes through five stages namely: drilling, sawing, blocking, recycling and the finished product. Colors used in the models are for simplicity and stages differentiation.

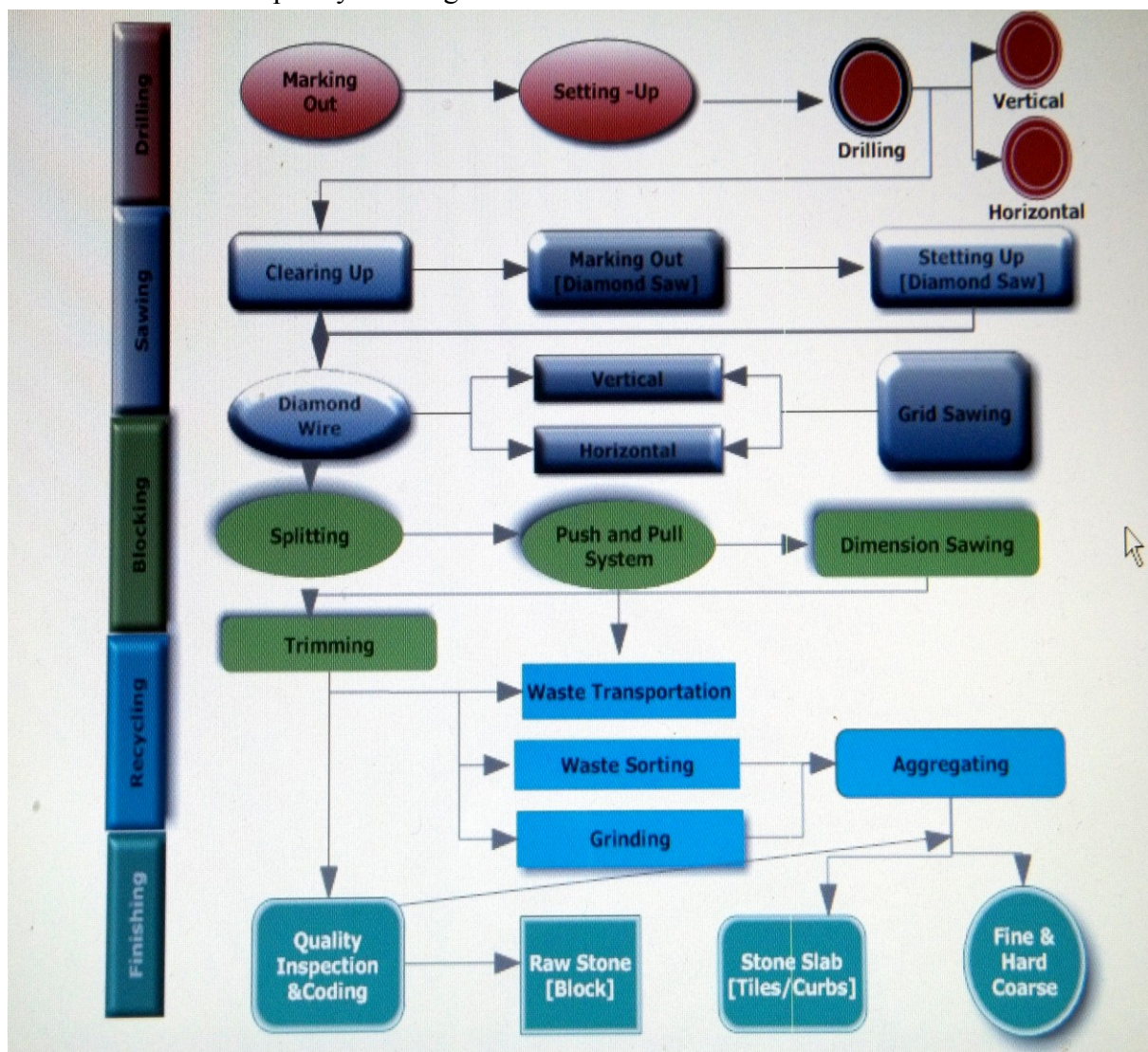


Figure 4.1 Operational Model

4.2 Drilling

Drilling is the process of creating hole in an object. To be able to achieve the diamond wire sawing for stone extraction drilling is the first most important activity to be carried out. The size of the hole varies from 80 mm to 120 mm depending on the bit to facilitate in making the holes with a drill rig. The process of extracting the stone demands both horizontal and vertical drilling holes concurrently to accommodate the diamond wire. The concurrent nature of holes makes it very technical and difficult. It is therefore imperatively impossible to get the horizontal and the vertical hole joins together without proper setting out with technical experience.

There are several drilling rigs and setting up instruments available on the market that can serve the purpose of drilling and the drill rig setup. In the writer's opinion, the profound advanced technological equipment that has been tested and known by the front liners in the industry endorses ATLAS COPCO 'ROC D65 SmartRig' also known as THE BEAST. The equipment has high standard of durability, flexibility and multi-functioning features which allow some other task to be carried out simultaneously to drilling. The impressive SmartRig D65 is known to be an 'eye opener'. It can drill holes of up 50 mm to 400 mm/16 inches in diameter. [18]

According to Dustin Penn, product line manager for blast-hole drills at 2008 MINExpo in Las Vegas, the reliability of the equipment makes it possible to maximize productivity and minimize non-drilling time while affecting fuel consumption and proving maintainability of the machine. [19]

The rig transportation is easy and setup with portable TREMBLE HV401 instrument is faster and accurate. The system accommodates single pass production drilling and it is safest and easiest way to pressure the class of the machine. Technically a drilling machine embodies air compressors which consume 30% of the rated in standby mode. Dustin Penn recommends the physical disconnection of the clutch in the air compressor from the engine in order to save horse power when changing drilling rods in standby mode.

The proper implementation of this plan affects the high cost benefit in the drilling operation and in turn increases the productivity and the performance of ROC D65. This has an exceptional run compared to other drilling rig in terms of availability, maintainability and

high performance which is very advantageous in the competitive drilling market of the stone extraction. The picture below depict a pictorial view of a stones in the earth stratum with drilled holes to carry diamond wire

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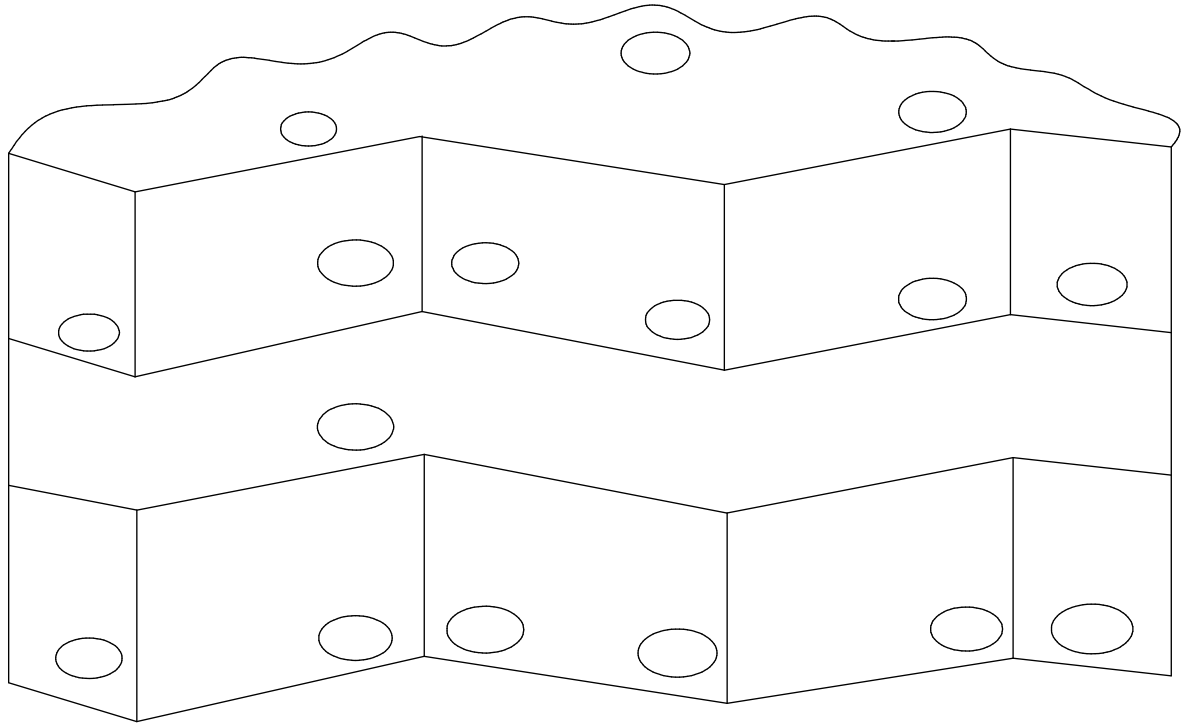


Figure 4.2 *Drilling Technique*

4.3 Mining machinery for extraction

The mining of hard and soft rocks such as granite, limestone and marble require the use of heavy-duty equipments in carrying out operations. Throughout the operations of excavating to the final packing of the stone blocks demand the use of machinery that are durable, reliable, flexible and maintainable to facilitate the mining process.

In compliance to meet the objectives of the research, there was a need to analyze the required work and the type of machinery that will be essential in carrying out the work. The main equipments that facilitate the diamond wire technology by driving production are shown below.



Volvo L350F Wheel loader



Atlas Copco ROC D9 Drill Rig



Benetti VIP 910 Diamond Wiresaw



Tamrock DQ 440 Trimmer



Cummings Power Plant

Figure 4.3 Mining machinery

Volvo L350F Wheel Loader: The Volvo L350 loader is a heavy duty machine that will be used for lifting raw stone blocks and the crushed stones from the quarry fields. It has flexibility of switching the wheel loader to a fork loader thereby assisting production for profitability. [20]

Atlas Copco ROC D9 Drill Rig: The ROC D9 is a powerful rock drill introduced Atlas to aid the mining industry for drilling hard stones. The drill rig has the ability to drill holes from 76- 115 mm which meet the required holes' needs to accommodate the diamond wire for the granite extraction. [21]

Tamrock DQ 440 Trimmer: The DQ 440 trimmer Tamrock is a product of Sandvik for increase productivity in splitting and trimming of dimensional stone quarry. It has the capability of drilling vertical and horizontal holes of up to 4600 mm. [22]

Benetti VIP 910 Wiresaw: The VIP 910 is an electronic diamond wire saw design by Benetti machines to facilitate the diamond wire technology emerged for stone extraction. The system works automatically by means of automatic inverter or super-card that allows the accurate management of the cutting the stone while travelling on the rail. [23]

Cummings Power Plant: An integrated power generation system which has the best design solution capable of distributing wide range power with high performance.

