KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

THREE ESSAYS ON SMALL-SCALE GOLD MINING OPERATIONS IN GHANA: AN INTEGRATED APPROACH TO BENEFIT-COST ANALYSIS

by

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CERTIFICATION

I hereby declare that this submission is my own work towards the Doctorate degree and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

The thesis is a monographic piece of three essays or papers on small-scale gold mining in Ghana synthesized into one document. The essays therefore, represent different but related essays as indicated in the title of the thesis. The first essay highlights on contemporary issues on small-scale gold mining operations in Ghana. The second essay focuses on comparative study in the Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining districts of the Minerals Commission of Ghana. The third essay which is the most dominant of the study is on an integrated approach to benefit-cost analysis on small-scale gold mining operations in the Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining districts of the Minerals Commission of Ghana.

The objective of the first essay is to discuss current issues, specifically, the challenges and potentials of small-scale gold mining operations in Ghana. Output, revenue and employment effects from small-scale mining; environmental and occupational health issues; operational constraints including financial issues, skills and training, occupational safety, constraints on women's participation; child labour abuse issues, tensions and conflicts of interest between large scale gold mining companies; and the long process involved in obtaining permits to operate as licensed small-scale miners are the main highlights of the essay. The research methodology used was a survey design.

The essay concludes that small-scale mining in Ghana is beset with environmental, occupational health and operational constraints or problems and that addressing them would help promote (a successful existence of) small-scale gold mining as a socially and economically viable activity in the country.

The second essay aims to provide a comparative study on small-scale gold mining industry in the Bibiani, Bolgatanga, Dunkwa and Tarkwa Districts of the Minerals Commission of Ghana. Variations in production, employment, number of licensed operators/concessions were the main focus of the essay. The study used both quantitative and qualitative methods.

The statistical tool employed was a two-way analysis of variance (ANOVA). The study tested for statistical interdependence of the means of equality between the mining districts (distance, that is, row effect) and the means of equality across time (years from 2005 – 2008, that is, column effect).

The essay concludes that even though the small-scale mining sub-sector in Ghana is plagued with a number of challenges, production and employment levels as well as the number of licensed operators or concessions have increased considerably over the years. Managerial structures, choice of technology and profitability are among the factors or issues that explain the magnitude of the differences in the mining districts.

Small-scale mining should be recognised as a significant contributor of rural livelihoods that has the potential to alleviate poverty and be a tool for sustainable development. The essay suggests that adequate technical, financial, economic and organizational assistance or support should be provided to enhance small-scale mining operations in Ghana.

The third essay undertakes to measure the expected net benefits, net future values and benefit-cost ratios resulting from small-scale gold mining operations particularly, in the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts of the Minerals Commission of Ghana. The essay discusses the conceptual and methodological framework, specification of benefit-cost operational models, data collection and analysis methods and empirical results and analysis.

A benefit-cost analysis was carried out in the individual four mining districts before a combined total benefit-cost analysis was performed for all the four mining districts. It must be emphasized that in this study, benefit-cost analysis (BCA) and cost-benefit analysis (CBA) imply the same thing. Hence, they are used interchangeably. The results showed that, the Bolgatanga Mining District that recorded an average net benefit of GH¢39,966,554.83 and therefore, promises to be worthwhile and worth continuing with the existing mining activities in that district. The outcomes of all the other mining districts: Bibiani, Dunkwa, Tarkwa with the combined total however, recorded negative average net benefits of (GH¢1,572,088.66), (GH¢ 7,588,627.13), (GH¢121,483,027.35)

and (GH¢90,252,809.70) respectively. This suggests that small-scale mining activities in these mining districts (Bibiani, Dunkwa and Tarkwa), are not worthwhile or viable and therefore, not worth continuing with the existing mining activities. In general, small-scale mining activities in all the four mining districts (Bibiani, Bolgatanga, Dunkwa and Tarkwa) combined are also not economically viable.

The analysis of variance indicates that enterprise profitability of operation across the activity sectors matters much in profitability of operation, though, location or mining district/area does not matter much so far as profitability of operation is concerned. The Chi square (χ^2) test also indicates that both the benefit and cost variables between the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts/areas and across sector activity, namely: physical environmental, social and aggregate economic factors are not statistically related or associated with each other. The sensitivity analysis performed shows that real NFVs tended to be responsive to the real rate scenarios.

The essay concludes that small-scale mining in Ghana is not economically viable and that if the small-scale mining sub-sector is to achieve its full potential, then more attention should be paid to the high negative environmental, social and aggregate economic impact or costs.

The essay recommends that regulations and guidelines that aim at promoting efficiency in mining operations; minimizing the negative environmental, social and aggregate economic costs or impact; promoting high health and safety standards; and identifying obligations for all stakeholders should be developed to make small-scale mining operations in Ghana economically viable and sustainable.

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LIST OF ABBREVIATIONS

ARM	Avoidance of Rural-Urban Migration
CIP	Conflicts with the Indigenous Population
CLE	Contribution to Local Economy
CPD	Contribution to Product Diversity
CSRPM	Centre for Scientific Research into Plant Medicine
CWSA	Community Water and Sanitation Agency
DFN	Destruction of Fauna
DFR	Destruction of Flora
DWB	Destruction of Water Bodies
ECA	Economic Commission for Africa
EPA	Environmental Protection Agency
GIZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit
GNATH	Ghana National Association of Traditional Healers
GSD	Geological Survey Department
GTZ	Gesellschaft für Technische Zusammenarbeit
IAB	Indirect/Ancillary Benefits
ILO	International Labour Organization
IMF	International Monetary Fund
LRC	Loss of Revenue to Large Scale Mining Companies
LSD	Landscape Destruction
MCG	Minerals Commission of Ghana
MLFM	Ministry of Lands, Forestry and Mines
NHC	Negative Health Consequences
NGOs	Non Governmental Organisations
PEB	Potential Environmental Benefits
PMMC	Precious Minerals Marketing Company
PWC	Precarious Working Conditions
SFE	Source of Foreign Exchange

SOE	Source of Employment
SSM	Small-Scale Mining
SSMs	Small-Scale Miners
TRV	Tax Revenue
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
WACAM	Wassa Communities Affected by Mining Activities

DEDICATION

I dedicate this work to the Almighty God and our Lord Jesus Christ whose divine guidance has made it possible for me to successfully complete this programme and also to my dear parents, Mr. & Mrs. Opoku-Antwi; my wife, Vida; my children, Antoinette, Henrietta, Eugene and Andrews; and finally, to all my siblings and friends.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Small-scale gold mining operations have been carried out in many parts of the world and many international organizations, notably the International Labour Organization (ILO) consider small-scale mining as an important economic activity in the informal sector, especially, in developing countries in terms of the employment opportunities it offers to millions of people. According to the ILO (1999), about 6 million of the world's 30 million mineworkers were engaged in small-scale mining. The ILO in 1999 further estimated that the total employment in small-scale mining in developing countries ranged between 8.25 – 10.1 million. For 25 African countries, employment ranged between 1.6 – 2.6 million; for ten Asia-Pacific countries, it was 6.0 – 6.6 million; and for 18 Latin American countries, it was 0.64 – 1.0 million. Hilson (2001) stated that there are other significant benefits in terms of boosting the national output and revenue if the small-scale mining sub- sector is well-developed.

In Ghana, small-scale gold mining has been carried out for hundreds of years. It is currently and widely operated in the country by both licensed operators and illegal miners popularly known as *galamsey* operators. The Ministry of Lands, Forestry and Mines (2008) explains that the number of small-scale miners has increased rapidly by 941.73% from 1984 to 2004 after its legalization by the Small-Scale Gold Mining Law, PNDC Law 218 of 1989. The intent of the legalization was to revive the small-scale mining sub-sector, facilitate the supervision and minimize the environmental hazards from small-scale mining.

Small-scale mining operations help to stem rural-urban migration, maintain the link between people and the land; makes a major contribution to foreign exchange earnings; and it enables the exploitation of what otherwise might be uneconomic resources (World Bank, 1995). The small-scale gold mining sub-sector employs a significant number of

the Ghanaian mining labour force. According to Hilson (2001), about 60% of the Ghanaian mining labour force is employed at the small-scale gold mines. A survey by the International Labour Organization in 1999 estimated that, about 300,000 people, especially the youth who would have otherwise migrated to the urban centres to seek for non-existing jobs were engaged in small-scale mining, thus, reducing the problems associated with rural-urban migration.

Small-scale gold mining contributes, in part, to economic and social development, particularly at the local level. It has not only generated substantial local purchasing power but also led to the demand for locally sourced inputs such as food, equipment, tools, and housing as well as encouraged their production (International Labour Organisation, 1999). In most of the mining communities, especially, in the Western and Ashanti Regions of Ghana, about 40% to 85% of households obtain regular income directly or indirectly from small-scale mining. These incomes do not only include the wages from mine labourers, but also earnings from people working in the mining service economy, notably, women who sell food items in the mining area, owners of small stores, cooks, artisans, transport providers, among others.

The mining revenues enhance the existence of local stores such that the people in the mining communities buy their daily life necessities without travelling to the urban centres as it used to be. In some places, small-scale miners contribute some amount of money to support the Unit Committees and Traditional Rulers towards the economic development of the local communities (Wassa Amenfi East District Assembly, 2008). Small-scale gold mining, indeed, carries the economies of the mining communities at the local levels.

However, in spite of the benefits, many governments feel reluctant to accept small-scale mining as a necessity for millions of people. The reluctance stems, in part, from the problems arising from occupational and community health hazards, safety and environmental problems, and the risk of dissuading large scale mines from their operations (Hilson, 2001).

In Ghana, the Minerals and Mining Act 2006, (Act 703) defines small-scale gold mining operation as the mining of gold by any effective and efficient method that does not involve substantial expenditure by an individual or group of persons not exceeding nine in number or by a co-operative society made up of ten or more persons. It must be emphasized that small-scale gold mining operations in Ghana are characterized by a few licensed operators and a larger number of unlicensed operators, a labour force that is not formally trained in mining and the use of rudimentary techniques for prospecting, extracting, and processing of gold (Davids, 1993).

According to the Minerals Commission Act, 1993, (Act 450), the Minerals Commission is the main governmental corporate body responsible for the regulation and management of the utilization of the mineral resources of Ghana. The Commission has seven Small-Scale Mining District Offices/Centres in the country to compile a register of all and prospective small-scale gold miners and to supervise and monitor their activities. These centres are located at Tarkwa, Dunkwa, Bibiani, Asankrangwa, Assin-Fosu, Akim-Oda and Bolgatanga (Minerals Commission, 2002). The Ministry of Lands, Forestry and Mines (MLFM), the Precious Minerals Marketing Corporation (PMMC), the Geological Survey Department (GSD), the Environmental Protection Agency (EPA), and the Municipal/District Assemblies (MDAs) are the other state organizations which aim at making small-scale gold mining a sustainable activity.

Jennings (1993) pointed-out that the lack of resources, formal training and skills in mining meant that small-scale mining operations in Ghana will continue to suffer from low productivity, inadequate incomes, poor safety and working conditions and environmental hazards. In addition, Gueye (2001) explains that there are criticisms from the administrative side on small-scale mining and this is mainly on the land degradation, pollution of the environment, unsafe measures and the social problems arising from small-scale mining operations.

Like most economic activities, small-scale gold mining operations have positive and negative effects on the Ghanaian economy (Appiah, 1998). The impact of small-scale

mining on sustainable economic development of the country needs close investigation. It is against this background that this study is carried out, first, to identify the contemporary issues on small-scale mining in Ghana; second, undertake a comparative study in four selected mining districts of the Minerals Commission of Ghana (namely, the Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining Districts); and third, perform a benefit-cost analysis on small-scale gold mining operations in Ghana.

1.2 IDENTIFICATION OF RESEARCH PROBLEM AND RESEARCH QUESTION

The relatively low contribution of gold revenue from the small-scale gold mining sub-sector to the government as compared to other developing countries is a concern to many people. The Ghana Minerals Commission estimated that, in 2002, the small-scale gold mining sub-sector contributed only 7% of the $694,970,543 gold revenue to the government (Ghana Minerals Commission, 2002). However, according to Campbell and Pittsfield (1994), the small-scale gold mining sub-sector in Zimbabwe contributed about 58% of gold revenue to the Zimbabwean government in 1994 while 68% of the Philippine's gold production in 1994 came from the small-scale mining sector. These figures indicate that the small-scale gold mining sub-sector is a potential contributor to the country's development in terms of foreign exchange earnings if it is well developed.

Furthermore, small-scale gold mining communities generally, are faced with community health problems such as poor sanitation and lack of clean water. According to the Ghana Health Service, malaria, acute respiratory infection, typhoid, dysentery, bilharzias, and enteric infections are common in small-scale gold mining areas (World Health Organisation, 1989). The World Health Organization's study in 2005 at Wassa Akropong in the Western Region of Ghana also revealed that mercury and other waste materials are washed into the Ankobra River and its tributaries during the extraction and amalgamation process (Wassa Amenfi East District Assembly, 2008). About forty-two communities with a population of approximately 3,852 in 2003 living down stream the Ankobra River and its tributaries use them as their main source of drinking water. Since mercury is a harmful substance, it can gradually accumulate in the body as toxic to those

who drink the polluted water or use them for domestic activities and these may cause health hazards to the communities and aquatic life. Records from the Wassa Amenfi East District Directorate of the Ghana Health Service at Wassa Akropong indicate that reported malaria cases rose by 38.6% between 1990 and 2001. In 2004, malaria reported cases constituted 54.2% of the top 10 common diseases in the District and was ranked as the highest in the mining communities. The economic implication is that many people in the District are contracting water related diseases by drinking polluted and contaminated water by small-scale gold mining operations thereby weakening the active labour force of the country.

The rate at which the land is being degraded as a result of small-scale gold mining operations needs attention. Some of the small-scale miners dig deep pits while others operate surface mining by taking the rich top soil. The miners fail to reclaim mined pits with mining waste. This endangers the environment and puts the lives of the people in the mining communities and wildlife at risk because people can fall into the pits (United Nations, 1992; and Davids, 1993). In addition, the uncovered land cannot be used for any economic activity such as farming.

Moreover, the cost involved in ensuring that the small-scale mining law is fully enforced is a major problem to many governments especially, those in the developing countries (Dzigbodi-Adjimah *et al*., 1995). In Ghana, there is a widespread lack of institutional capacity to implement small-scale mining regulations. Even though much of the small-scale mining operations take place illegally, the law implementing institutions such as the Ghana Police Service found it difficult to enforce the small-scale mining law to the letter because of inadequate personnel and equipment. However, the nature of lawbreaking and the reasons for it according to Jennings (1993) vary. Sometimes there is no land available for small-scale mining, because, it has all been allocated to large companies for prospecting and exploration. In addition, the procedure to obtain license to operate a small-scale mine in the country is tedious, requiring the completion of several forms, and final approval from governmental authorities. This calls for attention.

One of the major operational problems in small-scale gold mining in Ghana is the access to credit. According to the International Labour Organisation (1999), in 1998, over 96% of small-scale gold miners have no access to credit. The lack of capital is an obstacle to mechanization and improving efficiency. These in turn lead to low productivity, low revenues and low wages. Because of low revenues, the miners tend to ignore health, safety and environmental measures.

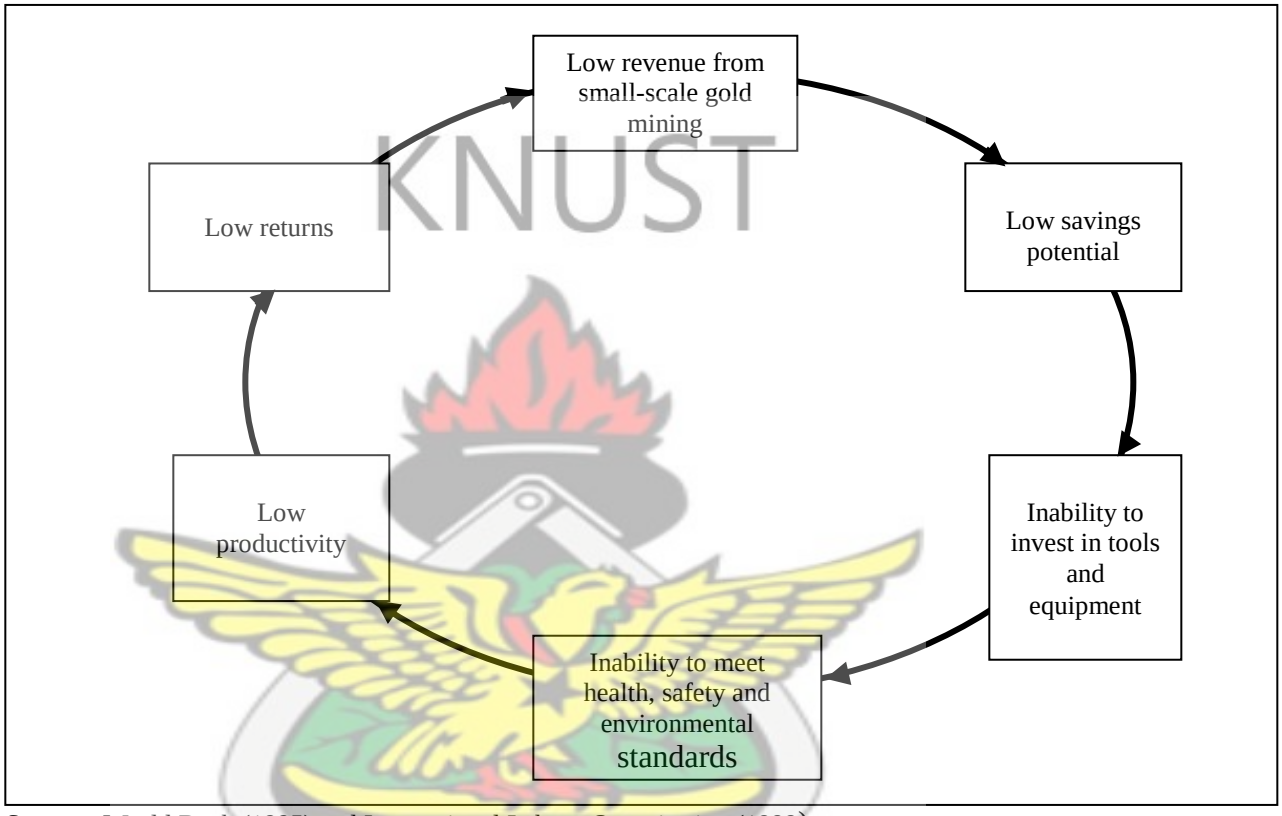
The mine owners and mineworkers, generally, have few assets that banks and other lending institutions in the country will accept as collateral. It is not until they start producing something saleable that they can get credit. The banks are not readily prepared, even when mining rights exist, to take them as security because of the geological risk of unmined reserves, the mobility of many small-scale miners and the widespread weak enforcement of laws and regulations (Dzigbodi-Adjimah *et al*., 1995).

Moreover, banks traditionally require borrowers to provide some security from their own resources, which is a formidable task for many small-scale miners. Small-scale miners according to the World Bank (1995) and ILO (1999), therefore find themselves in a vicious cycle: low revenue from mining $\rightarrow$ low savings potential $\rightarrow$ inability to invest in tools and equipment $\rightarrow$ inability to meet health, safety and environmental standards $\rightarrow$ low productivity $\rightarrow$ low returns from mining as shown in Figure 1.1.

The Ghana Chamber of Mines (1996) reports that few small-scale gold mine workers in Ghana have formal mining training and skills. They obtained the skills and benefited from on-the-job training during their former jobs as miners in large mines before turning to small-scale mining following redundancy. Most of the small-scale miners pick up skills from these experienced workers. According to the Minerals Commission (2007), about 91% of the miners do not have formal training in gold mining. The Inspectorate Division of the Ghana Minerals Commission and the Ministry of Lands, Forestry and Mines sometimes provide semi-formal training and skills to small-scale miners. For the most part, however, opportunities for training are few (Iddirisu and Tsikata, 1998).

Even when they are available, many small-scale miners cannot afford to take time off work for training or to travel to training sessions.

Figure 1.1 Vicious Cycle – Small-scale Gold Mining



Sources: World Bank (1995) and International Labour Organisation (1999)

Small-scale gold mining in Ghana has a poor reputation for occupational safety. Most of the miners are not familiar with safety regulations. In addition, observation at the various mining sites shows that the workers wear shorts and, sometimes, shirts. Hardly anyone uses helmet, earplug, mask or gloves. There are no safety procedures for work at the mining sites (Minerals Commission, 2002). The miners remove rocks with hand tools and load the ore into small sacks, which are carried to the surface for processing. Rock falls, cave-ins, perpetual dampness and lack of ventilation are the most frequently cited causes of accidents in small-scale mines. In addition, the close proximity of the pits to one another increases the risk of subsidence or a cave-in (Appiah, 1998).

Safety inspection is weak because the number of safety inspectors is insufficient in view of the nature of the task and the number and wide dispersion of small-scale mines. The International Labour Organisation (1999) explains that in Ghana, small-scale gold miners, most times, under-report or do not report at all accidents that occur at the mining sites because they have no wish to draw attention to themselves. In their opinion, the fact that there is no form of compensation or social security provision for injury and even for death can mean that reporting an accident will merely lead to unwanted administrative, legal and operational problems.

Observation and news of occasional disaster in the media throw some light on the situation, but not much. Hilson (2001) explains that a combination of lack of resources, lack of or non-application of safety regulations, lack of awareness, illiteracy, lack of training, inadequate equipment and remote location, all point to the likelihood of there being more accidents in many small-scale mining sites. According to the UNIDO (1997), the reported annual fatality in small-scale gold mining in Ghana in 1993 was 20 as compared to 13 in the larger mining companies. A case in point is the fatal incident that occurred at Nyafoman-Noyem a small-scale gold mining community in Eastern Region of Ghana, where about 40 miners were reported dead because of a cave-in. (Daily Graphic, August 15, 2005). Most of the accidents which do occur in small-scale mines can be considered to be preventable if there are strict adherences to safety procedures for work at the mining sites.

Apart from these, there are other non economic issues such as tensions and conflicts of interest between large and small-scale miners and the toxicity of mercury used in the recovery of gold by the small-scale miners which the study did not deal with in detail.

The above-mentioned challenges therefore, call for an analytical study into small-scale mining operations in Ghana and suggest measures that will help improve or transform small-scale gold mining into a sustainable activity. This study seeks to discuss the current issues, undertake a comparative study and perform a benefit-cost analysis on

small-scale mining operations in the Bibiani, Bolgatanga, Dunkwa and Tarkwa of the Minerals Commission of Ghana.

Research Questions

The study addresses four major research questions as follows:

- What are the current issues on small-scale mining in Ghana?
- What explains the magnitude of the differences (if any) in the mining districts?
- Do the costs (problems) associated with small-scale mining operations in Ghana outweigh the benefits?
- Is it worth or economically viable to continue with the existing mining activities?

1.3 OBJECTIVES OF THE STUDY

Main Objective

The main objective of the study is to carry out a benefit-cost analysis to establish whether small-scale gold mining operations in the selected mining districts of the Minerals Commission of Ghana are worthwhile or economically viable.

Specific Objectives

The specific objectives are to:

- Identify the current issues on small-scale gold mining activities in Ghana;
- Carry out a comparative study in the Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining districts of the Minerals Commission of Ghana;
- Estimate and compare the present value of the future benefits and costs of small-scale gold mining in the Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining districts to ascertain whether it is worth continuing with the existing mining activities; and
- Make policy recommendations.

1.4 JUSTIFICATION OF THE STUDY

The relevance of this study is as follows:

Small-scale mining activities are not only a major topical issue or area of concern but also assuming higher proportions in Ghana in recent times and a study into this area will help contribute to the economic development of the country.

The Government of Ghana has established a number of institutions notably, the Ministry of Lands, Forestry and Mines (MLFM), the Ghana Minerals Commission, the Precious Minerals Marketing Corporation (PMMC), the Geological Survey Department (GSD), the Environmental Protection Agency (EPA), and the District Assemblies (DAs) and committed substantial amount of resources towards the development of a sustainable small-scale gold mining sector in Ghana. However, these commitments have not yielded the desired results since the problems associated with small-scale gold mining still remain high. This therefore, calls for a study into small-scale gold mining operations in Ghana. This study will help small-scale gold mining in Ghana realize its full potential towards the economic development of the country.

The inadequate employment opportunities in the public sector in Ghana points to the need for developing a sustainable small-scale mining sub-sector as an area for self employment. Moreover, it is now recognized by international organizations, (especially the ILO), and the Government of Ghana that, one of the solutions to the problem of unemployment is through the development of a sustainable small-scale mining sub-sector (Daily Graphic, February 22, 1989).

The recommendations of the study will help policy makers and implementers such as the Ministry of Lands, Forestry and Mines, the Ghana Minerals Commission, the Precious Minerals Marketing Corporation, the Geological Survey Department, the Environmental Protection Agency, and the District Assemblies develop the small-scale mining sub-sector to become a sustainable one.

A well-developed small-scale mining sub-sector will not only help alleviate poverty in the local communities but also provide rural livelihood; serve as a potential source of government's tax revenue and foreign exchange.

The findings of the study will serve as a reference literature for further studies and contribute to knowledge in the field of small-scale gold mining.

1.5 HYPOTHESES STATEMENT

The study tests hypotheses of equality and hypotheses of independence in the second and third essays though there is no hypothesis testing in the first essay. In the second essay, as found in chapter four, we used a two-way ANOVA to test for the means of equality between the mining districts (Bibiani, Bolgatanga, Dunkwa and Tarkwa) and across the years (time from 2005-2008). Six hypotheses on production volume; employment levels by licensed operators; and the number of licensed operators/concessions in the mining districts were set up to ascertain their statistical significance as follows:

- The means of production volume between the districts (μ_1, μ_2, μ_3 and μ_4) are equal.
- The means of production volume across the years (μ_1, μ_2, μ_3 and μ_4) are equal.
- The means of employment levels between the districts (μ_1, μ_2, μ_3 and μ_4) are equal.
- The means of employment levels across the years (μ_1, μ_2, μ_3 and μ_4) are equal.
- The means in the number of licensed operators between the districts (μ_1, μ_2, μ_3 and μ_4) are all the same.
- The means in the number of licensed operators across the years (μ_1, μ_2, μ_3 and μ_4) are all the same.

As mentioned earlier, in the third essay presented in chapter five, however, both hypotheses of equality and hypotheses of independence were tested. Firstly, two hypotheses were tested to determine whether the means of profitability index of operation between the mining districts/areas - Bibiani, Bolgatanga, Dunkwa and Tarkwa

and across the sector activities - physical environmental, social and aggregate economic sectors are statistically equal by the use of a two-way ANOVA. The hypotheses tested were:

- The means of profitability index of operation between the four mining districts/areas (μ1, μ2, μ3 and μ4) are equal.
- The means of profitability index of operation across the three sectors (μ1, μ2 and μ3) are equal.

Secondly, two hypotheses of statistical independence were tested to verify if (i) benefit and (ii) cost variables across the mining districts/areas and across sector activity are statistically associated with each other. A Chi-Square (χ^2) test of independence was employed to establish the statistical relations between two sets of variables: namely, row variables (Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts/areas) and across the column variables (physical environmental, social and aggregate economic activity sectors). The hypotheses were set up as follows:

- There is no association in benefits between the mining districts/areas and across sector activity variables.
- There is no association in costs between the mining districts/areas and across sector activity variables.

The details of the null and alternative hypotheses are stated in the various essays in chapters four and five.

1.6 ORGANIZATION OF THE THESIS

The thesis is structured into six chapters. Chapter one deals with introduction, which is sub-headed as follows: background of the study, statement of problem, objectives of the study, relevance of the study, research questions to be addressed, organization of chapters and the limitation of the study.

This is followed by chapter two where related literature was reviewed. The chapter is broadly broken down into historical review; legal, institutional and policy framework;

theoretical review; methodological review; and empirical review. Chapter three presents the first essay and focuses on the contemporary issues on small-scale gold mining operations in Ghana while chapter four, the second essay, concentrates on comparative study in the Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining districts of the Minerals Commission of Ghana.

The fifth chapter which is the third essay highlights an integrated approach to benefit-cost analysis in small-scale mining in the Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining districts of the Minerals Commission of Ghana. Finally, chapter six provides a general summary of major conclusions and policy recommendations.

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CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

The purpose of this chapter is first, to examine the relevant literature on gold mining in Ghana; and second, to review the theories and practices of benefit-cost analysis, a tool or technique for decision making. The chapter has five sections: the first part looks at the historical background of gold mining in Ghana while the second part reviews the legal, institutional and legal framework on Ghana's mineral industry. The third section focuses on relevant theories on benefit-cost analysis. The fourth section also focuses on a review of pertinent methodological literature. Finally, the fifth part is devoted to a review of relevant empirical literature.

2.1 HISTORICAL REVIEW

This section reviews the chronological development of Ghana's gold mining industry which is examined in four time periods: namely, the pre-colonial period, colonial period, post independence period up to 1982 and post 1983 periods. These time periods are important in Ghana's mineral industry because they have witnessed different policy directions by different governments which have had a considerable influence on the industry.

2.1.1 GHANA'S GOLD MINING INDUSTRY: PRE-COLONIAL AND COLONIAL PERIODS

Archival sources show that small-scale gold mining operations in Ghana by the natives dates back more than 2000 years (Kaakpema Yelpaala, 2004). In explaining the early European gold mining ventures in Ghana, Kesse (1985) pointed out that the Phoenicians and the Carthaginians sailed to the coast of Guinea in the 5th or 6th centuries B.C but because of the Sahara Desert which acted as a great barrier, very little trade passed between West Africa and the Mediterranean coasts. However, by the end of the 9th century, north-south trade routes had been established and trade in gold was carried on.

Anin (1994) reported that gold trading with the indigenous people started in 1471 with the Europeans, particularly, the Portuguese when they landed near the estuary of the Pra River under the command of Juan do Santarem and Pedro de Escobar and discovered the trade of *Oro de la Mina* (Gold of the Mine) at Elmina or Shama. Later, Diego d' Azambuja made a follow up voyage to the Gold Coast and traded in gold with the indigenous people and after negotiations with the local chiefs, built a fort – *Fortress of Sao Jorge da Mina*, at *El mina* (the Mine) which is the modern Elmina Castle in 1482 (Kesse, 1985; citing Mosely and Waller, 1935).

Commenting on the early gold trading with the English sailors in the Gold Coast, McLaughlin and Owusu-Ansah (1994) citing Cook (1912) emphasized that in 1553, Captain Thomas Windham and Antonio Anes Pinteado made a voyage to the Gold Coast and traded east and west of Elmina and continued as far as to the Benin River. Captain Windham later returned home with 150 pounds weight of gold. By 1555, other English traders, like John Lok and William Towrson also sailed to the Gold Coast and traded in gold. John Lok then returned to Britain with about 400 pounds of gold dust while Towrson obtained gold and ivory from several places along the coast between Cape Three Points and Accra (Annin, 1994).

Mosely and Waller (1935) in their account on the appearance of other European traders in the Gold Coast stated that in 1595, the Dutch made a voyage to the Gold Coast purposely for gold trading. The Dutch settled and later built a fort at Mouree. Fernando Gomez, a Portuguese, opened up and worked a small gold mine at Abrobi Hill, near Komenda in 1482. Sutherland (1952), however, commented that, in 1622, a disaster occurred at this mine. The mine caved-in and killed all the underground workers. The Portuguese, in 1623, then operated a rich gold-bearing reef at Aboasi, near Axim and built a fort to protect their interests (Mosely and Waller, 1935).

Sutherland (1952) further observed that three methods were used as sources of obtaining gold by the indigenous people during the pre-colonial period. These were gold winning from streams and sea gravel, (as done by the inhabitants of Elmina and Shama area); alluvial gold, (as done by the inhabitants of lower Ankobra River); and gold obtained by

digging holes, (as done by the inhabitants from the rainforest zone (in the Ashanti and Tarkwa areas).

Gold digging during the pre-colonial period was undertaken on small-scale bases and according to Annin (1994) citing Winkle (1901), described the modus-operandi of gold digging as "hazardous, tedious and back-breaking". He clarified that the method of remuneration especially, in the rain forest zone of Ashanti was the *Abusa* system. Hilson (2001) in lending support to Annin's clarification, asserted that under the *Abusa* system, the chief on whose land the deposit is situated was entitled to one-third of the gold recovered; the lessee received one-third and the workman the other third. Where the chief employed slaves to win the gold, the chief naturally appropriated all the winnings.

Annin (1994) citing Meredith (1912) documented that gold trading between the indigenous people and the Europeans was by barter or what was known as the "silent trade". This took place mostly on the sea shore where neither the buyer nor the seller met each other. The Europeans brought in such articles as clothing, iron, pewter basins, bras, pots and pans, salt, drinks, guns, gun-powder among others from their countries in exchange for gold dust. The silent trade as described by Kesse, (1985), was "a trade purely on a code of honour and entirely on its own merit". By 1700, a very large quantity of gold was annually exported from the Gold Coast, even though, only a small proportion of the metal passed through the hands of the legitimate companies (Kesse, 1985; and Annin, 1994). The amount of gold which passed through the hands of the legitimate companies is summarized in Table 2.1.

Table 2.1: Annual Traded Gold by Legitimate Companies/Countries by 1700

Legitimate Company/Country	Annual Traded Gold
Dutch West India Company	£47,145
Royal African Company	£37,715
Dutch Interlopers	£47,145
English Interlopers	£36,430
Brandeoburges and the Danes	£31,702
Portuguese and French	£25,144

Sources: Kesse (1985); Annin (1994); and Mines Department of the Ministry of Lands, Forestry and Mines

This section has explored gold mining and trading activities in the Gold Coast during the

pre-colonial days and concludes that gold mining and trading activities in the Gold Coast during the period under review were well documented (Kesse, 1985; Annin, 1994; Meredith, 1912; Sutherland, 1952; and Mosely and Waller, 1935). Available literature on Ghana's gold mining industry suggests that the earliest historical records of the Guinea Coast contains unambiguous references to the activities of the Phoenicians who traded in gold dust and nuggets with the people of the Guinea Coast. The literature indicates that the Portuguese, Dutch, British and other Europeans dominated in the trade with the indigenous people. Developments in the mining industry were responses to economic and political developments in Britain and Europe in general rather than to market conditions.

Ghana's Gold Mining Industry in the Colonial Period

In 1874, the British formally established the British Crown Colony of the Gold Coast which legalized colonial policy on the people of the Gold Coast, even though there had, in fact, been in force some British authority since the signing of the Bond of 1844 between the coastal Chiefs and the British. In spite of the fact that the Chiefs never ceded or relinquished sovereignty to the British under the Bond, most of them allowed the British some interventions in judicial matters (McLaughlin and Owusu-Ansah, 1994). Large-scale mining by the British and other foreigners began in the Gold Coast in the late 19th century. In their comments on the policy framework on gold mining by the colonial administration, Akabzaa and Darimani (2001) emphasized that the policy in the mining sector was aimed, firstly, at establishing a legal and administrative framework that facilitated mining operations and secondly, ensuring the self-sufficiency of the British Empire. These writers asserted that the caveat shaped the formulation and implementation of mineral policy in the colony.

Annin (1994) and Songsore, *et al.* (1994) also asserted that the gold mining industry experienced a rapid growth especially, in the Tarkwa District which was described as the Apinto District of Wassaw and attracted a large number of people from both Ghana and overseas particularly, the Europeans in the Cape Colony of South Africa. Kesse (1985) reported that Monsieur Pierre Bonnet, who is described as the "father of gold

mining in Ghana", formed a French company, the African Gold Coast Company at Axim in 1877, and later opened up the Abosso, Tamso, Effuanta and Awudua mines. Several gold mines (both small and large scale) were opened in the Gold Coast Colony (see Table 2.2). The opening up of many mines and development of economic activities made the Colonial Government appoint a District Commissioner to the Tarkwa District to assist the chiefs in local administration in 1881. In 1882, it became necessary for the British Secretary of State to issue an official warning through the Governor of the Cape Colony of South Africa in order to prevent people from making unsafe journeys to Ghana (Annin, 1994).

Turner (1947) in explaining the early development of quartz reef mines in Ashanti, observed that in 1890, three Fante Concessionaires, namely, Joseph Edmund Biney, Joseph Ettruson Ellis and Joseph Peter Brown, started a gold mine in the Obuasi area. Ntiamoah-Adjaquah (1974) added that in 1895, J.E. Biney and colleagues released the concession to Edwin Arthur Cade, a West African merchant in the City of London who formed the Cote d'Or Mining Company. Mr. Cade in association with some friends later in 1897 formed the Ashanti Goldfields Corporation formerly, the Ashanti Goldfields Corporation (Ghana) Limited, and now AngloGold Ashanti (Ntiamoah-Adjaquah, 1974).

Gold from the Gold Coast played a major role in the English currency until the First World War and Annin (1994) described the role as follows:

> …."it is interesting to note that the first gold coins which were minted in England during the reign of Charles II were processed out of gold from the Guinea Coast of the Gold Coast. These coins were known as Guineas (to designate the source or supply) remained part Britain's currency until the First World War" p.38

Gold production in the colonial era was characterized by two major periods of peak production and three periods of stagnated production. The peak periods, known as the "Jungle Booms" occurred in two time periods, that is, between 1892 and 1901; and 1925 and 1935. However, there was a drastic decline in gold production during the First and the Second World Wars, 1914 – 1918 and 1939 –1945 respectively. The reasons for the decline in gold production during the First and the Second World Wars, as stated by

Akabzaa and Darimani (2001) were acute shortage of mining materials; men who could handle explosives were needed at the warfront; and the British taking-over or internment of German concessionaires. A chronology of the establishment of important gold mining companies in the colonial period is shown in Table 2.2.

Table 2.2: Establishment of Gold Mining Companies in the Colonial Period (1818-1956)

Year	Name of Mine
1818	• Oboum mine started
1880	• Effuanta mine started
1881	• Alanko mine started
1891	• Bibiani mine started
1898	• Ashanti Goldfields Corporation started operating
1900	• Akrokeri mines stated operating
1901	• Winneba- Mankwadze mine started operating
1902	• Bromasie mine started
	• Aboso mine started
	• Adja Bippo mine started
	• Abontiakon mines (part of SGMC)
1903	• Dredging on Pusu Pusu River started
	• Dredging on Tano River started (Tano Gold Dredging)
	• Dredging on Offin River started
1904	• Beposo mines started
	• Dredging on Ankobra and Fura Rivers started
	• Dredging on Birim River started
1905	• Bogoso (MARLU mines) started
1906	• Atassi (Gold Coast Selection Truste) Established
	• Kanyankaw mine started
	• Ariston mine started
1907	• Bilpraw mines started
	• Obenemase mines established
1908	• Ashanti Adowsena mines established
1909	• Dredging on Pra River started [Moruwa Ltd]
1911	• Tokobea mines started operating
	• Detchikrom mine started operating
1912	• Eduaprim mine started
1913	• Cinnamon Bippo mine started
1923	• Tarkwa & Aboso Amalgamated Corporation formed
1927	• Appanto mines and Prestea mines merged to form Ariston Gold mines
1930	• Gold Coast Blanket Areas Ltd ceased production
1935	• Fanti (Gold Coast Blanket Areas) started
	• Amalgamated Blanket Area (ABA) incorporated
1955	• MARLU Goldmine Areas Ltd closed down
1956	• Lyndhunt Deep Level (Gold and Silver) Ltd closed down
	• Tarkwa and Aboso mines Ltd closed down

Sources: Mines Department of the Ministry of Lands, Forestry and Mines; and Kesse (1985);

Furthermore, after the world wars, Kesse (1985) reported that the cocoa and construction industries were booming; the manganese and diamond mines emerged; and the growing number of Ghanaians who preferred to work on their small mines adversely affected labour availability. These factors, therefore, contributed to the decline in gold production over the period under review. Moreover, according to Nkrumah (1968), Britain, finally, had gained control over South Africa after the Boer War and many companies in the Gold Coast with original South African leanings went back to South Africa and this adversely affected gold production in the Gold Coast.