5 DIAMOND WIRE MANAGEMENT

The diamond wire used in the stone extraction industry is a modern technological development in recent years to eliminate physical manpower use. It is easy and fastest technological advancement for extracting and cutting stone. The wire consists of in-core cable with diamond beads centered at 20 mm - 25 mm with rubber fitted between gaps of the diamond beads.



Figure 5.1 Diamond Wire [24]

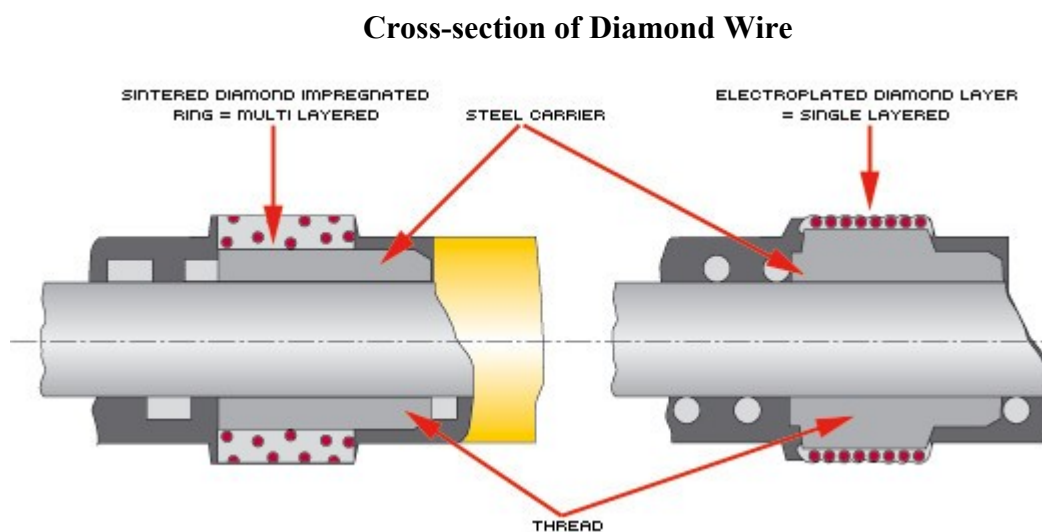


Figure 5.2 Cross-section of Diamond wire [25]

Diamonds are hard metals and their incorporation in the beads extensively makes them tougher to withstand the stresses in stones during extraction. It can be used to extract granite, marbles, limestone and other related quarrying stones. The diameter of the diamond wire ranges from 8,5 mm -12 mm. The indigenoucity of diamond in the wire makes it fairly expensive and all necessary precautions need to be followed for protection.

During extraction or trimming of the stone operations with the diamond wire needs adequate amount of water to stimulate and cool down the wire. When the wire is in operation it generates too much heat due to friction therefore every effort has to be made to maintain the life span of the wire. In every one meter long wire there are approximately 40 pieces of diamond beads. To maximize the life span of the wire, it has to be turned either clockwise or anti-clockwise direction such that the wire will rotate 360 degrees in every one meter length at 46 meters per second speed.

The above reengineering process has to be adopted to maximize the operational period of the wire to achieve greater returns on investment. When the wire is in operation it needs about 18-25 liter of water per minute to stimulate the total length of wire. The formula below can be used to determine the number wire turns ($W\tau$).

$$W\tau = L/2 + L \quad (2)$$

Where: $W\tau$ = Number of wire turns
 L = Total Length of wire

The table below shows researched values that increase the wire span for optimum production.

Table 5.1 *Production setting for Diamond wire plant.*

Bench height	Pull Set Value	Corner Saw	Wire Speed
(m)	(cm)	(min)	(m/s)
4	3	20	40
5	4	40	40
6	5	50	40
7	6	60	36
8	7	70	34
9	8	80	32
10	9	90	30
11	10	100	27
12	10	110	27
13	10	120	27
14	10	130	27
15	10	135	27
16	10	140	27

Table 5.2 *Extraction control limits for diamond wire plant.*

Wire Speed	Pull Limit	Pull Value	Comment
(m/s)	(cm/min)	(cm/hour)	(end results)
26-28	2.00	120	Safe
28-30	2.50	150	Safe
30-32	3.00	180	Safe
34-36	3.33	200	Safe
36-38	4.00	240	Almost Dangerous
36-40	5.00	300	Very Dangerous

During the wire sawing the observed in Table 5.2 will cut safely when the pull limit is between 2 - 3.33 cm/min but will start to be dangerous when set between 4 – 5 cm/min. When machine runs in dangerous states, the properties of the wire will damage to shorten its life span.

5.1 Fixing the diamond wire for extraction and trimming

The method involved in fixing the wire is a re-engineering process adopted placing the diamond wire in the drilled holes. There is no definite way of putting the wire through the drilled holes; however, the researched process outline in this project works with limited stress and reducing frustrations. When holes are drilled properly to meet targets it becomes easier to put the wire through.

In most cases, methods used in fixing the wire in vertical main cuts cannot be applied in horizontal main cut. To facilitate the wire fixing the following researched procedures and principles have to be adopted to shorten the process for fixing the wire for vertical and horizontal main cuts.

Vertical Main Cut

Attach a 20 g weight of mass to a string (nylon) with a loop trap.

Drop down the weight with the loop trap in the vertical hole.

Insert a flexible stick with fish trap to far end of the corresponding horizontal hole.

Rotate the stick until it traps the nylon loop trap.

Pull the nylon out carefully.

Connect the nylon with a hard flexible metal cable and pull the whole length of nylon out.

Connect the diamond wire to the cable and pull it through to get all the cable out.

Connect both ends of diamond wire and fix to the pulley plant.

Horizontal Main Cut

Attach a weightless ball to a string (nylon).

Insert the weightless ball into the horizontal hole.

Trap the connected ball to the string (nylon) at one end of the horizontal hole.

Push the ball with pressurized air or water from a source whilst releasing the nylon until ball gets out from other end.

In case of difficulties, insert a flexible stick with fish trap.

Rotate the stick until it traps the nylon loop trap.

Pull the nylon out carefully.

Connect the nylon with a hard flexible metal cable and pull the whole length of nylon out.

Connect the diamond wire to the cable and pull it through to get all the cable out.

Connect both ends of diamond wire and fix to the pulley plant.

5.2 Hydraulic hand press (Crimping Die Cramp)

Hydraulic hand press, also known as crimping die cramp, is the tool exclusively used in joining the diamonds wire together by fastening the connector. After fixing the required length of the wire through the holes, the crimping die device is used to make join the wire before being connected to the diamond wire pulley plant. The mounting and assembly of the all components with the device with the aid of the crimping die has to be done by a competent operator of at least 16 years of age. The cramp is designed manually or electronically to consisting of cramping dies in different shapes and sizes to crimp the connectors. Crimping die adapters shapes comes in the form of polygonal shapes. It is recommended to use hexagon die in the diamond wire connection for stone extraction. The table below gives detailed information on the crimping die tool and the necessary technical data to be followed for setup of the diamond wire.

Table 5.3 Hexagonal Crimping Die for Al, Cu and Steel

Description	Code	Width	Crimp Range(Cu)		Crimp Range(Al)		Crimp	
			Non-	Full	Non	Full	Al-	St-
MK 5-45	5	5	6	6				16/2.5
MK 6-45	6	5	10					50/8
MK 7-45	7	5						
MK 8-45	8	5	16	10-16				70/12
MK 9-45	9	5						
MK 10-45	10	5	25	25				
“10B-45	10	7			10	10		
“12-45	12	5	35	35				
“12B-45	12	7			16-25	16-25		
“14-45	14	5	50	50				
“14B-45	14	7			35	35	35/6	
“16-45	16	5	70	70				
“18-45	16	7			50	50	50/8	
“18B-45	18	5	95					
“20-45	18	7			70	70	70/12	
“20B-45	20	5	120	95				
“22B-45	22	7			95-120	95	95/15	

5.3 Water Supply System

Production of stone blocks with diamond wire technology relies heavily on water from a reliable source to facilitate the sawing. Without any water source, it is virtually impossible to operate the diamond wire system in facilitating the extraction of stones for reasons. Water in the diamond wire technology serves as coolants for the diamond wire and reduces friction when in operation. The management of water has greater significance for the life span of the diamond wire. Below is a figure describing the effect water has on the wire.

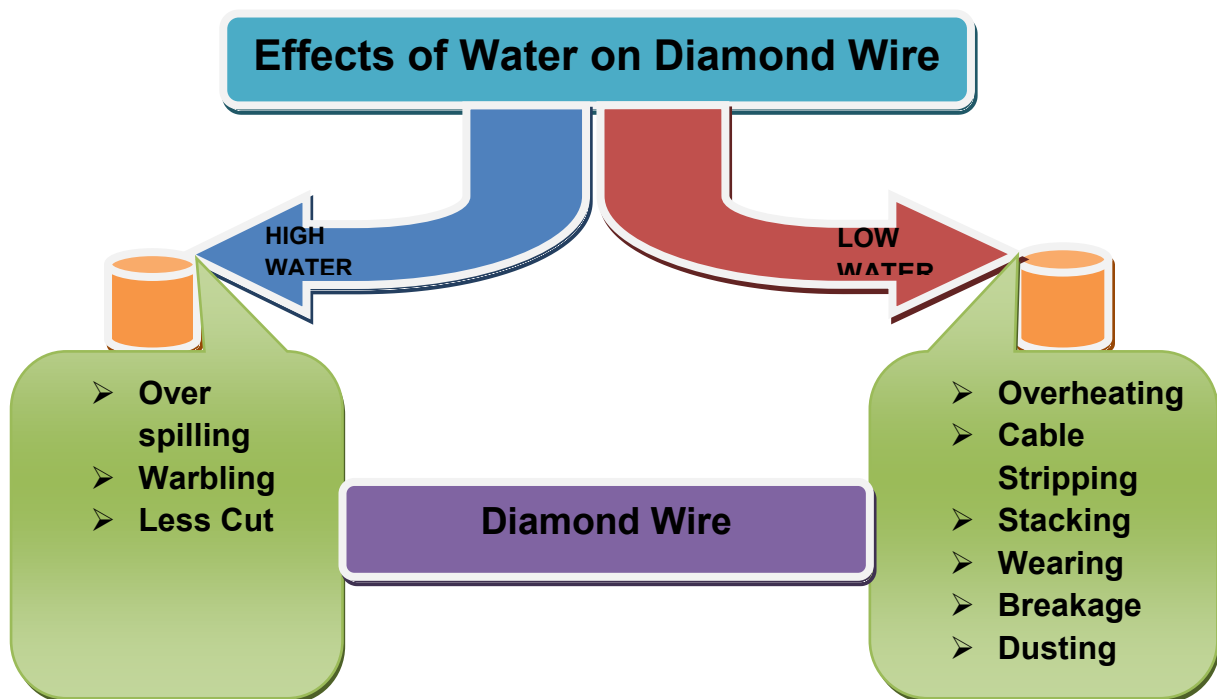


Figure 5.3 Effects of water on the diamond wire

In principle, it pays better off to have circulation of water in excess while in operation than in minimal. There are two ways to source water for diamond wire technology operation namely, surface water recovery plant and deep bore-hole water.