Following the unwillingness of the indigenous people to work for the Europeans, the Colonial Government passed the Mercury Ordinance of 1932 which made it illegal for the natives to use mercury for mining. The indigenous people found themselves without the main chemical for extracting the gold and were made to work for the Europeans. This in effect, resulted in an increase in gold production and the country officially reached its highest in 1933-34 (Kesse, 1985). After 1947, there was a general political struggle for independence and this discouraged the British and other foreign investors to open up new mines.

Kesse (1985) observed that before independence in 1957, there were eleven gold mining companies in the Gold Coast. They were Amalgamated Banket Areas Limited; Ariston Gold Mines Limited; Ashanti Goldfields Corporation Limited; Bibiani 1927 Limited; Bremang Gold Dredging Company Limited; Gold Coast Main Reef Limited; Konongo Gold Mines Limited; Lyndhurst Deep Level (Gold and Silver) Limited; Marlu Gold Mining Areas Limited; Manua Gold Mines Limited; and Tarkwa and Abosso Mines Limited.

In conclusion, the years of British administration of the Gold Coast witnessed a significant growth in the gold mining industry. The euphoria about gold mining in the country was still high. This led to the establishment of more gold mining companies in the country. In addition, the road, rail and communication networks to major mining and commercial centres were improved. The developments in the mining technology coupled with the existing mining regulations and enactments made gold mining,

especially the large scale ones, foreign-owned enterprises.

2.1.2 GHANA'S GOLD MINING INDUSTRY: POST-INDEPENDENCE PERIOD UP TO 1982

The state controlled Ghana's mining industry from 1957 to 1986. After independence, the government established the State Gold Mining Corporation (SGMC) in 1961 to acquire the Bibiani, Tarkwa, Prestea, Konongo and Dunkwa mines from the British companies (Coakley, 1999). Tsikata (1997) confirmed Coakley's account and added that in 1972, the government took majority shares (55%) in Ashanti Goldfields Corporation (AGC) now AngloGold Ashanti, Ghana Bauxite Company (BAC) and Ghana Consolidated Diamonds Company. Furthermore, the Ghana National Manganese Corporation (GNMC) took over manganese operations at Nsuta from the African Manganese Group (AMG), a British subsidiary of Union Carbide.

The main objectives of the government in acquiring these mines, according to Walde (1983), was to protect employment and also provide access to foreign currency generated by the mines because the policy at the time was aimed at maximizing government revenue, controlling resources and generating employment. However, in the light of Akabzaa and Darimani's (2001) observation, in spite of the above policy, the mining sector was constrained by lack of investment, maintenance and exploration. Capital became increasingly scarce. These left the state-run mines uncompetitive and apart from AGC and GNMC, which were operating profitably, the SGMC and BAC were operating at a loss and the State Gold Mining Corporation closed down its mines at Bibiani and Konongo which were making losses.

Between 1958 and 1964, annual gold output rose. However, the mining industry stagnated and annual gold output fell throughout from 1965 to 1986 except in 1980 when the country's gold output rose marginally. The sub-sector, therefore, contributed relatively little to the gross national earnings. Even though, various modifications were made to the mining sector code which was aimed at attracting private participation, they

failed to attract significant foreign private investment because the changes were characterized by high taxes and other duties along with significant state control of the industry (Akabzaa and Darimani, 2001).

In assigning reasons for the decline of output in the mining sector during the period under review, the World Bank (1995) and Akabzaa and Darimani (2001) reported that, the lack of foreign exchange to maintain and rehabilitate the mines; lack of capital; and investment for mining skills were some of the main reasons. To add to the World Bank's report, Songsore, *et al.* (1994) and Akabzaa and Dramani (2001) also specified that infrastructural deterioration, particularly, shortages of rail capacity for gold, manganese and bauxite; mining companies' financial problems due to the greatly over-valued currency and spiraling inflation; a declining grade of gold ore; high absenteeism and low worker discipline and pilfering; and illegal panning and smuggling of gold and diamonds were among the reasons that accounted for the decline of output in the mining sector.

This section has been developed to review Ghana's mining industry in the post-independence period up to 1982 and concluded that the industry was marked by state ownership of mineral resources. This period was generally characterized by stagnation of the industry, except for a few spikes which were recorded immediately after independence and in the early 1970s. The sluggish production, particularly in the gold sector, could be attributed to market conditions, investor uncertainty about the safety of mineral investment under Ghanaian self-rule and the effects of state intervention in the industry coupled with other reasons as outlined by the World Bank (1986); Songsore, *et al.* (1994); and Akabzaa and Darimani (2001) above. The mining sector, therefore, was in dire need of attention.

2.1.2 GOLD MINING INDUSTRY: POST 1983

The post-1983 gold mining sub-sector in Ghana was characterized by improved exploration, mining and processing methods. For instance, the development of mining processing methods such as cyanide heap-leach and bio-oxidation has not only made it

viable for the processing of low-grade material which hitherto was considered waste but has also made possible the efficient processing of more complex ores such as sulphides and oxides (Akabzaa and Darimani 2001). UNIDO (1997) also added that during the period under review, traditional underground gold mining was reduced in favour of surface mining. However, Kaakpema Yelpaala (2004) commenting on Akabzaa and Darimani and UNIDO's statement, pointed out that the proliferation of surface mining in the post-1983 Ghana's gold mining sub-sector has had negative environmental impact.

As the World Bank (1995) reported, the technological movement and the policy dynamics in the mining industry resulted in the widening of mining investment opportunities. During the late 1980s, the mineral industry worldwide and in Ghana, in particular, experienced major changes and there was a paradigm shift of state ownership of mines to private participation. The purposes of the privatisation programme according to Iddrisu and Tsikata (1998) were to reduce the role of the state in the economy and to improve business competitiveness and efficiency; to reduce the fiscal deficit by using the proceeds from the sales to retire external and domestic debt, and to generate new cash flows through investment and tax revenues.

In response to the global demand for policy changes to attract international mining investment, Ghana shifted its focus from direct state investment in the mining sector to the promotion and regulation of private companies. Within the framework of the country's Economic Recovery Programme (ERP) of 1983, and more specifically, under its Structural Adjustment Programme (SAP), the mining sector was a major target for reforms to address first, the concerns of investors and financiers and second, to reverse the fall in the industry and to ensure growth. As a result, the government in the mid 1980's promulgated new regulations, introduced some financial incentives and then set up new state institutions, like the Minerals Commission, to regulate the industry (Kaakpema Yelpaala, 2004; Lynn and Legge, 1996; and Sawyer, 1990).

In describing the post-1983 Ghana's gold mining sub-sector, Akabzaa and Darimani (2001) observed inter alia, that:

…..“with respect to investor perception of the investment environment, the country fast became a fortress of mining and commerce in West Africa. Internationally, Ghana was known to be among a few selected African countries with the most attractive geological and investment environment and comparative geological ranking of African countries placed Ghana third after South Africa and Zimbabwe.” p.14

The Bank of Ghana (2003) and the International Monetary Fund (2005) reported that the new mining environment boosted the issuance of mining and prospecting licenses to 154 local and 83 foreign mining companies, including some major international companies mainly related to gold, and another 23 companies had been granted mining leases as at the end of 1998. From 1983 to 2002, about US$5 billion private investment capital was injected into the mining sector for exploration, establishment of new mines, for example, Teberebie Goldfields Limited (TGL), Billiton Bogosu Goldfields Limited (BBGL) among others for the expansion of existing mines. By 1999, 14 companies were in operation as against seven mines that were in existence in the country in 1986. Five additional mining companies were granted mining licence in 2002.

Akabzaa and Darimani (2001) further affirmed that the policy changes achieved the desired results in terms of the volume and value of mineral output. Gold production, which declined from a peak of 915,317 ounces in 1960 to 282,299 ounces in 1984, rose to 998,195 ounces in 1992, exceeding the 1960 peak value. Output reached its highest record of 1,706,229 ounces in 1995. Similarly, one significant development in the diamond sector was the role of small-scale diamond winners. Their share of total diamond output increased from 4,328 carats to 337,457 in 1995. In 1994, gold exports constituted 45% of total export revenue, thus, beating cocoa which contributed 25% of total exports revenue (Akabzaa and Darimani, 2001).

Employment in the minerals sector also surged, at least up to the close of 1995. The total labour force of the sector rose from 15,069 in 1987 to 22,500 in 1995. This figure according to International Monetary Fund (2005) represented full-time employees of mining companies alone and excludes exploration companies and mining support service companies and those engaged in small-scale gold mining. The Bank of Ghana

(2003) explained further that since 1992, exports from the mineral sector increased and contributed about 40% of the country's total merchandise export earnings and it was one of the major sources of foreign exchange receipts to finance imports as well as other international transactions such as debt amortization and servicing.

2.2 LEGAL, INSTITUTIONAL AND POLICY FRAMEWORK IN GHANA'S MINERAL INDUSTRY

This section examines a number of enactments, establishments and policy structures set up to support the mining industry in order to make the industry vibrant and attractive to investors. It comprises three sub-sections, namely, legal framework, institutional framework and policy framework in the mining sector.

2.2.1 LEGAL FRAMEWORK

A number of enactments have been made by various Governments of Ghana since the colonial era to serve as regulatory or legal framework with regard to the mining industry in general and gold mining operations in particular.

Tables 2.3, 2.4 and 2.5 provide a summary of the list of the major enactments and legal regulatory framework in the mining sector.

More specific, Table 2.3 presents a list of enactments on gold mining in the colonial era. In sum, the enactments on gold mining in the colonial era focused on concession procedures, protection, restrictions, health, safety, corporate tax and export duty. As far back in 1900, there was the Concession Ordinance of 1900. During the colonial era, several ordinances were enacted and amended. Among them are the Gold Mining Products Protection Ordinance 1909, Gold and Diamond Protection Ordinances, Mercury Ordinance of 1932, Gold Duty Ordinance (Amendment) 1951 and Minerals Duty Ordinance 1952.

Table 2.4 also provides a list of enactments on gold mining in the post-independence era. In brief, the enactments on gold mining in the post independence era centered on

concession procedures, administration of lands, capital investment, companies code, conservation and development, subversion, stool lands settlement, income tax and environmental protection.

However, four mineral laws were selected for further review because they constitute the core of all the enactments made on the mineral industry in recent times. These include:

- The Minerals Act, 1962 (Act 126)
- The Minerals and Mining Law, 1986 (PNDC Law 153)
- Small-Scale Gold Mining Law, 1989 (PNDC Law 218)
- The Minerals and Mining Act, 2006 (Act 703)

Finally, Table 2.5 provides the regulatory framework on small-scale gold mining in Ghana. Notable among them is the Small-Scale Gold Mining Law, 1989 (PNDC Law 218), which is the basis or cornerstone for the legalization of small-scale gold mining in Ghana.

Table 2.3: List of Enactments on Gold Mining in the Colonial Era

- Concession Ordinance 1900 (Cap 27)
- Concession Ordinance 1903 (Extends Cap 27 to Ashanti)
- Gold Mining Products Protection Ordinance 1909 (Cap 149)
- Explosive Ordinance (Cap 56) of 1928
- Forest Ordinance (Cap 63) of 1928
- Gold Mining Procedures, Protection Ordinance (Cap 65) of 1928
- Immigration Restriction Ordinance (Cap 70) of 1928
- Mining Health Ordinance (Cap 106) of 1928 and Cap 150)
- Mining Rights Regulation Ordinance (Cap 107) of 1928 and
- Rivers Ordinance (Cap 148) of 1928
- Public Lands Ordinance (Cap 142)
- The Gold and Diamond Protection Ordinances
- The Radio-Active Mineral Ordinance (Cap 151)
- Survey Ordinance (Cap 159)
- The Minerals N.T. Ordinance (Cap 155)
- Mercury Ordinance No.2 of 1932
- Concession Ordinance of 1936
- Minerals Duty Ordinance 1952 (No.20)
- Corporate Tax Ordinance 1942/43
- Gold Duty Ordinance of 1948
- Gold Duty Ordinance (Amendment) 1951

Sources: Mines Department of the Ministry of Lands, Forestry and Mines; and Kesse (1985)

Table 2.4: List of Enactments on Gold Mining: Post-Independence Era

- Minerals Duty (Amendments) Act of 1961 (Act 52)
- Exchange Control Regulations 1961 (L.I. 133)
- Exchange Control Act 1961 (Act 71)
- Concessions Act 1962
- Administration of Lands Act 1962 (Act 123)
- Minerals Act 1962 (Act 126)
- Minerals Duty (Amendment) Act of 1963 Act 167)
- Capital Investment Act, 1963 (Act 172)
- Minerals (Off-shore Regulation) 1963 (L.I.257)
- The Companies Code, 1963 (Act 179)
- Capital Investment (Amendment) Act, 1965 (Act 267)
- The Mines and Minerals (Conservation and Development) Act 1965 (Act 278)
- The Minerals (Control of Smuggling) Act 1965 (Act 298)
- Minerals Control of Smuggling (Amendment) Act 1965, (Act 296)
- Minerals Act and Regulations Decree 1968 (N.L.C.D. 308)
- Mining Regulation L.I. 231
- Mining Regulation L.I. 665 of 1970
- Lands Commission Act 1971 (Act 362)
- Minerals Duty (Amendment) Act 1971 (Act 374)
- Lands Commission Decree 1972 (NRCD 24)
- Subversion Decree 1972 (NRCD 90)
- Lands Commission (Amendment) Decree 1972 (NRCD 112)
- Mining Operations (Government Participation) 1972 (NRCD132)
- Exchange Control (Amendment) Regulation 1972 (L.I. 738)
- Capital Investment Decree 1973 (NRCD 141)
- Stool Lands Settlement Decree 1973 (NRCD 172)
- Subversion (Amendment) Decree 1973 (NRCD 159)
- Lands Commission (Amendment) Decree 1973 (NRCD 192)
- Income Tax (Amendment) Decree 1973 (NRCD 202)
- Exchange Control (Amendment) Decree 1973 (NRCD 220)
- Gold Export Levy Decree 1974 (NRCD 269)
- Minerals Duty Decree 1975 (NRCD 346)
- Minerals Duty Decree 1975 (NRCD 346)
- Capital Investment (Amendment) Decree 1977 (SMCD 123)
- The Lands Commission (Amendment) Decree 1980 (AFRCD 63)
- The Investment Code, 1981
- Minerals and Mining Law, 1986, (PNDCL 153)
- Minerals Commission Law, 1986, (PNDCL 154)
- Minerals and Royalty Regulations 1987, (L.I. 134)
- Small-Scale Gold Mining Law, 1989, (PDCL 218)
- Precious Marketing Corporation Law, 1989 (PNDCL 219)
- Environmental Protection Law, 1994
- Minerals and Mining (Amendment) Act 1994
- Minerals and Mining Act, 2006 (Act 703)

Sources: Mines Department of the Ministry of Lands, Forestry and Mines; and Annin (1994

Table 2.5: Regulatory Framework on Small-Scale Gold Mining in Ghana

General Mining Laws

- Diamonds Decree, 1972 (NRCD 32)
- Environmental Protection Council Decree, 1974 (NRCD 239)
- Additional Profit Tax Law, 1985
- Minerals and Mining Law, 1986 (PNDCL 153)
- Diamonds (Amendment) Law, 1986 (PNDCL 217)
- Small-scale Gold Mining Law, 1989 (PNDCL 218)
- Precious Minerals Marketing Corporation Law, 1989 (PNDCL 219)
- Minerals Commission Act, 1993 (Act 450)
- The Minerals and Mining Act, 2006 (Act 703)

Regulations

- Mining Regulations, 1970 (LI 665)
- Explosives Regulations, 1970
- Minerals (Royalties) Regulations, 1987
- The Minerals and Mining Act, 2006 (Act 703) Section 110

Small-Scale Mining Enactments

- Diamond Mining Industry Protection Regulations, 1927
- Concessions Ordinance, 1939 (c.136, Laws of G.C. 1951 Revision), s.38
- Gold Mining Products Protection Ordinance
- Laws of the Gold Coast, 1951 (Revision)
- Mining Health Areas Ordinance (c. 150, Laws of the Gold Coast 1951 Revision)
- Mining Health Areas Regulations, 1935 (Vol. VIII, 1954 Laws of the Gold Coast)
- Prospecting & Digging License Regulations, 1950 (Vol. VIII, 1954 Laws of the Gold Coast
- Minerals Regulation, 1962 (L.I. 231), especially Regulation 1 and Form 5
- Minerals Regulations, 1963 (L.I. 253)
- Mining Regulations, 1970 (L.I. 665), especially Regulations 4,6,10 and 194–205
- Explosives Regulation, 1970 (L.I. 666)
- Diamonds Decree, 1972 (NRCD 32) (as amended by the PNDCL 216)
- Minerals and Mining Law, 1986 (PNDCL 153),
- Mercury Law, 1989 (PNDCL 217)
- Small-Scale Gold Mining Law, 1989 (PNDCL 218)
- Precious Minerals Marketing Corporation Law, 1989 (PNDCL 219)
- The Constitution, 1992
- Minerals Commission Act, 1993 (Act 450)
- Environmental Protection Agency Act, 1994 (Act 490)
- Water Resources Commission Act, 1996 (Act 552)
- Minerals and Mining Law, 1986
- Minerals and Mining Act, 2006 (Act 703) Sections 82 – 99

Relevant Codes of Practice

- Code of Practice for Small-scale Gold-mining Operations
- Ghana's Mining and Environmental Guidelines

Sources: Mines Department of the Ministry of Lands, Forestry and Mines and Akabzaa *et al.* (2004)

The Minerals Act, 1962 (Act 163)

In brief, this Act was enacted to consolidate with enactments and amendments relating to the administration of the mineral industry, mineral resources, stool and other lands in Ghana. The Act vested ownership of minerals in the President who may grant license for prospecting for minerals, dredging rivers, winning minerals and obtaining water or diverting streams for mining purposes and declare land for mining purposes. Under the Act, prospecting licenses were limited to 60 square miles and to a period of 2 years. In addition, any grant of any mining rights was not to exceed 60 years and mining rights could not aggregate more than 60 square miles for anyone applicant (Minerals Act, 1962, Act 123).

The Minerals and Mining Law of 1986 (PNDC Law 153)

The Minerals and Mining Law of 1986 (PNDC Law 153) is said to be one of the measures that have provided the framework for the resurgence of the mining sector. The law which has the underlying aim of creating a positive enabling climate for both local and foreign investment in the industry, provided for numerous incentives and benefits for mining companies. Among others, mining companies were to pay royalties on gold production from 3 to 12% depending on the rate of returns. A mining lease attracted an income tax of 45%, but where the rate of returns exceeded certain agreed levels, the company paid an additional profit tax. A holder of a mining lease qualified for a capital allowance of 75% of the capital expenditure incurred in the year of investment and 50% in subsequent years.

Mining companies under the Act were also granted allowances on capitalisation expenditure for reconnaissance and prospecting. Where the holder started development of a commercial find, the company was allowed an investment allowance of 5%. Another additional benefit provided was exemption from payment of customs import duties in respect of plant and machinery imported for mining operations. The Gold Mining Companies' Law permitted free transfer of dividends or net profits also allowed the detainment of 45 to 60% of foreign earnings. Unlike in Zimbabwe where it was mandatory for producers to sell what they produced to the central bank, in Ghana, gold

export according to the Act was done directly by the producers, giving investors more control over the marketing of their output (Minerals and Mining Law of 1986, PNDC Law 153).

One of the most significant features of the Minerals and Mining Law is the scaling down of corporate income tax liability and the provision of more specific fiscal allowances that aim to reduce the general tax liability of mining sector operators. For example, corporate income tax, which stood at 50-55% in 1975, was reduced to 45% in 1986 and further scaled down to 35% in 1994 (Biney,1998).

Small-Scale Gold Mining Law, 1989 (PNDC Law 218)

The Small-Scale Gold Mining Law, 1989 (PNDC Law 218) was enacted in pursuance of the Provisional National Defence Council (Establishment) Proclamation 1981. The importance of this law to this study is the fact that it gave birth to the legalization of small-scale gold mining operations in Ghana. The Law which was composed of twenty-one sections has three main parts. Part one deals with the registration and licensing of small-scale gold miners; part two focuses on the operations of small-scale gold miners; and finally, part three concentrates on licence to deal in gold and miscellaneous provisions.

According to the Small-Scale Gold Mining Law, 1989 (PNDC Law 218), licence for small-scale gold mining operation was granted to persons who are citizens of Ghana and have attained the age of eighteen years and furthermore, a licence granted to any person or group of persons other than a co-operative society should be for a period not more than three years from the date of issue in the first instance and may be renewed thereafter. The Secretary by legislative instrument was supposed to prescribe the fees that must be paid for the grant and renewal of a licence.

With regard to the operations of small-scale gold miners, the Law provided that a person licensed to mine gold may win, mine and produce gold by any effective and efficient

method and in his operations should observe good mining practices, health and safety rules and pay due regard to the protection of the environment.

The law, however, prohibited the miners from the use of any explosive in their operations. They were however, permitted to purchase mercury from any authorised dealer such quantities that may be reasonably necessary for the purposes of mining. For a period of three years from the date of the coming into force of the Law, all persons engaged in small-scale gold mining operations were to be exempted from the payment of income tax and royalties in respect of their mining operations.

According to legal experts, the Law failed to consolidate small-scale mining operations into the mining act. Again, the law did not reflect on new thinking and developments in the mining industry and hence, the need to revise the Law. This led to the enactment of the Minerals and Mining Act, 2006 (Act 703).

The Minerals and Mining Act, 2006 (Act 703)

The Minerals and Mining Act, 2006 (Act 703) is the current act which regulates the administration of the mineral industry and mineral resources in Ghana today. The purpose of the Act is to revise the existing Minerals and Mining Law, 1986 (PNDC Law 153) and consolidate the Small-scale Gold Mining Law, 1989 PNDCL 218 to reflect on new thinking and developments in the mining industry.

The Act highlights on the following: ownership of minerals and cadastral system; mineral rights; royalties, rentals and fees; dispute resolution; types of mining licences: reconnaissance licence, prospecting licence; mining lease; radio-active minerals; surrender, suspension and cancellation of mineral rights; surface rights and compensation; industrial minerals; small-scale mining; and administration and miscellaneous provisions. Sections 1 – 80 concentrate on large scale mining while sections 81 – 99 give attention to small- scale mining and sections 100 – 112 focus on administration and miscellaneous provisions.

On the ownership of minerals, like the Minerals and Mining Law of 1986 (PNDC Law 153), the Minerals and Mining Act, 2006 (Act 703) vests every mineral in its natural state in, under or upon land in Ghana, rivers, streams, water-courses throughout the country, the exclusive economic zone and an area covered by the territorial sea or continental shelf as the property of the Republic and is vested in the President in trust for the people of Ghana and the Minister responsible for mines on behalf of the President and on the recommendation of the Minerals Commission may negotiate, grant, revoke, suspend or renew mineral lights in accordance with this Act. Under the Act, mining activities require a mineral right and a person must be granted a mineral right before he/she engages in the search, reconnaissance, prospecting, exploration or mining activities

Holders of mineral rights have obligations which include: appointing a manager with the requisite qualification and experience to be in charge of that holder's mineral operations; notifying the Head of the Inspectorate Division of the Minerals Commission of the appointment of a manager and on each change of the manager; and obtain the necessary approvals and permits required from the Forestry Commission and the Environmental Protection Agency for the protection of natural resources, public health and the environment.

In respect of fees, royalties, and rentals, mining companies are obliged to pay the following: a prescribed application fee; annual ground rent to the owner of the land or successors; annual mineral right fees; and royalties between 3 – 6% of the total revenue of minerals obtained by the holder. A fee, royalty or other payment which falls due under this Act is a debt owed to the Republic and recoverable in the Court.

To oversee the efficient and effective operations of small-scale mining in the mining districts, the Act has made provision for the establishment of Small-Scale Mining Committees which is made up the following members: the District Chief Executive or his/her representative as the chairperson of the Committee; District Officer of the Minerals Commission; one person nominated by the relevant District Assembly; one

person nominated by the relevant Traditional Council; an officer from the Inspectorate Division of the Commission; and an officer from the Environmental Protection Agency.

It could be observed that even though, the Act does not permit foreigners to own or directly engage in small-scale mining, it permits foreign mining servicing companies to provide consultancy services, hiring and sale of equipment to the miners. Some indigenous miners may collude with foreigners with the pretext of hiring equipment and seeking consultancy from them only to form partnerships with them and increasingly add up to the number of illegal miners to the detriment of the national economy.

It is important to emphasize on the expected benefits or economic gains from the improved (investor-friendly) legal regime on the economy of Ghana. The consequence the new mining regime according to Vieta (1994) was the rapid expansion in existing mines, reactivation of abandoned mines and escalation of new exploration sites. Vieta (1994) further stated that at the beginning of 1992, as many as 82 local and 25 foreign companies held gold prospecting and reconnaissance licences in Ghana.

As at 2003, over 150 companies were operating, with 25 of them in active gold exploration and production. Notable among the companies with mining leases as per Vieta (1994) were Ashanti Goldfields Corporation (AGC) now AngloGold Ashanti (Gh) Ltd., Teberebie Goldfields Limited (TGL), Billiton Bogosu Goldfields Limited (BSSG), Goldenrae Mining Co Ltd, Ghanaian-Australian Goldfields Ltd (GAG), Goldfields (Gh) Ltd, Southern Cross Mining Company (SCMC) and State Gold Mining Corporation (SGMC). On the balance, according to the Bank of Ghana (2003), gold production and revenue rose by 217.51% between 1990 and 1995 and, thus, boosted Ghana's foreign exchange earnings.

2.2.2 INSTITUTIONAL AND POLICY FRAMEWORK

Available literature shows that there are a number of institutions established in recent times to provide administrative and the regulatory mechanisms for small-scale mining operations in Ghana (World Bank, 1993; IMF, 1994). They include the following:

- Ministry of Lands, Forestry and Mines
- Minerals Commission of Ghana
- Chamber of Mines
- Precious Minerals Marketing Company (PMMC)
- Geological Survey Department (GSD) of Ghana
- Environmental Protection Agency (EPA)

Ministry of Lands, Forestry and Mines

The Ministry of Lands, Forestry and Mines (MLFM) ensures the sustainable management and judicious utilization of the country's lands, forestry, wildlife and mineral resources for socio-economic growth and development of Ghana. The Mines Section of the MLFM (the former Ministry of Mines) is the principal governmental authority responsible for the mining sector in Ghana and has the task of advising and coordinating government policy on mining issues and reviewing recommended licences and important documents and agreements related to the mining sector (Minerals Commission, 2007).

Minerals Commission of Ghana

The Minerals Commission was established by the Minerals Commission Act, 1993, (Act 450). The Commission is responsible for the regulation and management of the utilization of the mineral resources of Ghana and the co-ordination of the policies in relation to them. The Commission among other things formulates recommendations of national policy for the exploration and exploitation of mineral resources with special reference to establishing national priorities having due regard to the national economy; advises the government on matters relating to minerals; monitors the implementation of laid down government policies on minerals and the operations of all bodies or establishments with responsibility for minerals (Minerals Commission, 2007).

The Minerals Commission has established seven Small-Scale Mining District Offices/Centres in the country to compile a register of all and prospective small-scale gold miners and to supervise and monitor their operations and activities. These centres are located at Akim-Oda, Asankrangwa, Assin-Fosu, Bibiani, Bolgatanga, Dunkwa and Tarkwa (Minerals Commission, 2007).

Precious Minerals Marketing Company (PMMC)

The PMMC was established by the Precious Minerals Marketing Corporation Law, 1989 (PNDCL 219) to buy from small-scale miners precious minerals, such as diamonds and gold, and sell such precious minerals to enhance Ghana's foreign exchange earnings from the mining sector. The PMMC also exists to promote the development of precious minerals and jewellery industry in Ghana by grading, assaying, valuing and processing precious minerals. It was also established to appoint licensed buying agents for the purchase of precious minerals produced by small-scale miners; and to perform any functions conferred upon it by the Precious Minerals Marketing Corporation Law, 1989.

Geological Survey Department (GSD) of Ghana

The GSD of Ghana was established in 1913 as the "Gold Coast Geological Survey". The main task of GSD is to undertake geological mapping, research and investigations to generate, collect and store geoscientific data and knowledge. The GSD has the responsibility to advise the state and the general public on matters relating to geological implications in national development such as issues concerning mineral resource, environment, groundwater management, land use planning and geohazards (Minerals Commission, 2007).

Environmental Protection Agency (EPA)

The Environmental Protection Agency (EPA) was also established by the Environmental Protection Agency Act, 1994, (Act 140). The EPA was set up, among other things, to provide protection of the environment through policy formulation and economic, scientific and technological interventions needed to mitigate any harmful impacts caused

by development activities including mineral exploration and processing. It exists to co-ordinate, supervise, monitor and evaluate the activities on the environment that support goals and targets of the national sustainable development. The EPA also provides standard setting and regulating activities with regard to the application of science and technology in managing the environment for sustainable development. Finally, the EPA promotes the activities needed to underpin the standards and polices required for planning and implementation of development activities (Environmental Protection Agency Act, 1994, Act 140).

In spite of the establishment of the above-mentioned institutional, administrative, legal and regulatory structures to regulate and provide a congenial environment for effective small-scale mining operations in the country, weak institutional structures, inadequate capacity to implement existing regulations, inadequate financial support services and sometimes lack of political will, further contribute to making small-scale mining far from achieving its full potential.

Policy Framework in the Mining Sector

The policy framework in the mining sector which commenced in 1986, formed an integral part of the macro-economic policy reforms of the Economic Recovery Programme (ERP) initiated in 1983 (Hilson, 2001). The mining sector which is a potential and major contributor to the gross foreign exchange received priority attention following the World Bank's policy recommendations for restructuring the key export sectors, especially mining, under the Structural Adjustment Programme (SAP). According to the World Bank (1986), the policy recommendations included: the need for a coordinated programme of rehabilitation of state-owned mines, a satisfactory degree of management autonomy, gradual divestiture of mines to private investors, together with financial assistance in order to reverse the downward trend of production.

According to Songsore, *et al.* (1994), two types of policy actions positively impacted on the mining sector. First, macroeconomic policy reforms; and second, sector specific policy reforms. In more specific terms, the mining sector policy reforms included: changes in mining sector legislation to make the sector attractive to foreign investment;

increasing fiscal liberation of the mining sector; strengthening and reorientation of government support institutions for the mining sector; privatisation of state mining assets; enactment of environmental laws and other mining sector legislative changes. At the macro level, the policy framework also focused on the following: trade liberalisation policies; public expenditure policies; state-owned enterprises reform; and public sector management. The World Bank (1993) reiterated that the SAP was implemented progressively over the years and during the early years of the programme, the mining sector policies were aimed at increasing the worth of the existing mines through rehabilitation. Some mines enjoyed loans from multilateral and bilateral financial agencies and this was facilitated and guaranteed by the government for expansion and rehabilitation while others were put on management contracts to improve their efficiency. According to IMF (1994), the Ashanti Goldfields had substantial funds during the period for expansion and rehabilitation while former state entities such as Tarkwa Goldfields, Prestea Mine and the Ghana Consolidated Diamond Company were given out to various groups of investors under management contract agreements.

The second stage entailed the privatisation exercise, which was carried out in a variety of ways including the following:

- Firstly, the government systematically disengaged itself by selling its shares in these mines to the private sector. In the case of Ashanti Goldfields Corporation, the government progressively reduced its stake to 19% in 1998, from its original 55% through the sale of its shares initiated in 1993, while in the case of Ghana Bauxite Company, the government reduced its shareholding from 55% to 20% in 1998 (Hilson, 2001; and Songsore, *et al.*, 1994).
- Secondly, complete divesture of hitherto state-owned mines to the private sector with government maintaining a statutory 10% free equity in those mines (Hilson, 2001; and Songsore, *et al.*, 1994).

Akabzaa *et al.* (2004) reported that initially, foreign companies were invited to participate in management contract agreements and eventually bought them where they found them viable. For instance, Goldfields South Africa ran the Tarkwa mine on management contract from 1993 and 1994 and eventually purchased it in 1995.

Johannesburg Consolidated Investments (JCI), another South African company, ran the Prestea mine on contract from 1995 to 1996 and purchased it in 1997. Dunkwa Goldfields and Ghana National Manganese Corporation were sold outright while Ghana Consolidated Diamonds, which was run by De Beers on contract, has failed to attract buyers and De Beers refused to exercise its option ((Hilson, 2001; and Songsore, *et al.*, 1994).

2.3 THEORETICAL REVIEW

This section focuses on relevant theories on benefit-cost analysis and it is structured in five sub-sections: namely, overview of benefit-cost analysis; benefit-cost analysis theory; the concept of Shadow Price of Papital (SPC); benefit-cost models; and the concept of small-scale mining.

2.3.1 THEORETICAL OVERVIEW OF BENEFIT-COST ANALYSIS

Literature on the definition of benefit-cost analysis (for example, Hunter, *et al.*, 1982; Hanke *et al.*, 1974; and Stokey, *et al.*, 1978) suggests that benefit-cost analysis is traditionally associated with government intervention and with the evaluation of government action and government projects or policies on issues and which are done through the organisation of data so as to compare benefits of an action with its cost for decision making.

In complement to the definition above, Willig (1976) added that the concept of benefit-cost analysis is regarded as a fundamental rule which is made up of a set of procedures for defining and comparing benefits and costs and it is a way of organizing and analyzing data as an aid to thinking. Stokey, *et al*. (1978), writing on the justification for the use of benefit-cost analysis stated that it is among the objective approaches to assist governments and businesses in making decision; and again, used to clarify factual information about politically controversial projects in order to make the range of choices more apparent.

Zerbe and Dwight (1994) further stated that benefit-cost analysis is sometimes used by one or more groups concerned about a project to support a particular position, with

different information being used in order to allow the analysis to reach different conclusions, while Kerry Turner (1997) view the need to conduct a benefit-cost analysis as a reason to delay a decision and thereby postpone a controversial action.

Considering the role which benefit-cost analysis plays in decision making, Zerbe and Dwight (1994) have observed that:

> ……"decisions are made by decision makers, and benefit-cost analysis is properly regarded as an aid to decision making and not the decision itself." p.2

The justification for benefit-cost analysis cannot be over emphasized. Kerry Turner (1997) documented that the broad purpose of benefit-cost analysis is to help social decision making. More specifically, the objective is to facilitate more efficient allocation of society's resources.

Writing on the types of benefit-costs analysis, Pollak (1998) and Slesnick (1998) explained that there are three major types: namely, *ex ante, ex post* and *in medias res*. *Ex ante* benefit-cost analysis conducted is before a project or policy is started or implemented. *Ex ante* benefit-cost analysis assists in the decision about whether scare resources should be allocated by decision makers to a specific project or policy. Thus, its contribution to policy decision making is direct, immediate, and specific.

Ex post benefit-cost analysis is also conducted at the end of a project. At this time, all of the costs are "sunk" in the sense that they have already been given up to do the project. The value of *ex post* analyses is broader but less immediate as they provide information not only about the particular intervention but also about the "class" of such intervention. In other words, they contribute to "learning" by government, managers and academics about whether particular classes of projects are worthwhile. *In medias res* benefit-cost analysis, studies are performed during the course of the life of a project. An in *medias res* analysis of an ongoing project can also be used for decision-making purposes where it is potentially feasible to shift resources to alternative uses.

There is a vast economic literature that has been developed to explain the theoretical

approaches to investment decisions in public projects and the most popular and frequently used theories according to Souleles (1987) and Arrow (1982) are:

- The benefit-cost analysis theory
- The concept of Shadow Price of Capital (SPC)

The next section reviews the theoretical approaches to investment decisions in public projects, beginning with the benefit-cost analysis theory.

Benefit-cost analysis theory according to Souleles (1987), Arrow (1982), Byrne (1987) and Kelman (1981), is based on the premise that if investment in a public project makes at least one individual better off and no one worse off, then the project is described as pareto satisfactory (named after the noted Italian economist Vilfredo Pareto). When all such projects have been undertaken, the situation is deemed Pareto optimal (Sen *et al*., 1982; Harsanyi, 1953; and Kemper, *et al*., 1983).

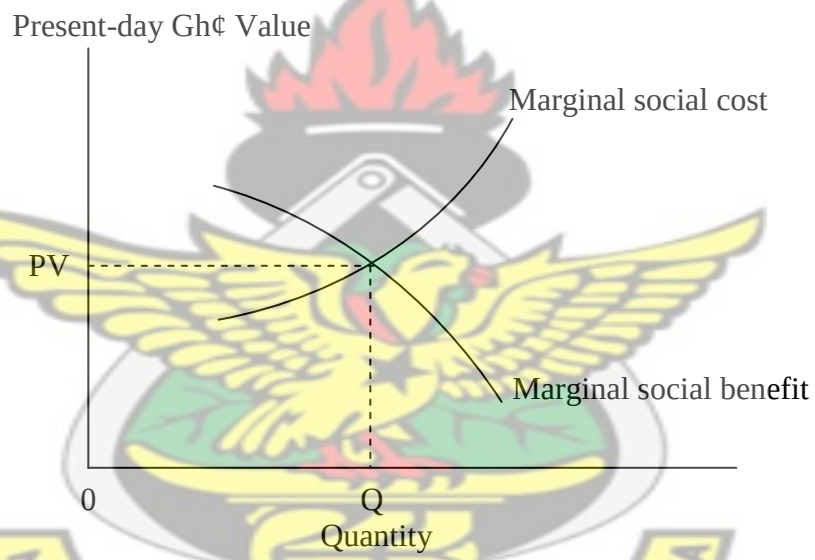
Pollak (1998) and Slesnick (1998) in a similar way submitted that in practice, most public expenditures on public investments, projects or programmes increase the welfare of some individuals while reducing the welfare of others. As a result, it is often regarded as too stringent to require that all public works fit the Pareto satisfactory criterion. Instead, it is often required that they meet the criteria of a potential Pareto improvement, in which there are positive net benefits. In other words, a government programme or project is deemed attractive under the potential Pareto improvement criterion when beneficiaries could fully compensate losers and still receive positive net benefit.

The potential Pareto improvement criterion provides the theoretical rationale for benefit-cost analysis. Thus public programmes and projects are desirable from a social standpoint so long as benefits exceed costs. In theory, public programmes and projects must be undertaken if marginal social costs equal marginal social benefits. This principle is similar to the profit-maximizing standard that output should increase to the point at which marginal revenue equals marginal cost (Zerbe and Dwight, 1994; Byrne, 1987; and Kelman, 1981).

The optimal allocation of social resources is shown in Figure 2.1 in which the marginal social cost (MSC) curve intersects the marginal social benefit (MSB) curve at quantity Q for a given present value (PV).

Potential Pareto improvement is maximized from government public-sector investments when the marginal social cost equals marginal social benefits. Output level Q maximizes society's net benefits. For output levels less than *Q*, the marginal net benefit to society is positive and marginal net benefit to society is negative at output levels greater than Q.

Figure 2.1: Maximization of Social Benefits from Public Sector Programmes and Projects



Source: Zerbe and Dwight (1994)

Potential Pareto improvement of a simplified case of two public-sector investment projects X and Y is expressed as

$$\frac{MSB_X}{MSB_Y} = \frac{MSC_X}{MSC_Y} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Equation (1) according to Zerbe and Dively (1994) explains that society attains its potential Pareto improvement or optimal social benefit for public-sector investment projects X and Y where the ratio of marginal social benefits equals the ratio of marginal social costs for both projects.

Pollak (1998), however, questions why two public sector projects X and Y but not six or ten? In response to Pollack's question, Zerbe and Dwight (1994) asserted that many economic problems, theoretically, are naturally formulated by means of a two commodity model. Alternatively, Potential Pareto improvement of a simplified case of two public-sector investment projects X and Y is attained where marginal social benefit to marginal social cost ratio is equal for each respective public-sector investment project. Thus,

$$\frac{MSB_X}{MSC_X} = \frac{MSB_Y}{MSC_Y} = ... \frac{MSB_K}{MSC_K} \quad \text{..... (2)}$$

Equation (2) shows the value of marginal social benefit relative to the dollar amount of marginal social cost for each project, in this case X, Y up to K projects.