Water Recovery

The use of water is extensive in the process of mining stones with the application of diamond wire technology. As the process evolves, used water from the mining process in common principle runs to lower levels which has the tendency of joining lakes, streams, rivers or sea that is of use to human.

The effects of used water from the mine stones can threaten the health of human and living organism in such medium of water. When such a situation happens it can damage the reputation of company because it violates Ghana's environmental protection law.

The need to recover used water spilling into water bodies arises in order to curb any situation violating international environmental laws which has severe consequences on business operation from government authorities. This sometimes can lead to a closure. The water recovery could be done by directing spilled water to an open or closed well on site.

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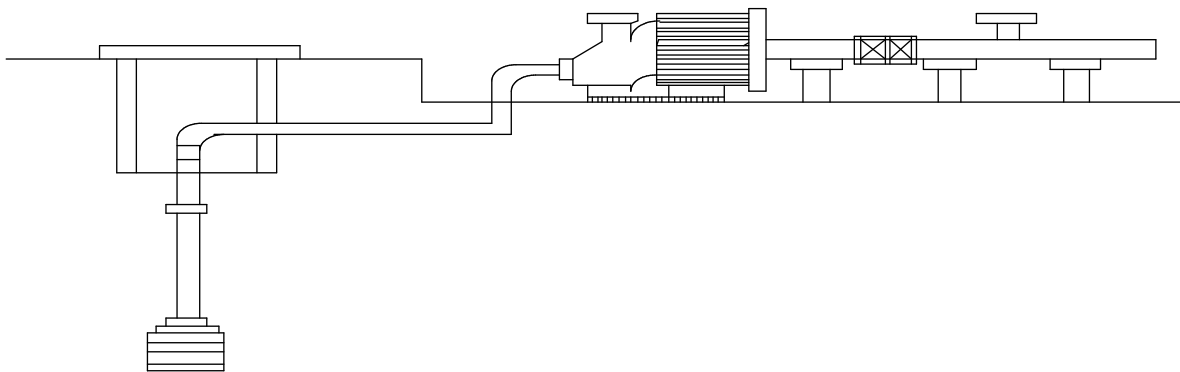


Figure 5.4 *Water supply System*

6 PUSH SLIDING TECHNIQUE

This is a system adopted from the traditional mechanized method. After big cuts (horizontal and vertical) the whole unit is divided into various slabs. The system is aimed at getting a unit of slab down is what has been defined as the push and pull system. The name is derived from how the process is done. Getting the slab down can be achieved by using an air-pack or water-pack in combination of hard metal pack to separate and slide down the slab. Both systems are almost same in application but the only difference between them is that water pack is made from thin metal sheets whereas air pack is made from plastic. The pack is inserted into the hole created by the diamond wire during sawing of the stone usually 0.2 mm- 12 mm. Then pressurized water from pump or pressurized air from air compressor is connected to water packs and air-packs respectively depending on which system is used. It is preferably suitable to use water pack in situations whereby the hole created by the diamond wire is between 5 mm – 10 mm. The needed pressurized air or water to slide down a unit of slab depends on the size and the height of the slab.

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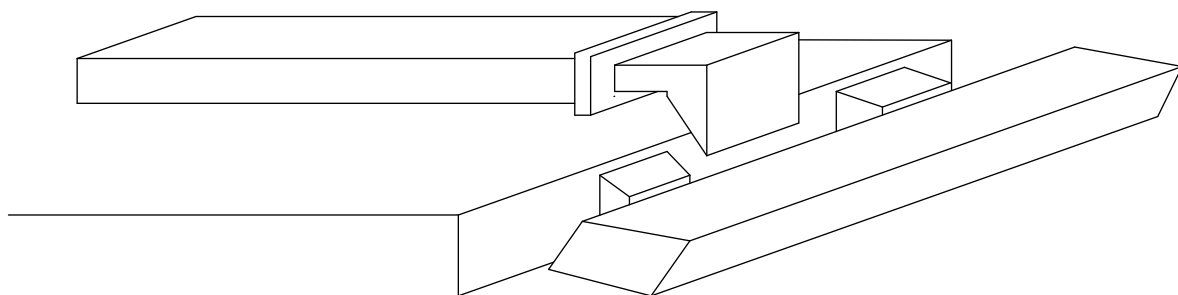


Figure 6.1 Sliding techniques (a)



Figure 6.1 Sliding techniques (b)

Based on the size of the slab the required force is calculated to be exerted with VOLVO DL5. In pushing down the stone slab the machine used to generate the 250 kN magnitude of force is aid of VOLVO DL5. It has large horse power which is able to generate the needed amount of force. While the Air or water pack is used to backup the pack whilst a similar force of VOLVO DL5 is connected to a chain to the slab at the opposite end to pull the unit down.

6.1 Standardizing the Block

After a slab of stone slided down, standardizing the block to suite the final customer or order specification is next in the process chain. The block is divided into marketable sizes by drilling out in square shape as well as possible. TAMROC QUARRYLING L8 is recommended to be used for this purpose due to its durability and flexibility. Shaping the block to marketable sizes needs vast years of technical experience. At that stage all possible cracks and non uniform colours of identified from the block has to be drilled out of the marketable block. This is in with quality checks on all products to be shipped to the customer. In standardizing the block, certain factors has to be taken into consideration

- Physical size
- Transportation regulation
- Shipping conformity
- Colour uniformity
- Defects
- Order specification
- Logistical cost
- Overall Quality

Physical Size

The block has to be physically accurate and attractive to meet the customer's needs and specification

Transportation Regulation

The look of the block has to meet the local and government set regulation for transportation.

Shipping Conformity

Raw blocks must conform to shipping rule to make it possible for loading and on loading in transit port and also meet the international shipping regulation.

Colour Uniformity

The stone structure develops certain colours which must be treated as defect by eliminating all those part off from the marketable products to meet quality standards.

Defects

A defect that may be identified on the stone slab is natural and cannot be prevented. Of course some may be artificial like for example a crack which may have been caused during push and pull system or the intensity of colliding on the ground. In this case all effort has to be done to prevent this and defected parts should be drilled off completely

Order Specification

In rare cases a customer may customize raw blocks to suit business needs and a situation like this demands that the technicians drill the blocks.

6.2 Trimming Blocks

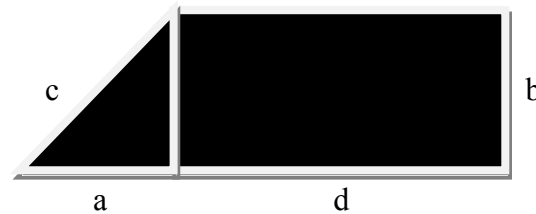
The final product and the physical outlook of raw block are affected by international standard requirements as well selling price. This is because bad outlook of the block unfold uncertainties and doubt about possible defects and cracks which are unforeseen to the customer. Concern for this situation has halted major industry players to seek new ways to develop systems to trim the blocks with diamond wire in order to get the required value of products.

Using the diamond wire and the plant require same processes like horizontal and vertical big cuts but with different systems which are applicable. There is no definite system as yet for this purpose. This study will review a new system developed from the researcher's point of view. The following steps have to be followed when trimming the block:

1. Load the stone block unto the trimming platform with fork lift machine for instance VOLVO DL5.
2. Set up the diamond saw linear or in line with riser wheels
3. Adjusts the stone block from behind or vice versa until the cut-off line is aligned with diamond wire cut line.
4. Fix the diamond wire and connect to the plant in the linear with the cut-off line of the stone block.
5. Connect water pipe from pump to the block to cool down the diamond wire to facilitate the cutting.
6. Switch power sources for pump and diamond wire plant to the power plant or the main grid.

7. Cross check that that everything is intact
8. Saw to trim the stone block by operating the diamond wire saw plant.

The total wires needed to trim the block under every situation can be known by combination of linear measured, angle calculations and application of the Pythagoras theorem. For instance the total wire (TW) in a simple geometry below can be calculated as below;



$$TW = c + 2(d) + b + a \quad (3)$$

Where:

$$c = \sqrt{a^2 + b^2} \rightarrow c^2 = a^2 + b^2 \rightarrow a^2 = c^2 - b^2$$

$$a = \sqrt{c^2 - b^2}$$

$$b = \sqrt{c^2 - a^2}$$

There are different systems which are applicable in trimming the block. There is no definite system in the case of trimming the block. There are two variable systems currently in the trimming of blocks. For an operator to manage well considering the safety and ergonomics, this research has researched an automated system to optimize the efficiency of the block trimming namely Solid base pull back system and Solid base press down system.

Solid Based Pull Back System

This system follows the same process involved in trimming the block. It has a movable base which serves as a platform for the stone block. The diamond wire is then wrapped around the block on the cut-off line marked on the block whilst it is on the movable platform.

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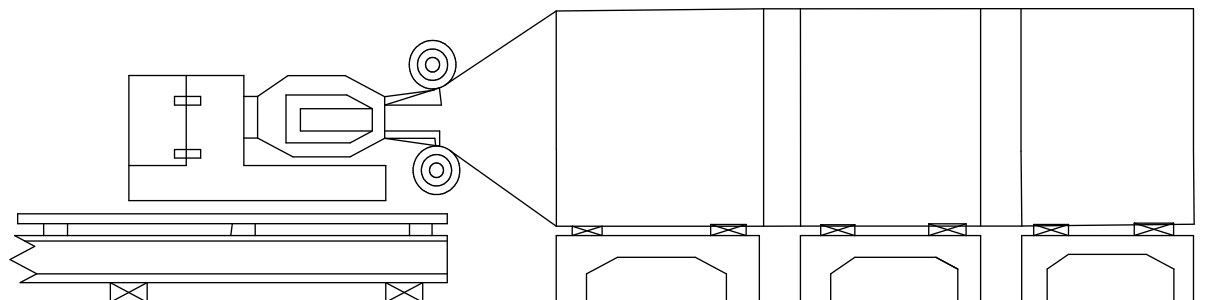


Figure 6.2 Solid based pullback system.

Solid Based Press-Down System

This system also follows same process as the solid pull-back system. This must have non-movable base or platform for the stone block. The diamond wire passes over the block on an upper razor wheel and one-side of the wire is placed on top of cut-off line of the block immediately from the down wheel. The wire cuts as it presses the stone down whilst in operation. This has improved efficiency of operation and production than the solid based pull-back system in accordance to the diamond.

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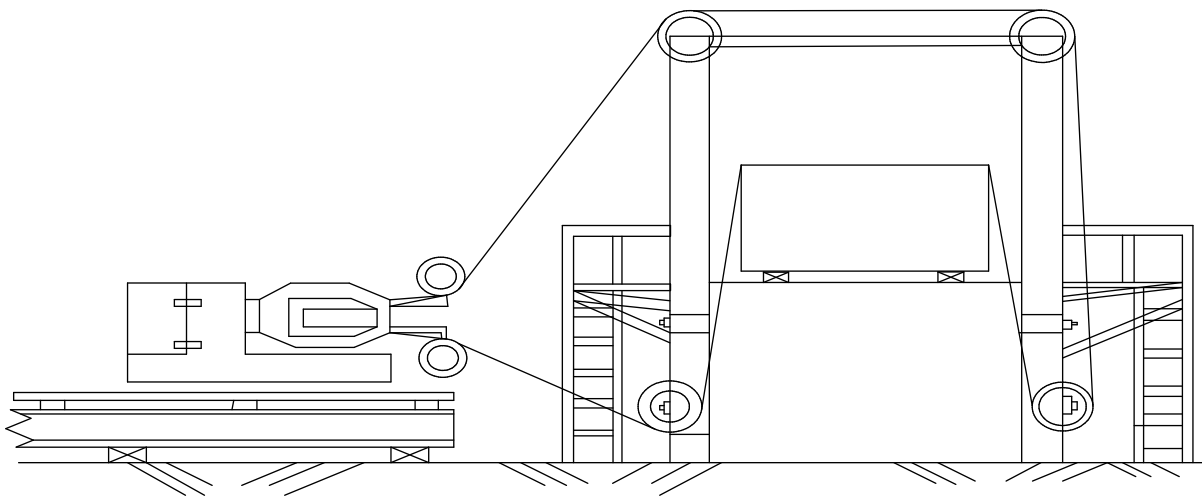


Figure 6.3 Solid based press-down system (a)



Figure 6.3 A principal drawing and photo from Solid based press-down system (b)

6.3 Quality Inspections

In order to remain competitive in business and international trade, the quality of product and its related services are a priority for a reputable company image and value for customer's money. Defective products need to be eliminated from the supply chain to prevent possible reverse logistics at the expense of company. Nowadays the practice for quality of products as managed by inspection departments is becoming a thing of the past. Quality is now embedded in the production processes which empowers the workforce at all levels to inspect products to meet specifications and standards.

6.4 Transportation of Stone Blocks

Throughout the mining process to the final delivery of the raw blocks to the consumer transportation play an essential role for the sustainable movement of workforce and raw blocks to storage and transit terminals. The proper management of sector with a modern logistical approach in the mining process has direct significance for provision of safety, reliability, efficiency of production and a good customer satisfaction.

There are several factors that can affect the logistics management to meet the production of and customer demands. The following factors needs to be taken into consideration are:

The size of locks	Storage method
The Weight of blocks	Type of transportation
Transportation distance	Transportation method
Transport regulation	Customer specification

Having the above information assists in the decision making process on storage and transport of the block much economical to both the producer and the customer to achieve strong customer relations. Most probable question is “Why the necessity of these factors is to be considered”? It is important because the physical features of the stone blocks affect the storage standards. In most countries there are laid down road policies and regulation which protect road users and national infrastructures.

Upon research and analysis of the mineral map of Ghana, it will be uneconomical on logistical cost to establish a quarry site in the northern part of Ghana where the greater

deposit reserves are located. In the opinion of the writer of the thesis, it will be much economical to establish the quarry in the central or southern part of Ghana to take advantage of sea and land transportation with 3PL adaptation to international ports.

Considering the socio-economic activities with the current infrastructure in Ghana, investors in mining sector have greater chances to benefit from the extensive road transport networks in the southern sector while growing to the northern sector. Transportation is a vibrant industrial sector in the Ghana, The writer recommends the use of 3PL application for both sea and land transport to curb the cost that may be incurred in using and maintaining independent transport at the expense of own company.

7 MINING REGULATION AND PROGRAMS IN GHANA

In many countries, the mining sector continues to have its own socio-economic and political vices which affect the start up operations due to legislative policies and regulations. The legislations that have effect on mining and mineral exploration in Ghana include the following

- The Minerals and Mining Law, 1986 (PNDCL 153), - amended by the Minerals and Mining Act, 1994 (Act 475)
- The Investment Promotion Act, 1994 (Act 478)
- The Additional Profit Tax Law, 1985 (PNDCL 122)
- The Minerals Commission Law, 1986 (PNDCL 154)
- The Minerals (Royalties) Regulations, 1987 (LI 1349)
- The Environmental Protection Agency Act, 1994 (Act 490)
- The Environmental Assessment Regulations, 1999, - amended, 2002.

The above laws have been instituted to protect Ghana and investors hence the continual developments and amendments of the 1986 mining law which has been instrumental in attracting over \$5 billion in foreign direct investment to the country's mining industry since 1986 and 2002. The legislation applies equally to both Ghanaians and foreign investors except for artisanal mining and exploitation which is only reserved for Ghanaians.

In Ghana all mineral resources are vested in the President on behalf and trust for Ghanaian populace. Under the constitution of Ghana, regardless of who owns a particular land or where mining is to be located, the Minister for Mines who acts as the State agent has the mandated right to issue license for mining operation. Before the issuance of license the Minerals Commission (MINCOM), the regulatory body for mining activities, advises the state minister.

The Ministry of Mines and Energy and the Minerals Commission has the explicit mandate of issuing leases and administering programmes, implementing the legislation, promoting minerals with Ghana Investment Promotion Council (GIPC) for Ghana Mineral Sector. The Ghana Geological Survey Department performs the geologic studies for use by the company and affiliated government institutions on mining matters. During operation, all mining accidents has to be reported to the Ghana Chamber of Mines which is a private association

for mining companies which in addition provides information on the mining laws for the public and negotiates with the mine labor union for member companies.

In accordance to Ghana's Mineral Law, the Government of Ghana (GOG) acquires 10 % free equity in all kinds of mining ventures which have an additional right to purchase an additional 20% participatory interest at a competitive fair price. The mining company is also responsible for paying minimum of 3 % up to 12 % of total revenue of minerals as royalties. The holder of mining lease is required by law to pay 35 % Income Tax, 25 % additional Profit Tax and rental charges as prescribed by regulations. [26]

The tax levels as described above can be decreased by the capital allowances below.

- (i) Depreciation 75 % of the capital expenditure incurred in the first year of investment and 50 % of the declining balance in subsequent years.
- (ii) Investment allowance of 5 % in the first year only.
- (iii) Losses in each financial year not exceeding the value of the capital allowance for the year may be carried forward. Capitalisation of all pre-production expenses approved by the authorities when the holder starts commercial mining

The holder of a mining Lease is also granted the following benefits:

- (i) Exempted of staff from out of Ghana payments of income tax relating to furnishing accommodation at a mine.
- (ii) Immigration quota for expatriate personnel free from any tax imposed by government for the transfer of foreign currency out of Ghana.
- (iii) Exemption from the selective alien employment under the selective alien employment decree.

Ghana's Minerals and Mining Act 2006, Act 703 have added some significant aspects to the country's commercial law, and, according to the Mining Journal. They are:

- (i) Expenditure on exploration and development may be capitalised in accordance with regulated amortisation provision for tax relief;
- (ii) Capital allowances have been designed to shorten the pay-back period and include 75 % write off of capital in the first year and 50 % annually thereafter on a declining balance;
- (iii) Retention of a proportion of revenue in foreign currency account for use in acquiring essential equipment and spare parts required for mining operations which would otherwise not be readily available without the use of such earnings;
- (iv) Exemption from import duties on imported plant and equipment. [27]

7.1 Health and Mining Safety

The potential for health and safety issues to arise while mining granite is greatly influenced by the quality of equipment provided and the safety procedures put into place at the mining site. With the use of Diamond wire, there is potential for the wire to snap when worn and without safety precautions, a person could seriously be injured. The cutting of granite also produces dust that is released into the air, which can be potentially hazardous to workers. Without proper precautions in place, disaster could become common.

Granite is a natural source of radiation, containing around 10 to 20 parts per million of uranium. Uranium is introduced to the human body through the air and water of surrounding mines. Depending on the amount of exposure, uranium can affect the immune system causing chronic fatigue, rash, hair and weight loss, ear and eye infections and chronic cough. Radon is the second leading cause of lung cancer after smoking and is considered especially dangerous to smokers, whose lungs are already compromised. Children and developing foetuses are also vulnerable to radiation, which can cause other forms of cancer. [28]

Due to speed and friction, diamond wires have a high tendency to snap when worn. As the process of cutting granite requires a great deal of effort from the diamond wire itself, it is of high importance that safety precautions are in place. The average size a block of granite is 2 m x 1.5 m x 3 m, at that size the diamond wire cuts at a speed of 45 m/s. If the diamond wire snaps, at that operating speed, the results can be disastrous.

To reduce the likelihood of work place hazards procedures and precautions must be implemented. Water flows over the granite as the diamond wire is cutting, to reduce and prevent overheating and dusting. As another precaution, safety stations are put into place to bring distance between the worker and the diamond wire cutting mechanism. When all procedures are followed the risk working in a granite mine are lowered.