If the ratio MSB/MSC > 1, the value of marginal social benefits exceeds the value of marginal social costs. If the ratio MSB/MSC < 1, then the value of marginal social benefits is less than the value of marginal social costs. If the ratio MSB/MSC = 1, the value of marginal social benefits exactly equals the value of marginal social costs. When MSB/MSC = 1, a dollar's worth of social benefit is received for each additional dollar spent on government programmes and public-investment projects (Zerbe and Dwight, 1994).

This relationship implies an important decision rule. If resources are fully used throughout the economy, society's net benefit will be maximized when MSB/MSC = 1 for the last or marginal government programme or public-sector investment project. Further, net marginal benefits to society are possible through an expansion in the public sector when MSB/MSC > 1 for the marginal public-sector project; resources are being wasted in the public sector when MSB/MSC < 1 for the marginal public-sector project.

The benefit-cost analysis theory therefore concludes that only when MSB/MSC = 1 for the marginal public-sector project and private sector project are resources effectively allocated between the public and private sectors. This section has discussed the benefit-

cost analysis theory as a basic theoretical tool to public projects or investment decision making and efficient allocation of limited resources.

The Concept of Shadow Price of Capital (SPC)

Several writers (for example, Lyons, 1990; Arrow, 1982; Zerbe and Dwight, 1994; Lesser, *et al.*, 1993; and Quirk, *et al.*, 1986) view shadow price capital as an alternative concept that can be used to convert public investments that displace private funds to consumption equivalents. That is, in shadow price capital, we simply convert all benefits and costs to consumption equivalents and discount by the social rate of time preference. The shadow price capital concept assumes that if the government invests $X or GH¢ X million in a public project, some of the funds will come from consumption foregone while others will also come from private investment foregone. According to Zerbe and Dwight (1994), the concept of shadow price capital is explained as follows:

Let θ_c be the fraction of a dollar of public spending that displaces private investment. That is, this is the amount by which private capital formation is reduced as a result of financing an additional dollar of government investment. Then (l - θ_c) will be the fraction of public investment funds that comes from consumption. Recognizing that consumption of a dollar in year *t* has a present value $X or Gh¢ X million in year *t*, the present value of a dollar of costs in year *t* will be

$$PV_c = \theta_c (V_t) + (1 - \theta_c) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

The term θ_c represents the present value of the fraction of the project's costs that come from private capital displaced. The present value of this is found by multiplying it by SPC. The term (1 - θ_c) is the fraction of the costs that come from foregone consumption. Thus the present value of costs as of year *t* incurred will be

$$C_t^* = C_t [\theta_c V_t + (1 - \theta_c)] \quad \ldots\ldots\ldots\ldots(4)$$

Where; V_t is the additional amount of consumption that society would expect in place of the $X or Gh¢ X million of private capital investment forgone; C_t is costs as ordinarily measured and C_t^* is adjusted costs as adjusted by Equation (4). Zerbe and Dwight (1994) further explain that a similar expression can be found for benefits.

Let θ_b be the fraction of each dollar of returns from public investment that is returned to private capital. That is, θ_b is the amount by which private capital is increased as a result of an increase of \$X or Gh¢ X million in the output of the government sector. Thus in any period *t*, the benefits B_t will have a consumption present value in that year of

$$B_t^* = B_t [\theta_b V_t + (1 - \theta_b)] \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

The change in consumption in each year can be expressed as

$$\Delta Y_T = B_t^* - C_t^* \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Equation (6) expresses the present value in each year of the benefits and costs of a project that takes into account the addition to or the displacement of private capital and the consumption gained or foregone. This is done by expressing all effects in terms of the result for consumption and discounting (for net present values) or compounding (for net future value) by the social rate of time preference. The change in welfare can then be found by plugging the values in equation (6) for adjusted benefits and costs into Equation (7a). The net present value of the consumption value for the project will then be

$$NPV = \sum_{t=1}^{t} \frac{B_t^* - C_t^*}{(1+r)^t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7a)$$

Alternatively, the net future value will be

$$NFV = \sum_{t=1}^{t} B_t^* - C_t^* (1+r)^t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7b)$$

Arrow (1982) and Quirk *et al.* (1986) added that equation (6) is the fundamental present value equation for benefit-cost analysis in a second-best world. It incorporates implicitly the correct interest rate for discounting the benefits and costs of public projects. This can be spelled out with all terms to give

$$NPV = \sum_{t=0}^{t} \frac{B_t[\theta_b V_t + (1-\theta_b)] - C_t[\theta_c V_t + (1-\theta_c)]}{(1+i)^t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

For simplicity, let the term in brackets on the benefit side be F_B, [that is, $F_B = [\theta_b V_t + (1-\theta_b)]$ and the corresponding cost term F_c. If the value of $\theta_b > \theta_c$, then $F_B > F_c$ and discounting by the social rate of time preference (SRTP) will understate the net present

value and if $F_c > F_B$, discounting by the SRTP will overstate NPVs. However, if $F_B = F_c$, then discounting by the SRTP will give a correct answer.

Available literature (for example, Arrow, 1982; Zerbe and Dwight 1994; Lesser, *et al*., 1993; and Quirk, *et al*., 1986) explain that the SPC concept could further be analyzed to determine the desirability of a project by considering the following cases:

Case 1: Where $\theta_b = \theta_c$**:** In this case the fraction of private investment displaced by the project is equal to the fraction of benefits that contribute to private capital, that is, $F_B = F_c$. In this case, equation (7) now becomes

$$PV = \sum_{t=0}^{t} \frac{F[B_t - C_t]}{(1+i)^t} \text{.......................................} (9)$$

In this situation, F is a multiplier that affects the size but not the sign of the discounted benefits and costs. A project is socially desirable when $\theta_b = \theta_c$. Therefore, in the case where a single project is being compared to the status quo, the correct result will follow from using the social rate of time preference applied to ordinary costs and benefits as the discount rate.

Case 2: Where $\theta_b = 1$; $\theta_c = 0$**:** This is the situation in which none of the costs of the project displace private capital but all of the returns to the project go to private capital. In this case the discounting equation is

$$PV = \sum_{t-0}^{T} \frac{B_t V_t - C_t}{(1+i)^t} \text{..........................} (10)$$

This indicates that discounting both costs and benefits at the SRTP will understate the net value of the project, unless an adjustment multiplication by the SPC is made to the benefits of the project. Where $\theta_b > \theta_c$ and the SRTP is used to discount benefits and costs, a project with a positive NPV clearly should be accepted.

Case 3: Where $\theta_b = 0$; $\theta_c = 1$**:** In this case all the costs of the project come from private capital and none of the benefits return to private capital The discounting equation is

$$PV = \sum_{t-0}^{T} \frac{B_t - C_t V_t}{(1+i)^t} \quad \text{..... (11)}$$

In this situation it is appropriate to discount the benefits by the social rate of time preference but not the unadjusted costs. Using the SRTP to discount both the unadjusted costs and benefits will overstate the present value.

2.3.2 THE CONCEPT OF SMALL-SCALE MINING

Texts on small-scale mining suggest that it is difficult to provide a general conceptualization and definition of small-scale mining because what constitutes a small-scale mine in country X (say the United States of America) may look quite large in country Y (say Ghana, Burkina Faso or Tanzania). Furthermore, what is a small mine for iron ore or limestone, may be a very large mine for gemstones. In addition, some of the mines that used to be considered as large some fifty years ago may be judged by today's standards, to be small. The concept of small-scale mine according to Chatterjee (1993) is, therefore, viewed as qualitative and quantitative and the quantitative parameters are based on country-relative, mineral-relative and time-relative factors.

Criteria for Defining Small-Scale Mining

Various writers (see for example, Chatterjee, 1993; Anders, *et al.* 1978; and Adams, 1980) define small-scale mining based on the examination of the characteristic features of small-scale mines which are recognized and stand out in different countries. These features are discussed as follows.

- OWNERSHIP: Some countries define small-scale mines by using the ownership criterion. For example, the Mineral and Mining Act, 2006 (Act 703) of Ghana and the Mining Law of Indonesia provide for such a definition. According to these enactments, small-scale mining is defined to include entities that are owned by co-operatives and individuals. However, this criterion hardly has any relevance to countries like USA, where the economy is dominated by private companies or Russia, where the economy is (completely) centralised.
- CAPITAL INVESTMENT: Small mines are considered as low capital-intensive (Chatterjee, 1993). This criterion varies from a specified limit of US$2.5 million in Argentina, R8 million in South Africa to US$1 million in Thailand. However,

the problem arises when an attempt is made to spell out the expenses to be covered under investment. Unlike in the case of manufacturing industries, establishment of a small mine involves investment on account of prospecting, exploration, acquisition of plant and machinery and development of infrastructure. Part of these investments may be made by the government on promotional basis, and part by the mine-owner. It is, therefore, impossible to set a ceiling on capital investment so as to enable a mine to qualify as small (Anders, *et al.* 1978; and Adams, 1980).

- DEGREE OF MECHANISATION: Generally, small mines in developing countries such as Ghana, Tanzania, Burkina Faso and Togo are labour-intensive and are not mechanised (Banks, 1977). However, Anders, *et al.* (1978) dissenting from Banks' view pointed-out that it is difficult to quantify the limit of mechanisation in terms of the value of the machines. Moreover, small mines in countries like Peru and India use machines either on a hired or on co-operative basis. Further, in some of the developed countries like the United States where technology is high, small mines use mechanised method.
- DEPTH OF WORKINGS: Most small-scale mines are described as surface and or shallow underground mines. The depth of mining largely depends on depth of the deposit, which is a natural attribute not subject to human manipulation (Barber, 1980).
- NATURE OF WORKING: In this criterion, small-scale mining is defined to work on seasonal basis. For example, most small-scale mines especially in developing countries such as Ghana, Tanzania, Burkina Fasso and Togo work on seasonal basis. But this criterion limits the definition of small mines only to those mines which do not have the means to purchase (or even hire) pumps for pumping water (Anders *et al.* 1978; and Adams, 1980).
- EMPLOYMENT: This is one of the commonest parameters used to define a small mine. This can be a criterion - both quantitatively and qualitatively. This differs from one country to the other. For example, in India, the Mines Act states that a mine which provides an average daily employment of less than 60 is considered as small (Chatterjee, 1993).

- SIZE OF THE DEPOSIT: In countries such as Tanzania and India, a geological area with small deposit is reserved for small-scale mining. However, this does not preclude small-scale mining in large deposits in some countries like the United States (Barnett, *et al.*, 1963).
- VALUE: The consensus reached at the International Conference on Small-Scale Mining in Mexico City – Mexico in 1978 was that a mine having a turn-over not exceeding US $150,000 per annum is classified as small. In Korea, it has been reported in 1984 that a mine which produces minerals worth less than US $140,000 per year is considered as small (Anders, *et al.*, 1978).
- PRODUCTION: This is a very common parameter. It has certain advantages inasmuch as that (i) it is a quantitative parameter (ii) it is easily understandable (iii) it can be statutorily monitored and (iv) it is directly related to the economic indices like the Gross Domestic Product. The United Nations (1992) recommended that any single unit mining operation having an annual production of ore of 50,000 tonnes or less, as measured at the entrance of the mine, be classified as a small-scale operation. At the International Conference held in Mexico City – Mexico in 1978, the suggested limit was 500 tonnes a day. The International Workshop on Small Mining held in New Delhi-India in 1984 also set an annual production ceiling of 100,000 tonnes.

The section has explored the different criteria in defining small-scale mining and concludes that, apparently, there is no single parameter that can serve the purpose of defining a small-scale mine and the quantitative indices of the parameters have to be country-specific and mineral-specific. This study therefore, adopts the following: (i) ownership, (ii) degree of mechanization, (iii) depth of workings, (iv) nature of working and (v) capital; investment criteria. These criteria are in consonance with the Mineral and Mining Act, 2006 (Act 703) of Ghana which is the current legal framework governing Ghana's mineral industry.

Thus small-scale mining is defined as mining operation by a person, a group of persons or co-operative societies (nationals/citizens) that use labour intensive mining technique, employ unsophisticated technology and require low capital investment. This includes

operations at the lower end of the scale. On the upper end of the scale, small-scale mining operations refer to mining operation by a person, a group of persons or co-operative societies that employs basic mining and processing technology such as mechanical drilling and water pumping, blasting, manual loading, mill with gravity concentrator and other similar techniques.

Socio-Economic Significance of Small- Scale Mines

Some writers (Limon, 1972; and Mackenzie, *et al.*, 1980) wonder why small-scale mining activities should be encouraged, especially in developing countries like Tanzania due to its emerging problems. This issue is of keen interest to this study. The International Conference on Small-Scale Mining held in Mexico City - Mexico in November 26 - December 15, 1978 has helped pooling global opinion regarding the socio-economic significance of small mines. These, as per UNIDO (1997) are summed up as follows:

- Small-scale mines are large in number. Consequently, their collective impact is considerable. The United Nations in 1992 estimated that about 10% of the world mineral production is contributed by the small mines (United Nations, 1992). This estimation is, of course, based on intuitive judgment, and has not found total acceptance. The estimates by others, as recorded, vary up to about 20 per cent (UNIDO, 1997).
- Small-scale mines contribute significantly to the development of entrepreneurship. These can serve as a sort of training ground for the entrepreneurs so as to prepare them for bigger and more challenging ventures (United Nations, 1992).
- Small-scale mines serve as an impetus for the cooperative movement. For certain services of common utility, such as transport, power, marketing, among others, small mines individually may not be in a position to afford the cost; moreover, their individual needs may also be limited. This sort of situation is ideal for taking initiative to form cooperatives, so as to distribute the cost of those services amongst a large number of mines. The cooperative spirit amongst the small-scale mine owners is very strong in the Latin American countries, where there is a

long history of their successful operation. In Indonesia also, many small mines operate under cooperative ownership (United Nations, 1992).

- Working for a mineral in a large number of mines helps to create an atmosphere of competition and to prevent formation of monopolies (United Nations, 1992).
- Opening and working of a small-scale mine within a deposit often helps to understand the geology of the deposit better than exploration alone would facilitate. Also, a separate programme of intensive exploration may sometimes be avoided, thus effecting reduction in the overall cost of exploration. Later on, if the geology of the deposit turns out to be favourable, the small mine can be gradually transformed into a large mine. If, on the other hand, a large mine were to be opened straightaway, a lot of preparatory development work preceded by intensive exploration, would perhaps be necessary. In India, the production in Bombay High Oil Field was started in phases while exploration and development works were continuing (UNIDO, 1997).
- There are certain minerals which occur in nature in highly erratic forms. Their extension, reserve, and quality are so uncertain that the results of exploration are almost unpredictable. Mining becomes more or less a sort of gambling. Mica and graphite are such minerals. Small-scale mining is the answer to the problems of exploitation of such mineral deposits (UNIDO, 1997).
- Small, isolated deposits of any mineral are not amenable to large scale mechanized mining. The only way to get the best out of such deposits is to exploit them as small-scale mines (UNIDO, 1997).
- Even, large deposits may, sometimes, have to be mined on small-scale. This situation arises, when the mineral has uncertain demand - either quantity-wise or quality-wise. For example, in the case of gemstones, market demand is very unpredictable; sometimes, demand for a particular quality may shoot up, at other times some other quality may be preferred. In such cases, small-scale mining (even if the deposit is large), may be desirable, because it is this type of mine that can quickly adjust to the buoyancies and slumps of the demand. During lean periods, this type of mines can even be temporarily closed down without much of

side problems (Mackenzie, *et al.,* 1980).

- Small-scale mines require small investments and also short gestation periods. At times of urgency, therefore, small-scale mines are opened in order to tide over the crises. In India, this sort of situation arose when the Bombay High Oil Field was discovered. At that time a world-wide crisis in petroleum market had been prevailing following the unprecedented fourfold hike in price by the OPEC in 1973. After the discovery of that oil field, the government did not want to wait for a systematic planned development of its full potentiality; and instead, decided to start exploiting whatever could be exploited with the minimum gestation (Mackenzie, *et al.,* 1980).
- Small-scale mines, being scattered in remote areas, can serve best the local demand. More so, if the mineral happens to be a low-value one, because in that case it will not be economically feasible to transport it to distant markets. Building sand, limestone for lime burning, brick earth, etc. can be cited as examples (Mackenzie, *et al.,* 1980).
- Small mines are usually located in remote areas. Such mines serve to boost up infrastructure development like roads, railways and power in those areas (Mackenzie, *et al.,* 1980).
- Produce from small mines, sometimes, supplement the output of large mines and help the latter in making good some of the unutilized capacities of their processing plants. Further, large mines may supply some of their idle machines to the nearby small mines on hire basis. This also helps in better utilisation of capacities of the plants and machineries of large mines. In Peru, some small-scale mine-owners operate their iron ore mines with the help of machineries hired from some large mining concerns (Mackenzie, *et al.,* 1980).
- Small-scale mining is usually labour-intensive. Since their number is large, the overall employment level is sizable. In Malaysia, it has been reported, small-scale tin mines employ twice as many labour as in medium scale mines, and 25 times as many as in large scale fully mechanized mines (Limon, 1972).
- Small mines by virtue of their rural bias provide employment to rural people.

The working of small mines is, often, seasonal in nature, and so they are able to provide additional opportunities of employment to agricultural labourers during the latter's idle times. Thus, the small mines serve to counter the migration of labourers from villages to cities (Limon, 1972).

- Small-scale mines generate downstream economic and industrial activity in remote rural areas. This provides employment opportunities to many more skilled and unskilled workers. For example, around steatite quarries in Bheraghat near Jabalpur, many handicraft industries thrive, and many artisans earn their livelihood. This not only increases the volume of employment, but also spreads the economic activity far and wide, and distributes the income at various levels (Limon, 1972).
- Small mines support ancillary industries in villages. Such mines require traditional unsophisticated machineries which can be catered by local village workshops, giving the latter a chance to flourish. This increases and spreads the economic activity, with accompanying income generation and distribution (Limon, 1972).

2.4 METHODOLOGICAL REVIEW

Available literature, for example, Rogers, 1980; Clawson, *et al.*, 1996; and Brookshire, *et al.*, 1982) suggests that four different approaches can be used to describe benefit-cost analysis: These include: cost-oblivious approach, cost-effective approach, cost-sensitive approach and strict cost-benefit analysis approach.

The cost-oblivious approach is one in which decision makers reach a decision without regard for the costs involved. The most obvious examples of such situations involve environmental regulations. Many pollution control or health protection standards mandate achievement of specified control levels regardless of the costs. In some cases, these decisions may reflect implicit benefit-cost analyses conducted by the decision makers (Dorfman, *et al.*, 1993); and Brookshire, *et al*., 1982).

Cost-effective approach involves identifying the best approach to meet a particular goal.

Often, the goal is set through a separate process that may or may not have recognized the benefits and costs. Once the goal is set, policy makers specify efforts to achieve the goal and do an assessment and implementation based on their cost effectiveness. Administrators then review alternative approaches and choose those that will allow the goal to be achieved at the lowest cost (Rogers, 1990; Clawson, *et al.*, 1996; Schulze, *et al.*, 1982).

Cost-sensitive approach requires that the costs of a project or policy be considered, but stops short of requiring a strict benefit-cost analysis. In such a case, economic costs are often only one of the factors that the government or organization is required to consider in establishing policies or regulations. The cost-sensitive approach is the most common model used in federal and state policy making in the United States since it allows elected officials to set major policy goals while also allowing the development of detailed policies and regulations to be left to specialized agencies (Rogers, 1980; Clawson, *et al.*, 1996; Schulze, *et al.*, 1982).

Strict benefit-cost analysis approach also requires a formal benefit-cost calculation to be used in reaching a policy decision. In the view of Rogers (1980), Clawson, *et al.* (1996) and Schulze, *et al.* (1982), the strict benefit-cost analysis model involves the following steps: first, enumerating all the ways in which a proposed project or policy would impinge on the economy; second, tracing the effects of the project, measure or programme on the economy; third, translating those effects into monetary terms by discounting; and finally, aggregating the resulting benefits and costs into an estimate of the net effect of the project, measure or programme.

Related literature (for instance, Gentry, *et al.* (1984) and Noble (1979) suggest that several methods are used to make economic and financial decisions. These include: the Future Value (FV), Net Future Value (NFV), Net Present Value (NPV), Benefit-Cost Ratios (BCRs), Internal Rate of Return (IRR), and the Pay Back Period (PBP) and wealth-maximizing rate (WMR). The writers stated that these methods help investors to make decisions on three basic problems that can be approached using financial or benefit-cost analysis.

- The first category involves assessing the desirability of a single mining project or investment to know whether the undertaking will increase or decrease real wealth and thus to ensure that the undertaking makes us better off than alternative decisions, including the decision to do nothing.
- The second category of problem involves the comparison of mining projects in order to ascertain the preferred project, that is, the project that increases our real wealth.
- The third category of problem also covers mining activities we need to undertake, even though they may not necessarily increase real wealth. We need to compare different alternatives to accomplish the same objective involved. For example, a mining company decides to rebuild a highway and needs to know which design to choose. In this category, these methods help us to select the alternative that accomplishes the goal at the lowest possible cost.

The methods used in decision making under benefit-cost analysis are reviewed as follows:

Future Value (FV_t) and Net Future Value (NFV_t)

Boardman, *et al.* (2006) explain that the future value is the value of a project or an asset at a specific period of time. It measures the nominal future sum of money that a given sum of money is worth at a specified time in the future assuming a certain interest rate or more generally, rate of return. According to Breadly and Myers (1981) this method compares what an investor will receive in the future if he/she invests in a project or asset with what he/she will receive in the future if he/she invests the money in the best alternative.

Boardman, *et al.* (2006) state that in general, if the value of a project, amount or an asset denoted by P is invested for *t* years and the interest rate is compounded at *r* percent per annum, then the future value FV_t is

$$FV_t = P(1+r)^t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

According to Boardman *et al.* (2006), this is the fundamental formula for compound interest and is one of the most important equations of finance. The compound interest is in contrast with the simple interest. The major disadvantage of simple interest from an

investor's standpoint in that interest is not paid on interest already received. Interest is paid only on the original principal, thus the amount of interest paid per period is constant. Because of this problem, simple interest is rarely encountered in modern finance.

The study used compound interest in its empirical work in chapter five since almost all charges, contracts (in the form of loans from the banks) in Ghana today use compound interest in one form or another.

The Net Future Value expresses the sum of the difference between the benefits and costs of a project at a compounded rate of interest over a period of time (Boardman, *et al.*, 2006; Bready and Myers, 1981; Zerbe and Dwight, 1994). Given that *B* denotes benefits, *C* is costs, *r* the interest rate and *t* time period, the Net Future Value (NFV_t) is

$$NFV_t = \sum_{t=0}^{n} B_t (1+r_t)^t - \sum_{t=0}^{n} C_t (1+r_t)^t \quad \text{.....(13)}$$

Again, the study adopted the Net Future Value (NFV_t) approach in its empirical work in chapter five. The reason is that the study aims at comparing the present value of the future benefits and costs of small-scale gold mining in the Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining districts to ascertain whether it is worth continuing with the existing mining activities.

Benefit-Cost Ratios (BCRs) Using the Net Future Values (NFV_t)

Hoel, *et al.* (1983) stated that BCRs are seen as efficiency criterion on the benefits and costs of a mining project and use these relationships to decide whether a particular mining project is a good investment (or efficient). They also acknowledged that there are three forms of the BCR that are commonly encountered: the uncopounded BCR_u; the compounded BCR, and the net BCR_n.

- **Uncompounded BCR (BCR_u)** The uncompounded BCR (BCR_u) is the total benefits from a project divided by the total costs which is expressed as

$$BCR_u = \sum_{t=0}^{n} \frac{B_t}{C_t} \quad \text{.....(14)}$$

Where B_t represents the benefits in period *t*, C_t represents the costs in periods *t*, and *n* is the project life span. Any project whose BCR_u is greater than 1 or exceeds 1 has benefits that exceeds costs, and hence is a good investment according to this criterion. It must be noted that in this form of BCR, no compounding of interest occurs so payments in the distant future are treated as equivalent to payments made immediately.

Critics of this criterion notably, Arrow (1982); Dively, *et al*., (1999); and Lesser, *et al.* (1993) argued that the uncompounded BCR is incorrect since the time value of money is completely ignored and suggested that the compounded BCR is more appropriate.

- **Compounded BCR (BCR_d):** A more sophisticated form of BCR that recognises the time value of money is the compounded BCR (BCR_d). It is expressed as:

$$CBR_d = \frac{\sum_{t=0}^{n} B_t (1+r_t)^t}{\sum_{t=0}^{n} C_t (1+t_t)^t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

Where; r_t is the appropriate compound rate at time *t*. Again, if the BCR_d is greater than 1 or exceeds 1, then the project is considered to be economically viable or increase real wealth.

In the view of Arrow (1982); Dively, *et al*., (1999); and Lesser, *et al.* (1993), this version of the BCR produces correct decisions about projects since it allows for the time value of money. It could be observed that the BCR_d is very similar to the calculation of NFV expressed in equation (12). The only difference is the operation used to compare costs and benefits: while the NFV uses subtraction, the BCR_d uses division. An NFV greater than 0 is equivalent to a BCR_d greater than 1 and an NFV less than 0 is equivalent to a BCR_d less than 1. Thus NFV and the compounded BCR_d will always produce identical decisions about projects.

- **Net Benefit-Cost Ratio (BCR_n):** The BCR_n according to Zerbe and Dwight (1994) is defined as the ratio of the compounded net benefits (benefits minus costs) to the compounded costs, and is usually expressed as a percentage:

$$BCR_n = \frac{\sum_{t=0}^{n} B_t(1+r_t)^t - \sum_{t=0}^{n} C_t(1+r_t)^t}{\sum_{t=0}^{n} C_t(1+r_t)^t} \text{ x } 100\% \quad \text{.....(16)}$$

From equation (16), it could be observed that the numerator is simply the NFV; hence equation (16) is equivalent to

$$BCR_n = \left[\frac{NFV}{\sum_{t=0}^{n} C_t(1+r_t)^t}\right] \text{ x } 100\% \quad \text{.....(17)}$$

Lesser, *et al.* (1993), stressed that the BCR_n is closely related to the compounded Benefit-Cost Ratio (BCR_d). Thus as noted therein, equation (16) which is

$$BCR_n = \frac{\sum_{t=0}^{n} B_t(1+r_t)^t - \sum_{t=0}^{n} C_t(1+r_t)^t}{\sum_{t=0}^{n} C_t(1+r_t)^t} \text{ x } 100\% \text{.....(18)}$$

is equivalent to

$$BCR_n = \left[\frac{\sum_{t=0}^{n} B_t(1+r_t)^t}{\sum_{t=0}^{n} C_t(1+r_t)^t} - 1\right] \text{ x } 100\% \quad \text{.....(19)}$$

The first term on the right-hand side of equation (19) is the compounded benefit-cost ratio (BCR_d).

Hence, $$BCR_n = (BCR_d - 1) \text{ x } 100\% \quad \text{..... (20)}$$

From the above equations, it could be observed that the BCR_n shows the percentage increase in real wealth generated by a project and any project with a BCR_n greater than 1

should be accepted. The BCR_n criterion produces results exactly comparable to NFV since it allows for the time value of money. Furthermore, the BCR_n can be used to compare projects, just as the NFV was. Either the BCR_d or BCR_n will give an accurate comparison between projects, with the project having the highest BCR being the most desirable.

Lesser, *et al.* (1993), therefore, conclude that the BCR_d and BCR_n can be used to compare projects if the following two rules are observed:

- Cash flows must be defined consistently for all projects.
- Projects must have equal outlays, or be adjusted through replication or additional investments until outlays are equal.

Net Present Value (NPV) Method

Brealey, *et al.* (1981), writing on *"*the principles of corporate finance" affirmed that the NPV is a preferred method by most experts and the theoretical rationale is that it always provides the correct answer and is relatively easy to calculate while others are complex. The NPV is sufficiently defined as the sum of the difference between the benefits and costs of a project in today's dollar (Ghana cedis). In other words the NPV is the sum of discounted net cash flows in order to determine whether a project is worthwhile (Zerbe and Dwight, 1994; Noble, 1979; Brookshire, *et al.*, 1982; and Knetsch, 1996).

The NPV is expressed mathematically as:

$$NPV = \sum_{t=o}^{n} \frac{B_t}{(1+r_t)^t} - \sum_{t=0}^{n} \frac{C_t}{1+r_t)^t} \quad \text{.....(21)}$$

Given benefits *B*, costs *C*, and time *t*, the NPV rule for the first-best world, which calls for investment in a mineral project is: NPV is greater than zero. Thus, a project is considered to be economically viable if the NPV of the benefits and costs is positive. This is the fundamental equation for evaluating projects in general and mineral projects in particular. Zerbe and Dwight (1994) reported that most analysts use NPV, and suggested that we follow this convention.

Benefit-Cost Analysis and Inflation

Boardman, *et al.* (2006) explain that benefit-cost analysis, especially, the net present and net future values calculations provide a valuable theoretical approach for handling financial analyses, but many practical questions have been left unanswered and one such question involves the treatment of inflation. Many benefit-cost analysis calculations require accurate estimates of cash flows and interest rates. However, these estimates are likely to be strongly affected by inflation (Zerbe and Dwight, 1994).

To account for inflation, interest rates can be expressed in nominal amount which includes the effects of inflation and thus directly comparable from year to year. A Ghana cedi today is not the same in nominal terms as a cedi a year from now, since the cedi is inflated and has less actual purchasing power. Net present and net future values' calculations can also be expressed as a real amount, which has the effects of inflation removed (Breadly and Myers, 1981).

According to Boardman, *et al.* (2006), if r is the nominal interest rate, R is the real interest rate, and i is the inflation rate, then

$$1+R=\frac{1+r}{1+i} \quad \text{.....22}$$

A cedi has the same purchasing power, regardless of when it is earned. Similarly, a real interest rate reflects only the time value of money, not changes in the general price level. Thus, in periods of inflation, nominal interest rates will be higher than real ones, since nominal rates also include the effects of a higher level of prices throughout the economy. The study calculated the nominal and real amounts for the net future values (NFVs) in the location analysis and the sensitivity analysis respectively in chapter five.

Net Terminal Value (NTV)

The NTV is a method which is occasionally used in lieu of NFV and produces directly comparable results (Mishan, 1984). That is, any project that is accepted by the NFV criterion will be accepted by the NTV standard. The NTV is simply the value of a project at its termination and it is given as:

$$NTV = \sum_{t=0}^{n} B_t (1+t_t)^{n-t} - \sum_{t=0}^{n} C_t (1+r_t)^{n-t} \quad \ldots\ldots\ldots\ldots\ldots\ldots (23)$$

According to Mishan (1984), instead of discounting the cash flows, we credit them with interest until the termination of the project. Thus, a cash flow produced in the final year (year *n*) receives no interest, while an initial cash flow (year 0) receives interest for *n* years.

Internal Rate of Return (IRR) Method

The internal rate of return (IRR) is the discount rate for which a project's benefits exactly balance its costs and can be thought of as the "break-even" rate (Harberger, 1978). At the IRR, the NPV of a project is exactly equal to 0. The IRR is the discount rate that sets a project's discounted benefits equal to its discounted costs:

$$\sum_{t=0}^{n} \frac{B_t}{(1+IRR)^t} = \sum_{t=0}^{n} \frac{C_t}{(1+IRR)^t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (24)$$

Equation (24) is equivalent to

$$\sum_{t=0}^{n} \frac{X_t}{(1+IRR)^t} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (25)$$

Where X_t represents any cash flow. X_t is positive for benefits and negative for costs.

Once the IRR is found, we have to decide if a project is worthwhile. If the actual interest rate on borrowed capital (that is, if the opportunity cost of capital) is less than the IRR, the project is desirable since it earns returns at a higher rate than the borrowing rate. On the other hand, if the borrowing rate is greater than the IRR, the project cannot earn enough to pay for the borrowed funds and thus is not desirable. This conceptual appeal of simply comparing rates of return is one of the main benefits of the IRR approach (Kemper *et al*., 1983).

The IRR technique has many proponents. For example, Musgrave (1969); and Kelman (1981) find it more concrete and less esoteric than the NPV technique. These writers criticize the NPV technique since it requires that a discount rate be assumed, and prefer,

instead, to perform one IRR computation rather than calculate the NPV for a variety of discount rates.

However, writers who oppose the IRR technique (see for instance, Quirk, *et al*. (1986); and Zerbe, 1991) state that the IRR can be difficult to calculate and can give misleading results in some situations, and thus cannot be generally recommended over the NPV technique. In general, it can be said that the IRR can provide useful information and care must be taken to avoid the possibilities of errors.

Reconciliation of Different Methods

In sum, it could be observed that the NFV, BCR_d and BCR_n provide consistent evaluations of individual projects and consistent rankings among multiple projects. Although the calculations are different, each of these methods uses real values for benefits and costs, compounds cash flows to reflect the time value of money, and employs a logical decision rule. For individual projects, each of the methods yields a single result that can be compared to the appropriate decision rule. A project that is acceptable using one method will also be acceptable using all the other methods.

Based on the above, the NFV, BCR_d have been used by several writers such as Mireku-Gyimah (2007), Byrd, *et al.* (2007, Hilbak and Xu Shaoshi (2010) and Knapp, *et al.* (2009 in their empirical studies. This study, therefore, follows the views of these writers and adopted these methods to evaluate small-scale gold mining operations in Ghana in chapter five.

2.5 REVIEW OF EMPIRICAL LITERATURE

Benefit-cost analysis is a research tool widely used in different fields of study in recent times. However, for the interest of this study, this section reviews only those empirical studies applicable in mining projects. These empirical studies were adopted in the third essay in chapter five.

Byrd, *et al.* (2007) published a paper entitled "The Socio-Economic Impact of Mine Action in Afghanistan: A Benefit-Cost Analysis." This study was conducted as part of the World Bank-funded "Afghanistan Watching Brief Programme", jointly implemented by UNDP and the World Bank. It was an outgrowth of a report entitled "Study of the Socio-Economic Impact of Mine Action in Afghanistan" (SIMAA), which was subsequently revised and rewritten. The main objective was to estimate the socio-economic costs of mines (and correspondingly the benefits of de-mining) and the costs of mine clearance activities.

The study estimated benefit-cost ratios for clearance of mines from different types of land using different de-mining techniques, through the use of case studies. The quantified economic benefits from de-mining were related to reductions in the numbers of mine accidents (affecting both people and livestock) and reclamation of mined land for productive use. The cost side included the costs of the economic loss attributable to accidents suffered by de-miners. Benefits and costs were converted to net present and future values using an interest rate of 10% and sensitivity analysis on real inflation rates were conducted.

The economic loss according to Byrd, *et al.* (2007) related to a fatal casualty from a mine accident in Afghanistan was estimated at US$ 12,000. The loss from a typical mine victim was also estimated at US$ 9,000. One casualty every year over 15 years then represented a total economic loss of US$ 69,000 in net present value terms. Turning to the cost side, the clearance costs of mined areas were estimated to US $ 0.77 per m^2 for the year 1999, while clearance of former battlefields costs US $ 0.03 per m^2.

The net benefits of the MAPA mine clearance programme for 1999 was estimated at US$ 40 million, with a solid benefit-cost ratio of 1.5. The net benefits were sensitive to changes in real inflation rates at inflation rate of 15%. The largest portion of the net economic benefits originated from clearance of agricultural land with dogs. Clearance of agricultural land and irrigation systems with manual methods as well as roads with dogs also make strong contributions.

The study concluded that dog teams, the most efficient technique overall, on average clear 3.5 times the amount of mined land cleared by manual teams per team hour. However, this technique cannot be used on all types of land (Byrd, *et al.,* 2007). Again, according to the study, relatively large cost variations were found to exist between some of the mine clearance agencies.

Byrd, *et al.* (2007) strongly recommended that the MAPA mine programme should continue conducting benefit-cost analysis on a regular basis and in particular related to the annual presentation of the programme work-plan to the donor community. It may be commented that the setting of the study was wonderful as the study made use of net present and future values, benefit-cost ratio and sensitivity analysis methods but more of internal rate of returns could have been included.

Hilbak and Xu Shaoshi (2010) writing on "Benefit-Cost Analysis of Mining Activities in Peru: A Case Study of Freeport-McMoRan Copper and Gold Inc," stated that the impact of mining activities in Peru was a great concern. The study was meant to look at the benefits and costs associated with mining activities in Peru using Freeport-McMoRan Copper and Gold Inc, as a case study.

A benefit-cost analysis (BCA) was performed on monthly costs and benefits (revenue) from January, 2006, to December, 2008, on data from Freeport-McMoRan Copper and Gold Inc. It used a discount rate of 10.49 % for the analysis. The value of the benefit-cost ratio was 1.44 which is greater than one, the Net Present Value (NPV) was US$ 1,972,521.66 and that is greater than zero while the total Net Future Value (NFV) compounded at 10.49% for 5 years was US$7,384,740.85 and the average was US$1,476,948.17.

The Internal Rate of Return (IRR) also gave the value of 22.91% which is also greater than the discount rate of 10.49%. These clearly showed that, the benefits the Peruvian economy derived from Freeport-McMoRan Copper and Gold Inc were more than the costs incurred. The study concluded that, the operations of Freeport-McMoRan Copper and Gold Inc in Peru was economically viable. It could be mentioned that the setting of

the study was wonderful as the study made use of net present value, net future value and benefit-cost ratio methods but more of sensitivity analysis and could have been included

In another empirical study, Knapp, *et al.* (2009) analyzed the benefits and costs associated with the proposed uranium mining and milling facility at the Swanson Site in Pittsylvania County, Virginia. The writers reviewed and evaluated information presented in support of the project by the companies proposing a joint development of the site. In addition, the authors provided independent estimates for benefits and costs. The study made use of the NPV, NFV, BCR and IRR methods on benefit-cost analysis of the proposed uranium mining and milling facility.

The findings illustrated that the net present value was US$ 4,075,213.77 at a discount rate of 10%, the net future value was US$ 4,903,225.81 while the benefit-cost ratio was estimated at 1.3264. The Internal Rate of Returns (IRR) was 13.25% which was greater than the discount rate of 10%. The study therefore, concluded that the proposed uranium mining and milling facility at the Swanson Site in Pittsylvania County, Virginia was economically viable. It could be remarked that the setting of the study was brilliant as the study made use of net present value and benefit-cost ratio method but more of sensiti vity analysis and future values could have been included

Further more, "A Benefit-Cost Analysis of Mine Clearance Operations in Cambodia" by Bjorn, *et al.* (2005) was launched by the national regulatory and coordinating body, the Cambodian Mine Action and Victims Assistance Authority (CMAA) in cooperation with the United Nations Development Programme (UNDP). In this study, the socio-economic benefits of mine action were assessed covering the period since the start of the programme in 1992, and a benefit-cost analysis model was also developed for the use of the Royal Government of Cambodia and stakeholders involved in mine clearance.

The net present value, net future value and benefit-cost ratios were the main methods used in the study. The study found that the benefit-cost ratio was 0.88 while the annual average net present and future recorded negative values of (US$ 638,119.45) and (US$

704, 683.11) respectively. The study concluded that the mine clearance operations in Cambodia were not economically viable.

The study recommended that though, the mine clearance operations were not economically viable, the Royal Government of Cambodia and the UNDP should continue with the project because of its socio-cultural impact on the victims, mining communities and the other stakeholders. It could be stated that the setting of the study was great as the study made use of net present value and benefit-cost ratio methods but more of sensitivity analysis method could have been included.

In their study on "benefit-cost analysis of mining in protected forest: a case study of PT Weda Bay Nickel, Central Halmahera, Indonesia," Irawan and Chang Youngho (2008) emphasized that the Government of Indonesia (GoI) had demonstrated strong commitment in seeking to prudently manage the forest resources by issuing the Republic of Indonesia Law Number 41/1999 in 1999. This was seen as a positive step in an improved commitment to environmentally sustainable use of forestry resources which have been exploited recklessly by small-scale miners in the past decades (Irawan and Chang Youngho, 2008).

According to the study, about 155 small-scale mining companies had, in previous years, been granted contract of work rights to operate in areas that were later designated under this law as protected areas. This law compelled the companies to suspend all activities as it prohibits open pit mining in protected forests areas. The GoI has to choose and foster the most desirable alternative and needed assessment tools such as benefit-cost analysis which will enable it to make informed and justifiable determinations.

The net benefits from mining activities and forest preservation were estimated and compared. The study revealed that the benefits of the forest preservation exceeded costs by US$ 12.32 million while that of mining activities exceeded costs by US$ 14.78 million. The study concluded that though, the net benefits accrued from mining activities outweighed the net benefits from forest preservation, mining activities must be prohibited. The writers further explained that should the forest be preserved, it will last

for a potentially infinite period of time, and remain as a life support system for current as well as future generations. On the other hand, the benefits accrued from mining activities will last for only 20 years, and with limited additional benefits in terms of post-mining operations. It could be remarked that the setting of the study was brilliant as the study made use of net benefit method but more of benefit-cost ratio and sensitivity analysis methods could have been included.

Furthermore, Brooks *et al*., (2009) attempted to apply benefit-cost analysis to the most promising untapped ocean mineral resource - manganese nodules in the Blake Plateau off the South Eastern Coast of the United States of America. The writers made a follow up study already taken by Rodgers, *et al*. (2004).

The study estimated a total net future value of US$230,200,268.51 at annual average interest rate of 6.42% over a period of 12 years. The closest known manganese-iron oxide reserves lie at depths of 350 to 1,000 meters and cover an area of about 1,800 square kilometres. The total reserves were estimated to be 1.45 billion tonnes. The analysis on the present status of marine mineral recovery indicated that, under optimistic assumptions concerning demand elasticities and interest rates compounded on expected net revenues, a manganese nodule mining system would, at present, result in massive capital gains.

Brooks *et al*., (2009) concluded that the prospect for profitability will improve in the next decade because the existence of large, untapped land-based reserves of all the contained minerals, together with continuing improvements in the technology of extraction and processing, will make it unlikely for conditions of supply to force general price increases. The study stated further that any revolutionary breakthrough in techniques of processing manganese nodules would immediately open up vast new reserves of low- grade ores on land, obviating the need for ocean mining. And there is no reason to assume that the estimated pioneering costs of a deep-water dredging system will fall in the future.

Finally, the recovery and processing of manganese nodules will result in significant output of manganese ore, cobalt, nickel, and copper. It could be remarked that the setting of the study was wonderful as the study made use of net future value and of sensitivity analysis methods but more on benefit-cost ratios could have been included.

In another study titled "A Benefit-Cost Analysis of a Custom Mill for Small Copper Mines in Northern Chile," Henrique (2009) suggested that one form of encouragement for the small copper mining sector in Chile was the construction and management of custom mill facilities to process the ore. The paper described an economic analysis framework for the evaluation of government custom milling opportunities. Feasible mill locations and capacities within a mining region, particularly, northern Chile were selected and the infrastructure and milling costs associated with each combination of location and capacity were assessed. For each combination, the economics of developing and operating known copper deposits in the region was evaluated, and an optimum cut-off grade and mine capacity was selected for the deposits which justified development.

In addition, the best custom mill location and capacity was selected on the basis of overall benefits and costs. A copper mining region in northern Chile was used to illustrate the application of the model and mobile mill approach was examined and compared with the fixed location mill alternatives. Sensitivity analysis, NPVs and NFVs were the main methods used in the benefit-cost analysis of the construction and management of custom mill facilities or project. The net benefits were estimated to be US$ 1,639,442.83 for the fixed location mill and US$ 2,772,581.47 for the mobile mill. The total net future values compounded at an interest rate of 11.34% for a 10 – year period were US$ 31,027,873.47 and 52,473,502.25 for the fixed and mobile locations respectively.

The study therefore, concluded that since the net benefits of mobile mill facility exceeded the fixed mill facility, the Government of Chile should provide more mobile mill facility to the mineral industry. Again, since total ore supply from mines in the region exceeded a particular custom mill capacity, mine development was scheduled to optimize the economics of the mill facility. It may commented that the setting of the

study was brilliant as the study made use of sensitivity analysis, NPVs and NFVs but more of benefit-cost ratios could have been included.

In his empirical study, Mireku-Gyimah (2007) wanted to find out, in 1996, if the Seafor Mining Company (Ghana) Limited was economically viable. Seafor Mining Company (Ghana) Limited identified lode deposit of commercial value in its gold concession located at Mpaesem in the Upper Denkyira District in the Central Region of Ghana. The study showed that the measured lode reserves were 9.67 metric tonnes with an average grade of 2.53 grammes per tonne (g/t). These reserves according to the study can be mined at a production rate of 1.08 metric tonnes per year using open-pit mining method. The run-off-mine ore was treated by carbon-in-leach processing plant.

The methods used in the study were the NPVs, IRR and scenario analysis. The results showed that the capital investment required for the lode mining project was US$24.12 million and was sensitive to changes in the world market price of gold. The operating cost was US$2.4/g. With a gold price of US$12.40/g (US$385/oz) in 1996 and a minimum rate of return of 15%, the project's NPV was US$9.52m and the IRR was 27%.

The study therefore, concluded that the lode mining project was economically viable. The sensitivity analysis showed that the project continued to be economically viable until the operating costs increase by more than 20% or until, as a result of decrease in gold price or gold produced the value of the revenues decrease by more than 20%. It could be remarked that the study was fantastic as it included the use of net present values, internal rate of return and sensitivity analysis methods.

The next three chapters are not chapters as such. They represent different but related essays as indicated in the title of the thesis. Chapter three which is the first essay discusses contemporary issues on small-scale mining in Ghana. Chapter four is the second essay and focuses on comparative study in the Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining Districts of the Minerals Commission of Ghana while chapter five, the third essay deals with integrated approach to benefit-cost analysis in the Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining Districts/Areas of the Minerals Commission.

Finally, chapter six provides the major summary of the three essays in the form of general conclusions to the thesis.

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CHAPTER THREE

ESSAY ONE
SURVEY OF CONTEMPORARY ISSUES ON SMALL-SCALE GOLD MINING OPERATIONS IN GHANA

3.1 INTRODUCTION

Concerns on small-scale gold mining activities are receiving global attention in recent times and since Ghana is rich in gold deposits and gold is the most important mineral in terms of foreign exchange earnings, it calls for further investigations into this area. The central goal or main theme of this essay is to discuss the major potentials and challenges of the small-scale gold mining sub-sector in Ghana. Other general issues on the potentials from small-scale gold mining were discussed as well.

The essay, therefore, highlights on the definition and modus operandi of small-scale gold mining in Ghana. It then discusses the output, employment and GDP effects of small-scale mining operations. Furthermore, environmental and occupational health issues are explained as well. Besides, the essay, addresses the operational constraints of small-scale mining including issues on financial credit facilities, skills and training, operational/occupational safety, constraints on women participation, child labour and abuse, tensions and conflicts of interest between large and small-scale miners and finally, the long process involved in obtaining permits to operate as licensed small-scale miners (constraints on access to permits).

3.2 SCOPE AND DESIGN

The Study Area

The Minerals Commission of Ghana has designated prospective areas called blocked-out areas where gold and diamonds are known to occur for small-scale mining activities. The purpose was to provide interested small-scale miners access to undertake legitimate mining operations. To achieve this purpose, the Commission has established seven mining districts located at Assin-Fosu, Asankrangwa, Bibiani, Tarkwa, Akim-Oda,

Dunkwa and Bolgatanga. It must be emphasized that the mining districts are different from the political or conventional districts and municipalities.

This study was taken in the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts. Proximity, familiarity and intensity of small-scale mining activities are among the reasons that accounted for the selection of these districts. Appendix 12 displays the map of the study area. A description of the study areas is as follows:

Bibiani Mining District

The Bibiani mining district covers an area of 61,715.56 acres. Eight (8) blocked-out areas have been demarcated for small-scale mining activities at or around Berekum, Bodwease, Adankwame, Nyamebekyere, Adwumadiem, Pionkrom/Boadi, Juaboso and Asawinso. The district stretches to cover eight political districts/municipalities. Berekum and Adankwame blocked-out areas were selected for the study.

Bolgatanga Mining District

The district which comprises of three designated areas at or around Datoko, Dakrupe and Damango in the Bolgatanga, Bole and West Gonja political districts/municipalities respectively covers a total area of 29,521.47 acres. Bolgatanga and Dakrupe areas were used for the study.

Dunkwa Mining District

A total area of 151,041.21 acres has been designated for the Dunkwa mining district. The district is made up of six (6) blocked-out areas at or around Dunkwa Continental, Atia/Ofoase, Bomfa, Mpatuam, Manso Asumengya and Jacobu. The district stretches to cover 8 political districts/municipalities. Jacobu and Mpatuam areas in the Amansie Central and Amansie West Districts respectively were selected for the study.

Tarkwa Mining District

In this district, seven (7) blocked-out areas located at or around Bondae, Huniabawe, Kutukrom, Tinso, Tarkwa, Prestea and Hiawa has been demarcated for small-scale mining activities. The district covers an area of 647,100.51 acres and also covers 5

political districts/municipalities. Prestea and Hiawa areas all in the Preastea-Huni Valley District were selected for the study.

Table 3.1 provides details of the study area in respect of demarcated area, the political district or municipality, and size of designated or blocked-out areas.

Table 3.1: The Study Areas

Mining District	Name of Designated/ Blocked-out Area	Political District/Municipality	Size of Blocked-out Area (Acres)
Bibiani	Berekum*	Sunyani / Berekum	20,954.70
	Bodwease	Ahafo-Ano North	3,620.73
	Adankwame*	Atwima	3,569.20
	Nyamebekyere	Atwima Mponua	10,762.45
	Adwumadiem	Juaboso/Asunafo	3,780.49
	Pionkrom/Boadi	Juaboso	1,446.15
	Juaboso	Juaboso	4,828.71
	Asawinso	Bibiani-Anhwiaso-Bekwai	12,753.13
			61,715.56
Bolgatanga	Datoko*	Bolgatanga	16,815.87
	Dakrupe*	Bole	3,029.80
	Damango	West Gonja	9,675.80
			29,521.47
Dunkwa	Dunkwa Continental	Atwima/Amansie East & Central/Upper Denkyira/ Adansi North	100,958.10
	Atia/Ofoase	Sekyere East/Ejisu Juaben	35,420.26
	Bomfa	Ejisu Juaben	4,719.07
	Mpatuam*	Amansie West	2,047.34
	Manso Asumengya	Amansie West	505.58
	Jacobu*	Amansie Central	7,390.86
			151,041.21
Tarkwa	Bondae	Prestea-Huni Valley	619,856
	Huniabawe	Prestea-Huni Valley	2,792.83
	Kutukrom	Nzema East	3,798.66
	Tinso	Prestea-Huni Valley	1,142.17
	Tarkwa	Tarkwa-Nsueam	2,583.16
	Prestea*	Prestea-Huni Valley	6,841.69
	Hiawa*	Preastea-Huni Valley	10,086.00
			647,100.51

Source: Minerals Commission of Ghana
*Note: * = Area selected for the study*

Survey Design

Bolick, *et al.* (2003) state that studies on contemporary subject normally apply survey design to obtain baseline information. This study therefore, used a survey design to

obtain baseline information from small-scale mining operators, and other stakeholders such as traditional rulers and assembly members in the selected mining communities as well as the officials of selected public and private institutions. Primary and secondary data were also used. For primary data, one-on-one interviews were conducted with the small-scale miners and the other stakeholders as mentioned above from the selected mining communities in September 2009. The interview technique enabled the researcher to have a face-to-face interaction with all stakeholders, especially, the small-scale miners since most of them did not have time to read and answer the questionnaires.

A fifteen (15) – item questionnaires were prepared and given out to the officials of targeted offices and respondents were requested to anonymously answer questions that were applicable to them. The officials included the District/Municipal Assemblies, Minerals Commission, Ghana Police Service, Environmental Protection Agency in the study areas, Newmont Ghana (Ahafo Mine) Ltd., and Wassa Association of Communities Affected by Mining (WACAM). The open-ended questions type were used to allow respondents to provide answers. Follow ups were made to assist respondents in the completion of the questions.

In addition, direct observations were made in the natural settings of all the four mining districts. The researcher took special note on the developments in the operations of small-scale mining sub-sector. Specifically, the researcher had the opportunity to closely observe the entire gold production process: namely, prospecting, exploration, processing and marketing.

Furthermore, we also observed the social, economic and political ways of life of the miners as well as the socio-cultural practices in the mining communities. We noted the sentiments or concerns of all the stakeholders in the mining sector, particularly, the miners, non miners, opinion leaders in the mining communities, government organizations as mentioned earlier.

Secondary data were obtained from published reports and studies such as journals, magazines, newspapers, text books, policy documents, as well as archival records and the internet as well as extant literature such as of the Bank of Ghana and Ghana Minerals Commission annual reports and publications.

Population and Sample Size

The population for the study was 787 and 449 were sampled. Purposive sampling technique was also used for the interview because most of the small-scale mining operations are carried-out in very remote areas. The miners were, therefore, selected based on accessibility. However, the traditional rulers and assembly members were selected at random for interview. Tables 3.2 and 3.3 show the details of the population and sample sizes respectively of the miners, traditional rulers and assembly members in the four mining districts.

Finally, photographs were used to give pictorial presentation of salient current issues on small-scale mining activities in Ghana.

Table 3.2 Population Size of the Study

Stakeholders / District	Miners	Traditional Rulers	Assembly Members	Total
Bibiani	132	19	38	189
Bolgatanga	118	16	22	156
Dunkwa	145	24	39	208
Tarkwa	162	23	49	234
Total	557	82	148	787

Source: Source: Field Survey, September 2009

Table 3.3 Sample Size

Stakeholders / District	Miners	Traditional Rulers	Assembly Members	Total
Bibiani	68	14	27	109
Bolgatanga	57	13	14	84
Dunkwa	65	18	30	113
Tarkwa	92	16	35	143
Total	282	61	106	449

Source: Field Survey, September 2009

3.3 DEFINITION AND MODUS OPERANDI OF SMALL-SCALE GOLD MINERS

3.3.1 DEFINITION

Small-scale mining is defined as mining operation by a person, a group of persons or co-operative societies (nationals/citizens) that use labour intensive mining technique; employ unsophisticated technology and require low capital investment. This includes operations at the lower end of the scale. On the upper end of the scale, small-scale mining operations refer to mining operation by a person, a group of persons or co-operative societies that employs basic mining and processing technology such as mechanical drilling and water pumping, blasting, manual loading, mill with gravity concentrator and other similar techniques.

According to the Precious Minerals Marketing Corporation, generally, any mining operation with a concession of up to 25 acres is considered a small-scale mine. Specifically, three acres of a designated area is granted to one person or a group of persons not exceeding four in number; five acres to a group of persons not exceeding nine in number; and twenty-five acres to a co-operative society of ten or more persons (Small-Scale Gold Mining Law, 1989).

A person licensed to mine gold under the Small-Scale Gold Mining Law (1989), may win, mine and produce gold by any effective and efficient method and must observe good mining practices, health and safety rules and pay due regard to the protection of the environment in his/her operations. A small-scale gold miner may purchase from any authorised mercury dealer such quantities of mercury as may be reasonably necessary for the purposes of mining operations (Small-Scale Gold Mining Law, 1989). Where a license is granted in a designated area to any person other than the owner of the land, the licensee must pay to the owner of the land a compensation for the use of the land. Small-scale gold miners are not expected to use any explosive in their operations. License to operate a small-scale gold mine is granted to Ghanaian citizens who have attained the age of 18 years (Small-Scale Gold Mining Law, 1989).

3.3.2 SMALL-SCALE MINING METHODS

In the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts which constitute the study area, small-scale gold mining operators use three methods in the exploitation or extraction and processing of gold. They are chisel and hammer method, surface *("dig and wash")* method and underground or deep mining *("ghetto")* method.

Chisel and Hammer Method

Tekpor (2005) explains that the chisel and hammer method is used for the mining of hard rock (lode) formations occurring mainly as outcrops and involves the following process:

- The vegetation and the top soil are removed either manually or mechanically to expose the rock.
- Fragmentation of the gold bearing rock is done by the use of chisels and hammers
- The broken rock is transported to be crushed and ground by mechanical crushers or manually with metal mortars and pestles into very fine powder.
- Sluicing is usually used to recover the gold particles from the crushed or grounded material.

Underground or Deep Mining *("Ghetto")* Method

In this method, hard formations are mined from underground workings. The miners dig pits and create small holes on the pits to enable the miners descend underground and ascend to the open or surface. The pits are usually supported at the entrance with timber. The fragmented gold bearing rock is transported to the surface in bags for processing.

Many writers, for example, Davids (1993) explains that the underground method is labour intensive and very risky due to the possibility of the system caving in as a result of the lack support systems as shown in the Plates 3.1 and 3.2 below.

Plate 3.1: An underground pit dug by small-scale miners using labour intensive method
Source: Hilson (2001)

Plate 3.2: One of the pits at Kajetia, a mining community in the Bolgatanga District Mining District
Source: Field Study, September 2009

Surface Mining *("Dig and Wash")* Method

Hilson (2001) reports that in the surface mining ("*dig and wash*") method, a number of people are employed to dig, transport and wash the gold bearing soil. The surface (*"dig and wash"*) method involves the following processes:

- Digging/breaking of soil/ore with mattocks/hammers to sizes that makes gold accessible for further processing.
- Loading and carrying of soil/ore in sacks.
- Adding water to the broken up soil or pulverized ore to form slurry.
- Washing the slurry in a sluice lined box with blankets or old cocoa sacks to separate valuable gold particles from the finely crushed sediment (as seen from Plate 3.3).
- Hand washing the blanket or sack with the gold-infested sediment/black sand in a pan (as seen from Plate 3.4).
- Dumping of tailings on the river/stream banks.
- Amalgamating the pre-concentrate gold-infested sediment/black sand with mercury.
- Heating/burning the gold-mercury amalgam on fire to evaporate the mercury to obtain pure gold residue.
- Marketing the gold.

Plate 3.3: Washing the slurry in a sluice lined box

Source: Field Study, September 2009

Plate 3.4: Hand washing the blanket with the gold-infested sediment in a pan

Source: Field Study, September 2009

Traditional Versus Mechanized Methods

The methods used at present by small-scale miners as compared to the past have not changed much, even though, it could be observed that the equipment used at the various mining sites have improved significantly. While some miners still use the traditional methods, others use mechanized methods. In the traditional method, simple tools such as shovels, pick axes, head pans, cutlasses, axes, sacks, among others are used.

In recent times, a number of miners use relatively sophisticated equipment in their operations at the mining sites. Some of the equipment is the hammer mills, especially, the Chinese hammer mills (the *chang fa* machines), excavators, generators, moist mechanisms, compressors, drilling machines, pumps and disc mills as shown in the following photographs. These methods according to Jennings (1999) and Hilson (2001) have caused environmental risk on the soil, water bodies, air, flora, fauna, landscape and ecosystems.

Furthermore, small-scale mining of late has assumed international dimension with the involvement of Chinese, Koreans, Russians and other foreigners according to Tekpor (2005) in the use of mechanized methods as shown in Plates 3.5 – 3.8.

Plate 3.5: An excavator found at one of the small-scale gold mining sites, which is used to move large quantities of earth or soil for small-scale mining activities

Source: Minerals Commission of Ghana

Plate 3.6: A generating plant providing electricity at Kajetia, a small-scale mining site near Dakoto in the Bolgatanga Mining District of Ghana

Source: Field Study, September 2009

Plate 3.7: Grinding machine used to grind or crush gold ore or rocks at Bantema, a small-scale mining site near Dakoto in the Bolgatanga Mining District of Ghana

Source: Field Study, September 2009

Plate 3.8: A Chinese hammer mill popularly known as *chang fa* machine is used to wash slurry in a sluice lined box with blankets to separate valuable gold particles from the finely crushed sediment.

Source: Minerals Commission of Ghana

3.4 OUTPUT AND GDP EFFECTS OF SMALL-SCALE MINING

The proportion of gold production from the small-scale mining sub-sector nationwide has increased rapidly over the years. Comparatively, output rose by 203.30% between 2000 and 2008 while that of the entire mining sector rose marginally by 15.57% within the same period as depicted in Table 3.4.

Table 3.4: Comparative Gold Production (2000 - 2008)

	Gold Production From		
	Small-Scale Mining (SSM) in oz	Mining Sector * in oz	SSM as % of Mining Sector
2000	147,663	2,457,152	6.01
2001	185,596	2,381,345	7.79
2002	160,879	2,236,833	7.19
2003	221,063	2,029,970	10.89
2004	248,571	2,029,970	12.25
2005	225,411	2,138,944	10.54
2006	274,979	2,423,265	11.35
2007	308,052	2,628,291	11.72
2008	447,865	2,839,802	15.77

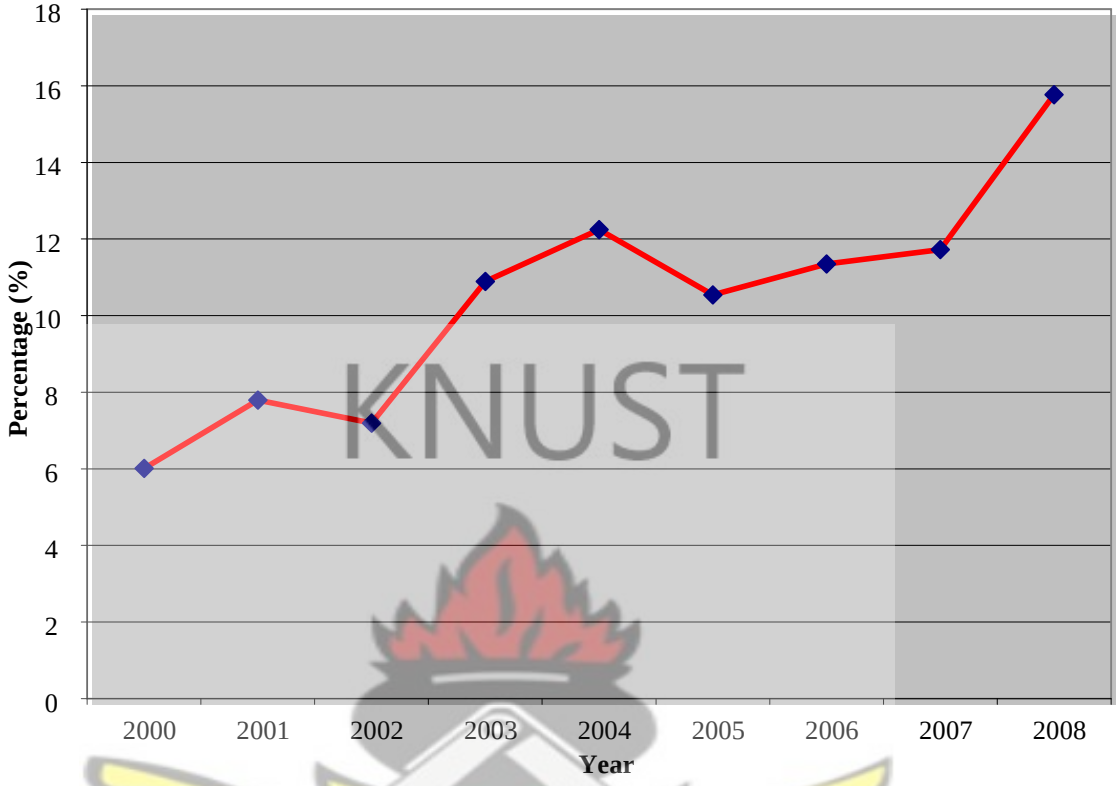
Source: Minerals Commission of Ghana

*Note: * Include production from both small & large scale mining*

The relative contribution of small-scale mining to the mining sector showed an increasing trend over the period and it ranged between 6.01% in 2000 and 15.77% in 2008. Figure 3.1 presents the trend graphically.

Furthermore, the small-scale gold mining sub-sector employs a significant number of the Ghanaian mining labour force. According to Hilson (2001), about 60% of the Ghanaian mining labour force is employed at the small-scale gold mines. A survey by the International Labour Organisation (1999) estimated that, about 300,000 people, especially the youth who would have migrated to the urban centres to seek for non existing jobs were engaged in small-scale mining, thus reducing the problems associated with rural-urban migration.

Figure 3.1: Contribution of Small-Scale Mining as % of the Mining Sector



One of the important issues on the small-scale mining sub-sector in recent times is its contribution to the country's GDP. Even though, the sub-sector's contribution to GDP on annual basis as presented in Table 3.5 is marginal, it soared significantly by 181.93% for the entire 2000-2008 period.

Table 3.5: Contribution of Small-Scale Mining to GDP

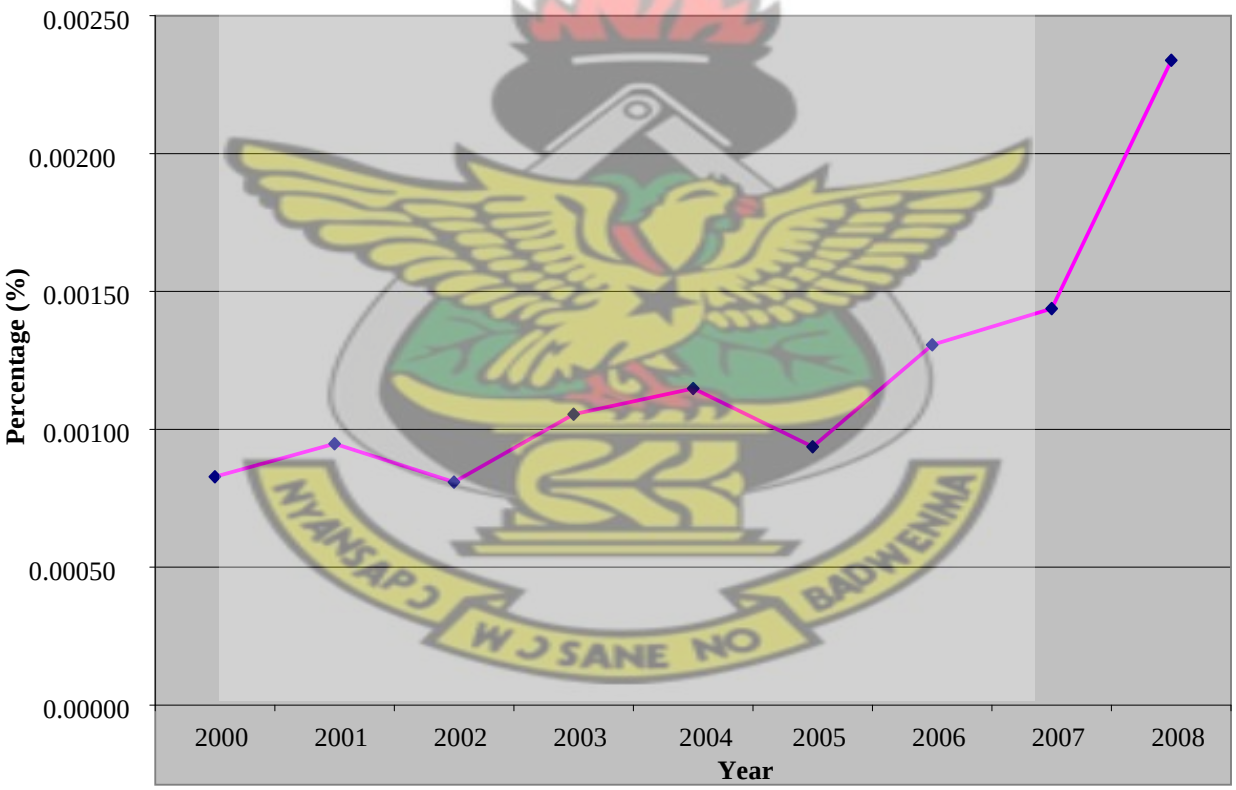
Year	Production from Small-Scale Mining (SSM) in US$m	GDP in US$m	SSM as % of GDP
2000	41.21	4,980,000.00	0.00083
2001	50.30	5,310,000.00	0.00095
2002	49.83	6,160,000.00	0.00081
2003	80.33	7,620,000.00	0.00105
2004	101.84	8,870,000.00	0.00115
2005	100.25	10,700,000.00	0.00094
2006	165.94	12,700,000.00	0.00131
2007	214.22	14,900,000.00	0.00144
2008	390.52	16,700,000.00	0.00234

Sources: Bank of Ghana Annual Reports; and Minerals Commission of Ghana

In Figure 3.2, the contribution of the small-scale mining sub-sector to GDP showed an increasing trend throughout except, in 2005 when it dropped as a result of a decline of gold production from US$ 101.84 in 2004 to US$100.25 in 2005.

It must be emphasized that the small-scale gold mining sub-sector could contribute much to the country's GDP and foreign exchange earnings if it is well developed, as found in the Philippine's where it contributed 58% to total gold exports in 1995 (Jennings, 1999). Incomes of small-scale gold miners generate substantial local purchasing power and lead to a demand for locally sourced inputs such as food, equipment, tools, housing and transport and encourage their production.

Figure 3.2: Contribution of SSM as % of GDP



Sources: Bank of Ghana Annual Reports; and Minerals Commission of Ghana

3.5 ENVIRONMENTAL AND OCCUPATIONAL HEALTH ISSUES

One of the environmental issues associated with the small-scale gold mining operations in Ghana is its impacts on the lithosphere (Aryee, *et al.*, 2003). The primary impact, land degradation, is a common phenomenon at many uncontrolled and unmonitored small-scale mining sites. A survey by this study confirmed that small-scale gold mining operations cause a substantial degree of environmental degradation. In some places in the Tarkwa mining district for instance, many miners operate over the tailings of old mines in an already degraded environment.

Apart from this, the miners dig pits of various depths, and leave them uncovered after the mining operations. These activities have detrimental effect on the environment and are a potential threat to human life and wildlife. In places of intensive mining activities such as Nananko, Dadieso and Japa in the Wassa Amenfi East District in the Western Region, the landscape has been completely transformed into a degraded area of pits and waste materials.

Furthermore, as found in Plate 3.10, the excavated pits and trenches render the land barren and unsuitable for plant growth and other agricultural activities in addition to being left exposed to erosion. (Aryee, *et al.*, 2003). Many of these pits have filled with water and serve as breeding grounds for malaria-infected mosquitoes.

Another environmental issue associated with the small-scale gold mining operations is the impact on the hydrosphere. The drainage system in many small-scale mining areas is adversely affected as rivers and streams are polluted by solid suspensions and mercury, which are commonly discharged into resident water bodies during the sluicing process and amalgamation, respectively. This in turn leads to siltation and coloration of such waters. Improperly disposed tailings also find their way into streams and rivers during heavy rains, creating sedimentation problems and rendering streams unusable for both domestic and industrial purposes (Aryee *et al.*, 2003).

Small-scale gold mining communities generally, are faced with community health problems such as poor sanitation and lack of clean water. Malaria, typhoid, dysentery,

bilharzias, and enteric infections are common in small-scale gold mining areas. Investigations at the Wassa Association of Communities Affected by Mining (WACAM) at Wassa Akropong in the Western Region of Ghana revealed that mercury and other waste materials are washed into the Ankobra River and its tributaries during the extraction and amalgamation process.

Plate 3.9: Small-scale activities leading to environmental degradation at Dadieso near Wassa Akropong in the Western Region of Ghana

Source: Field Study, September 2009

Plate 3.10: The excavated pits and trenches found at Japa near Wassa Akropong in the Western Region of Ghana, which render the land infertile and unsuitable for plant growth

Source: Field Study, September 2009

About forty-two communities with a population of about 3,852 in 2003 living downstream the Ankobra River and its tributaries use the Ankobra River and its tributaries as their main source of drinking water. Since mercury is a harmful substance, it may gradually accumulate in the body as toxic to those who drink the polluted water or use them for domestic activities and these may cause health hazards to the communities and aquatic life. Records from the Wassa Amenfi East District Directorate of the Ghana Health Services at Wassa Akropong indicate that malaria cases rose by 38.6% between 1990 and 2001 and ranked as the highest in the mining communities because of community health problems such as poor sanitation and lack of clean water in most small-scale gold mining communities.

The effect of small-scale mining on the atmosphere has generally been considered to be significant since operations are carried out in ambient air (Coakley, 1999). Coakley (1999) further writes that small-scale mining operations that involve size reduction of ore generate some dust that could be hazardous to human health since the particles generated from such sources fall within the respirable dust range and are capable of causing dust-related diseases.

Furthermore, a common practice of small-scale gold miners in Ghana is the burning of gold amalgam in the open air. This practice produces mercury fumes, which are released into the atmosphere. In some instances, the burning of amalgam is conducted in poorly ventilated rooms, exposing miners to the dangers of mercury contamination. (Aryee, *et al.*, 2003). The economic implication is that a lot of people in the mining districts are contracting dust-related diseases and water related diseases by inhaling and drinking polluted and contaminated air and water thereby weakening the active labour force of the country.

3.6 OPERATIONAL CONSTRAINTS OF SMALL-SCALE MINING

3.6.1 FINANCIAL ISSUES

One of the major issues in small-scale gold mining in Ghana is the access to credit. Figure 3.3 shows that about 97% of respondents do not have access to credit. The lack

of capital is an obstacle to mechanization and improving efficiency. These in turn lead to low productivity, low revenues and low wages. As a result, the miners tend to ignore health, safety and environmental measures.

The mine owners and mineworkers generally have few assets that banks and other lending institutions in the country will accept as collateral. It is not until they start producing something saleable that they can get credit. The banks are not readily prepared, even when mining rights exist, to take them as security because of the geological risk of unmined reserves, the mobility of many small-scale miners and the widespread weak enforcement of laws and regulations.

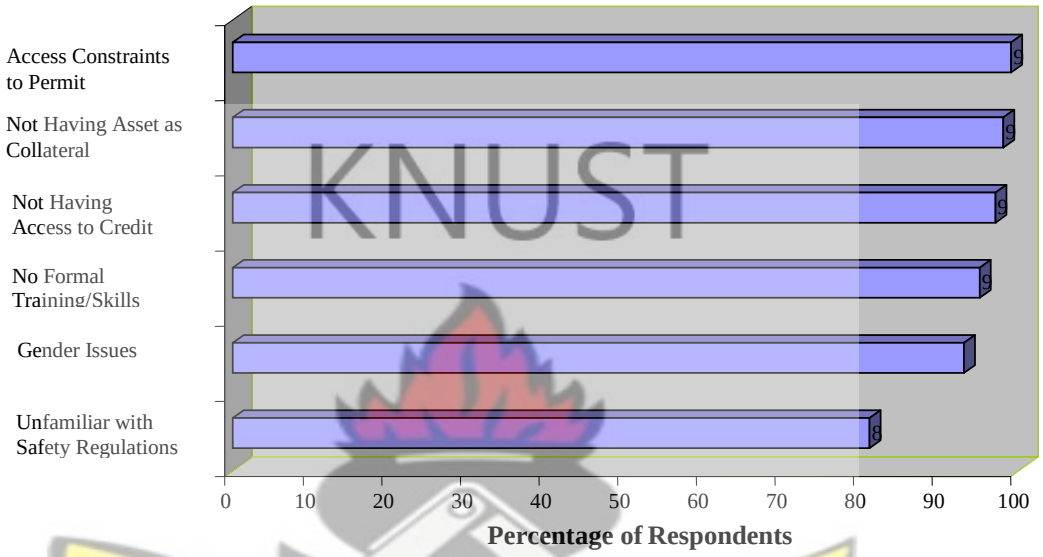
Moreover, banks traditionally require borrowers to provide some security from their own resources, which is a formidable burden for many small-scale miners. In Figure 3.3, approximately 98% of respondents do not have assets to serve as collateral. Small-scale miners according to the World Bank (1995), therefore find themselves in a vicious cycle: low revenue from mining → low savings potential → inability to invest in tools and equipment →inability to meet health, safety and environmental standards → low productivity → low returns.

3.6.2 SKILLS AND TRAINING

In Ghana, few small-scale gold mineworkers have any formal mining training and skills. They obtained the skills and benefited from on-the-job training during their former jobs as miners in large mines before turning to small-scale mining following redundancy. Most of the small-scale miners pick up skills from these experienced workers. Figure 3.3 shows that about 95% of respondents do not have formal training in small-scale gold mining. Semi-formal training and skills is sometimes provided to small-scale miners by the Inspectorate Division of the Ghana Minerals Commission and the Ministry of Lands, Forestry and Mines. For the most part, however, opportunities for training are few and far between. Even when they are available, many small-scale miners cannot afford to take time off work for training or to travel to training sessions.

Figure 3.3 displays the components of the responses from a survey on issues in small-scale gold mining activities in the study area.

Figure 3.3: Survey on Issues in Small-scale Gold Mining



Source: Field Survey, September 2009

3.6.3 OPERATIONAL/OCCUPATIONAL SAFETY

Small-scale gold mining in Ghana has a poor reputation for occupational safety. Most of the miners are unfamiliar with safety regulations. Data from the survey presented in Figure 3.3 shows that about 81% of respondents are not familiar with safety regulations. Also, our observation at the various mining sites showed that the workers routinely wear shorts and, sometimes, a shirt. Hardly anyone uses a helmet, earplugs, mask or gloves.

There are no safety procedures for work at the mining sites (Plate 3.11). The miners remove rocks with hand tools and load the ore into small sacks which are carried to the surface. Rock falls, cave-ins, perpetual dampness and lack of ventilation are the most frequently cited causes of accidents in small-scale mines. In addition, the close proximity of the pits to one another increases the risk of subsidence or a cave-in (Appiah, 1998).

Safety inspection is weak because the number of safety inspectors is insufficient in view of the nature of the task and the number and wide dispersion of small-scale mines.

Plate 3.11: Lack of safety procedures for work at the mining sites at Dadieso near Wassa Akropong in the Western Region of Ghana

Source: Field Study, September 2009

Small-scale gold miners most times under-report or do not report at all accidents that occur at the mining sites because they have no wish to draw attention to themselves. In their opinion, the fact that there is no form of compensation or social security provision for injury and even for death can mean that reporting an accident will merely lead to unwanted administrative, legal and operational problems. Observation and news of occasional disaster in the media throw some light on the situation, but not much. A combination of lack of resources, lack of or non-application of safety regulations, lack of awareness, illiteracy, lack of training, inadequate equipment and remote location, all point to the likelihood of there being more accidents in many small-scale mining operations.

Looking at the nature of small-scale mining (i.e. low level of mechanization, low intensity of operation) it is expected or felt that risks and fatal accidents should be lower than in large, formal mines but that is not the case. According to the UNIDO (1997), the reported annual fatality in small-scale gold mining in Ghana in 1993 was 20 as

compared to 13 in the larger mining companies. A case in point is the fatal incident that occurred at Nyafoman-Noyem, a small-scale gold mining community in Eastern Region of Ghana, where about 40 small-scale gold miners were trapped to death as a result of a cave-in (Daily Graphic, February 22, 2006) and a report that over 100 miners were entrapped in a pit at Akyempem near Dunkwa-on-Offin (Daily Graphic, November 12, 2009).

The photograph below (Plate 3.12) shows some of the bodies of small-scale miners which were retrieved from a caved-in pit at Dompoase near Wassa Akropong in the Wassa Amenfi East District of the Western Region. In fact, most of the fatal accidents which occur in small-scale mines can be considered to be preventable if there is strict adherence to safety procedures for work at the mining sites.

Plate 3.12: Some of the bodies of small-scale miners which were retrieved from a caved-in pit.
Insert: Some members of the rescue team digging for more bodies

Source: Daily Graphic, Thursday, November 12, 2009

3.6.4 CONSTRAINTS ON WOMEN PARTICIPATION

Women play a significant role in small-scale mining. Women are involved either directly in the processing (carrying, loading, crushing, sieving washing, panning), or

indirectly as purveyors of goods and services at the mining sites and in the mining communities. The growth in women's involvement in small-scale mining according to Ofei-Aboagye (1995) has been brought about by several factors. First, the high unemployment rate due to inadequate employment opportunities in the formal sector and well established private organizations; and second, women who relied on subsistence agriculture, seek new alternative or additional paid employment in small-scale gold mining for a better quality of life.

Traore (1997) explains that there are constraints on Ghanaian women's participation in small-scale mining because of gender issues and these make women face additional constraints to increasing the level and scope of their participation. These include: less technical know-how than their male counterparts; lack of representation and support; lack of management and administrative skills; widespread illiteracy; socio-economic perceptions about their status; and cultural traditions that impose a heavy family burden and limit their independence and mobility.