7.2 Environmental Effects of Granite Mining

Any natural space across the earth's biosphere represents the environment. Pollutants are disturbances to this natural space. The pollutants include noise, degradation of land, air, water and health; with land degradation having the most impact on the environment. The essential components of the environment are air, water and land; these three components are what sustain all living things. Without these three components all life would end. [29]

Pollution is the undesirable change in the physical, chemical and biological characteristics of the components of the environment, living conditions and cultural assets. [30] Granite is generally made up of biotite, plagioclase, quartz, amphibole, and will sometimes contain potassium feldspar. While cutting granite, water is used to reduce overheating, wear and tear of the diamond wire cutter, and dust. The resulting water, which contains silicates found in granite, creates waste that drains into nearby lakes, streams and rivers, affecting water quality and fish population.

Silicates are a product of granite that can be found in the dust that results in the cutting of a granite block. With prolonged exposure to silica, a person can develop silicosis which is a condition that could eventually leave a person with severe shortness of breath and eventually, in its severe stages, tuberculosis. In the late 1930s a vast majority of workers contracted silicosis, causing severe impairment and even death. The use of water during the cutting process drastically reduced these occurrences. [31]

Land degradation changes the ecological balance with the cutting of trees and hilltops, resulting in climate changes, soil erosion, landslides and destruction of environmental landscape. Sixty percent of the generated waste accounted for in granite mining is from rubble and cobble unsuitable for production. Most of this waste is left after the mining is complete, leaving an unsightly mess to a once flourishing landscape. [32]

Using the country's natural resources to help to develop the country economically can create devastating consequences that should be considered. The environment and all of its inhabitants can be affected with irreversible results. It is the country's leadership that should consider the extent environmental degradation is permitted for the sake of the country's economic gains. It is important to have in place safety precautions and proper equipment usage as to reduce risk to workers and further environmental squalor. [33]

7.3 Entering Ghana mining Industry [The Market]

Ghana's endowment in mineral resources is properly managed by well established mining sector under the Ministry of Lands and Natural Resources (MLNR) with its affiliated agencies which are mandated for the sartorial management, promotion and marketing to potential local and foreign investors. The European Commission (EC) has supported the sector in many forms for improved administration and the industrial performance as a result of long term trade relations.

Entering Ghana mining market is great investment decision that needs to be backed by a comprehensive strategic planning. The strategic plan has to be transformed into a business model that accommodates the rules and regulations' governing the industry is a first step to get into business environment. The government of Ghana continues to institute strong economic policies in the enhancement of the sector to stimulate growth to benefit the investor and the people of Ghana on a win-win base.

Operating in stone or any other related mining activities within the geographical boundaries of Republic of Ghana regardless of where it will be mined requires permits and licenses. To successfully integrate into the mining business, investors may find it useful to liaise with following agencies to gather specific information to tailor their needs and secure the necessary permits and licenses.

Ministry of Lands and Natural Resource (MLNR) Is the authorized government agency with right to issue mining lease.

Minerals Commission (MC) is a regulatory commission mandated for the management in the development of mineral resources and mining policy implementation.

Inspectorate Division of Minerals Commission (ID) is an agency is under MC and responsible for mine inspection and law enforcement on mineral operations in the country.

Geological Survey Department (GSD) is mandated in providing up-to-date geological data and savings in the information service database.

Environmental Protection Agency (EPA) is a body mandated by the constitution to give a go ahead permit to mining companies after submitting Environmental Impact Assessment Report.

7.4 Project *PEST* Analysis

Gaining access to operate as a mining company in any community in today's challenging world goes beyond traditional process of registering a business and acquiring the necessary permit. This is a proven fact in Africa, Asia and South America. Of course registration and permits are important part to start the mining business but it does not entirely end up at that stage.

Recent research as a result of experience from commerce has shown the need to acquire a social licence. Social license is an informal permission from the indigenous people within locality of a proposed mining to engage them in an interactive mutual event to for instance forum to create awareness of a mining project. This shows a sign of respect to the community that helps companies to abreast themselves their business environment which limits project risks. The effectiveness of the social license acquisition, which as an integral part of situational analysis, reinforces mining business start up.

To achieve success in acquiring a social license as part of the operational process design serve as the foundation. PEST analysis is a tool used in situational analysis determine the Political, Economics, Social and Technological information in a particular area to ascertain applicable strategies. The analysis gives a "big picture" of the project and represent the micro and macro environmental factors in mining planning worldwide.

In Ghana, the possibility of facing resistance from the indigenous people is not different from some other countries due to complications of our network of tribes and royal families as head of traditional areas. The acquisition of social license is a means by which mining companies can avoid community resistance. This must be done sensitively not to fall into concentric corruption. The way out of not falling into deep trench when seeking the people mandate is to seek the partnership of a face lifted personality within the people to direct what to do and what not to do at any particular moment.

The diagram below shows the PEST analysis and some important factors that will affect a project.

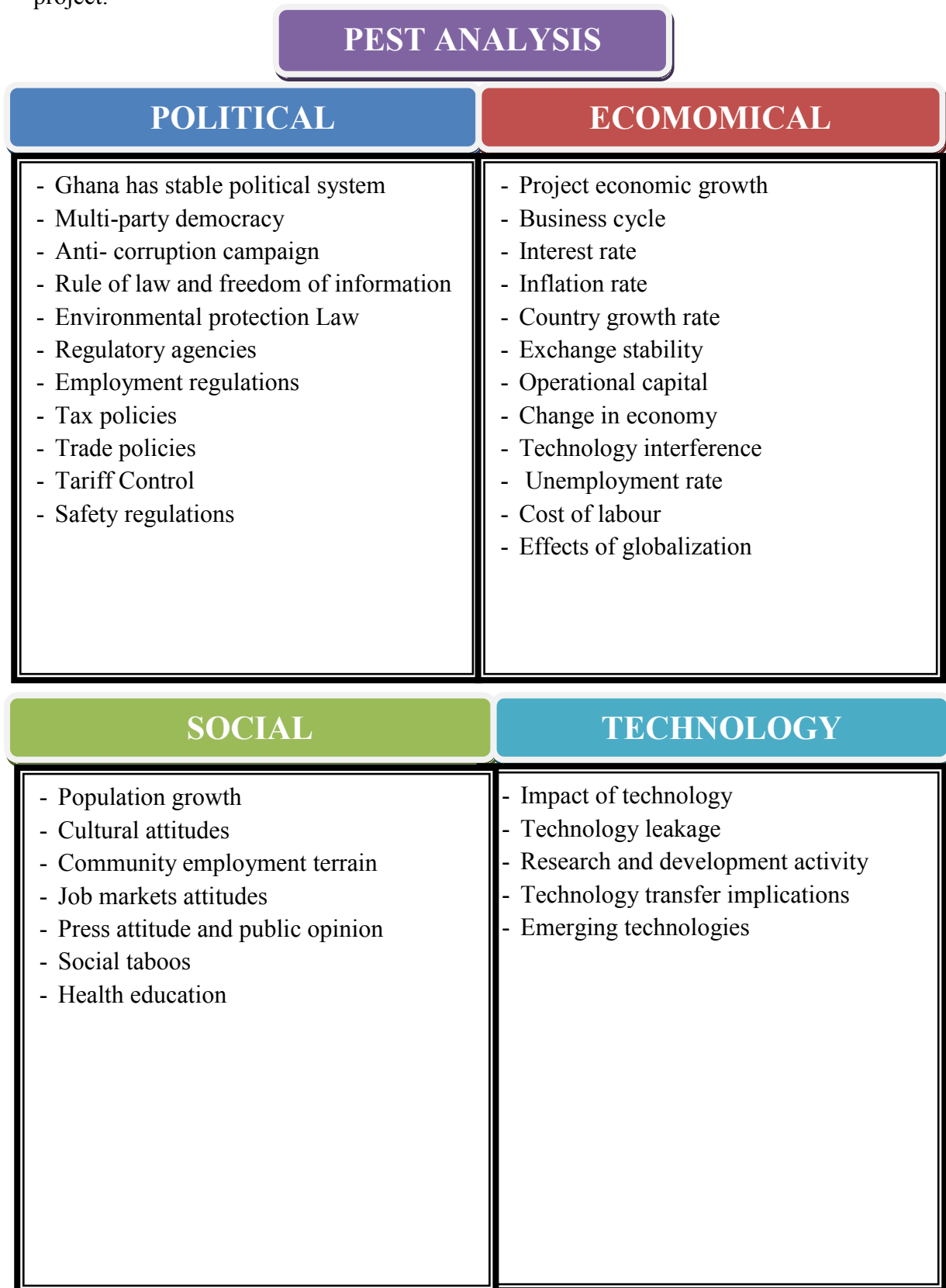


Figure 7.1 Project PEST Analyses

8 MANAGEMENT STRATEGIES

8.1 Mining Project Financing

The management of financial issues in the mining sector of business is very important as in any profitable business. The impact of financial management has relation to the success of the mine especially in the start-up stages. This is due to uncertainties in production, inflation and unforeseen risks that embattle projects. Therefore manager's competence with regards to finance and management concept is an essential that has to be born in mind when selecting of manager. However, the experience has shown that the application of "management by exception concept" has proven success in start up of small business. With this technique, finance management actions are required to control in critical times and in specific areas. [34]

By inception of this system all data are segregated to represent major financial drives with a development of strategic and comprehensive report. Therefore the manager has to make the decision based on received reports by addressing to the most pertinent data to steer in the direction of the company's profitability plan. The following data has to be looked out for in the report as "exception" cases that require action.

- | | |
|--------------------------------|----------------------------|
| - Shift in fuel prices | - Cost reductions |
| - Shift in diamond wire prices | - Delays in receivables |
| - Increase in labour cost | - Machinery breakdown |
| - Sales orders volume | - Forecast sales deviation |

Negligence on the part of management to take action when there is any change in the above indicators can slowly poison the business into financial problems leading to bankruptcy.

8.2 Investing In Mining

Mining is one of the very profitable investment portfolios that can yield high returns when managed properly with and with state of the art technologies. The decision of making an investment in a mining company as compared to any other sectors normally focuses on method from other types of investment. While the choice of investment is important, the

investment strategy process, administering the investment and the operational strategy plays a major role in the economic life of the organisation which involves much more than can be imagined.