In Figure 3.3, approximately 93% of respondents indicated that women are constrained with gender and or cultural issues. Some married women in particular face opposition from their husbands and families to engage in small-scale gold mining activity which takes them to remote areas for long periods of time, thus making it difficult to combine work with family and other household responsibilities.

3.6.5 CHILD LABOUR AND ABUSE ISSUES

In all the study areas, it was observed that, children aged 12-16 years work in small-scale mines. Children working in small-scale mines are not only exposed to immediate risk but they are also jeopardizing their long-term development both physical and socio-economic. Observation at the various mining sites shows that children do the work which the adults do: carrying, loading, crushing, sieving washing, panning; and purveying goods and services at the mine site and in the mining communities. An interview with school teachers at Nananko, Japa and Ankonsia (the study area) shows that truancy and school dropout rate especially, among Junior High School pupils are

high. Where children do go to school, they often work in the mines after school, at the weekends and in the holidays.

3.6.6 TENSIONS AND CONFLICTS OF INTEREST BETWEEN LARGE AND SMALL -SCALE MINERS

The relationship between large and small-scale mines in Ghana needs to be emphasized. There have often been a number of clashes of interest between small-scale and large scale mining companies. From the point of view of the large mining companies, small-scale mining is synonymous with illegal mining. Small-scale miners on the other hand often accuse large mining companies of tying up large tracts of land with speculative mineral rights, denying them their rightful access to mineral resources. Many small-scale gold miners know the economic value of the land and consider the land has been taken from them because of their weak bargaining power and are now resorting to the second best option to enable them enjoy their fair share of the land.

The continuing presence of unorganized and uncontrolled small-scale gold mining activities in Ghana does not only serve as a threat to potential investors to establish new mining companies but also discourages the existing mining companies. There have been several clashes in Ghana, especially, in the Western and Ashanti Regions, as small-scale miners have sought to re-enter what they considered to be their rightful mining territory which had been assigned by the government to large mining companies. A number of conflicts have erupted between small-scale gold miners and the local security forces of large scale mining companies such as AngloGold Ashanti (Ghana) Limited, Goldfields Limited, Newmont (Ghana) Limited, Prestea Sankofa Gold Limited among others where the small-scale gold miners entered companies' concessions at Obuasi, Tarkwa, Kenyasi and Prestea respectively.

Tension and conflict between alienated and displaced small-scale miners and large mining companies according to Gueye (2001) is economically, financially and politically damaging for foreign investors and national governments, particularly, if it discourages new mining activity. The potential for conflict over access to mineral resources is likely to increase as mining companies seek new prospective areas in the

country and focus first on sites in the vicinity of existing successful small-scale mining activity. These conflicts and tensions do not only affect the mining companies' day-to-day operations, but also have negative impact on the mining communities, mineral development, and the national economy as a whole.

3.6.7 LONG PROCESS IN OBTAINING OPERATING PERMITS

Another major issue in small-scale gold mining in Ghana in recent times is the long process in obtaining permits to operate as licensed small-scale miners. The procedure is tedious, requiring the completion of several forms, and final approval from governmental authorities. The fact is that before one could be given a permit to operate a small-scale mine, he/she has to go through complex and lengthy administrative procedures from the Ministry of Lands, Forestry and Mines (MLFM), the Ghana Minerals Commission, the Geological Survey Department (GSD), the District Assemblies (DAs) and to the Environmental Protection Agency (EPA). Coakley (1999) explains that complex and lengthy administrative procedures, a lack of technical knowledge and, in many cases, the lack of a basic education militate against easy access to obtain permit to operate in small-scale gold mining.

Ghanaian small-scale gold mining operations are supervised and managed by government's Ministries, Departments and Agencies (MDAs). It is therefore, important to define clearly the distribution of management duties between different government agencies for planning and coordination purposes to prevent the difficulties in obtaining mining permits because having different agencies responsible, inevitably, means that responsibility and action can be pushed from one part of the bureaucracy to another.

3.7 CONCLUSIONS AND RECOMMENDATIONS

Small-scale gold mining operations in Ghana popularly known as *galamsey* is characterized with a few licensed operators and a larger number of unlicensed operators. Traditional and mechanized methods of mining are used nowadays at the mining sites. The methods used by small-scale miners today as compared to the past have not changed

much, nevertheless, there has been considerable improvement in the equipment used in their operations

Gold production from small-scale mining operations has increased substantially over the years. Between 2000 and 2008, production rose by 203.30% and its relative contribution to GDP also increased by 181.93%.

Small-scale gold mining operations cause a substantial degree of environmental degradation and most of the miners do not have access to credit from the banks. A larger number of small-scale gold mineworkers do not have any formal training and relevant mining skills and there are no occupational safety measures and regulations, thus leading to preventable accidents at the mining sites. There are constraints on Ghanaian women's participation in small-scale mining because of gender issues and cultural traditions. Long processes are involved in obtaining mining permits. Assistance based on an integrated approach that considers operational, financial, organisational, social, economic, legal, technical and environmental issues should be offered to enhance small-scale mining operations in Ghana.

The subsequent chapter discusses comparative study in the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts of the minerals commission of Ghana.

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CHAPTER FOUR
ESSAY TWO

COMPARATIVE STUDY IN THE BIBIANI, BOLGATANGA, DUNKWA AND TARKWA MINING DISTRICTS OF THE MINERALS COMMISSION OF GHANA

4.1 INTRODUCTION

This essay attempts a comparative study on the Ghanaian small-scale gold mining industry with a focus on the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts of the Minerals Commission of Ghana. Proximity, familiarity and the high intensity of small-scale mining activities are the main considerations for the selection of these districts.

The essay is organized as follows. The first section focuses on the methodology. Next, the inter-district comparisons with particular reference to production volume; employment levels; and the number of licensed operators/concessions are analyzed. In addition, a two-way analysis of variance on production volume; employment level; and the number of licensed operators/concessions is carried out. The essay concludes and provides recommendations. Finally, details of some important background reading list are also provided.

4.2 METHODOLOGY

Data for the essay were collected from 2005 to 2008 to undertake a comparative study on Ghanaian small-scale gold mining in the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts. Primary and secondary data were collected from the district centres/offices of the Minerals Commission of Ghana. In this essay, both qualitative and quantitative methods were employed. The qualitative methods included the use of in-depth interviews with small-scale miners in selected mining communities. The quantitative part involved a total of a twenty-two (22) - item questionnaires made up of 13 structured and 9 unstructured questionnaires which were administered to the officials of the Bibiani, Bolgatanga, Dunkwa and Tarkwa small-scale mining districts of the Minerals Commission of Ghana. Secondary data were also obtained from journals, magazines, news papers, text books and the internet. Again, annual reports and quarterly

bulletins of the Ghana Minerals Commission, Precious Minerals Marketing Company, Bank of Ghana and Ghana Statistical Service were the other secondary sources consulted.

Percentages and graphs were the key techniques of data analysis in this essay. Percentages were used to describe relationships between the study variables while graphs were also used to present components of the variables. A two-way analysis of variance (ANOVA) was used as a statistical tool to test for statistical interdependence between the mining districts and across the years (Koutsoyiannis, 2006).

The map of Ghana showing the study area is provided in the Appendix.

4.3 DISTRICT COMPARATIVE ANALYSIS

This section concentrates on the analysis of differences in the districts in terms of production, employment, number of licensed operators/concessions.

4.3.1 PRODUCTION

As presented in Table 4.1 and Figure 4.1, the volume of gold production in the four mining districts showed an increasing trend over the years except the Bibiani mining district/area, which recorded a decrease of 31.62% between 2007 and 2008. Relatively, the Tarkwa mining district/area recorded the highest of 54.35% of total production in the study area. Dunkwa, Bolgatanga and Bibiani districts with 23.29%, 13.66% and 8.70% respectively, followed it. Table 4.1 shows the production figures from 2005-2008.

An interesting issue was the sharp rise, in real terms, in the Bolgatanga district where production volume rose by approximately 386.03% between 2006 and 2007. In addition, in 2007, the Bibiani, Tarkwa and Dunkwa Districts also recorded significant increases of approximately 279.50%, 276.66% and 60.03% respectively over 2006 production. With reference to the annual average production in the four districts, it was reported that production fell by 0.94% between 2005-2006 but rose sharply by 210.67% and 7.99% between 2006 and 2007 and 2007 and 2008 respectively.

Table 4.1: Annual Gold Production (in ounces)

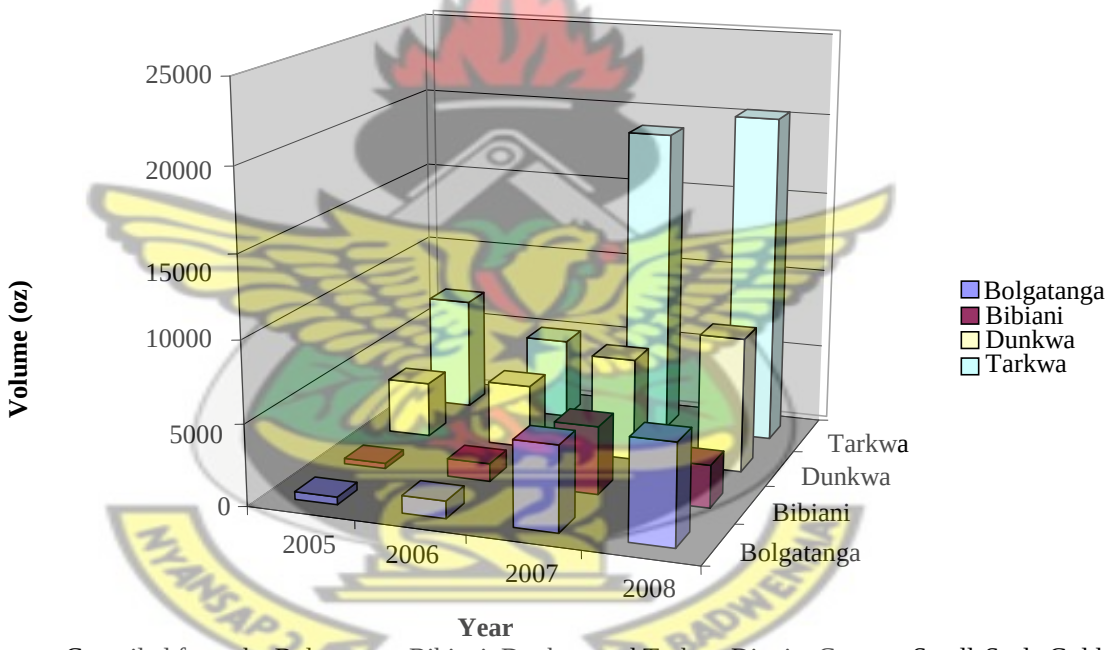
Year / District	2005	2006	2007	2008	Total	Average	Percentage
Bibiani	332.17	1,102.53	4,184.08	2,610.15	8,228.93	2,057.23	8.70%
Bolgatanga	472.38	1,073.07	5,215.46	6,156.82	12,917.73	3,229.43	13.66%
Dunkwa	3,422.41	3,956.75	6,332.11	8,317.63	22,028.90	5,507.23	23.29%
Tarkwa	7,042.81	5,031.42	18,951.18	20,369.38	51,394.79	12,848.70	54.35%
Total	11,269.77	11,163.77	34,682.83	37,453.98	94,570.35	23,642.59	100.00%
Average	2,817.44	2,790.94	8,670.71	9,363.50			
		-0.94%	210.67%	7.99%			

Source: Compiled from the Bolgatanga, Bibiani, Dunkwa and Tarkwa District Centres, Small-Scale Gold Mining Department, Minerals Commission of Ghana, August 2009

Note: These figures exclude production from illegal miners

Figure 4.1 shows the volume of gold production from 2005-2008 graphically.

Figure 4.1: Gold Production (2005 -2008)



Source: Compiled from the Bolgatanga, Bibiani, Dunkwa and Tarkwa District Centres, Small-Scale Gold Mining Department, Minerals Commission of Ghana, August, 2009

The introduction of mechanised mining methods such as the use of the Chinese hammer mill (the *chang fa* machine), excavators, equipment like generating plants, compressors, drilling machines, conveyors, pumping machines in 2007 by Chinese, Korean, Russian and other foreign companies in addition to mining consultancy services provided by mine support service companies, accounted for the significant increase in the volume of

production between the 2006 and 2007 period. Table 4.2 provides detailed data on the quarterly production volume in the mining districts**.**

Table 4.2: Quarterly Production of Gold (2005-2008)

District / Period	Bibiani	Bolgatanga	Dunkwa	Tarkwa
2005: I	78.36	115.04	637.66	1,531.14
2005: II	54.87	93.62	492.51	1,028.73
2005: III	110.41	139.01	1,329.45	2,698.17
2005: IV	88.53	124.71	962.79	1,784.77
	332.17	**472.38**	**3,422.41**	**7,042.81**
2006: I	202.76	198.38	711.35	842.27
2006: II	128.14	161.85	474.09	771.95
2006: III	511.70	403.11	1,721.18	2,316.32
2006: IV	259.91	309.73	1,050.13	1,100.88
	1,102.53	**1,073.07**	**3,956.75**	**5,031.42**
2007: I	617.43	831.07	1,326.67	3,781.48
2007: II	520.37	429.89	537.89	753.90
2007: III	2,057.25	2,181.42	2,473.03	8,645.69
2007: IV	989.03	1,773.08	1,994.52	5,770.11
	4,184.08	**5,215.46**	**6,332.11**	**18,951.18**
2008: I	473.19	762.37	2,140.84	4,329.07
2008: II	314.71	1,042.58	581.36	838.61
2008: III	1,096.83	2,615.64	3,083.13	8,998.87
2008: IV	725.42	1,745.23	2,512.30	6,202.83
	2,610.15	**6,156.82**	**8,317.63**	**20,369.38**

Source: Compiled from the Bibiani, Bolgatanga, Dunkwa and Tarkwa District Centres, Small-Scale Gold Mining Department, Minerals Commission of Ghana, August, 2009

Note: Period I = January–March; Period II = April–June; Period III = July–September; and Period IV = October –December

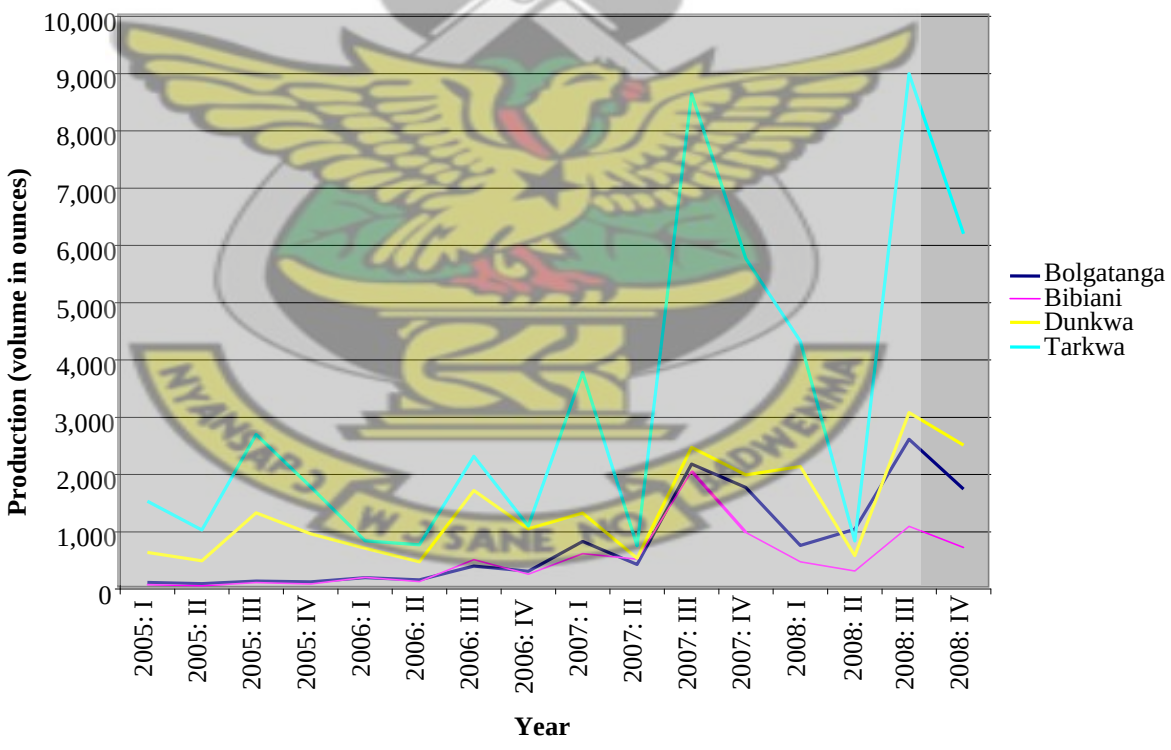
It is interesting to report that during the period under review, quarterly production volume in all the four mining districts followed a trend. Production volume remained robust with higher volumes of gold produced in the third quarter (July - September) of the each year as compared to the first quarter (January – March) where lower volumes of production figures were recorded. The volumes of gold production in the second and fourth quarters were however, volatile as compared to the third quarter of each year where production reached its peak.

As mentioned earlier, a larger proportion of small-scale miners rely on traditional/manual methods of mining, where simple equipment like cutlasses, axes, shovels, pick-axes, head pans, chisels, hammers and sacks, among others are used. The mineralized material is removed and transported to nearby rivers or streams because the traditional method

depends solely on these water bodies as the main source of water for sluicing to recover the gold. The flow of water in the streams and rivers also depends on rains.

It could be observed that in Ghana, generally, July–September is a period where the country experiences moderate rainfall. Mining activities become more brisk, less risky and less expensive. Many people engage in mining operations and, thus, boost gold output from the small-scale mining sub-sector. In October – March, however, the country enters into the dry season where most of the water bodies get dried up. Many miners abandon their work and look for other manual jobs. Some pits get flooded during the second quarter (April – June) because this period is characterised with heavy rain fall making small-scale mining activities more risky as more cave-ins of pits normally do occur and hence affects production volume negatively. The quarterly production volumes are graphically presented in Figure 4.2.

Figure 4.2: Quarterly Production (2005-2008)



Source: Compiled from the Bibiani, Bolgatanga, Dunkwa and Tarkwa District Centres, Small-Scale Gold Mining Department, Minerals Commission of Ghana, August, 2009

4.3.2 EMPLOYMENT

One significant contribution of small-scale mining is the employment opportunities it offers for thousands of people. The study therefore, looked at the number of miners employed by licensed small-scale mining operators in the four districts. The details are reported in Table 4.3 and Figure 4.3. Apart from the Tarkwa mining district which recorded a 49.87% drop in 2006, employment of labour by licensed operators kept on increasing in all the districts.

The Bolgatanga district accounted for the highest share of 30.56% of the total employment level for the 2005-2008 compared with the Bibiani, Dunkwa and Tarkwa districts which registered 23.39%, 27.14% and 18.91% in that order.

The highest and upward employment trend in the Bolgatanga district was attributed to the influx of small-scale miners from the southern to the northern Ghana for the purpose of avoiding rampant conflicts or conflicts of interest between small-scale miners and the larger-scale mining companies over ownership of mineral resource. Table 4.3 shows employment level by the licensed operators from 2005 – 2008.

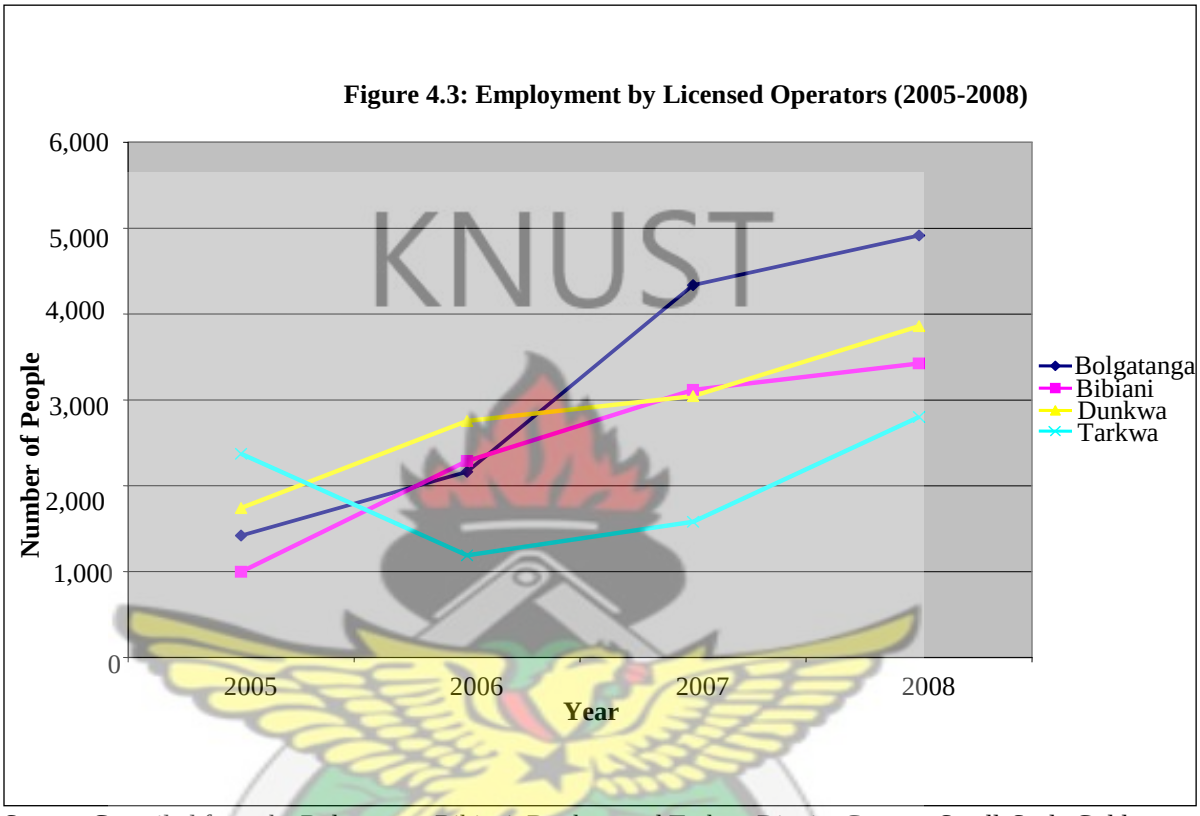
Table 4.3: Employment by Licensed Operators

Year / District	2005	2006	2007	2008	Total	Average	Percentage
Bibiani	996	2,287	3,116	3,423	9,822	2,456	23.39%
Bolgatanga	1,419	2,163	4,335	4,915	12,832	3,208	30.56%
Dunkwa	1,741	2,755	3,043	3,859	11,398	2,850	27.14%
Tarkwa	2,372	1,189	1,579	2,801	7,941	1,985	18.91%
Total	6,528	8,394	12,073	14,998	41,993	10,498	100.00%
Average	1,632	2,099	3,018	3,750	10,498		
Percentage		28.58%	43.83%	24.23%			

Source: Compiled from the Bolgatanga, Bibiani, Dunkwa and Tarkwa District Centres, Small-Scale Gold Mining Department, Minerals Commission of Ghana, August, 2009
Note: The averages were converted to the nearest whole number*

Unlike production volumes, the annual average number of people employed by licensed operators rose throughout but fluctuated by 28.58%, 43.83% and 24.23% in the 2005-2006, 2006-2007 and 2007-2008 period respectively, although, the inter district average

number of people employed by licensed operators reached approximately 2,456, 3,208, 2,850 and 1,985 in the Bibiani, Bolgatanga, Dunkwa and the Tarkwa mining districts correspondingly.



Source: Compiled from the Bolgatanga, Bibiani, Dunkwa and Tarkwa District Centres, Small-Scale Gold Mining Department, Minerals Commission of Ghana, August, 2009

4.3.3 LICENSED OPERATORS/CONCESSIONS

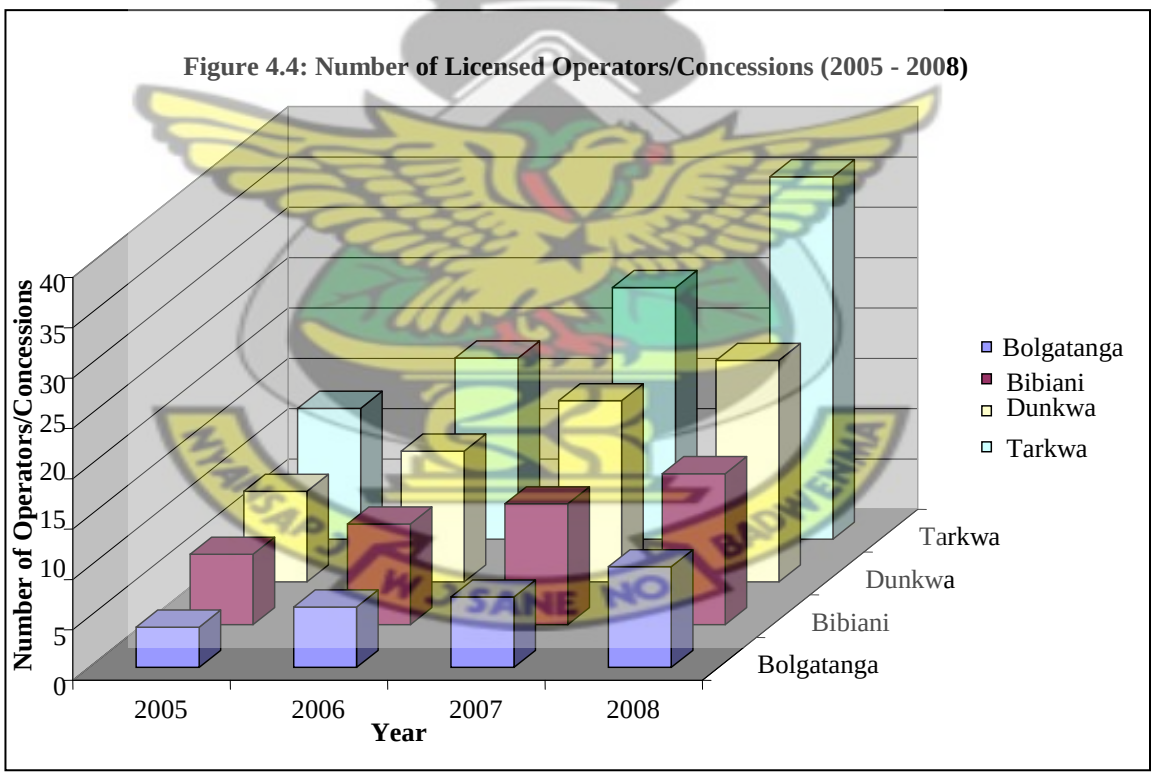
Small-scale mining in Ghana is characterized by a large percentage of illegal or unlicensed operators. The study, however, reveals that people are gradually registering with the Minerals Commission and other stakeholder institutions to obtain mining license or mining concessions to operate legally. In relative terms, the Tarkwa district recorded the highest number of licensed operators/concessions which stood at 40.89% in 2008 while the Bolgatanga district recorded the lowest number of 12%. Between 2005-2006, 2006-2007 and 2007-2008 period, annual growth in the number of licensed operators and concessions were 42.42%, 31.91%, and 33.87% respectively. This suggests that small-

scale miners are gradually showing interest in investing in legal small-scale gold mining business. Table 4.4 and Figure 4.4 present the number of licensed operators/concessions in the four mining districts.

Table 4.4: Number of Licensed Operators/Concessions

Year / District	2005	2006	2007	2008	Total	Average*	Percentage
Bibiani	7	10	12	15	44	11	19.56%
Bolgatanga	4	6	7	10	27	7	12.00%
Dunkwa	9	13	18	22	62	16	27.56%
Tarkwa	13	18	25	36	92	23	40.89%
Total	33	47	62	83	225	56	100.00%
Average*	8.	12	16	21			
		42.42%	31.91%	33.87%			

Source: Compiled from the Bolgatanga, Bibiani, Dunkwa and Tarkwa District Centres, Small-Scale Gold Mining Department, Minerals Commission of Ghana, August, 2009
Note: The averages were converted to the nearest whole number*



Source: Compiled from the Bolgatanga, Bibiani, Dunkwa and Tarkwa District Centres, Small-Scale Gold Mining Department, Minerals Commission of Ghana, August, 2009

4.4 ANALYSIS OF VARIANCE

The essay used an analysis of variance (ANOVA), which is a statistical tool developed by Fisher (1970). It analyzed data on production volume; employment levels by licensed operators; and the number of licensed operators/concessions in the mining districts as reported in Tables 4.1, 4.3 and 4.4. ANOVA was used to simultaneously test for the means of equality between the mining districts (location i.e. row effect) and the means of equality across the years (time from 2005-2008 i.e., column effect). The essay made use of the Predictive Analytics Software (PASW) version 16 for the analyses of variances.

4.4.1 HYPOTHESES TESTING

The following hypotheses of equality were tested.

- **Hypothesis I: Hypothesis testing of equality of production volume (output) between the four districts.**

  The means of production volume between the four districts (μ_1, μ_2, μ_3 and μ_4) are equal.

  H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

  H_1: Not H_0

- **Hypothesis II: Hypothesis testing of equality of production volume (output) across the four years.**

  The means of production volume across the four years (μ_1, μ_2, μ_3 and μ_4) are equal.

  H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

  H_1: Not H_0

- **Hypothesis III: Hypothesis testing of equality of employment levels between the four districts.**

  The means of employment levels between the four districts (μ_1, μ_2, μ_3 and μ_4) are equal.

  H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

  H_1: Not H_0

- **Hypothesis IV: Hypothesis testing of equality of employment levels across the four years.**

The means of employment levels across the four years (μ_1, μ_2, μ_3 and μ_4) are equal. Thus

H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

H_1: Not H_0

- **Hypothesis V: Hypothesis testing of equality of the number of licensed operators between the four districts**.

  The means in the number of licensed operators between the four districts (μ_1, μ_2, μ_3 and μ_4) are all the same.

  H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

  H_1: Not H_0

- **Hypothesis VI: Hypothesis testing of equality of the number of licensed operators across the four years.**

  The means in the number of licensed operators across the four years (μ_1, μ_2, μ_3 and μ_4) are all the same.

  H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

  H_1: Not H_0

4.4.2 RESULTS AND DISCUSSIONS

The results of the two-way ANOVA are reported in Tables 4.5, 4.6 and 4.7.

Results and Analysis of the Inherent Hypothesis

Three categories of hypotheses on production volumes, employment levels and number of licensed operators/concessions were analysed as follows.

Production – Hypotheses I & II

In Table 4.5, the observed variance ratio (or computed *F*) F* is 10.284 while the critical *F* at 0.05% level of significance is 3.862. Since F* > *F*, we rejected the null hypothesis In Hypothesis I and accepted the alternative hypothesis. This means that there is a significant difference between the means of the production volume across the districts. In the same way, since the computed *F* (F*) of 5.679 exceeds the critical *F* value of

3.862, our suggestion is to reject the null hypothesis in Hypothesis II and accept the alternative hypothesis that the means of the production volume across the years are not equal.

Table 4.5: Production Results: Two-Way/Factor ANOVA

Source of Variation	*SS*	*df*	*MS*	*F**	*P-value*	*F crit*
Rows (Mining Districts)	281348034.2	3	93782678	10.28473	0.002886	3.862548
Columns (Years:2005-2008)	155362254.1	3	51787418	5.679294	0.018373	3.862548
Error	82067734.92	9	9118637			
Total	518778023.2	15				

Source Author's Estimations, October 2009

The rejection of the null hypothesis suggests there are different volumes of gold production between the mining districts. In the same vain there is a considerable differences in production across the years.

Employment – Hypotheses III & IV

In Hypothesis III, we fail to reject the null hypothesis because the *F* statistic (F*) of 1.917 < *F (3.862)* at 0.05% level of significance as shown in Table 4.6. Therefore, there are no significant differences between the means of employment levels in the various districts. However, because *F* (6.197) > F (3.862)* we reject the null hypothesis in Hypothesis IV. This implies that there are significant differences between the means of employment levels over the years.

In conclusion, employment levels between the mining districts do not vary while those of employment levels across the years vary. The essay, therefore, suggests that location (Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts) does not matter much but time (years from 2005-2008) matters much (so far as employment levels are concerned).

Table 4.6: Employment Results: Two-Way/Factor ANOVA

Source of Variation	*SS*	*df*	*MS*	*F**	*P-value*	*F crit*
Rows(Mining Districts)	3318313	3	1106104.23	1.917173347	0.197347	3.862548
Columns (Years:2005-2008)	10726439	3	3575479.56	6.197258757	0.014312	3.862548
Error	5192508	9	576945.34			
Total	19237259	15				

Source: Author's Estimations, October 2009

Licensed Operators/Concessions – Hypotheses V & VI

It could be observed from Table 4.7 that the *F* statistic (F*) is 16.697 while the critical *F* value was 3.862. We reject the null hypothesis in Hypothesis V and failed to reject the alternative hypothesis that there is a significant difference between the means of the number of licensed operators/concessions between the mining districts as F* > *F*. Similarly, in Hypothesis VI, since the computed *F* (F*) of 9.908 exceeds the critical *F* value of 3.862, our conclusion is to reject the null hypothesis and accept the alternative hypothesis that the means of the number of licensed operators/concessions across the years are not equal.

Table 4.7 Licensed Operators/Concessions Results: Two-Way/Factor ANOVA

Source of Variation	*SS*	*df*	*MS*	*F**	*P-value*	*F crit*
Rows(Mining Districts)	579.1875	3	193.0625	16.6972973	0.000508	3.862548
Columns (Years:2005-2008)	343.6875	3	114.5625	9.9081081	0.003274	3.862548
Error	104.0625	9	11.5625			
Total	1026.938	15				

Source: Author's Estimations, October 2009

This indicates that there is a difference between the number of licensed operators across the districts. Also there seems to be a difference in the number of licensed operators and across the years. The essay, therefore, suggests that mutually, location (Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts) and time (years from 2005-2008) matter much as far as the number of licensed operators/concessions are concerned.

4.5 ANALYSIS OF STRUCTURE-CONDUCT-PERFORMANCE (SCP) IN SMALL-SCALE MINING PERATIONS

It could be emphasized that the differences in production volumes, employment levels and number of operators in the four mining districts were expected. What is most interesting to the study is what explains the magnitude of the differences in the mining districts. Some factors or issues of the SCP approach which according to Worthington, *et al.* (2005) was first proposed by Mason (1939) and later modified by Bain (1959) were used to explain the magnitude of the differences in the mining districts.

4.5.1 ANALYSIS OF STRUCTURE

Under the structure, two key factors or issues, namely, managerial structures and ownership were analysed.

Managerial Structures

Managerial structures according to Hill (2007), include the understanding of the working relationships of employees with their manager, subordinates and peer group. As mentioned earlier, two categories of small-scale mining operators exist in Ghana: licensed operators who are very few and illegal operators who form the majority.

Generally, all illegal small-scale mining operators and most of the licensed operators in the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts operate a simple, informal or organic management structure. The leader of each mining group (*gang*) defines the tasks, communicates the strategic goals and uses his or her authority to influence the other miners or workers such as *talii* boys and girls, *karl* men and women (for the meaning of *talii* boys and girls, *karl* men and women, see the notes under Table 4.8). Unlike the large scale mining companies, the organic management structure is prevalent in most of small-scale mining operations in Ghana and is characterized by flexible task definition, lateral communication, low degrees of formalization, expertise-based influence, decentralized control and low degree of co-ordination.

The reason for the simple, informal or organic management structures is the fact that the environment in which most small-scale mining organisations operate is highly uncertain

and unstable (Hill, 2007). Hardly do we see small-scale mining operators using balanced score-card to measure both the organisation and individual performance.

There are insignificant number of small-scale mining operators formalized organisational structure which is hierarchical in nature, reflecting clearly defined lines of authority and responsibility based on management theory. Hardly did we obtain documented records specifying the key components that underpin the management structure such as task definition, communication style, influencing techniques, centralization, co-ordination and formalization in small-scale mining operations in the study areas.

Ownership

It must be emphasized that there were no differences as far as ownership of mining concessions or operations in the four mining districts are concerned. In each of the districts, there were a few legal or licensed mining concessions or operations that are owned by a person (sole proprietorship), group of persons (partnership) or co-operative societies. However, most of the small-scale mining operations in the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts are done illegally and the miners neither observe good mining practices, health and safety rules nor pay due regard to the protection of the environment during mining operations.

4.5.2 ANALYSIS OF CONDUCT

In analysing conduct, the key factor or issue considered was the choice of technology.

Choice of Technology

Technology choice has important implications for growth and productivity in the small-scale mining sub-sector because the growth and productivity in the sub-sector depends on the ability of the miners to identify, select and use the most suitable or appropriate technology (Ngahu, 1992). According to Ngahu (1992), the tools and equipment used and access to credit are among the key factors influencing the choice of technology in the small-scale enterprises.

Small-scale miners in the Tarkwa and Dunkwa Mining districts use relatively a higher technology because they are exposed to the services of mining servicing companies from China, Korea, Russia and other foreign countries as compared to their counterparts in the Bibiani and Bolgatanga mining districts. This is as a result of the presence of large numbers of large scale mining companies localized in the Tarkwa and Dunkwa Mining districts.

The use or choice of modern equipment such as the hammer mills, especially, the Chinese hammer mills (called the *chang fa* machines), excavators, generators, moist mechanisms, compressors, drilling machines, pumps and disc mills and technical advice in small-scale mining is prevalent and therefore, accounted for the differences in production levels and number of licensed operators/concessions in the Tarkwa and Dunkwa Mining districts.

In addition, lack of access to credit affects technology choice by limiting the number of alternatives that can be considered. Most private individuals (mining sponsors) prefer financing small-scale mining operations in the Tarkwa and Dunkwa mining districts to the Bibiani and Bolgatanga mining districts. They explained that investing in the Tarkwa and Dunkwa Mining districts brings quick and higher returns and they are less risky.

Many small-scale miners in the Bolgatanga and Bibiani mining districts on the other hand use simple tools such as shovels, pick axes, head pans, cutlasses, axes, sacks and therefore, affect output and efficiency.

It must be noted that the differences in the relatively higher levels of production and employment levels in the Tarkwa and Dunkwa mining districts on one hand and relatively lower levels of production and employment levels in the Bibiani and Bolgatanga Mining districts on the other hand did not consider the negative impacts on the physical environment. It was observed that the more the miners use mechanized methods in production, the more the environment is destroyed.

4.5.3 ANALYSIS OF PERFORMANCE

Profitability

Profitability was the main factor or issue considered under the analysis of performance which is one of the major variables that explain the magnitude of differences in the mining districts. The miners, particularly, the concessionaires (site owners) explained that profitability in small-scale mining depends on the revenue and operating cost. Revenue from small-scale mining operations also depends on the price of gold, carat (the quality of gold) and quantity of gold in the area while the operating cost includes cost of wages, cost of hiring machinery or equipment, feeding cost, transportation cost or nearness of the location of the mine or the mining site to a source of water body, fees paid to the community – traditional rulers, unit committees and landlords)

Table 4.8 provides details of the differences in the districts in terms of cost of wages paid to workers and gold price as well as revenue, operating cost and profit for operators using the traditional or mechanized method. This means two kinds of revenue, operating costs and profitability exist in all the mining districts: one for operators using traditional method of mining and the other for those using mechanized method.

In terms of wage payments, operators in the Bibiani Mining District for example, paid between GH¢12.00 – 15.00 to *talii* boys, GH¢15.00 to *talii* girls and GH¢20.00 – 25.00 to *karl* men while *talii* boys, *talii* girls and *karl* men are paid GH¢20.00, GH¢15.00 and GH¢25.00 respectively in the Tarkwa and Dunkwa mining districts.

The average operating cost per week for operators using the traditional method in the Bibiani, Bolgatanga, Dunkwa and Tarkwa were GH¢1,050.00, GH¢1,050.00, GH¢1,250.00 and GH¢1,500.00 correspondingly whereas those using mechanized method in the Bibiani, Bolgatanga, Dunkwa and Tarkwa districts were GH¢2,700.00, GH¢3,100.00, GH¢3,750.00 and GH¢4,600.00 in that order.

Finally, with respect to profit, operators using traditional methods earn a weekly profit of GH¢350.00, GH¢300.00, GH¢350.00 and GH¢400.00 in the Bibiani, Bolgatanga, Dunkwa and Tarkwa districts in that order as operators using mechanized method also

earn GH¢750.00, GH¢530.00, GH¢790.00 and GH¢820.00 in the Bibiani, Bolgatanga, Dunkwa and Tarkwa districts respectively.

Table 4.8 Profitability in the Mining Districts

District / Issues	Bibiani	Bolgatanga	Dunkwa	Tarkwa
Cost of wages per day	GH¢12.00 – 15.00 [a] GH¢15.00 [b] GH¢20.00 – 25.00 [c]	GH¢8.00 – 10.00 [a] GH¢7.00 – 9.00 [b] GH¢15.00 – 20.00 [c]	GH¢20.00 [a] GH¢15.00 [b] GH¢25.00 [c]	GH¢20.00 [a] GH¢15.00 [b] GH¢25.00 [c]
Feeding** Cost per day	GH¢12.50	GH¢12.00	GH¢12.50	GH¢15.00
Type of mining	▪ Underground (pit/ghetto) ▪ Surface/open pit (dig & wash)	▪ Underground (pit/ghetto) ▪ Surface/open pit (dig & wash)	▪ Underground (pit/ghetto) ▪ Surface/open pit (dig & wash) ▪ Dredging	▪ Underground (pit/ghetto) ▪ Surface/open pit (dig &wash) ▪ Dredging
Gold Price per pound (lb)	GH¢45.00 – 60.00	GH¢50.00 – 60.00	GH¢50.00 – 65.00	▪ GH¢50.00 – 65.00 for unrefined gold ▪ GH¢90.00 – 100.00 for refined gold
Cost of hiring equipment*	GH¢500.00 per day	GH¢500.00 per day	GH¢500.00 per day	GH¢500.00 per day
Revenue per week	▪ GH¢1,400.00 [d] ▪ GH¢3,450.00 [e]	▪ GH¢1,350.00 [d] ▪ GH¢3,630.00 [e]	▪ GH¢1,600.00 [d] ▪ GH¢4,540.00 [e]	▪ GH¢1,900.00 [d] ▪ GH¢5,420.00 [e]
Operating Cost per week	▪ GH¢1,050.00 [d] ▪ GH¢2,700.00 [e]	▪ GH¢1,050.00 [d] ▪ GH¢3,100.00 [e]	▪ GH¢1,250.00 [d] ▪ GH¢3,750.00 [e]	▪ GH¢1,500.00 [d] ▪ GH¢4,600.00 [e]
Profit per week	▪ GH¢350.00 [d] ▪ GH¢750.00 [e]	▪ GH¢300.00 [d] ▪ GH¢530.00 [e]	▪ GH¢350.00 [d] ▪ GH¢790.00 [e]	▪ GH¢400.00 [d] ▪ GH¢820.00 [e]

Source: Field Study, July 2009

Note: Equipment = Excavator*

*** = Feeding cost for a group (gang) of 6 people*

[a] = wage for talii boys (Talii boys are mostly boys of school-going age and few men employed to carry out mining job as assigned by the operator)

[b] = wage for talii girls (Talii girls are mostly girls of school-going age and women employed to carry out mining jobs as assigned by the operator)

[c] = wage for karl men (karl men are mainly men and few women employed to carry out mining jobs such as digging, chiselling, sluicing etc the mineralized material

[d] = Traditional method of operating surface mining or open pit (dig & wash)

[e] = Mechanized method of operating surface mining or open pit (dig & wash)

It could be observed that very few legalized small-scale mining operators in the mining districts prepare financial statements such as the profit and loss account and balance sheet to ascertain their financial standing. Furthermore, a very few legalized small-scale mining operators measure both the organisation and individual performance in terms of efficiency and effectiveness by the use the balanced score card.

It must be said that the structure (managerial structures), conduct (choice of technology) and performance (profitability) of small-scale mining operations in the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts are not the best. However, by educating the miners, especially, the licensed operators on the best mining practices and providing financial and technical support, it is possible for small-scale mines to graduate to become large mines in the near future.

4.6 CONCLUSIONS AND RECOMMENDATIONS

In general, volume of production, levels of employment and the number of licensed operators increased significantly in the four mining districts over the period under review. The Tarkwa mining district produced the highest output and contributed 54.35% of the total gold production in the four mining districts while Bibiani mining district produced the least of approximately, 8.70% of total production. In terms of the number of miners employed by the licensed operators, the Bolgatanga mining district recorded the highest employment of 30.56% of the total employment whereas the Tarkwa district registered the least employment of 18.91%.

Besides, 40.89% of the total number of licensed operators/concessions in the four mining districts was located in the Tarkwa mining district as the Bolgatanga district recorded the least of 12.00%. The results of the two-way or factor ANOVA showed that both location (mining districts) and time (years) matter much in the mining districts (Bibiani, Bolgatanga, Dunkwa and Tarkwa) so far as production volume and the number of licensed operators/concession are concerned. However, in respect of employment levels, location of mining districts does not matter but the employment levels matter with respect to years.

Managerial structures, choice of technology and profitability are among the major factors or issues that explain the magnitude of the differences in the mining districts and the more the miners use mechanized methods in production, the more the environment is destroyed.

The essay concludes that small-scale mining sector has contributed and continues to contribute to national development in terms of gold production and the employment it offers to thousands of people and should therefore be recognised as a significant generator of rural livelihoods that has the potential to alleviate poverty and be a tool for sustainable development. The essay suggests that efforts should be made to improve the production and employment potentials of the small-scale mining sub-sector.

This will help the small-scale mining sector to contribute significantly to poverty reduction in the rural communities in Ghana. Adequate financial support must be provided to small-scale miners. This will help them improve the level of production and employment. Furthermore, technical equipment should be provided for mining and environmental regulatory institutions to ensure effective monitoring of small-scale mining in Ghana. This would also enable the institutions to build the capacity of the local communities to monitor environmental compliance.

The ensuing chapter which is the most dominant focuses on integrated approach to benefit-cost analysis in the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts/areas of the minerals commission.

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CHAPTER FIVE

ESSAY THREE

INTEGRATED APPROACH TO BENEFIT-COST ANALYSIS IN THE BIBIANI, BOLGATANGA, DUNKWA AND TARKWA MINING DISTRICTS/AREAS OF THE MINERALS COMMISSION

5.1 INTRODUCTION

Small-scale mining (SSM) since its formal legalization in 1986 is increasingly gaining popularity in Ghana. The trend can be observed in other developing countries in Africa as well. The significant economic benefits to be reaped from small-scale mining activities have recently been recognized by several African countries. Indeed, the potential of the sector to contribute significantly to socio-economic development is great. Such contributions include the role it plays in poverty alleviation, especially, in rural areas; reducing rural-urban migration especially, for the unemployed youth; maintaining the vital link between people and the land; creating alternative economic activities; contributing to national incomes; and contributing to state revenues (Economic Commission of Africa, 2002).

Small-scale mining encourages the exploitation of otherwise uneconomical reserves and provides a lead to many discoveries of large-scale deposits. In addition, because small-scale mining is usually labour intensive, it offers a greater opportunity for direct and indirect job creation than do large-scale operations. At the micro level, revenues generated from these activities increase local purchasing power as well as the demand for local products, such as, food, working tools, housing, and furniture. In turn, this creates more employment opportunities in other economic sectors for example, agriculture, transport and industry.

However, as with many economic activities, small-scale mining has its negative aspects or costs to the economy as a whole. It is characterized by (i) environmental risk, emissions and damage to earth: soil, water bodies, air, flora, fauna, landscape and

ecosystems; (ii) social threats such as precarious working conditions, negative health consequences due to poor health and safety standards (causing frequent sickness and accidents), infra-human living conditions, complicated dependency relations, child labour, employment of rudimentary technology, illegal mining and marketing activities, violation of indigenous community rights, changes in the system of ethical values and lack of social security. Apart from these, it also has negative macroeconomic aspects including: low productivity and hence earnings, tax evasion, smuggling, conflicts with large scale mining companies and with governing bodies, lack of planned exploitation and lack of financial resources, technical and managerial skills. In this regard, the main challenge confronting many governments, especially, those in developing countries is a better approach that takes into account the existing socio-economic systems and considers how small-scale mining can best contribute to poverty reduction and sustainable economic growth and development in the context of holistic local or regional development.

In an attempt to address ways of improving or maximizing the positive aspects and minimizing the challenges confronting the small-scale mining sub-sector, the various Governments of Ghana have established institutional, administrative, legal and regulatory structures to regulate and provide a congenial environment for effective small-scale mining operations in the country. However, weak institutional structures; inadequate capacity to implement existing regulations, inadequate financial support services and access to information and technology and sometimes lack of political will, further contribute to making small-scale mining far from achieving its full potential.

More importantly, the little attention paid to the environmental, social and aggregate economic costs and benefits of small-scale mining has made it difficult to know the extent of losses suffered by the Ghanaian economy as a result of small-scale mining activities since many people especially, the small-scale miners are always interested in the immediate gains rather than the sustainability of the small-scale mining sub-sector for livelihood and poverty alleviation.

There is, therefore, the need to investigate the monetary valuation or estimation of environmental, social and aggregate economic benefits and costs of small-scale mining activities in Ghana. This study intends to perform a benefit-cost analysis focusing on the environmental, social and aggregate economic variables of small-scale gold mining activities in Ghana to ascertain whether it is worth continuing with the existing mining operations.

The essay is divided into five main sections. The first section focuses on the conceptual and methodological framework. This is followed by the specification of benefit-cost operational models. In the third section of the essay, data collection and analysis methods were explained. The fourth section presents the empirical results and analysis. Finally, the last section highlights on the conclusions and recommendations

5.2 CONCEPTUAL AND METHODOLOGICAL FRAMEWORK

This part discusses the conceptual and methodological structure of the study. This section consists of three sub-sections. Sub-section one focuses on the integrated concept to benefit-cost analysis in small-scale mining as advanced by Hentschel, Hruschka and Priester (2002). Sub-section two presents the revised integrated concept of benefit-cost analysis while sub-section three focuses on the definitions of variables of the revised integrated concept of benefit-cost analysis and explains how they could be measured.

5.2.1 AN INTEGRATED CONCEPT TO BENEFIT-COST IN SMALL- SCALE MINING

The integrated approach to benefit-costs in small-scale gold mining is adopted from Hentschel, *et al.* (2002). This was originally provided in a Global Report commissioned by the Mining, Minerals and Sustainable Development (MMSD) project of the International Institute for Environment and Development (IIED) and the World Business Council for Sustainable Development (WBSD). This is presented in Table 5.1.

In the report, four key areas or factors were integrated to define benefit and cost in small-scale gold mining operations. These are geologic-mining, physical environmental, social and macroeconomic factors. The geological factor, according to the report, deals with the losses and gains from the actual mining engineering activities. The geologic-mining costs comprise (a) exploitation of a non-renewable resource and (b) losses, for example, in irrational working of the mineral, incomplete exploitation, processing methods and transport while the geologic – mining benefits are made up of the possibility of: (a) exploiting smaller deposits (b) working in abandoned pillars and tailings and (c) discovering important deposits in remote areas.

Furthermore, the report explains the physical environmental factor to include effects of small-scale mining operations on the surroundings. The cost encompasses environmental risks, emissions and damage to earth, soil, water (underground and surface), air, flora and fauna, energy sources and ecosystems. The report however, did not account for any possible physical environmental benefit even though it exists.

In respect of the social factor, Table 5.1 identified (a) precarious working conditions; (b) negative health consequences (sickness, accidents); (c) infra-human living conditions; (d) complicated dependency relations; (e) child labour; (f) unbalanced development between men and women; (g) violation of resident and indigenous community rights; (h) changes in the system of ethical values and its consequences; and (i) insufficient social security as the main social costs. The social benefits, however, are (a) labour qualification; (b) source of income (in money); and (c) job creation.

Finally, the macro-economic factor considers the real costs and benefits to the communities, organisations and the national economy as a whole as a result of small-scale mining activities. The macro-economic costs according to Table 5.1 cover (a) conflicts due to or with land and water usage, governing bodies, large scale mining companies, the indigenous population and landscape protection objectives (national parks, protected areas); (b) smuggling to other countries; (c) no tax generation; (d) costs of controlling the sector; (e) continuous costs resulting from social issues; and (f) uncontrolled development due to lack of planned exploitation. The macro-economic benefits on the other hand consist of (a) mobilization of natural resources; (b) tax

collection; (c) active effect for the balance of payments; (e) buffer for the labour market in cases of programmes for structural adaptation; (f) provides personnel reserves for large scale mining; (g) contribution to regional economic development by cash circulation (social product), investment, demand for products and services, mobility and structural consequences (alternative to agriculture); (h) avoids rural exodus; (i) infrastructure development (road building, schools, energy supply) by small-scale mining and neighbouring population; (j) comparative financial advantages (products with a high labour coefficient in countries with high labour availability); (k) relative stable product supply even with market fluctuations; (l) contributes to product diversity and exports; and (m) substitutes import.

Details of the physical environmental, social and macroeconomic factors are explained in section 5.2.3.

5.2.2 THE REVISED INTEGRATED APPROACH'S CONCEPTS OF BENEFIT-COST ANALYSIS

As indicated earlier, the report, however, did not account for any possible physical environmental benefit even though it exists. In spite of this, some potential benefits could be derived from the small-scale mining activities. This study has therefore, made provision for benefits under physical environment.

The geological factor, mostly, deals with the actual mining engineering process which is a field of study that falls outside the scope of this study. For this reason, the geologic aspect has been ignored. In addition, some of the variables in the key areas namely, physical environment, social and macroeconomic factors are not feasible to be quantified in monetary values.

In view of this major challenge, the study has adopted an integrated concept and has therefore, come out with a more feasible conceptual framework in a revised integrated approach to benefit-cost analysis in small-scale gold mining in Ghana.

Table 5.1: Overview of Integrated Approach to Benefit-Cost Variables in Small-Scale Mining

Costs	Benefits

Geologic – Mining costs
− Exploitation of a non-renewable resource
− Losses e.g.
  − irrational working of high grade material
  − incomplete exploitation
  − processing methods
  − transport
	Geologic – Mining benefits
	+ possibility of exploiting smaller deposits
	+ ASM achieves successful prospecting without high cost
	+ Working of abandoned pillars, tailings etc.
	+ Small-scale miners discover important deposits in remote areas

Physical environmental costs
− environmental risks, emissions and damage to:
  − earth
  − soil
  − water (underground and surface)
  − air
  − flora and fauna
  − energy sources
  − ecosystems
	Physical environmental benefits

Social cost − precarious working conditions − negative health consequences (sickness, accidents) − infra-human living conditions − complicated dependency relations − child labour − unbalanced development between men and women − violation of resident and indigenous community rights − changes in the system of ethical values and it's consequences − insufficient social security	**Social benefits** +labour qualification + source of income (in money) + job creation/employment

Macro-economic costs
− conflicts
  − due to land and water usage
  − with governing bodies (judicial conflicts)
  − with large scale mining
  − with the indigenous population
  − with landscape protection objectives (national parks, protected areas)
− smuggling –illegality (products & profit)
− no tax generation
− costs of controlling the sector
− continuous costs resulting from social causes
− uncontrolled development due to lack of planned exploitation
	Macro-economic benefits
	+ mobilization of natural resources
	+ tax collection
	+ active effect for the balance of payments
	+ buffer for the labour market in cases of programmes for structural adaptation
	+ provides personnel reserves for large scale mining
	+ contribution to regional economic development by
	  + cash circulation (social product)
	  + investment
	  + demand for products and services
	  + mobility
	  + structural consequences (alternative to agriculture)
	+ avoids rural exodus
	+ infrastructure development (road building, schools, energy supply) by small-scale mining and neighbouring population
	+ comparative financial advantages (products with a high labour coefficient in countries with high labour availability)
	+ relative stable product supply even with market fluctuations
	+ contributes to product diversity and exports
	+ substitutes imports

Source: Culled from Hentschel, Hruschka and Priester (2002)

Note: − = *Cost and*
+ = *Benefit*

For the purpose comparison, revised integrated approach is presented in Table 5.2 and incorporates the variables that were used to estimate benefits and costs in the study.

Table 5.2 Revised Integrated Approach to Benefit-Cost Analysis in Small-Scale Mining

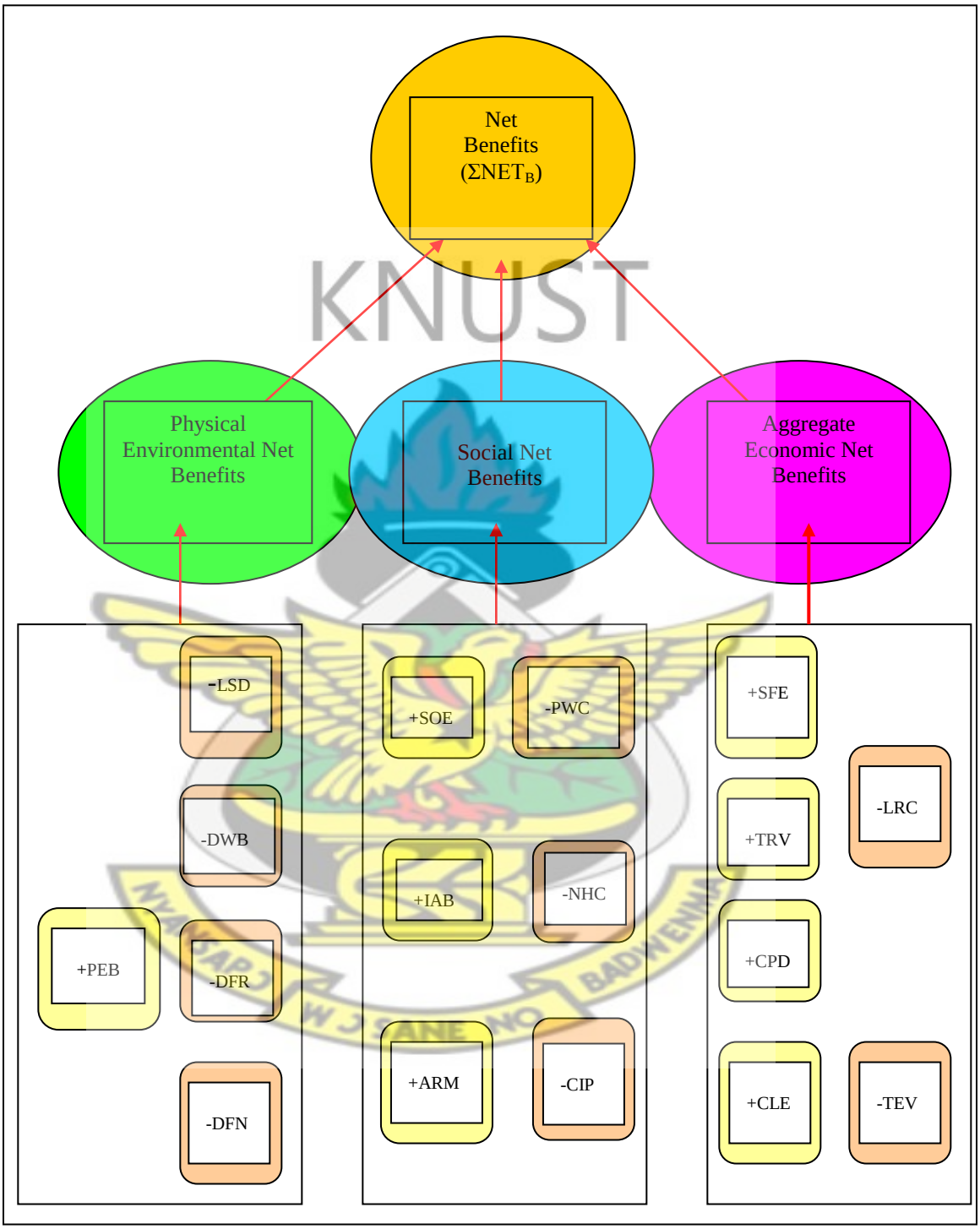
	Costs	Benefits
Physical Environmental Factor	**Physical Environmental Cost Elements** − Landscape Destruction (LSD) − Destruction of Water Bodies (DWB) − Destruction of Flora (DFR) − Destruction of Fauna (DRN)	**Physical Environmental Benefit Element** + Potential Environmental Benefits (PEB)
Social Cost Factor	**Social Cost Elements** − Precarious Working Conditions (PWC) − Negative Health Consequences (NHC) − Conflicts with the Indigenous Population (CIP)	**Social Benefit Elements** + Source of Employment (SOE) + Indirect/Ancillary Benefits (IAB) + Avoidance of Rural-Urban Migration (ARM)
Aggregate Economic Factor	**Aggregate Economic Cost Elements** − Loss of Revenue to Large Scale Mining Companies (LRC) − Tax Evasion (TEV)	**Aggregate Economic Benefit Elements** + Source of Foreign Exchange (SFE) + Tax Revenue (TRV) + Contribution to Product Diversity (CPD) + Contribution to Local Economy (CLE)

Source: Culled from Hentschel, Hruschka and Priester (2002)
Note: − = *Cost and* + = *Benefit*

In this essay's context therefore, the integrated approach to benefit-cost analysis focuses on the estimation of a combined physical environmental, social and aggregate economic costs and benefits from small-scale gold mining operations in Ghana. In addition, the study employs applied interlinked theoretical approaches in order to help understand the environmental, social and economic benefits and costs to small-scale mining operations in Ghana at individual, community, district and national levels. The purpose is to help capture the transitional dynamics of small-scale gold mining operations in Ghana.

Diagramme 5.1 presents the conceptual network form of the revised integrated approach to benefit-cost analysis in small scale mining. This concept was used to estimate the benefits and costs of all the four mining districts/areas.

Diagramme 5:1 Conceptual Form of the Revised Integrated Approach to Benefit-Cost Analysis in Small-Scale Mining



Source: Author's Concept, September 2009

Note: - = *Cost*

\+ = *Benefit*

Where;

+PEB	=	Potential environmental benefits
+SOE	=	Source of employment
+IAB	=	Indirect/ancillary benefits
+ARM	=	Avoidance of rural-urban migration
+SFE	=	Source of foreign exchange
+TRV	=	Tax revenue
+CPD	=	Contribution to product diversity
+CLE	=	Contribution to local economy
-LSD	=	Landscape destruction
-DWB	=	Destruction of water bodies
-DFR	=	Destruction of flora
-DFN	=	Destruction of fauna
-PWC	=	Precarious working conditions
-NHC	=	Negative health consequences
-CIP	=	Conflicts with the indigenous population
-LRC	=	Loss of revenue to large scale mining companies
-TEV	=	Tax evasion

The study adopted an *in medias res* benefit-cost analysis since small-scale mining operations in Ghana is on-going (Boardman, *et al.,* 2006) and the modified version of integrated approach to benefit-cost as explored by Hentschel, *et al.* (2002) because their study is in conformity with the main objective of the study. The study however, deviates from an e*x ante* and ***ex post*** benefit-cost analysis which are respectively conducted before and at the end of the implementation of a project (Pedroso, *et al.,* 2007). It also deviates from other studies such as Cohen (1986) and Beck and Finney (1987), which estimated only the environmental costs and benefits in their studies.

From Table 5.2 and Diagramme 5.1, net benefits or returns from small-scale mining operations is derived from three sources, namely: physical environmental net benefits, social net benefits and aggregate economic net benefits. In each of the three sources, costs were measured against benefits.

In respect of the physical environmental net benefits, potential environmental benefits (PEB) were measured against four cost items identified as costs to the operations of small-scale gold mining. The four cost items comprise (a) landscape destruction (LSD); (b) destruction of water bodies (DWB); (c) destruction of flora (DFR); and (d) destruction of fauna (DFN).

For the social net benefits, three benefit and three cost variables were also recognized. The benefits are made up of (a) source of employment (SOE); (b) indirect/ancillary benefits (IAB); and (c) avoidance of rural-urban migration (ARM) while the costs covered (a) precarious working conditions (PWC); (b) negative health consequences (NHC); and (c) conflicts with the indigenous population (CIP).

Lastly, under the aggregate economic net benefits, four benefit variables were measured against two cost variables. The benefit variables consisted of (a) source of foreign exchange (SFE); (b) tax revenue (TRV); (c) contribution to product diversity (CPD); and (d) contribution to local economy (CLE) whereas the cost variable comprised (a) loss of revenue to large scale mining companies (LRC); and (b) tax evasion (TEV). The details of the definitions and measurement of these variables are provided in the next section.

5.2.3 DEFINITIONS AND MEASUREMENT OF REVISED VERSION OF INTEGRATED APPROACH

As indicted in Table 5.2 and Diagramme 5.1, the benefit-cost variables presented for the physical environment, social and aggregate economic factors are defined and measured as follows:

The Physical Environmental Factor

The physical environmental factor encompasses the physical environmental costs and physical environmental benefits. The environmental costs and benefits were measured as follows:

Physical Environmental Cost Elements

The physical environmental cost elements are defined to include the loss to the ecology as a result of small-scale mining activities. The physical environmental cost elements are made up of landscape destruction (LSD); destruction of water bodies (DWB); destruction of flora (DFR); and destruction of fauna (DFN). These are defined and measured as follows:

(a) Landscape Destruction (LSD)

In the course of their operations, small-scale miners devastate the visually distinct scenery or natural beauty of the mining area or surroundings where they operate.

The LSD variable was measured as the:

- cost of reclaiming an acre of destroyed landscape (CDL) which is made up of backfilling cost and re-vegetation cost; multiplied by
- total acres of destructed land (ΣADL) in each mining district/area.
- Thus, **LSD = (CDL) x (ΣADL)**

(b) Destruction of Water Bodies (DWB)

Most of the small-scale mining communities are found in the rural areas where water bodies such as streams and rivers are the main source of drinking water and the people also use them for domestic and agricultural activities. Mining activities cause water pollution and have adverse effects on the people and aquatic life. The DWB involves the estimation of the:

- cost of drilling one borehole (CDB) to provide an alternative source of good drinking water for the people; multiplied by
- number of boreholes (NBH) in all affected mining communities in each mining district/area; plus
- cost of constructing one dug-out well (CCD) in each mining district/area for agricultural activities; multiplied by
- number of dug-out wells (NDW) to be constructed in each mining district/area; plus
- cost of raising fingerlings (CRF) (to cater for the loss of aquatic life in the destroyed water bodies); multiplied by
- the number of fish per water body (NFW) multiplied by
- Number of water bodies destroyed in each mining district/area (NWB).

Thus, **DWB = [(CDB x NBH) + (CCD x NDW) + (CRF x NFW x NWB)]**

(c) Destruction of Flora (DFR)

Small-scale mining activities destroy the vegetation which consists of a mass of plants growing in the mining area or surroundings. Since flora is part of the ecosystem and the

ecosystem deals with the interdependence and interrelationship between plants and animals, the study could not easily quantify the link between flora and fauna. Again, data were not available. A proxy was therefore, used. The study used the proceeds from herbal medicine (PHM) nationwide per year as a proxy to represent the loss of flora as found in Thompson (1980); and Cartel (1975). The study employed area/district weighted averages developed by the Statistical Service of Ghana because data on herbal medicine proceeds from the districts were not available. Each district's proceeds from herbal medicine were calculated out of the national proceeds to obtain data for **DFR**.

(d) Destruction of Fauna (DFN)

This includes the killing and destruction of the natural homes or undomesticated state of wild animals, birds, and other living things in the mining area or surroundings. Like flora, since fauna is part of the ecosystem and the ecosystem deals with the interrelationship between plants and animals, the study could not easily quantify the link between flora and fauna. Again, data were not available. A proxy was used. The study used the proceeds from bush-meat export (PME) per year as a proxy to represent the cost/loss of fauna as found in and Cartel (1975); and Halvorson, *et al.*, (1981). The study used area/district weighted averages developed by the Statistical Service of Ghana because data on bush-meat proceeds from the districts were not available. Like the previous variable, each district's proceeds from herbal medicine were calculated out of the national proceeds to obtain data for **DFN**.

Physical Environmental Benefit Element

The physical environmental benefits are defined to include the potential paybacks to society on the ecology as a result of small-scale mining activities. Since the current operations of small-scale mining do not provide any physical environmental benefit to society, potential environmental benefits (PEB) were used to estimate the physical environmental benefits. It must be highlighted that Hentschel, Hruschka and Priester (2002) did not identify any physical environmental benefit element in their study. This study, however, identified potential environmental benefit (PEB**)** variable as physical environmental benefit. The physical environmental benefits estimated one variable: namely, potential environmental benefit (PEB).

Potential Environmental Benefit (PEB)

The study assumed that if a mined-out area is reclaimed, some of the pits could be developed into fish ponds. In addition, economic plants like teak could be grown to serve as woodlot as found in Nanaimo Woodlot, British Columbia, Canada (Musgrave, 1997). These could serve as a potential environment benefit to society and they were estimated as follows: The

- net income from a fish pond (NIF) , that is, the average proceeds from a - 30 x 30 x 10m sized fish pond; multiplied by
- number of fish ponds (NFP) in each district; plus
- net income from teak tree (NIT) (the average sized teak tree) multiplied by
- the number of teak trees (NTT) in each district.

Therefore, **PEB = (NIF x NFP) + (NIT x NTT)**

The Social Factor

Like the physical environmental factor, the social factor also consists of two major components: the social costs and social benefits. The social costs were estimated as follows:

Social Cost Elements

The social costs were defined to include the loss of income and time to humanity, community or the general public as a result of small-scale mining activities. The main social cost elements are precarious working conditions (PWC); negative health consequences (NHC); and conflicts with the indigenous population (CIP).

(a) Precarious Working Conditions (PWC)

The PWC were defined to embrace the unsafe conditions under which small-scale miners work. Rock falls, cave-ins, perpetual dampness and lack of ventilation are common at the mining sites thereby causing accidents and injuries. PWC comprised of the sum of direct cost of treating injuries; income loss to accident victim(s); time spent by a relative in caring for the accident victim(s); and compensation to the accident victim(s). The estimation was as follows:

(i) Direct Cost of Treating Injuries (CTI)

- actual (hospital) average cost of treating injuries (ACT_I) [at 2009 constant price] multiplied by
- frequency of accidents/injuries (FAI) occurring at the mining sites or district/area per year

$CTI = ACT_I \times FAI$

(ii) Income Loss to Accident Victims (ILA_V) was obtained as the:

- number of injuries (NIJ) from small-scale mining activities reported to health facilities in each district; multiplied by
- number of days the accident victims (NDV) were absent from work; multiplied by
- accident victim's daily wage (WGE_V)

$ILA_V = NIJ \times NDV \times WGE_V$

(iii) Time spent by a relative (TSR) [in caring for the accident victims]

- frequency of reported accident victims (FRA_V) to health facilities in each mining district/area per year
- number of days a relative (NDR_V) spent on a victim while the victim was undergoing or receiving treatment.
- daily wage of a relative (WGE_R)

$TSR = FRAV \times NDR_V \times WGE_R$

(iv) Compensation to the Accident Victims (CAV) was measured as the:

- number of reported accident victims (NRA_V) to health facilities in each mining district/area per year; multiplied by
- the amount paid by large scale mining companies as compensation (MCC) for different degrees of injuries of accident victims was used as a proxy.

$CAV_S = NRA_V \times MCC$

Consequently, **$PWC = CTI + ILA_V + TSR + CAV$**

Negative Health Consequences (NHC) Small-scale mining communities are faced with community health problems such as poor sanitation and lack of clean water. Illnesses

such as malaria, typhoid, diarrhoea and dysentery are common in the mining communities.

NHC as a social cost variable was made up of the sum of direct cost of treatment of illness; income loss to patients; and time spent by a relative in caring for the patient.

(i) Direct Cost of Treatment of Illness (DCT_I) To obtain the DCT_I, we estimated the:

- annual number (AAN_{1989}) of reported cases to health facilities in each mining district/area on illness such as malaria, typhoid, diarrhoea and dysentery before (1989) the proliferation of small- scale mining activities.
- annual number (AAN_{2009}) of reported cases to health facilities in each mining district/area on illness such as malaria, typhoid, diarrhoea and dysentery after (2009) the proliferation of small-scale mining activities.
- actual (hospital) cost of treating illness (CTI*) such as malaria, typhoid, diarrhoea and dysentery (at 2009 constant price).

For this reason, **$DCT = CTI^* (AAN_{2009} - AAN_{1989})$**

(ii) Income loss to patients (ILP) To obtain the ILP, we estimated the:

- number of patients reported (NPR) to health facilities in each mining district per year
- number of days the patient (NDP) was absent from work
- patient's daily wage (WGE_P). That is, how much the patient would have earned if not sick

Therefore, **$ILP = NPR \times NDP \times WGE_P$**

(iii) Time spent by a relative (TSR*) [in caring for a non accident victim]

This included the estimation of the:

- number of patients reported (NPR) to health facilities in the mining district per year; multiplied by
- number of days a relative (NDR) spent on patient while the patient was receiving treatment; times
- daily wage of a relative (WGE_R)

$TSR^* = NPR \times NDR \times WGE_R$

Consequently**, NHC = DCT + ILP + TSR***

(c) Conflicts with the Indigenous Population (CIP)

CIP takes account of conflicts between the indigenous people and small-scale miners with respect to encroachment on traditional and culturally protected lands and national parks. This therefore, causes violation of resident and indigenous community rights and traditional ethical values in the communities.

CIP was measured as the:

- number of encroached traditional and culturally protected lands (ETP) in each mining district/area; multiplied by the
- shadow price of how much a protected area could have fetched the communities and country from tourism (Lyons, 1990). Specifically, the annual proceeds from Buabeng-Fiema Monkey Sanctuary in the Nkoranza North District of the Brong-Ahafo Region which is a traditionally and culturally protected area (TCP_A) was used.

  Hence, **CIP = ETP x TCP_A**

Social Benefit Elements

The social benefits were defined to include the gains to humanity, community or the general public as a result of small-scale mining activities. The social benefit elements consist of (a) source of employment (SOE); (b) indirect/ancillary benefits (IAB); and (c) avoidance of rural-urban migration ARM).

(a) Source of Employment (SOE)

Small-scale mining operations provide direct source of livelihood, job creation or employment to thousands of people. The SOE variable was measured as follows: The estimation of the:

- number of small-scale miners (NSM) in each mining district/area ; multiplied by
- wages/earnings of each miner per year (WGS_M)

Therefore, **SOE = NSM x WGS_M**

The study used the wages of four categories of small-scale miners: namely, *talii* boys and girls; *karl* men and women; *masters* and *site owners*.

Talii boys and girls as the name implies are mainly children, (boys and girls), women or students who are employed as casual labours or miners to carry the mineralized material in sacks or pans to nearby rivers or streams while *karl* men and women are mostly men and few women who are employed also for sluicing the mineralized material to recover the gold.

The *masters* are predominantly men and few women. They do the digging/breaking of soil/ ore with mattocks/hammers and loading the soil/ore in sacks for talii boys and girls to carry to nearby streams or rivers. Where there are no legal concessions, (i.e. illegal mining), the masters amalgamate the pre-concentrate gold-infested sediment (black sand) with mercury, heat/burn the gold-mercury amalgam on fire to evaporate the mercury to obtain pure gold residue, market the gold and pay all the other workers (*talii* boys/girls and *karl* men/women) and other expenses.

Site owners are the licensed/legal operators who own the concessions. The site owners or their representatives or agents amalgamate the pre-concentrate gold-infested sediment (black sand) with mercury, heating/burn the gold-mercury amalgam on fire to evaporate the mercury to obtain pure gold residue, market the gold and pay all the workers (talii boys/girls, karl men/women and in some cases the masters) and disburse other operating expenses.

(b) Indirect/Ancillary Benefits (IAB)

The IAB was made up of all secondary benefits in terms of those who earn their living indirectly from the mining service economy. These include the earnings of food vendors, the owners of stores, transport, artisans and other service providers. The IAB was measured as follows: The study estimated the:

- daily earnings of the highest ancillary earners per year
- daily earnings of the lowest ancillary earners per year
- average earnings of the highest (maximum) and lowest (minimum) ancillary beneficiaries (AEA_B) per year; multiplied by
- number of ancillary beneficiaries (NAB) in each mining district/area.

Thus, **$IAB = AEA_B \times NAB$**

(c) **Avoidance of Rural-Urban Migration (ARM)**

Small-scale mining activities hold back many people, especially, the youth from migrating to the urban centres to look for non-existing jobs. The study used wage differentials (see for example, Kelman, 1981) between small-scale miners and farmers to serve as a proxy for ARM as follows: We computed the:

- average wage of small-scale miners per year;
- average wage of farmers per year (since farming is the main alternative economic activity);
- wage differences (WDS) ; multiplied by the
- number of small-scale miners (NSM) in each mining district/area.

Consequently, **ARM = WDS x NSM**

The Aggregate Economic Factor

The aggregate economic factor consists of the cost and benefit elements. These were measured as follows:

Aggregate Economic Cost Elements

The aggregate economic cost elements are the losses to the mining communities, organisations and the national economy as a whole as a result of small-scale mining operations. The two aggregate economic cost elements which are made up of loss of revenue to large scale mining companies (LRC) and tax evasion (TEV) were estimated as follows:

(a) Loss of Revenue to Large Scale Mining Companies (LRC)

The LRC variable is defined to consist of revenue loss to large scale mining companies due to tension and conflict of interest and clashes between large and small-scale miners over mineral resource. LRC was measured as:

- the frequency of interruptions (FOI) by small-scale miners per year in each mining district/area; multiplied by
- the average revenue lost to large scale mining companies per interruption (RTL)

Therefore, **LRC = FOI x RTL**

(b) Tax Evasion (TEV)

TEV is operationally defined to involve all small-scale miners who shirked their tax obligations to the government. Except the *site owners* who pay tax, most small-scale miners do not pay tax. Since the *talii* boys/girls are predominantly children and students, the number and average incomes of *karl* men /women and *masters* were used to determine or ascertain tax evaders.

TEV encompassed the estimation of the:

- revenue loss to the government (RLG) per miner per year in each mining district/area; multiplied by
- number of miners who evaded tax per year (MET)

Therefore, **TEV = RLG x MET**

The individual tax rates as at April 2010 was used.

Aggregate Economic Benefit Elements

The aggregate economic benefit elements are the gains from small-scale mining operations to the local, district, regional and the national economy as a whole. The aggregate economic benefit elements include source of foreign exchange (SFE); tax revenue (TRV); contribution to product diversity (CPD); and contribution to local economy (CLE). Availability of data was the main rationale for estimating these benefit elements The Aggregate economic benefit elements were estimated as follows:

(a) Source of Foreign Exchange (SFE)

SFE is the value of gold exports from small-scale mining operations in a year. Gold production from small-scale mining operations serves as a major source of foreign exchange to the government. The often large numbers involved in small-scale mining activities means that on a national scale, total production is significant and in some cases equalling or exceeding that produced by some large mines.

The estimation of SFE comprised the value of gold sold in each mining district/area to the Precious Minerals Marketing Company as follows: The

- volume of gold produced (VGP) by licensed small-scale mining operators per mining district/area per year; multiplied by

- average world market price of gold per year (APG) (at 2009 constant price)

  Thus **SFE = VGP x APG**

(b) Tax Revenue (TRV)

TRV entailed the total value of tax revenue from small-scale miners to the government per year.

TRV involves the estimation of the:

- tax revenue to the government (TRG) per licensed operator per year; multiplied by
- number of licensed operators (NLO) in each mining district/area.

Therefore, **TRV = TRG x NLO**

(c) Contribution to Product Diversity (CPD)

The large number of small-scale miners and increased volume of gold production from the small-scale mining sub-sector has added to make the existing economic activities such as cocoa and other cash crop production in the districts expand into new areas of business such as construction, entertainment, transport and communication and also become more varied. CPD is measured by comparing the total gold revenue from small-scale mining (RSM) and the revenues from cocoa production (RCP) in each district.