In this industry, early entry to potential markets is crucial to the success of investors. This is because it gives market advantage ranging from negotiations, flexible contract agreement, license acquisitions and government (political) relations. As discussed in Chapter 2 of this thesis Ghana is an attractive investment destination with huge infrastructural developments ongoing. By this reasons investors who sees this as an advantage posses the chance of extending business to West African sub region or the African market on top of their international sales thereby fostering to higher and faster return on investment (ROI).

I. Investment Strategy

In order to meet set goals and target for any particular investment and any endeavour there must be a strategy which will serve as a pathway to achieve required results. The approach by which an investor will distribute the assets in operations by taking into consideration factors such as goals, tolerance, horizons and risks involved will affect the production output. Based on this before an investing capital into assets, there should be a deliberate taught on how production is needed to be affected to meet the profitability plan. [35]

II. Business Strategy

Johnson and Scholes define business strategy as the direction and scope of a business over a long term to gain market advantage through the management of resources to fulfil the needs of markets and stakeholders expectation in a challenging environment. [36]

In the opinion of the writer of this thesis it is inappropriate for local firms to compete against each other to take advantage of local market but rather sensible to cooperate to be strong on international markets. If this makes sense then the local market can be accessed equally while gaining popularity market share and power internationally.

These are positive strategic measures that will catapult businesses to drive them along the pathways for their profitability plan.

8.3 Operations Management

Operations strategy also known as operations management is the development of long term plan by allocating all available resources of a company in daily activities to achieve common goal. The incorporation of resources into the operational strategy must place emphasis on the following factors to meet optimal production.

- Product
- Services
- Process and Technology
- Capacity
- Quality
- Facilities
- Sourcing
- Operating Systems



Figure 8.1 Strategic Plan Model [37]

8.4 Implementation Plan

The successful implementation of transferring the technology of mining stone with diamond wire demands a comprehensive business and financial plan. The generation of such document aids in legal consulting and serves as a guide in setting up business organizational structures. It becomes a mandatory prerequisite for business's registration, local authorities and the purpose

of acquiring required licensees. Before the organizational structures are instilled, a very important decision has to be taken on the type of business to run. Within the confinement of this project the decision is limited to partnership or sub family type of business. As shown on the mind map for the project implementation plan, three major departments needs to be created for the up-keep of the business, namely

- Production
- Finance and Sales
- Administration and Management

All representatives in the various departments including the workforce in the production section have to access a common health center and benefit. Top managers in departments are then responsible for the task assigned to their departments whilst reporting weekly to the management which is responsible for welfare of its workers, acquisitions, negotiations, international trade and partnerships.

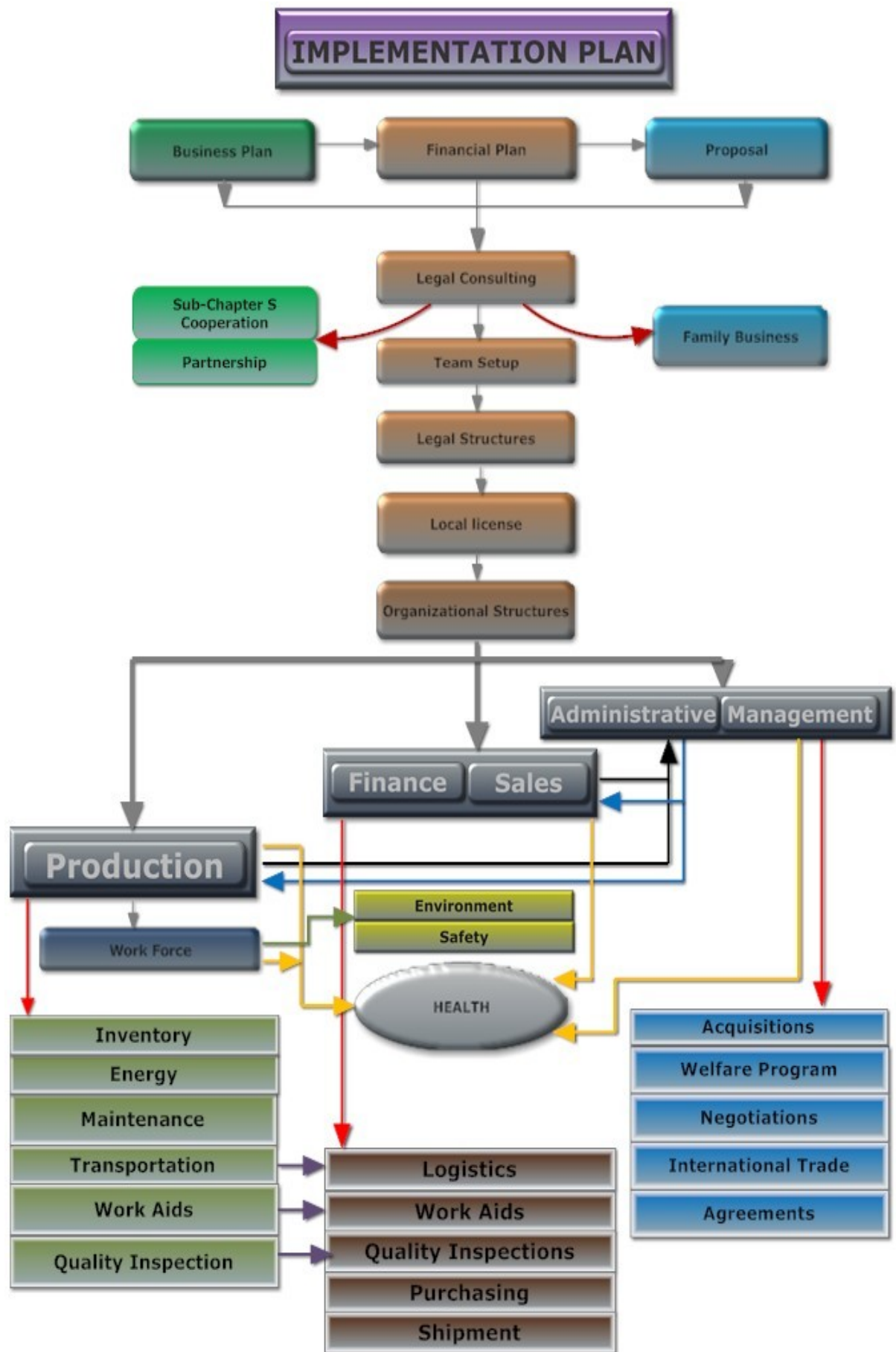


Figure 8.2 Project Implementation Plan

8.5 Financial plan

The relevance of involving every major aspect of any organization is crucial to its planning and sustainability. It is an unbeatable decision to consider the financial planning of a project to ascertain the role in which finance plays to impact the needed results. The financial plan has three major sections: Capital Structure plan, Capital Expenditure plan and Cash flow plan. [38]

For the purpose of this project, data has been derived in accordance to the strategic operations modeled to achieve profitability. Data follows in financial analysis.

9 FINANCIAL ANALYSIS

The importance of financial statement or analysis also known as Pro – Forma financial statements in any business firm cannot be taken for granted. Not only does such document aid securing business registration at public authority offices but also a tool to project company's current and future situations. It is used to value all components of company's and analysed to plan, control and making decision. [39]

The data analysed in the financial statement by taking into consideration the stretched years can predict easily with common sense the strength, weakness and future trend in performance. For this reason it is a fundamental responsibility of management to distinguish financial integrity and profitability of company. If management are active it is possible to recognize developing trends whether negative or positive and steer them for financial sustainability. [40]

The table in this section shows is a financial analysis carried out for the purpose of this project to by the writer to ascertain the project economic standings and profitability. Ghana mining business environment was taken into consideration in the financial planning for the purpose of data accuracy.