Consequently, CPD = RSM – RCP

Where; RSM is expressed as the:

- volume of gold produced (VGP) in each mining district/area per licensed small-scale mining operator per year multiplied by
- average local price of gold per year (ALP)

  RSM = VGP x ALP

While RCP is also comprised of the:

- volume of cocoa produced (VCP) in each mining district/area per year multiplied by
- producer price of cocoa per year (PPC)

  RCP = VCP x PPC

Therefore, **CPD = [(VGP x ALP) – (VCP x PPC)]**

(d) Contribution to Local Economy (CLE)

CLE was defined to include the growth of cash flows in respect of investments and demand for local products and services. Increased small-scale mining activities have strengthened cash flows for local, regional and national economy for development. To avoid over estimation, the study compared annual capital growth, before and after the proliferation of small-scale mining activities.

Since data on the volume of annual capital growth was not available, the study used data on currency in circulation (CIC) as proxy and this was obtained from the Bank of Ghana. Data on real currency in circulation (CIC) was obtained in order to cater for inflation. To measure each district's value of real currency in circulation (CIC), the study used the area or district weighted indices developed by the Ghana Statistical Service. Each district's index was divided by the national index (the summation of all areas' or districts' indices which is equal to 1 in terms of decimals or 100 in terms of percentages) and then multiplied by the national real currency in circulation (CIC) for each year.

The study compared the value of real currency in circulation from 1990 to 1999 ($CIC_{1990-1999}$), representing the period before the proliferation of small-scale mining activities in each mining district/area and again, from 2000 to 2009 ($CIC_{2000-2009}$) representing the period after the proliferation of small-scale mining activities in each mining district/area as follows:

- sum of value of real currency in circulation ($CIC_{2000-2009}$) after the proliferation of small-scale mining activities in each district ; minus
- sum of value of currency in circulation ($CIC_{1990-1999}$) before the proliferation of small-scale mining activities in each mining district/area

  Thus, **CLE = ($CIC_{2000-2009}$) - ($CIC_{1990-1999}$)**

It must be stressed that data and transportation constraints did not allow the study to estimate all the social and aggregate economic cost and benefit elements elements/variables as found in the benefit-cost outline developed by Hentschel, Hruschka and Priester (2002). Such cost and benefit elements/variables include complicated

dependency relations, child labour, unbalanced development between men and women, changes in the system of ethical values and its consequences on the mining communities, labour qualification and insufficient social security, mobilization of natural resources, buffer for the labour market in cases of programmes for structural adaptation, provision of personnel reserves for large scale mining, infrastructure development by small-scale miners and relative stable product supply even with market fluctuations, conflicts due to land and water usage, conflicts with governing bodies (e.g. District Assemblies), smuggling, costs of controlling illegal miners, continuous costs resulting from social causes and uncontrolled development due to lack of planned exploitation

As Zerbe and Dwight (1994) stated, benefit-cost analysis is intrinsically dependent on organised process for the specification of variables on which to calculate benefits and costs. Hence, the addition or ignoring of certain variables (cost and benefit) elements cannot have any effect on the validity or reliability of the final outcomes of results (Zerbe and Dwight, 1994).

5.3 SPECIFICATION OF BENEFIT-COST OPERATIONAL MODELS

The three models consisting of the net benefit (NET_B) model, the Net Future Value (NFV) model and the benefit-cost ratio (BCR) model were specified as follows:

Model I: The Value of the Net Benefit (NET_B)

The study adopted net benefits analysis approach as the basic framework. Following Rodgers, *et al.* (2002); Byrne, (1987); Harsanyi, (1953); Kelman, (1981); Kemper, *et al.*, (1983); Sen, *et al*, (1982); and Souleles, (1987), the value of the Net Benefit (NET_B) is specified as

$$NET_B = \sum \left(B_i - C_i\right)$$

For the i^{th} item variable for all the benefit and cost factors and it is expressed as follows:

Thus NET_B = (PEB +SOE + IAB+ ARM+ SFE +TRV+ CPD+ CLE) –

(LSD+ DWB + DFR + DFN +PWC +NHC+ CIP+ LRC +TEV)

where; the benefit variables are:

PEB = Potential environmental benefits
SOE = Source of employment
IAB = Indirect/ancillary benefits
ARM = Avoidance of rural-urban migration
SFE = Source of foreign exchange
TRV = Tax revenue
CPD = Contribution to product diversity
CLE = Contribution to local economy

and the cost variables are:

LSD = Landscape destruction
DWB = Destruction of water bodies
DFR = Destruction of flora
DFN = Destruction of fauna
PWC = Precarious working conditions
NHC = Negative health consequences
CIP = Conflicts with the indigenous population
LRC = Loss of revenue to large scale mining companies
TEV = Tax evasion

$$FV_t = P(1+r)^t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

Model II: Net Future Value (NFV) Model

The Net Future Value expresses the sum of the difference between the benefits to costs of a project at a compounded rate of interest over a period of time (Boardman, *et al.*, 2006; Bready and Myers, 1981; Zerbe and Dwight, 1994). The Net Future Value (NFV_t) is expressed as

$$NFV_t = \sum_{t=0}^{n} B_t(1+r_t)^t - \sum_{t=0}^{n} C_t(1+r_t)^t$$

where;

B_t = the Ghana Cedi (GH¢) value of benefits in period *t*,
C_t = the Ghana Cedi (GH¢) value of costs in period *t*,
t = the number of compounding time periods in the study period (2005-2009),
r_t = the compounded rate of interest per period (10%, 26.54% and 50% rates were used)

Thus, a project is considered to be economically viable if the NFV of the benefits and costs is positive (Boardman *et al.*, (2006); Zerbe and Dwight, 1994; Noble, 1979; and Layard, 1972). The future value of benefits (FV_B) which is the value of the benefits in period *t* (B_t) is a combination of environmental, social and aggregate economic benefits

and it is expressed as

$$FV_B = \sum_{t=0}^{n} B_t (1 + r_t)^t = \sum_{t=0}^{n} (PEB + SOE + IAB + ARM + SFE + TRV + CPD + CLE)(1 + r_t)^t$$

where; PEB, SOE, IAB, ARM, SFE, TRV, CPD and CLE are as already defined.

Essentially, PEB = $\sum peb_{ij}$

represents the potential environmental benefit of the i^{th} item of the potential benefit variable for the j^{th} mining district/area and j = 1, 2, 3 and 4 representing Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts/areas respectively.

Also; SOE = $\sum pbf_{ij}$

IAB = $\sum Iab_{ij}$

ARM = $\sum arm_{ij}$

represent the social benefit of the i^{th} item of the appropriate variable for the j^{th} mining area and j = 1, 2, 3 and 4 representing Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts/areas respectively.

and finally; SFE = Σsfe_{ij}

TRV = $\sum trv_{ij}$

CPD = $\sum cpd_{ij}$

CLE = $\sum cle_{ij}$

represent the aggregate economic benefit of the i^{th} item of the appropriate variable for the j^{th} mining district/area and j = 1, 2, 3 and 4 representing Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts/areas respectively.

In a similar manner, the future value of costs (FV_c) which is the value of costs in period t (C_t) is also comprised of environmental, social and aggregate economic costs and is expressed as:

$$FV_C = \sum_{t=0}^{n} C_t (1 + r_t)^t = \sum_{t=0}^{n} (LCD + DWB + DFR + DFN + PWC + NHC + CIP + LRC + TEV)(1 + r_t)^t$$

Where; LSD, DWB, DFR, DFN, PWC, NHC, CIP, LRC and TEV are as already defined.

Actually; LSD = $\sum lsd_{ij}$

DWB = $\sum dwb_{ij}$

DFR = $\sum dfr_{ij}$

DFN = $\sum dfn_{ij}$

represent the environmental cost of the i^{th} item of the environmental cost variable for the j^{th} mining district/area and j = 1, 2, 3 and 4 representing Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts/areas respectively.

Furthermore; PWC = $\sum pwc_{ij}$

NHC = $\sum nhc_{ij}$

CIP = $\sum cip_{ij}$

represent the social cost of the i^{th} item of the social cost variable for the j^{th} mining district/area and j = 1, 2, 3 and 4 representing Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts/areas respectively.

and lastly; LRC = $\sum lrc_{ij}$

TEV = $\sum tev_{ij}$

represent the aggregate economic cost of the i^{th} item of the economic cost variable for the j^{th} mining district/area and j = 1, 2, 3 and 4 representing Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts/areas respectively.

Model III: Benefit-Cost Ratio (BCR) Model

The BCR provides direct relationships between the costs and benefits of a mining project. The relationships are used to decide whether small-scale mining operations in Ghana are a good investment (Harberger, (1966). The compounded BCR (BCR_d) recognizes the time value of money and it is expressed as:

$$BCR_d = \frac{\sum_{t=0}^{n} B_t (1+r_t)^t}{\sum_{t=0}^{n} C_t (1+t_t)^t}$$

Where; r_t is the appropriate compound rate at time t. Again, if the BCR_d is greater than 1 (or exceeds 1), the project is considered to increase real wealth (Harberger, 1966).

It must be emphasized that there are alternatives or options of compound rates r such as the base rate (British) or prime rate (US), lending rate, borrowing rate, fixed rate, floating rate, simple interest, compound interest and discounted rate that are used in making capital investment decisions (Dively, *et al.*, 1991).

Base rate or prime rate is the lowest rate of interest on loans that is available from a bank at a given time. The Bank of Ghana's base or prime rate, for example, is the rate at which the central bank charges on overnight funds to banks or best customers and this influences the inter-bank market rate and other interest rates.

Lending rate refers to the rate at which financial institutions charge to their customers when the customers borrow from them. It constitutes the base from which banks then lend money to the final customer**.** On the other hand, borrowing rate is the rate at which financial institutions pay to customers when customers deposit with them. The borrowing rate according to Aboagye, *et al.* (2007) reflects the actual cost of capital.

A fixed interest rate according to Dively, *et al.* (1991) is a rate that does not fluctuate during a given period of time. This allows the investor to accurately predict their future payments while a floating interest rate, also known as a variable rate or adjustable rate, refers to any rate that does not have a fixed rate of interest over time. It uses an index or other base rate for establishing the interest rate for each relevant period. The term compound interest rate is an interest rate a bank charges on its customers.

As mentioned earlier in section 2.4 (methodological review), the compound interest is in contrast with the simple interest. The major advantage of compound interest from an investor's standpoint is that interest is paid on interest already received. Interest is not paid only on the original principal, thus the amount of interest paid per period is not constant. Because of this advantage, compound interest is often used in modern finance.

The study compounded the interest rates in its empirical work in this chapter since almost all charges, contracts (in the form of loans from the banks) in Ghana today use compound interest in one form or another. Actual average annual interest rates (lending rates) of 26.37%, 24.85%, 23.92%, 23.26% and 29.48% charged on mining and quarrying activities in Ghana were also used for the status quo scenario for 2005, 2006, 2007, 2008 and 2009 respectively and for the optimistic and pessimistic scenarios, interest rates of 10% and 50% were used the empirical results analysis in section 5.5.

5.4 DATA COLLECTION AND ANALYSIS METHODS

This section provides a detailed discussion on sources of data collection and analysis.

5.4.1 SOURCES OF DATA

The data for the study were generated or obtained by a number of methods, including estimation, comparison, simulation, observation, and quotation from various sources.

Primary and secondary data were gathered from three main sources: government establishments, stakeholders in the small-scale gold mining communities and the small-scale gold miners themselves. The details are summarized in Table 5.3.

Table 5.3: Sources of Data

Sector/Element/Variable	Source
The Physical Environmental Factor	
Physical Environmental Cost Elements (a) Landscape Destruction (LSD) • Cost of reclaiming an acre of destroyed landscape (i.e. backfilling and re-vegetation costs) • Total acres of destroyed land per year in each mining district/area	• Environmental Protection Agency (EPA), Newmont Ghana Ltd; AngloGold Ashanti (Ghana) Ltd.; and Goldfields Ltd • Bolgatanga, Bibiani, Dunkwa and Tarkwa District Centres - Small-Scale Gold Mining Department of the Minerals Commission of Ghana
(b) Destruction of Water Bodies (DWB) • Cost of drilling one borehole • Number of boreholes in all the affected mining communities in each mining district/area. • Cost of constructing/drilling one dug-out well in each mining district/area • Number of dug-out wells to be constructed in each mining district/area. • Cost of raising fishes and the number of fishes per water body. Average estimates were used. • Number of water bodies destroyed in each mining district/area	• Bibiani, Bolgatanga, Dunkwa and Tarkwa District/Municipal Offices of Community Water and Sanitation Agency • -do- • -do- • -do- • Friends of Rivers and Water Bodies an NGO • Bibiani, Bolgatanga, Dunkwa and Tarkwa District/Municipal Offices of Community Water and Sanitation Agency.
(c) Destruction of Flora (DFR) • Area/district weighted averages • National proceeds from herbal medicine	• Statistical Service of Ghana Annual Bulletins • Centre for Scientific Research into Plant Medicine
(d) Destruction of Fauna (DFN) • Area/district weighted averages • National proceeds on bush meat	• Statistical Service of Ghana Annual Bulletins • Wildlife Division of Forestry Commission
Physical Environmental Benefit Element Potential Benefits (PEB) • Net income from a fish pond and the average proceeds from a - 30 x 30 x 10m sized fish pond was used. • Number of fish ponds to be constructed in each district. • Net income from average sized and the number of teak trees per acre • Number of acres in each district	• Journals and the Ministry of Food and Agriculture (MOFA) Bulletins • District/Municipal Directorates of the Environmental Protection Agency (EPA) at Bibiani, Bolgatanga, Dunkwa and Tarkwa • Faculty of Forest Resources Technology, KNUST and the Forestry Commission of Ghana • Bolgatanga, Bibiani, Dunkwa and Tarkwa District Centres - Small-Scale Gold Mining Department of the Minerals Commission of Ghana

The Social Factor Social Cost Elements (a) Precarious Working Conditions (PWC) (i) Direct Cost of Treating Injuries • Actual average cost of treating injuries • Frequency of accidents/injuries occurring at the mining sites or district/area per year	• Bibiani, Bolgatanga, Dunkwa and Tarkwa District/Municipal Directorates of Ghana Health Service • -do- • -do-
(ii) Income Loss to Accident Victims • Number of injuries from small-scale mining activities reported to health facilities in each district • Number of days the accident victims were absent from work • Accident victim's daily wage	• Bibiani, Bolgatanga, Dunkwa and Tarkwa District/Municipal Directorates of Ghana Health Service • -do- • Small-scale miners
(iii) Time Spent by a Relative • Frequency of reported accident victims • Number of days a relative spent on a victim while the victim was receiving to treatment. • Daily wage of a relative	• Bibiani, Bolgatanga, Dunkwa and Tarkwa District/Municipal Directorates of Ghana Health Service • -do- • Small-scale miners
(iv) Compensation to the Accident Victims • Number of reported accident victims • The amount paid by large scale mining companies as compensation to accident victims	• Bibiani, Bolgatanga, Dunkwa and Tarkwa District/Municipal Directorates of Ghana Health Service • Publications of Newmont Ghana Ltd, AngloGold Ashanti (Ghana) Ltd.; and Goldfields Ltd.
(b) Negative Health Consequences (NHC) (i) Direct Cost of Treatment of Illness • Annual number (AAN_{1989}) of reported cases to health facilities • Annual number (AAN_{2009}) of reported cases to health facilities • Actual (hospital) cost of treating illnesses such as malaria, typhoid, diarrhoea and dysentery	• Bibiani, Bolgatanga, Dunkwa and Tarkwa District/Municipal Directorates of Ghana Health Service • -do- • -do-
(ii) Income loss to patients • Number of patients reported to health facilities in each mining district per year • Number of days the patient was absent from work • Patient's daily wage	• Bibiani, Bolgatanga, Dunkwa and Tarkwa District/Municipal Directorates of Ghana Health Service • -do- • Small-scale miners
(iii) Time spent by a relative • Number of patients reported to health facilities in the mining district per year • Number of days a relative spent on patient while the patient was receiving treatment • Daily wage of a relative	• Bibiani, Bolgatanga, Dunkwa and Tarkwa District/Municipal Directorates of Ghana Health Service • -do- • Small-scale miners
(c) Conflicts with the Indigenous Population (CIP) • Number of encroached traditional and culturally protected lands in each mining district/area • Proceeds from traditionally and culturally protected area	• Ghana Tourist Board Publications (2005-2009) • Buabeng-Fiema Monkey Sanctuary

Social Benefit Elements (a) Source of Employment (SOE) • Number of small-scale miners in each Mining district/area • Wages/earnings of miners	• Bibiani, Bolgatanga, Dunkwa and Tarkwa District/Municipal Assemblies; and Bibiani, Bolgatanga, Dunkwa and Tarkwa District Centres - Small-Scale Gold Mining Department of the Minerals Commission of Ghana. • Small-scale miners
(b) Indirect/Ancillary Benefits (IAB) • Daily earnings of the highest ancillary earners per year • Daily earnings of the lowest ancillary earners per year • Number of ancillary beneficiaries in each mining district/area.	• Opinion Leaders (Assembly members) in the mining communities and small-scale miners • -do- • Bibiani, Bolgatanga, Dunkwa and Tarkwa District/Municipal Assemblies
(c) Avoidance of Rural-Urban Migration (ARM) • Wage of small-scale miners per year • Wage of farmers per year • Number of small-scale miners in each mining district/area.	• Small-scale miners and Opinion Leaders (Assembly members) in the mining communities • -do- • Bibiani, Bolgatanga, Dunkwa and Tarkwa District Centres - Small-Scale Gold Mining Department of the Minerals Commission of Ghana and Opinion Leaders (Assembly members) in the mining communities
The Aggregate Economic Factor Aggregate Economic Cost Elements: (a) Loss of Revenue to Large Scale Mining Companies (LRC). The : • Frequency of interruptions by small-scale miners per year in each district • Revenue lost to large scale mining companies per interruption	• AngloGold Ashanti (Ghana) Ltd. Annual Reports and Goldfields Ltd Annual Reports/Publications • -do-
(b) Tax Evasion (TEV) • Revenue loss to the government • Number of miners who evaded tax per year	• Bibiani, Bolgatanga, Dunkwa and Tarkwa District/Municipal Offices of Internal Revenue Service • -do-
Aggregate Economic Benefit Elements (a) Source of Foreign Exchange • Volume of gold produced by licensed small-scale mining operators per mining district/area (2005-2009) • World market price of gold (2005-2009)	• Precious Minerals Marketing Company Bulletins and Minerals Commission of Ghana Annual Reports • Bank of Ghana Annual Reports (2005-2009)
(b) Tax Revenue (TRV) ▪ Tax revenue to the government per licensed operator per year • Number of licensed operator in each mining district/area	• Bibiani, Bolgatanga, Dunkwa and Tarkwa District/Municipal Offices of Internal Revenue Service • Bibiani, Bolgatanga, Dunkwa and Tarkwa District Centres - Small-Scale Gold Mining Department of the Minerals Commission of Ghana
(c) Contribution to Product Diversity (CPD) • Volume of gold produced in each mining district/area per licensed small-	• Bibiani, Bolgatanga, Dunkwa and Tarkwa District Centres - Small-Scale Gold Mining Department of the

scale mining operator for 2005-2009 • Local price of gold per year • Volume of cocoa/shea nuts produced in each mining district/area for 2005-2009 • Producer price of cocoa/shea nuts for 2005-2009	Minerals Commission of Ghana • Small-scale miners • Bibiani, Dunkwa and Tarkwa Offices of Ghana COCOBOD and Bolgatanga Office of OLAM Company Ltd • -do-
(d) Contribution to local economy (CLE) • Volume of currency in circulation (1990-2009 • Area/district weighted averages	• Bank of Ghana Annual Reports (1990-2009) • Ghana Statistical Service Bulletins (1990-2009)

Source: Field Study, March 2010

5.4.2 DATA COLLECTION METHOD

Prior to field work, four research assistants, who are natives from each of the four mining districts, were engaged and trained on the rudiments of research. At the training, the objectives of the study and information on data collection were explained. Data from 2005 to 2009 were collected for the study. Primary and secondary data were collected via a review and compilations from the municipal or district centres/offices as reported earlier in Table 5.3.

Primary Data

The research instruments used to obtain primary data were as follows:

(a) Interviews

One-on-one interviews were conducted with the small-scale miners, and the other stakeholders such as traditional rulers, landlords and assembly members in the selected mining communities. Informed verbal and written consent was sought before the interview. Structured interview schedules were used. In all two hundred and sixty (260) respondents were interviewed and the details are reported in Table 5.4. The interview technique enabled the researcher to have a face-to-face interaction with all stakeholders, especially, the small-scale miners since most of them did not have time to read and answer the questionnaires.

Table 5.4: Summary of the Number of Interviewees

District/Area / Interviewees	Bibiani	Bolgatanga	Dunkwa	Tarkwa	Total
Small-Scale Miners	50	50	50	50	200
Traditional Rulers	5	3	7	6	21
Assembly Members	11	6	9	13	39
Total	66	59	66	69	260

Source: Field Study, March 2010

(b) Questionnaires

A twenty-five (25) – item questionnaire was constructed and given to the officials of target offices and respondents were requested to answer questions that were applicable to them. The open-ended questions type was used to allow the respondents to provide answers. The entire questionnaire was administered through personal visits to the offices in the various mining districts/areas.

Questionnaires were administered personally to respondents but officers who could not be met on arrival had theirs through their Public Relations Officers. Follow-ups were made to assist respondents in the completion of the questionnaires and to ensure that those who were supposed to have the forms had them. In all, ninety-three (93) questionnaires were collected and analyzed and the details are shown in Table 5.5.

(c) Observation

Direct observations were made in the natural settings of all the four mining districts: namely, the Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining districts. Every observation was recorded in the observation guide and dated immediately. The researcher took special note of the developments in the operations of the small-scale mining sub-sector. Specifically, the researcher had the opportunity to closely observe the entire gold production process: namely, prospecting, exploration, processing and marketing.

Table 5.5: Questionnaire Administration

Source \ District/Area	Number of Questionnaires					
	Bibiani	Bolgatanga	Dunkwa	Tarkwa	Others	Total
Small-Scale Mining Centres	2	2	2	2		8
Fish Farmers Association of Ghana	1	-	1	1		3
Forestry Commission of Ghana	2	2	2	2		8
Environmental Protection Agency	2	2	2	2		8
Newmont Ghana Ltd					2	2
AngloGold Ashanti (Ghana) Ltd					2	2
Goldfields Ltd.					2	2
Ghana COCOBOD	2		2	2		6
OLAM Ghana Ltd		2				2
Community Water and Sanitation Agency	2	2	2	2		8
Friends of Rivers and Water Bodies					2	2
Ghana National Association of Traditional Healers					2	2
Centre for Scientific Research into Plant Medicine					2	2
Statistical Service of Ghana					2	2
Wildlife Division of Forestry Commission	2	2	2	2		8
Ghana Health Service	2	2	2	2		8
Food and Agriculture	2	2	2	2		8
Internal Revenue Service	2	2	2	2		8
Buabeng-Fiema Monkey Sanctuary					2	2
Faculty of Forest Resources Technology, KNUST					2	2
Total	19	18	19	19	18	93

Source: Field Study, March 2010

Note: Others include organisations that are not part the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts.

Furthermore, we observed the social, economic and political ways of life of the miners as well as the socio-cultural practices in the mining communities. We also noted the sentiments or concerns of all the stakeholders in the mining sector, particularly, the miners, non miners, opinion leaders in the mining communities, government organizations (the District/Municipal Assemblies, Minerals Commission, Ghana Police Service, EPA among others) and non-government organizations (Large Scale Mining Companies, Wassa Association of Communities Affected by Mining among others).

Secondary Data

Secondary data were obtained from journals, magazines, news papers, text books and the Internet. Annual reports and quarterly bulletins of the Bank of Ghana, Internal Revenue Service, Ghana Statistical Service and Ghana Tourist Board were consulted to search out data. The rest of the data were taken from the publications of the Ghana Minerals Commission, Precious Minerals Marketing Company, Ministry of Trade and Industry, Centre for Scientific Research into Plant Medicine, Wildlife Division of Forestry

Commission, Newmont Ghana Ltd,. AngloGold Ashanti (Ghana) Ltd., Goldfields Ltd., Ghana National Association of Traditional Healers, Ghana Health Service, Ghana COCOBOD and OLAM Company Ltd.

5.4.3 SAMPLING PROCEDURE

A multistage sampling technique was employed in selecting respondents for the interview and questionnaire administration in the four mining districts/areas, blocked out areas and the communities. Blocked out areas are pieces of land reserved by the Minerals Commission of Ghana for small-scale mining purposes. It must be noted that all the four mining districts for the study area have been clustered into blocked out areas based on the Mineral Commission's demarcation. The blocked out areas selected for interview or primary data collection purposes are indicated in Table 3.1.

However, since most of the small-scale mining operations are carried out in very remote areas and the nature or behaviour of the miners, selective sampling technique was used for the mining communities. The communities were, therefore, selected based on their accessibility and familiarity of the lead researcher and the research assistants with some of the miners, traditional rulers and assembly members. For the interview with the miners, traditional rulers and assembly members, random sampling was employed to collect data from the selected communities. The details of the number of interviewees are found in Table 5.5. In respect of the respondents for the questionnaires, deliberate (purposive) sampling technique was utilized to select schedule officers responsible for providing the data/information which the researcher requested for, from the targeted organisations (data sources) after consultations with the respective Public Relations Officers.

5.4.4 DATA HANDLING

Sorting was done to ensure quality control of data. Other quality control measures were checks for completeness, internal consistency and accuracy of data processing (categorizing and coding of data). Data were double entered by the lead investigator with

the help of the four field assistants and two data entering clerks. The report writing was done in Microsoft word.

5.4.5 PRE-TESTING OF DATA COLLECTION TECHNIQUES

Pre-testing of data collection techniques was done in the Bibiani Mining District because of its proximity and familiarity of the lead researcher and the research assistants with some of the miners, traditional rulers and assembly members. The pre-testing exercise involved the lead researcher and one research assistant. Two days were used to complete the pre-test. The experiences from the pre-testing were incorporated into finalizing the data collection techniques. The pre-testing exercise was to ensure the reliability and validity of the data collecting instruments.

5.4.6 ETHICAL CONSIDERATION

Written consent was sought from the management of all the target organisations visited through their respective Public Relations Officers. Confidentiality of the information provided by the respondents was protected. The study was expected to pose no physical or psychological harm to the study participants.

5.4.7 TECHNIQUES OF DATA ANALYSIS

The following techniques were used to analyze the data.

For the categorized variables, percentages were used to describe relationships between study variables. Averages were also used to provide a single value that is meant to represent a list of values. Graphs were employed to present components of the variables. A two-way analysis of variance (ANOVA) was carried-out to simultaneously test for statistical interdependence between mining districts and across sector activity variables for enterprise profitability.

In addition, net benefit, net future value (NFV) and benefit-cost ratio criteria were used to ascertain the economic viability of small-scale mining activities in the mining

districts/areas. The study carried out sensitivity analysis to establish the degree of responsiveness of: first, interest rate scenarios and second, inflation rate scenarios on the net future values. Cross sectional data from the four mining districts (the study area) were examined to capture the transitional dynamics of the Ghanaian economy.

5.5 EMPIRICAL RESULTS AND ANALYSIS

The section centres on the results of the location benefit-cost analysis, combined total benefit-cost analysis, profitability index analysis; and sensitivity analysis using inflation scenario.

5.5.1 RESULTS AND DISCUSSIONS ON LOCATION BENEFIT-COST ANALYSIS

This section evaluates the models as operationally specified in section 5.3. It is organized in five sub-sections as follows: Location Analysis of the Bibiani Mining District, Location Analysis of the Bolgatanga Mining District, Location Analysis of the Dunkwa Mining District, Location Analysis of the Tarkwa Mining District and the Combined Total Analysis.

The study aims at ascertaining whether small-scale mining activities in the mining districts are economically viable and if it is worth continuing with the existing mining activities. This was done by looking at the present value of the future net benefits (benefits and costs). To obtain the value of the existing mining activities, the average net benefit of each of the four mining districts for the study period 2005- 2009 in Table 5.6 was used to represent their respective present value (Bjorn *et al.*, 2005). The future values were then estimated by employing three interest rate *r* scenarios, namely, optimistic, status quo and pessimistic (Knapp *et al.*, 2009).

For the status quo scenario, the average (that is, 26.54%) of the actual interest rates (lending rates) of 27.37%, 26.95%, 25.12%, 23.78% and 29.48% charged on mining and quarrying activities by the Ghana Commercial Bank for 2005, 2006, 2007, 2008 and 2009 respectively were used. Optimistic and pessimistic scenarios, interest rates of 10%

and 50% were also used. The study assumed that an optimistic scenario of 10% interest rate for a developing country like Ghana is suitable for investment purposes and price stability and 50% according to the Ghana Statistical Service is the highest recorded rate of interest in recent times particularly, in 1996.

(a) Location Analysis: Bibiani Mining District

This sub-section of the location analysis focuses mainly on Bibiani Mining District. The issues that were analyzed were benefits and costs; net benefits; Net Future Values and benefit-cost ratios of the Bibiani Mining District.

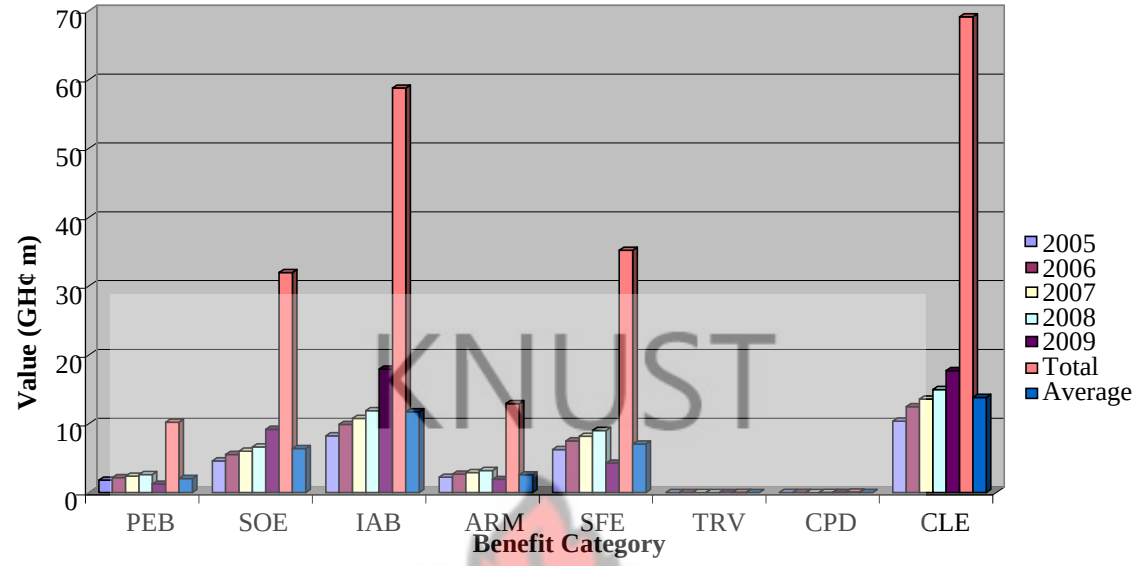
Benefits and Costs Approaches: Bibiani Mining District

The study examined the totality of the benefit variables in the district over the study period (2005-2009). Available data reported in Appendix 1 and graphed in Figure 5.1 show that the most notable benefit variable in the Bibiani Mining District is CLE which constituted 31.66% of the total benefits. This was followed by IAB, SFE, SOE, ARM, PEB, CPD and TRV which are made up of approximately 26.92%, 16.13%, and 14.64%, 5.92%, 4.69%, 0.03% and 0.01% respectively of the total benefits.

The relatively high proportion of the CLE benefit variable was accounted for by the accelerated commercial activities in the mining communities as compared with non mining communities in the district while the relatively low tax revenue (TRV) variable is attributed to weak enforcement of tax laws in the small-scale mining communities. Annual average benefits rose by 20.14%, 8.85%, 10.30%, and 8.13% between 2005-2006, 2006-2007, 2007-2008 and 2008-2009 in that order.

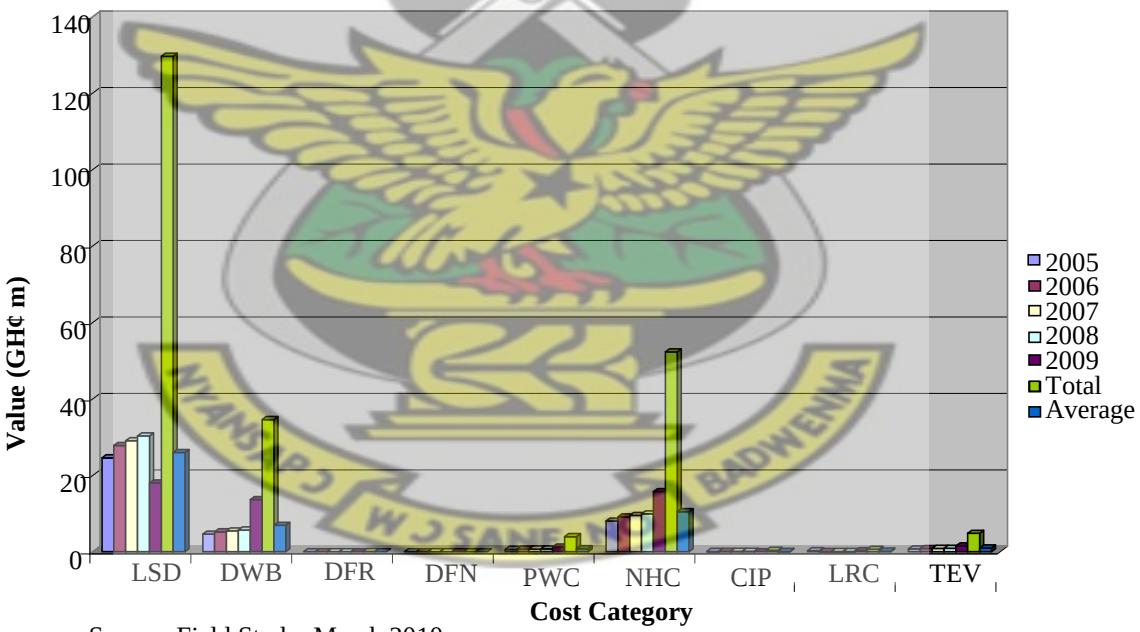
With regard to the cost variables, LSD was prominent and recorded 57.31% of all the cost variables in the district. The others were : NHC, 23.11%; DWB, 15.28%; TEV, 2.12%; PWC, 1.75%; LRC, 0.27%; CIP, 0.15%; DFR, 0.01%; and the least, DFN, 0.002%. Environmental degradation and haphazard mining partly explained the reason for the high percentage of LSD.

Figure 5.1: Benefit Components: Bibiani Mining District (2005-2009)



Source: Field Study, March 2010

Figure 5.2: Cost Components: Bibiani Mining District (2005-2009)



Source: Field Study, March 2010

The behaviour of the cost variables over time is presented in Figure 5.2 and Appendix 2. Even though the percentage of DFN is relatively low as compared to the other cost variables, its total value of GH¢ 3,931.55 was significant. Annual average cost variables

also rose by 12.50%, 4.54%, 4.26%, 5.82%, 2005-2006, 2006-2007, 2007-2008 and 2008-2009 respectively.

Net Benefits and Benefit-Cost Ratios Approaches: Bibiani Mining District

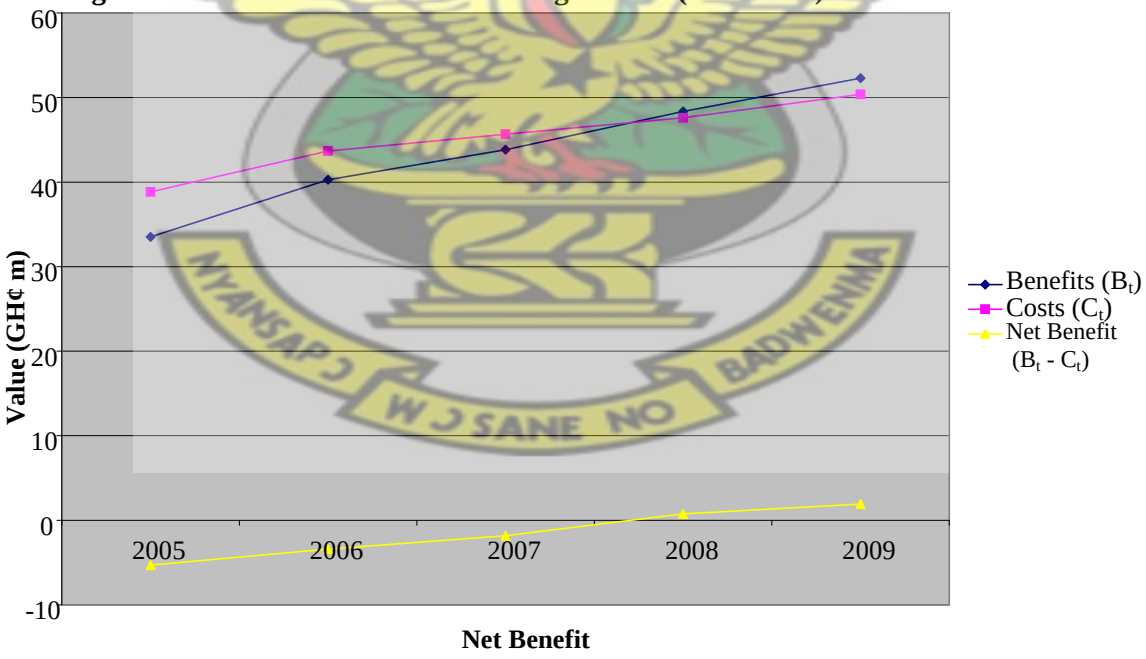
The district recorded negative net benefit for the 2005-2007 period but positive net benefits for the 2008-2009 periods. The results of the net benefits (NET_B) analysis for the Bibiani Mining District are shown in Table 5.6 and Figure 5.3.

Table 5.6: Net Benefits and Benefit-Cost Ratios: Bibiani Mining District (in GH¢)

Year	Benefits (B_t)	Costs (C_t)	Net Benefit (B_t - C_t)	BCR
2005	33,521,904.92	38,826,067.07	-5,304,162.15	0.86
2006	40,273,990.14	43,677,819.30	-3,403,829.15	0.92
2007	43,839,917.20	45,659,947.30	-1,820,030.10	0.96
2008	48,357,028.31	47,604,075.26	752,953.05	1.02
2009	52,290,003.43	50,375,378.39	1,914,625.04	1.04
Total	218,282,844.00	226,143,287.32	-7,860,443.32	4.8
Average	43,656,568.80	45,228,657.46	-1,572,088.66	0.96

Source: Field Study, March 2010

Figure 5.3: Net Benefits: Bibiani Mining District (2005-2009)



Source: Field Study, March 2010

The result showed negative net benefit for 2005-2007 but positive for the 2008-2009 periods. The BCRs were 0.86, 0.92 and 0.96 for 2005, 2006 and 2007 respectively. Since each BCR < 1, it indicates that small-mining activities for the period were not worthwhile and therefore, not worth continuing with the existing mining activities.

The result showed negative net benefit for 2005-2007 but positive for the 2008-2009 periods. The BCRs were 0.86, 0.92 and 0.96 for 2005, 2006 and 2007 respectively. Since each BCR < 1, it indicates that small-mining activities for the period were not worthwhile and therefore, not worth continuing with the existing mining activities.

The total and average net benefits for the entire period (2005-2009) were (GH¢7,860,443.32) and (GH¢1,572,088.66) respectively. This suggests that small-scale mining activities in the district for the period under review were not economically viable and it is not worth continuing with the existing mining activities.

Nominal Net Future Values Approach: Bibiani Mining District

The average net benefit of (GH¢1,572,088.66) for 2005-2009 as in Table 5.6 was used to represent the value of the existing mining activities in the district. To estimate the nominal NFVs, the average net benefit of (GH¢1,572,088.66) was then compounded at interest rates *r* of 10%, 26.54% and 50% for the optimistic, status quo and pessimistic scenarios respectively over a period of 11 years (see Model II of section 6.3). Table 5.7 and Figure 5.4 report the result of the nominal NFVs of the different scenarios.