STONE MINING PROJECT						
PERFORMA INCOME STATEMENT						
JANUARY - DECEMBER EACH YEAR						
Year		2012	2013	2014	2015	2016
		US \$	US \$	US \$	US \$	US \$
INCOME						
Sale of stone blocks		48,775,680.00	48,775,680.00	48,775,680.00	48,775,680.00	48,775,680.00
Sale of fine aggregate				50,000.00	70,000.00	100,000.00
Sale of coarse aggregate					153,600.00	192,000.00
Other income (Wasteage)			10,000.00	10,000.00	10,000.00	10,000.00
Total Income (Revenue)		48,775,680.00	48,785,680.00	48,835,680.00	49,009,280.00	49,077,680.00
OPERATIONAL COST (COGS)						
Opening Inventory		0.00	0.00	0.00	0.00	0.00
Electricity		12,000.00	12,001.00	12,002.00	12,003.00	12,004.00
Fuel		1,947,744.00	1,947,744.00	1,947,744.00	1,947,744.00	1,947,744.00
Telephone / Data Service		3,000.00	3,000.00	3,000.00	3,000.00	3,000.00
Water		2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
Paints		500.00	500.00	500.00	500.00	500.00
Explosives		10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
Diamond wire		144,072.00	144,072.00	144,072.00	144,072.00	144,072.00
Lubricants		15,000.00	15,000.00	15,000.00	15,000.00	15,000.00
Engineering services		8,000.00	8,000.00	8,000.00	8,000.00	8,000.00
Depreciation of equipments		130,374.00	130,615.33	130,615.33	130,624.67	130,615.33
Health and equipments insurance		6,000.00	6,000.00	6,000.00	6,000.00	6,000.00
Equipments maintenance		15,000.00	15,000.00	15,000.00	15,000.00	15,000.00
Environmental Protection		10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
Storage		1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
Transportation of products		5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
Security		1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
Maintenance / repairs cost		10,000.00	10,001.00	10,002.00	10,003.00	10,004.00
Inflation		220287.6	219212.8	219213	219220.2	219213.4
Closing inventory		2,540,977.60	2,540,146.13	2,540,148.33	2,540,166.87	2,540,152.73
TOTAL EXCL. INFLATION		2,320,690.00	2,320,933.33	2,320,935.33	2,320,946.67	2,320,939.33
TOTAL OPERATIONAL COST		2,540,977.60	2,540,146.13	2,540,148.33	2,540,166.87	2,540,152.73
GROSS PROFIT		46,234,702.40	46,245,533.87	46,295,531.67	46,469,113.13	46,537,527.27
SELLING, GENERAL AND ADMINISTRATIVE COST						
Royalties		2,715,975.26	2,716,877.15	2,717,117.02	2,726,301.91	2,727,818.36
Environmental rehabilitation		12,000.00	12,000.00	12,000.00	12,000.00	12,000.00
Marketing		1,000.00	1,000.00	1,500.00	1,500.00	1,500.00
Entertainment		500.00	500.00	800.00	800.00	800.00
Local travels		500.00	800.00	1,500.00	1,500.00	1,800.00
Foreign travels		21,000.00	21,000.00	21,000.00	21,000.00	21,000.00
Exhibitions/Seminars/Conferences		3,000.00	3,000.00	3,000.00	3,000.00	3,000.00
Donations		1,000.00	1,500.00	2,000.00	2,500.00	2,500.00
Employee training		7,000.00	7,000.00	7,000.00	7,000.00	7,000.00
Consultancy (Legal)		5,000.00	5,000.00	3,000.00	3,000.00	1,000.00
Management fees		1,000.00	1,000.00	2,000.00	2,000.00	3,000.00
Salaries		-	-	-	-	-
<i>CEO</i>		57,600.00	57,600.00	57,600.00	57,600.00	57,600.00
<i>Sales Manager</i>		38,400.00	38,400.00	38,400.00	38,400.00	38,400.00
<i>Finance/Account Manager</i>		38,400.00	38,400.00	38,400.00	38,400.00	38,400.00
<i>Production Manager</i>		38,400.00	38,400.00	38,400.00	38,400.00	38,400.00
<i>Production Assistant / Supervisor</i>		20,160.00	20,160.00	20,160.00	20,160.00	21,120.00
<i>Quarry Masters (Drillers)</i>	3	57,600.00	57,600.00	57,600.00	57,600.00	60,480.00
<i>Diamond saw engineers</i>	3	57,600.00	57,600.00	57,600.00	57,600.00	57,600.00
<i>Security officer</i>		5,760.00	5,760.00	5,760.00	5,760.00	5,760.00
<i>Cleaners</i>		528.00	528.00	528.00	528.00	528.00
Research and Development		2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
Diversity investment fund		10,000.00	10,000.00	20,000.00	20,000.00	25,000.00
Sustainable investment fund		10,000.00	10,000.00	20,000.00	20,000.00	25,000.00
TOTAL OPERATING EXPENSES		3,104,423.26	3,106,125.15	3,127,365.02	3,137,049.91	3,151,706.36
Financing fees		500,000.00	500,000.00	500,000.00	500,000.00	500,000.00
OPERATING INCOME		42,630,279.14	42,639,408.71	42,668,166.65	42,832,063.23	42,885,820.91
OTHER EXPENSES						
Exploration		10,000.00	-	-	-	-
Licenses		20,000.00	-	-	-	-
Risk Fund		50,000.00	75,000.00	100,000.00	120,000.00	150,000.00
TOTAL ADDITIONAL COST		80,000.00	75,000.00	100,000.00	120,000.00	150,000.00
NET INCOME BEFORE TAX		42,550,279.14	42,564,408.71	42,568,166.65	42,712,063.23	42,735,820.91
TAXATION		10,637,569.78	10,641,102.18	10,642,041.66	10,678,015.81	10,683,955.23
NET INCOME AFTER TAX		31,912,709.35	31,923,306.54	31,926,124.98	32,034,047.42	32,051,865.68
SUPLUS INCOME ACCOUNT						
Balance as at 1st January		0.00	31,912,709.35	63,836,015.89	95,562,140.87	127,396,188.29
Diversiture deduction				-200,000.00	-200,000.00	-200,000.00
Net Income		31,912,709.35	31,923,306.54	31,926,124.98	32,034,047.42	32,051,865.68
Balance as at 31st December		31,912,709.35	63,836,015.89	95,562,140.87	127,396,188.29	159,248,053.97
PROJECT CURRENT ASSETS						
Bank (Running Cash)		5,866,830.00	5,877,690.00	5,888,550.00	5,899,830.00	5,910,690.00
Insurances (Health and Equipments)		35,000.00	35,000.00	35,000.00	35,000.00	30,000.00
Securities		10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
TOTAL CURRENT ASSETS		5,911,830.00	5,922,690.00	5,933,550.00	5,944,830.00	5,950,690.00

NON CURRENT ASSETS						
Production equipments		1,885,000.00	-	-	-	-
Volvo L350F		850000.00	-	-	-	-
Atlas Copco		330000.00	-	-	-	-
Diamond wire saw [3]		360000.00	-	-	-	-
Quarry Master's Machine [3]		210000.00	-	-	-	-
Top Hammer		70000.00	-	-	-	-
Water pumps [4]		1000.00	-	-	-	-
Power plant		50000.00	-	-	-	-
Fuel reservior		1000.00	-	-	-	-
Work Vehicles [2]		10000.00	-	-	-	-
Mobile structures [2]		1000.00	-	-	-	-
Design systems		2000.00	-	-	-	-
Office Equipments		2,550.00	-	-	-	-
Furniture		200.00	-	-	-	-
Multi-Office Machine		200.00	-	-	-	-
Cooker		200.00	-	-	-	-
Dishwasher		170.00	-	-	-	-
Microwave		50.00	-	-	-	-
Boiler		20.00	-	-	-	-
Refridgerator		150.00	-	-	-	-
Radio		10.00	-	-	-	-
Stationary		50.00	-	-	-	-
Computers [10]		1500.00	-	-	-	-
Personal protective equipments		1,000.00	-	-	-	-
Production accessories		11560.00	1810.00	1810.00	1880.00	1810.00
Wire Connector Steel Tube (1 box)		500.00	500.00	500.00	500.00	500.00
Hydraulic grip		80.00	-	-	-	-
Cutter		50.00	-	-	50.00	-
Tape measure		10.00	10.00	10.00	10.00	10.00
Knife		300.00	300.00	300.00	300.00	300.00
Digital calipers		20.00	-	-	20.00	-
Laser guage		2000.00	-	-	-	-
Water tubes (Large and small holes)		1000.00	-	-	-	-
Valves		100.00	-	-	-	-
Electric cables		5000.00	-	-	-	-
Hydro-Bags and Air pushing bags		2500.00	1000.00	1000.00	1000.00	1000.00
Buildings		30,000.00	-	-	-	-
Head Office		10,000.00	-	-	-	-
Maintenace hall		20,000.00	-	-	-	-
Furniture		500.00	-	-	-	-
Land		15,000.00	-	-	-	-
Maintenance tools		10,000.00	-	-	-	-
TOTAL END OF YEAR ASSETS ACQUIRED		1,955,610.00	3,620.00	3,620.00	3,760.00	3,620.00
TOTAL NON CURRENT ASSETS		1,955,610.00	1,959,230.00	1,962,850.00	1,966,610.00	1,970,230.00
CASH FLOW						
Cash flow fom operations		43,653,137.08	43,660,233.77	43,730,536.36	43,877,856.30	43,954,968.53
Cash flow from financing		16,549,399.78	16,563,792.18	16,575,591.66	16,622,845.81	16,634,645.23
Cash flow from investment		2,055,610.00	2,054,230.00	2,102,850.00	2,126,610.00	2,170,230.00
NET CASH FLOW		58,146,926.86	58,169,795.95	58,203,278.02	58,374,092.11	58,419,383.76

9.1 Return on Investment in Capital Assets

Return on investment in capital also known as Return on Assets (ROA) is an economic indicator of a company or project that reflects profitability relative to the amount of capital injected into assets. This measures the management efficiency of by using total earnings against total capital assets. It shares the most of technical problem associated with payback or breakeven point calculations. This is expressed as capital is expressed as a simple arithmetic formula below. ROA is also sometimes referred to as ROI. [41]

$$\text{ROA} = \frac{\text{Net Income}}{\text{Total Assets}} \quad (4)$$

To ascertain the total Net Income for the project, it is estimated that three (3) quarry masters will produce 8 blocks of stones each day at a standard size of 3 m x 2 m x 2 m throughout the year at a fixed selling price of 700 us dollars/m³. Assuming 232 working days in a year each for QM'S without any sick leave.

Total Number of Stone Blocks → 3(8 blocks x 232 days) = 5568 blocks

Number of Meter Cubes per year → (3 m x 2 m x 2m) x 5568 blocks = 66816 m³.

Net Income → 730 US dollars x 66816 m³ = 48 775 680 US dollars

$$\begin{aligned} \text{ROA [Year 1]} &= \frac{31,912,709.35}{5,911,830.00 + 1,955,610.00} = \frac{31,912,709.35}{7,867,440} \\ &= 4.06 \end{aligned}$$

$$\begin{aligned} \text{ROA [Year 5]} &= \frac{32,051,865.68}{5,950,690.00 + 1,970,230.00} = \frac{32,051,865.68}{7,920,920} \\ &= 4.05 \end{aligned}$$

Liquidity - Is the ability for a company to convert assets to cash as quickly as possible to pay bills when they are due. This is a vital business health indicator and it is calculated as below

$$\text{Liquidity} = \frac{\text{Cash} + \text{Marketable Securities} + \text{Account Receivables}}{\text{Liabilities}}$$

$$\begin{aligned}
 [\text{Year 1}] &= \frac{48,775,680.00 + 5,911,830.00 + 2,000.00 + 10,000.00 + 10,000.00 + 50,000.00}{3,104,423.26 + 500,000.00 + 30,000 + 2,540,977.60} \\
 &= \frac{54,749,510.00}{6,175,400.86} \\
 &= 8.87
 \end{aligned}$$

$$\begin{aligned}
 [\text{Year 5}] &= \frac{49,077,680.00 + 5,950,690.00 + 2,000.00 + 25,000.00 + 25,000.00 + 150,000.00 + 200,000.00}{2,540,152.73 + 3,151,706.36 + 500,000.00} \\
 &= \frac{55,405,370.00}{6191859.09} \\
 &= 8.95
 \end{aligned}$$

Profitability - This is an analytical test carried out in a business to investigate the profit margin of a company. This helps to know the future or viability of a business.

$$\text{Profitability} = \frac{\text{Sales} - (\text{COGS} + \text{Administrative Cost} + \text{Financing fee} + \text{Tax} + \text{Other Expenses})}{\text{Sales}}$$

$$\text{Profitability} = \frac{\text{Sales} - \text{Net Income after Tax}}{\text{Sales}}$$

$$\begin{aligned}
 \text{Year 1} &= \frac{48,775,680.00 - 31,912,709.35}{48,775,680.00} \\
 &= 0.345
 \end{aligned}$$

$$\begin{aligned}
 \text{Year 5} &= \frac{49,077,680.00 - 32,051,865.68}{49,077,680.00} \\
 &= 0.346
 \end{aligned}$$

By the above calculation it means that the business will do very well since 35 cents out of every sale dollar will be spent on final product.

10 CONCLUSIONS

The research has not only outlined the stability of Ghana as a good destination with positive economic indicators to attract entrepreneurs and investors to reap the advantages of high returns the Cedi's or Pessewa's sowed in Ghana as investment. Also there are programs as discovered under this project that support the industry by the people of Ghana with the Government to make headways internationally as well as social intervention responsibilities to aid the population.

When looking into the confinement of the research, it has proven in the project a transfer of modern technology by which diamond wire is used in the extraction of stone blocks in Ghana. The processes lead a development of operational model with considerable factors such as the type and availability of deposit in Ghana, the ecosystems, health and safety issues that are often underestimated in previous years. In order to arrive at the required results of the project, an implementation plan was derived in accordance with the project objectives to meet the industrial policies of mining code of conduct to conform to the laws of Ghana.

Based on the results obtained from the financial plan to foster the profitability of the project implementation indicates its viability. The financial calculation in this research has proven the whopping percentage of returns that will be gained after investing a considerable amount to fund the machinery and operations.

In the point of view of the writer, the diamond wire, a new technology of extracting stone deposits, is very technical in its nature and may not be a straight line success for practitioners who have little or no knowledge about the system. The writer recommends the use of consultancy and technical expertise in the field to aid practitioners wishing to use this system with no previous idea.

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APPENDIX 1**Project Information Sources**

Ministry of Mines and Energy

P.O. Box 40

Stadium, Accra, Ghana

Telephone: 233-21-667151-3, 667090

Fax: 233-21-668262

Mines Department

P.O. Box 3634

Accra, Ghana

Telephone: 233-21-776802

Fax: 233-31-24344 (Takoradi office)

Geological Survey Department

P.O. Box M 80

Accra, Ghana

Telephone: 233-21-228093

Ghana Chamber of Mines

P.O. Box 991

Minerals House #10

6th Street, Airport

Accra, Ghana

Telephone: 233-12-760652 or 761893

Fax: 233-12-760653

E-mail: chamine@ghana.com

Internet: <http://www.ghanachamines.com>

Minerals Commission

P.O. Box M 248

Plot#9, Switchback Road

Residential Area - Cantonments

Accra, Ghana

Tel: 233-21-771318/773053/772783

Fax: 233-21-773-324

E-mail: mincom@mincomgh.org

Internet: <http://www.mincomgh.org>

Environmental Protection Agency – Ghana

Executive Director

P. O. Box M.326

91 Starlets Road

Accra, Ghana

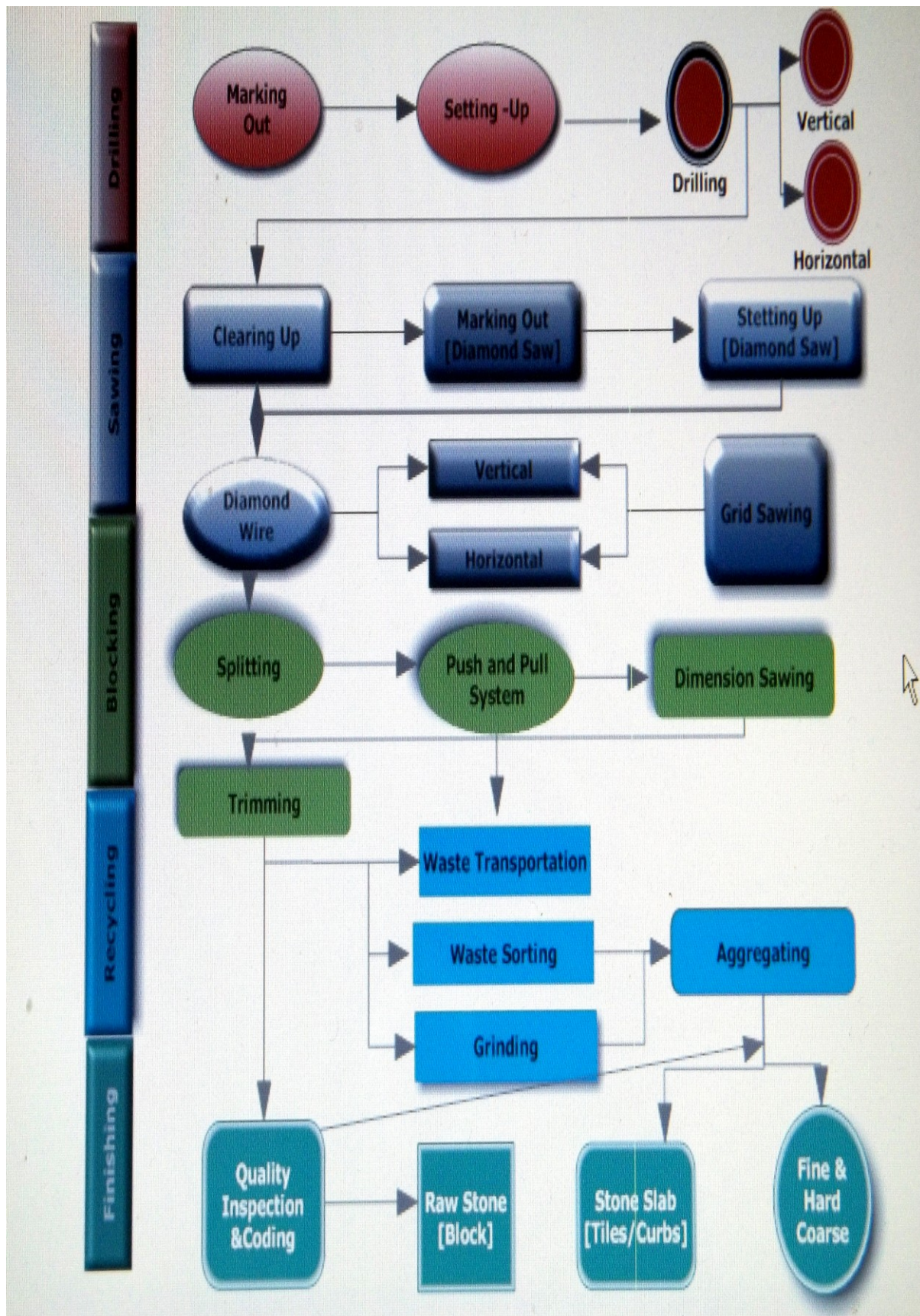
Telephone: (021) 664697-8

Fax: 233 (021) 662690

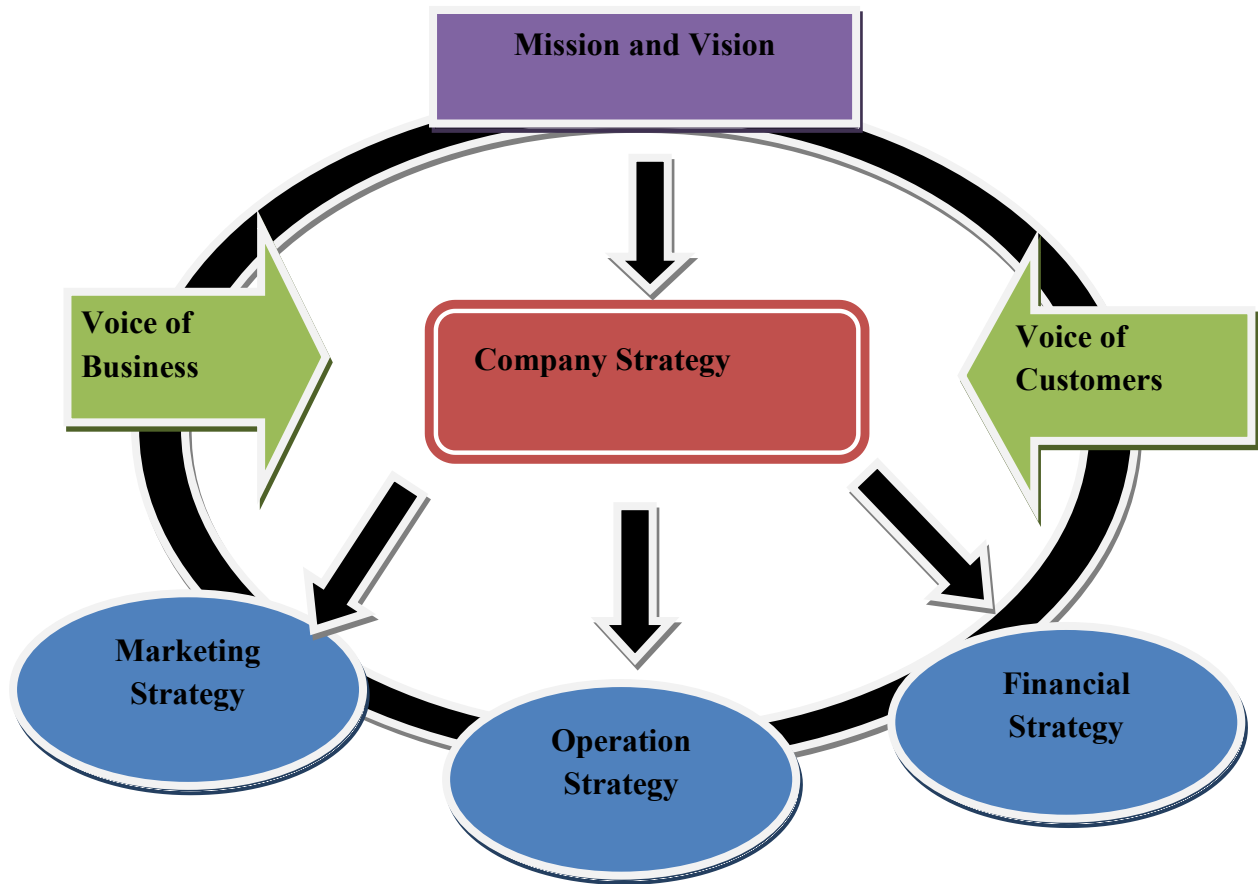
E-mail: epaed@africaonline.com.gh

Internet: <http://www.epa.gov.gh>

APPENDIX 2



Proposed Operational Model

APPENDIX 3*Strategic Plan Model [21]*