Again, Table 5.7 recorded total negative nominal NFVs of (GH¢ 33,617,990.01), (GH¢ 93,740,084.30) and (GH¢ 404,801,315.63) for the optimistic, status quo and pessimistic scenarios respectively for the 12-year period under consideration. This suggests that small-mining activities in the Bibiani District for the period were not worthwhile and not worth continuing with the existing mining activities. This result is consistent with the net benefit result observed by Bjorn, *et al.* (2005).

Table 5.7: Nominal Net Future Values: Bibiani Mining District

Year	*t*	NFV *r* =10%	NFV *r* =26.54%	NFV *r* =50%
2005-2009	0	-1,572,088.66	-1,572,088.66	-1,572,088.66
2010	1	-1,729,297.53	-1,988,849.36	-2,358,132.99
2011	2	-1,902,227.28	-2,516,093.33	-3,537,199.49
2012	3	-2,092,450.01	-3,183,109.67	-5,305,799.23
2013	4	-2,301,695.01	-4,026,952.05	-7,958,698.84
2014	5	-2,531,864.51	-5,094,497.03	-11,938,048.26
2015	6	-2,785,050.96	-6,445,048.20	-17,907,072.39
2016	7	-3,063,556.05	-8,153,630.47	-26,860,608.59
2017	8	-3,369,911.66	-10,315,157.91	-40,290,912.88
2018	9	-3,706,902.83	-13,049,706.28	-60,436,369.33
2019	10	-4,077,593.11	-16,509,183.41	-90,654,553.99
2020	11	-4,485,352.42	-20,885,767.93	-135,981,830.98
Total		-33,617,990.01	-93,740,084.30	-404,801,315.63

Source: Estimation, March 2010

Note: r = nominal interest rate

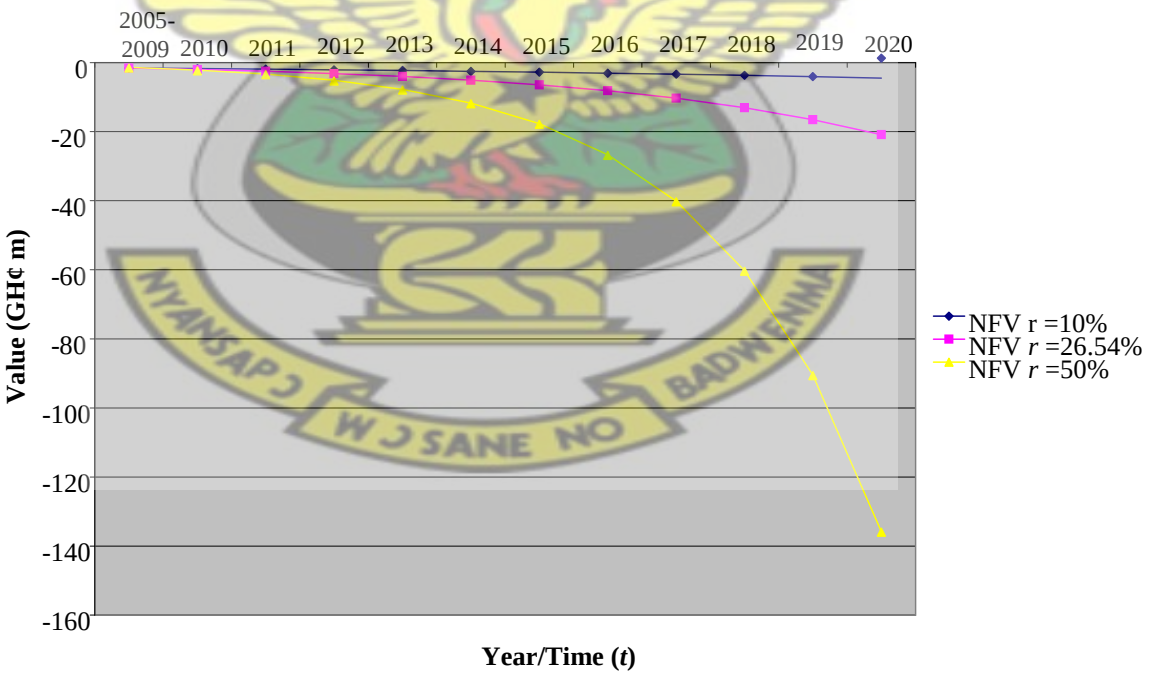
Optimistic Scenario: r = 10%

Status quo Scenario: r=26.54 which is the average of the actual interest rates of 27.37%, 26.95%, 25.12%, 23.78% and 29.48% for 2005, 2006, 2007, 2008 and 2009 respectively charged by GCB

Pessimistic Scenario: r = 50%

Value of existing mining activities in the district/present value = (GH¢1,572,088.66), see Table 5.6

Figure 5.4: Nominal NFVs: Bibiani Mining District/Area



Source: Field Study, March 2010

Note: r = nominal interest rate

Optimistic Scenario: r = 10%

Status quo Scenario: r=26.54 which is the average of the actual interest rates of 27.37%, 26.95%, 25.12%, 23.78% and 29.48% for 2005, 2006, 2007, 2008 and 2009 respectively charged by GCB

Pessimistic Scenario: r = 50%

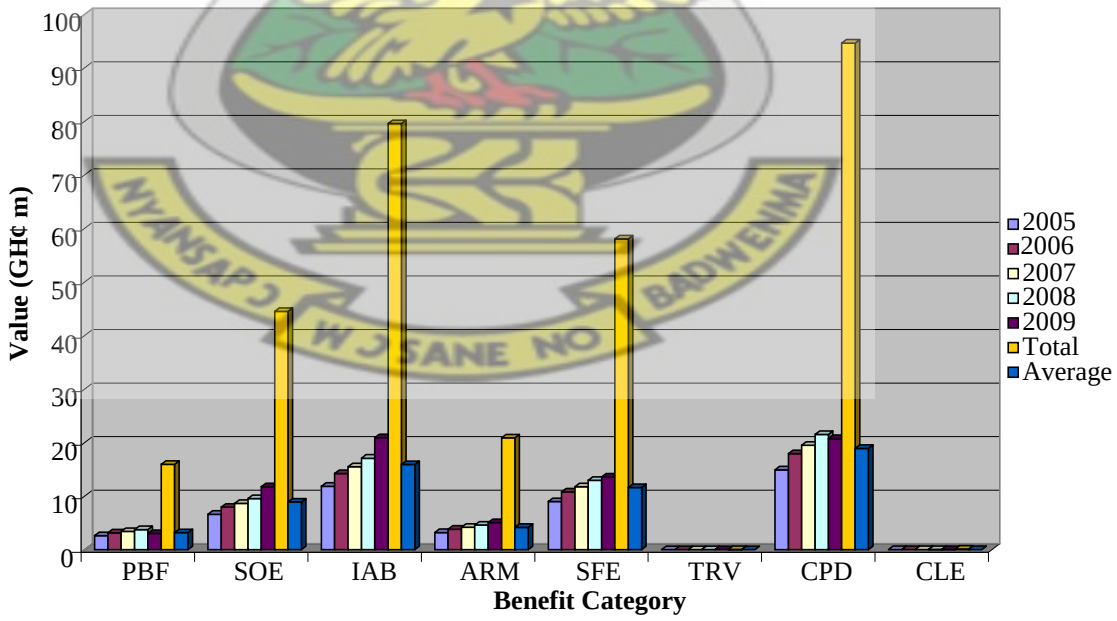
(b) Location Analysis: Bolgatanga Mining District

This part of the location analysis concentrates on benefits and costs; net benefits; net future values and benefit-cost ratios of the Bolgatanga mining District. The details are as follows:

Benefits and Costs Approaches: Bolgatanga Mining District

Unlike the Bibiani mining District, CPD was the most outstanding benefit variable and it constituted 33.13% of the total benefit variables. This was followed by IAB, SFE, SOE, ARM, PEB, CLE and TRV with 24.61%.16.69%, 14.24%, 7.51%, 3.77%, 0.03% and 0.01% correspondingly. As mentioned earlier, the large number of small-scale miners and increased volume of gold production from the small-scale mining sub-sector has added to make the existing economic activities such as cocoa and other cash crop production in the districts expand into new areas of business such as construction, entertainment, transport and communication and also become more varied. This explained the reason for the outstanding proportion of the CPD benefit variable in the Bolgatanga Mining District.

Figure 5.5: Benefit Components: Bolgatanga Mining District (2005-2009)



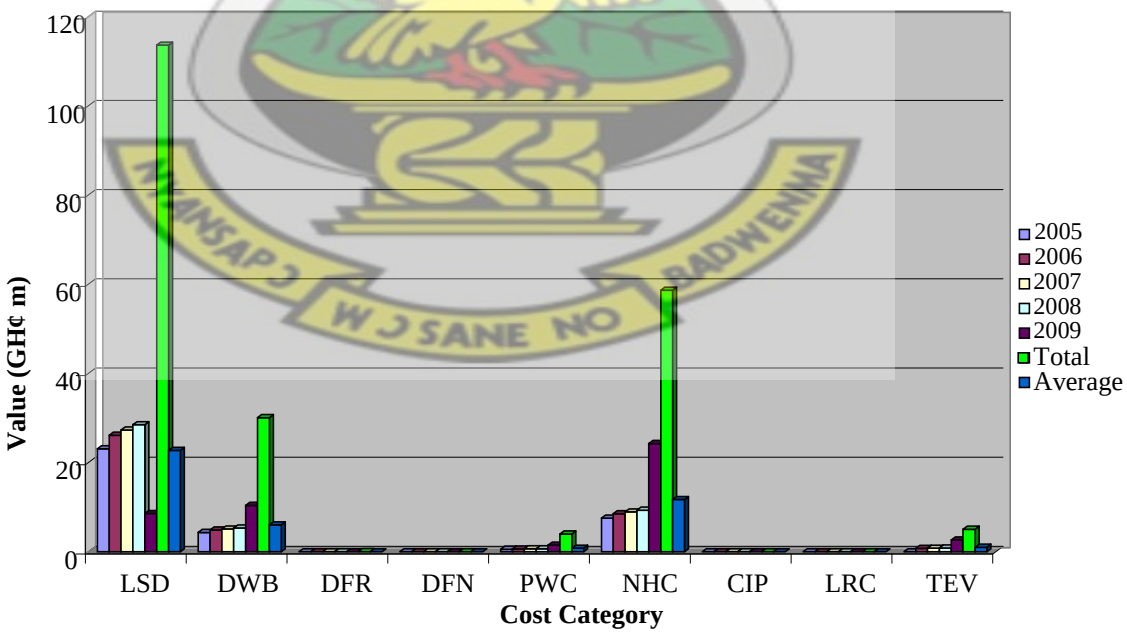
Source: Field Study, April 2010

The relatively low tax revenue (TRV) variable, like the Bibiani Mining District, was attributed to weak enforcement of tax laws in the small-scale mining communities. Again the annual average benefits increased by approximately 20.15% from 2005 to 2006, 6.09% from 2006 to 2007, 13.18% from 2007 to 2008 and 8.13% from 2008 to 2009.

Similar to the Bibiani Mining District, the Bolgatanga Mining District also recorded LSD of 53.75%, of the total cost value as the major cost variable. The others were: NHC, 27.74%; DWB, 14.23%; TEV, 2.39%, PWC, 1.89%; DFR, 0.01%; and DFN, 0.0013%. Data on CIP and LRC were however, not available. Relatively, 15.31%, 4.54%, 4.26% and 6.10% represented the annual average increase of the cost variables between 2005-2006, 2006-2007, 2007-2008 and 2008-2009 respectively.

Appendices 4 and 5 incorporate data of the components of the benefit and cost variables in the Bolgatanga Mining District for 2005-2009. Figures 5.5 and 5.6 present the graphical illustration of the components.

Figure 5.6: Cost Components: Bolgatanga Mining District (2005-2009)



Source: Field Study, April 2010

Net Benefits and Benefit-Cost Ratios Approaches: Bolgatanga Mining District

The Bolgatanga Mining District interestingly recorded positive net benefits throughout the study period. The total and average net benefits for the entire period (2005-2009) were GH¢ 199,832,774.15 and GH¢ 39,966,554.83 respectively. This suggests that that small-scale mining in the district during the period under review was economically viable and it is worth continuing with the existing mining activities. This result is consistent with the benefit-cost result observed by Henrique (2009).

The trend of the net benefits could be predicted to be positive in the future. Table 5.8 and Figure 5.7 report the result of the net benefits (NET_B) and BCR analyses for the Bolgatanga Mining District.

Table 5.8: Net Benefits and Benefit-Cost Ratios: Bolgatanga Mining District (in GH¢)

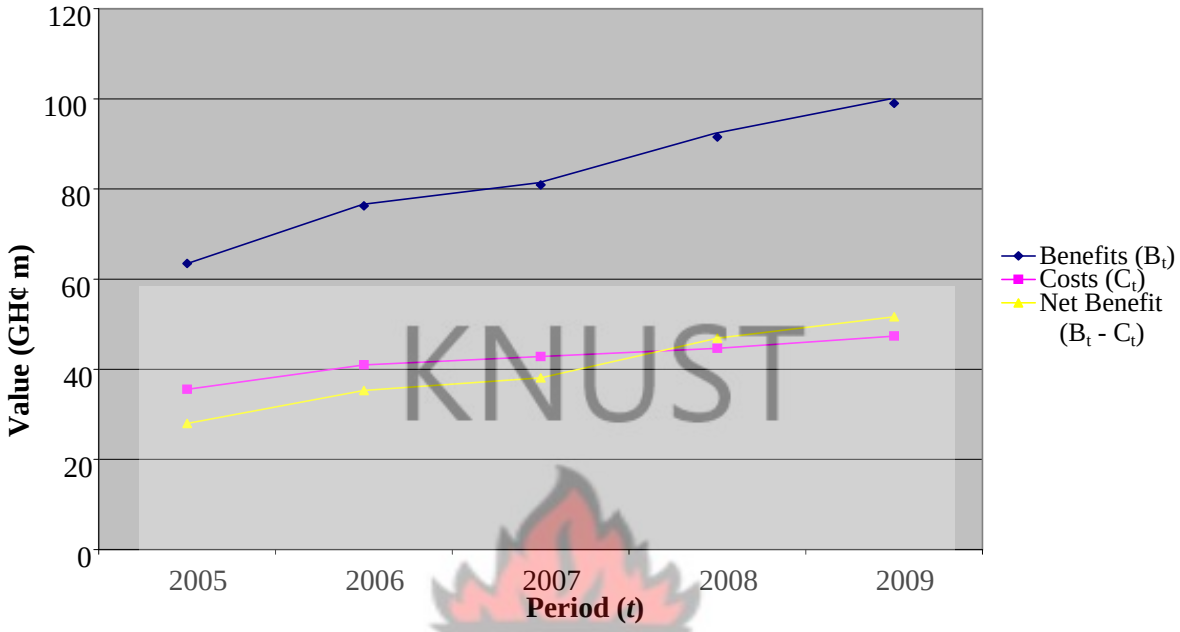
Year	Benefits (B_t)	Costs (C_t)	Net Benefit (B_t - C_t)	BCR
2005	63,468,285.85	35,527,282.96	27,941,002.89	1.79
2006	76,252,263.26	40,967,459.16	35,284,804.10	1.86
2007	80,897,745.94	42,826,351.92	38,071,394.02	1.89
2008	91,556,184.08	44,649,829.88	46,906,354.20	2.05
2009	99,002,634.03	47,373,415.10	51,629,218.93	2.09
Total	411,177,113.17	211,344,339.02	199,832,774.15	9.68
Average	82,235,422.63	42,268,867.80	39,966,554.83	1.94

Source: Estimation, March 2010

The reason for the positive net benefits was the absence of conflicts with indigenous people (CIP) and with large scale mining companies (LRC) which were frequent in the other mining districts in the southern part of the country. This has reflected in total value of the cost variables.

The result showed positive net future values throughout the study period. In addition, the BCRs were 1.79, 1.86, 1.89, 2.05, and 2.09 for 2005, 2006, 2007, 2008 and 2009 respectively. Since each BCR > 1, small-mining activities for the period were considered to be economically viable and therefore, worth continuing with the existing mining activities in the Bolgatanga District.

Figure 5.7: Net Benefits: Bolgatanga Mining District (2005-2009)



Source: Field Study, March 2010

Nominal Net Future Values Approach: Bolgatanga Mining District

The study used the average net benefit of GH¢ 39,966,554.83 for the study period 2005-2009 in Table 5.8 to represent the value of the existing mining activities in the district. To estimate the nominal NFVs, the average net benefit of 39,966,554.83 was compounded at rates of interest *r* of 10%, 26.54% and 50% for the optimistic, status quo and pessimistic scenarios respectively over a period of 11 years as reported in Table 5.9.

The positive values of the total nominal NFV for the interest rates of the three scenarios for the period were signs that small- mining activities in the Bolgatanga District were worthwhile and therefore, worth continuing with the existing mining activities. The result in Table 5.9 is graphically presented in Figure 5.8.

Table 5.9: Nominal Net Future Values: Bolgatanga Mining District

Year	*t*	NFV *r* =10%	NFV *r* =26.54%	NFV *r* =50%
2005-2009	0	39,966,554.83	39,966,554.83	39,966,554.83
2010	1	43,963,210.31	50,561,688.52	59,949,832.25
2011	2	48,359,531.34	63,965,592.14	89,924,748.37
2012	3	53,195,484.48	80,922,870.62	134,887,122.55
2013	4	58,515,032.93	102,375,523.62	202,330,683.83
2014	5	64,366,536.22	129,515,274.93	303,496,025.74
2015	6	70,803,189.84	163,849,774.31	455,244,038.61
2016	7	77,883,508.83	207,286,349.48	682,866,057.92
2017	8	85,671,859.71	262,237,960.73	1,024,299,086.87
2018	9	94,239,045.68	331,757,244.12	1,536,448,630.31
2019	10	103,662,950.25	419,706,089.54	2,304,672,945.47
2020	11	114,029,245.27	530,970,173.87	3,457,009,418.20
Total		854,656,149.68	2,383,115,096.71	10,291,095,144.93

Source: Estimation, March 2010

Note: r = nominal interest rate

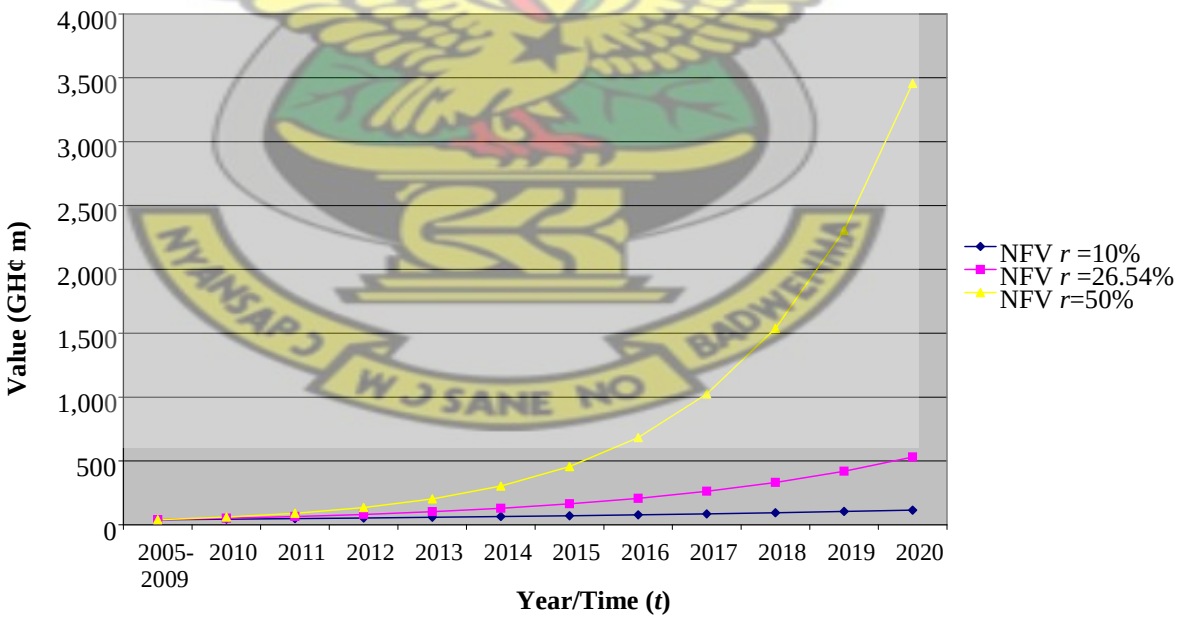
Optimistic Scenario: r = 10%

Status quo Scenario: r=26.54 which is the average of the actual interest rates of 27.37%, 26.95%, 25.12%, 23.78% and 29.48% for 2005, 2006, 2007, 2008 and 2009 respectively charged by GCB

Pessimistic Scenario: r = 50%

Value of existing mining activities in the district/present value = 39,966,554.83, see Table 5.8

Figure 5.8: Nominal NFVs: Bolgatanga Mining District



Source: Survey, March 2010

Note: r = nominal interest rate

Optimistic Scenario: r = 10%

Status quo Scenario: r=26.54 which is the average of the actual interest rates of 27.37%, 26.95%, 25.12%, 23.78% and 29.48% for 2005, 2006, 2007, 2008 and 2009 respectively charged by GCB

Pessimistic Scenario: r = 50%

(c) Location Analysis: Dunkwa Mining District

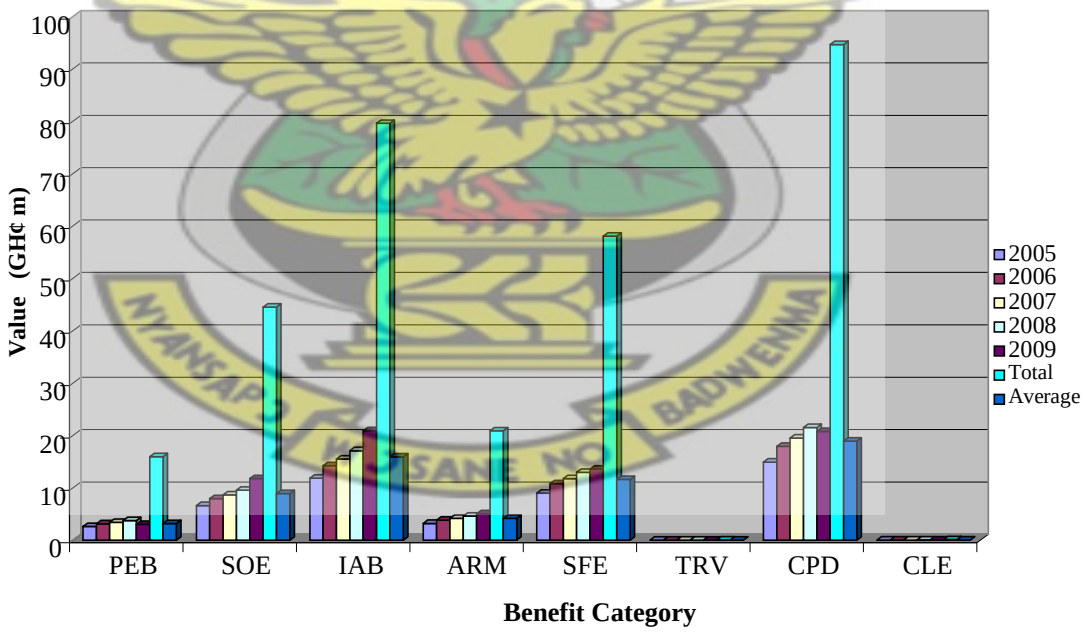
This subdivision of the location analysis focused on the benefits and costs; net benefits; net future values and benefit-cost ratios of the Dunkwa Mining District and following are the details.

Benefits and Costs Approaches: Dunkwa Mining District

In terms of significance, the Dunkwa Mining District like the Bibiani mining District recorded CPD of 30.16% as the highest benefit variable. The others were IAB, SFE, SOE, ARM, PEB, CLE and TRV with 25.37%, 18.51%, 14.18%, 6.66%, 5.08%, 0.03% and 0.01% respectively. The low TRV documented in the district which was similar to the Bolgatanga District emanated from the same reason as explained earlier. The annual average benefits improved by approximately 20.14%, 8.88%, 10.28%, and 8.13% from 2005 to 2006, 2006 to 2007, 2007 to 2008 and 2008 to 2009 in that order.

Figures 5.9 and 5.10 illustrate the components of the benefit and cost variables.

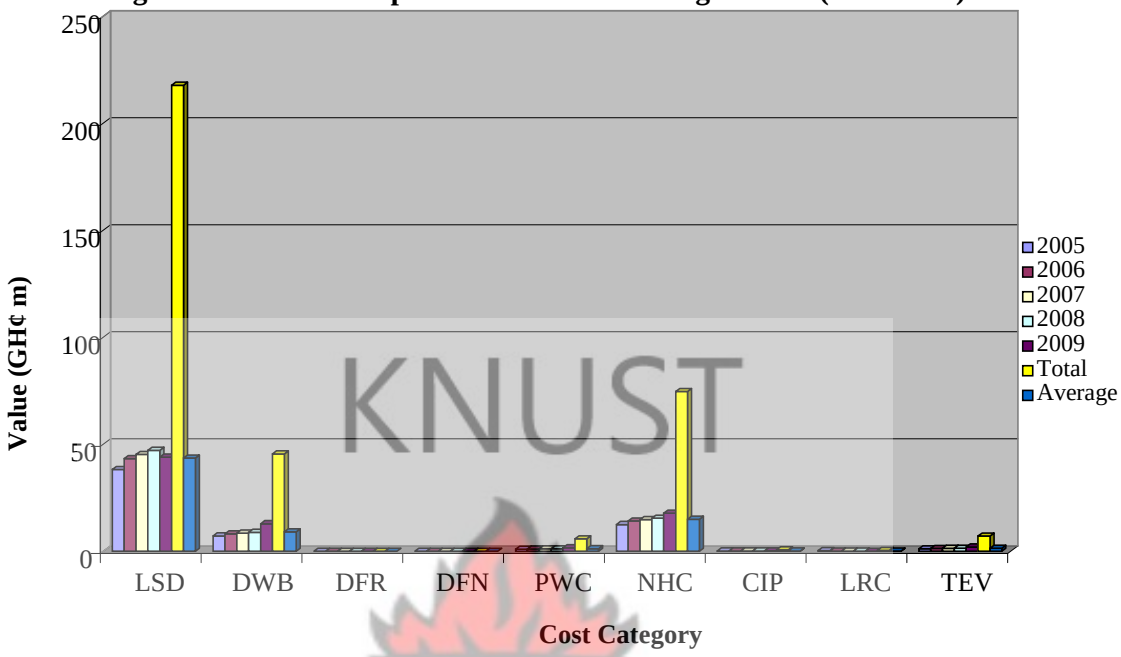
Figure 5.9: Benefit Components: Dunkwa Mining District (2005-2009)



Source: Field Study, April 2010

Like the Bibiani and Bolgatanga Mining districts, the Dunkwa District recorded LSD of 61.89% as the highest cost variable.

Figure 5.10: Cost Components: Dunkwa Mining District (2005-2009)



Source: Field Study, April 2010

This was followed by NHC, 21.21%; DWB, 12.92%; TEV, 2.02%; PWC, 1.65%; CIP, 0.19%; LRC, 0.11%; DFR, 0.01%; and DFN, 0.0012%. Comparatively, annual average costs rose by 12.73%, 4.54%, 4.26% and 5.85% between 2005-2006, 2006-2007, 2007-2008 and 2008-2009 respectively. Appendices 5 and 6 present the data on the benefit and cost variables respectively in the Dunkwa Mining District for 2005-2009.

Net Benefits and Benefit-Cost Ratios Approaches: Dunkwa Mining District

The results of the net benefits (NET_B) analysis for the Dunkwa Mining District are reported in Table 5.10 and Figure 5.11.

In contrast to the Bolgatanga Mining District, the Dunkwa Mining District documented negative net benefits throughout the study period. The value of the total and average net benefits for the entire period (2005-2009) amounted to (GH¢ 37,943,135.65) and (GH¢7,588,627.13) respectively.

The benefit-cost ratios of 0.80, 0.85, 0.89, 0.94 and 0.96 recorded for the 2005-2009 period suggest that, taking into consideration the environmental, social and aggregate economic factors, small-scale mining activities in the Dunkwa Mining District was not

economically viable and consequently, not worth continuing with the existing mining activities. This result again is consistent with the net benefit result observed by Irawan *et al.* (2008).

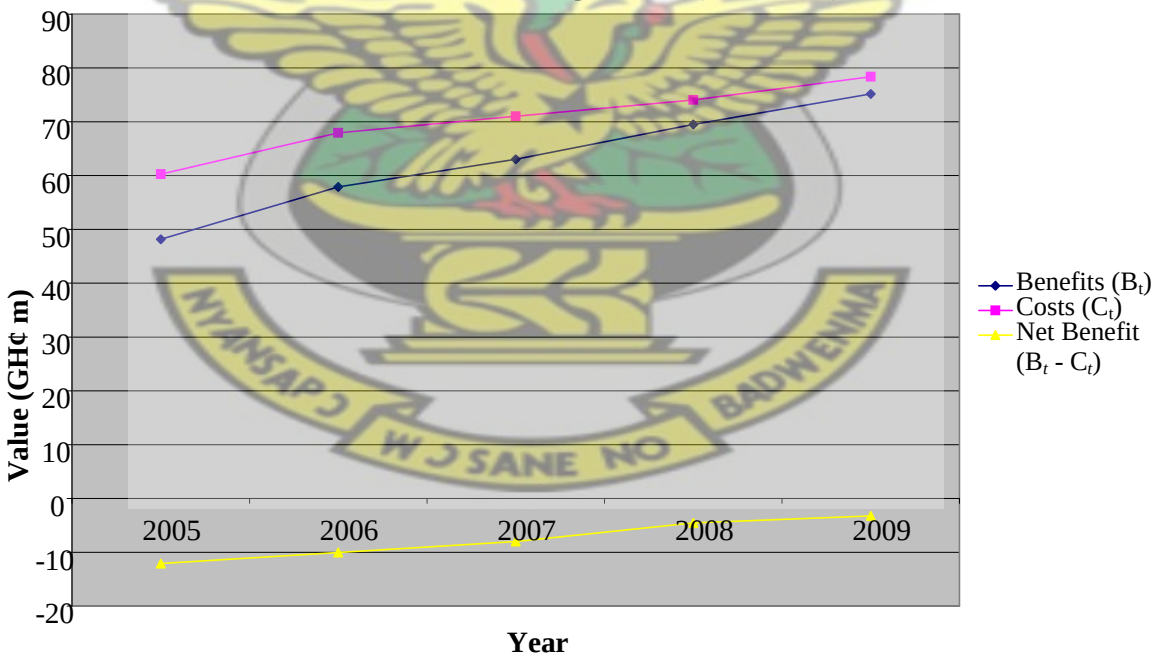
Table 5.10: Net Benefits and Benefit- Cost Ratios: Dunkwa Mining District (in GH¢)

Year	Benefits (B_t)	Costs (C_t)	Net Benefit (B_t - C_t)	BCR
2005	48,180,881.54	60,274,394.29	-12,093,512.75	0.80
2006	57,885,622.93	67,947,748.84	-10,062,125.91	0.85
2007	63,023,534.72	71,031,019.29	-8,007,484.57	0.89
2008	69,503,336.98	74,055,407.15	-4,552,070.17	0.94
2009	75,156,184.19	78,384,126.43	-3,227,942.24	0.96
Total	313,749,560.36	351,692,696.01	-37,943,135.65	4.44
Average	62,749,912.07	70,338,539.20	-7,588,627.13	0.89

Source: Estimation, March 2010

Figure 5.11 illustrates the trend in the net benefits in the Dunkwa mining district.

Figure 5.11: Net Benefits: Dunkwa Mining District (2005-2009)



Source: Field Study, April 2010

Nominal Net Future Values Approach: Dunkwa Mining District

In the Dunkwa district, the average net benefit of (GH¢7,588,627.13) for 2005- 2009 in Table 5.10 was employed to represent the present value or the value of the existing mining activities. To estimate the nominal NFVs, the average net benefit of (GH¢7,588,627.13) was compounded at rates of interest *r* of 10%, 26.54% and 50% for the optimistic, status quo and pessimistic scenarios respectively over a period of 11 years as shown in Table 5.11.

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The components of the NFVs at different interest rates scenarios portrayed in Figure 5.12 substantiates that small-scale mining operations in the district during the period under review did not improve real wealth or was not worthwhile and not worth continuing with the existing mining activities in the district. This result is consistent with the net benefit result observed by Bjorn, *et al.* (2005).

Table 5.11: Nominal Net Future Values: Dunkwa Mining District

Year	*t*	NFV *r* =10%	NFV *r* =26.54%	NFV *r* =50%
2005-2009	0	-7,588,627.13	-7,588,627.13	-7,588,627.13
2010	1	-8,347,489.84	-9,600,372.18	-11,382,940.70
2011	2	-9,182,238.83	-12,145,430.85	-17,074,411.04
2012	3	-10,100,462.71	-15,365,184.57	-25,611,616.56
2013	4	-11,110,508.98	-19,438,494.99	-38,417,424.85
2014	5	-12,221,559.88	-24,591,640.02	-57,626,137.27
2015	6	-13,443,715.87	-31,110,883.78	-86,439,205.90
2016	7	-14,788,087.45	-39,358,379.08	-129,658,808.85
2017	8	-16,266,896.20	-49,792,285.37	-194,488,213.28
2018	9	-17,893,585.82	-62,992,220.22	-291,732,319.92
2019	10	-19,682,944.40	-79,691,457.80	-437,598,479.88
2020	11	-21,651,238.84	-100,817,663.26	-656,397,719.82
Total		-162,277,355.95	-452,492,639.25	-1,954,015,905.21

Source: Estimation, March 2010

Note: r = nominal interest rate

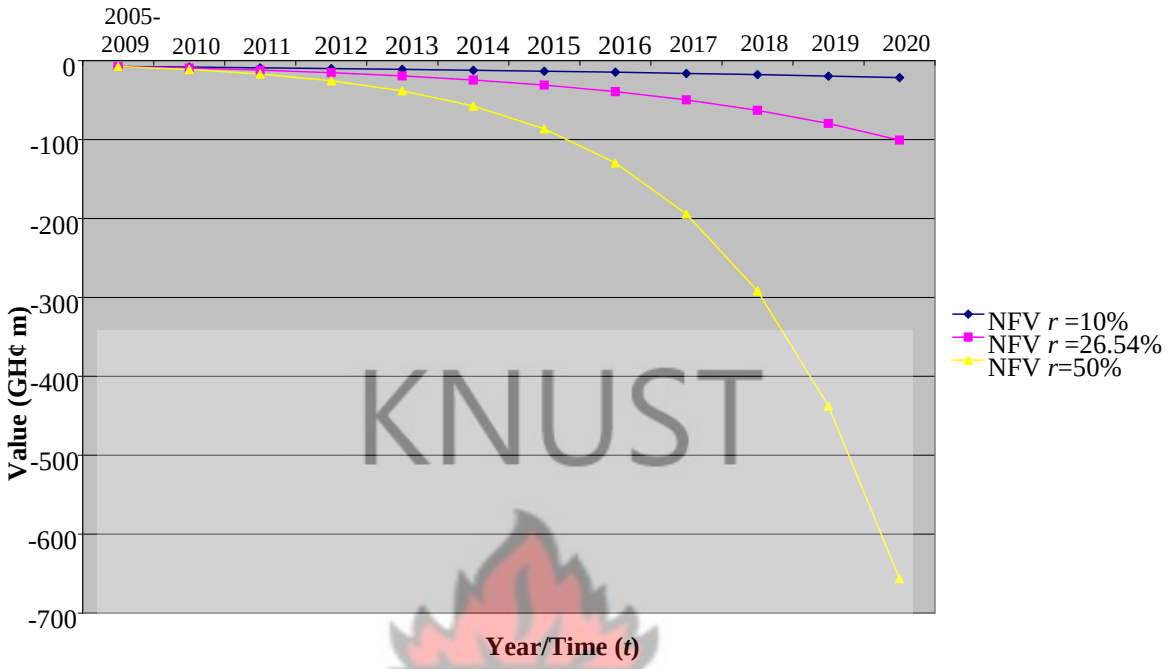
Optimistic Scenario: r = 10%

Status quo Scenario: r=26.54 which is the average of the actual interest rates of 27.37%, 26.95%, 25.12%, 23.78% and 29.48% for 2005, 2006, 2007, 2008 and 2009 respectively charged by GCB

Pessimistic Scenario: r = 50%

Value of existing mining activities in the district/present value= (GH¢7,588,627.13) see Table 5.10

Figure 5.12: Nominal NPVs: Dunkwa Mining District



Source: Estimation, March 2010

Note: r = nominal interest rate

Optimistic Scenario: r = 10% while the Pessimistic Scenario: r = 50%

Status quo Scenario: r=26.54 which is the average of the actual interest rates of 27.37%, 26.95%, 25.12%, 23.78% and 29.48% for 2005, 2006, 2007, 2008 and 2009 respectively charged by GCB

(d) Location Analysis: Tarkwa Mining District

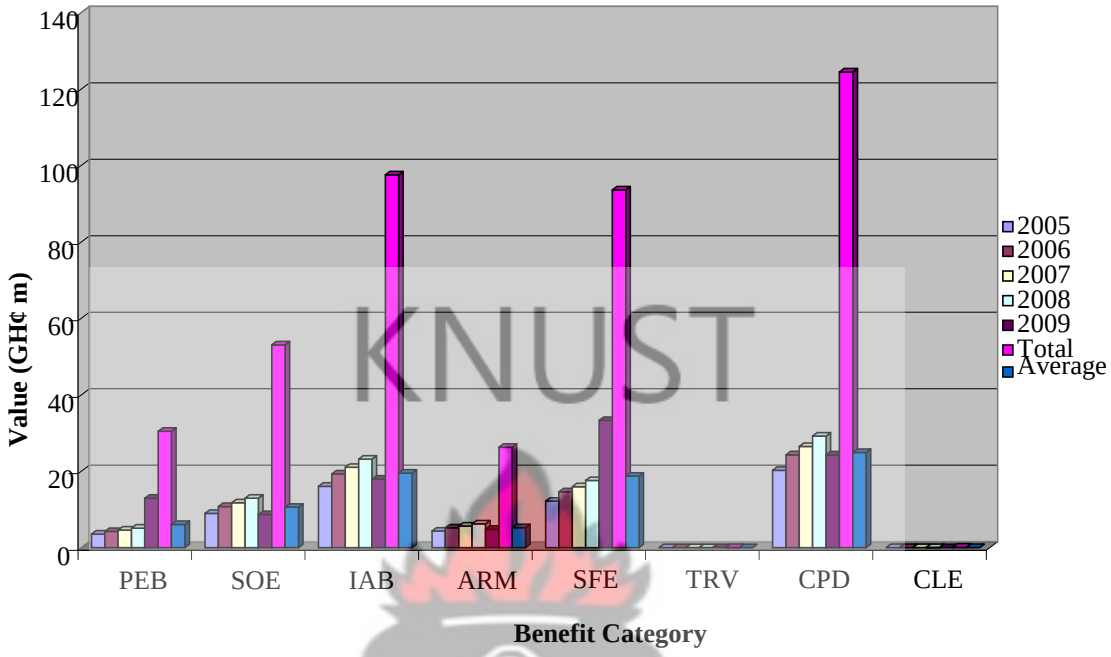
This part centres on benefits and costs; net benefits; net future values and benefit-cost ratios of the Tarkwa mining District.

Benefits and Costs Approaches: Tarkwa Mining District

In the Tarkwa mining District, the most remarkable benefit variable like the other districts such as the Bolgatanga and Dunkwa districts was CPD which constituted 29.24% of the total benefits. It was followed by IAB, SFE, SOE, PEB, ARM, CLE and TRV with approximately 22.91%, 22.00%, and 12.47%, 7.16%, 6.18%, 0.03% and 0.01% in that order.

The result showed negative net benefit for 2005-2007 but positive for the 2008-2009 periods. The BCRs were 0.86, 0.92 and 0.96 for 2005, 2006 and 2007 respectively. Since each BCR < 1, it indicates that small-mining activities for the period were not worthwhile and therefore, not worth continuing with the existing mining activities.

Figure 5.13: Benefit Components: Tarkwa Mining District



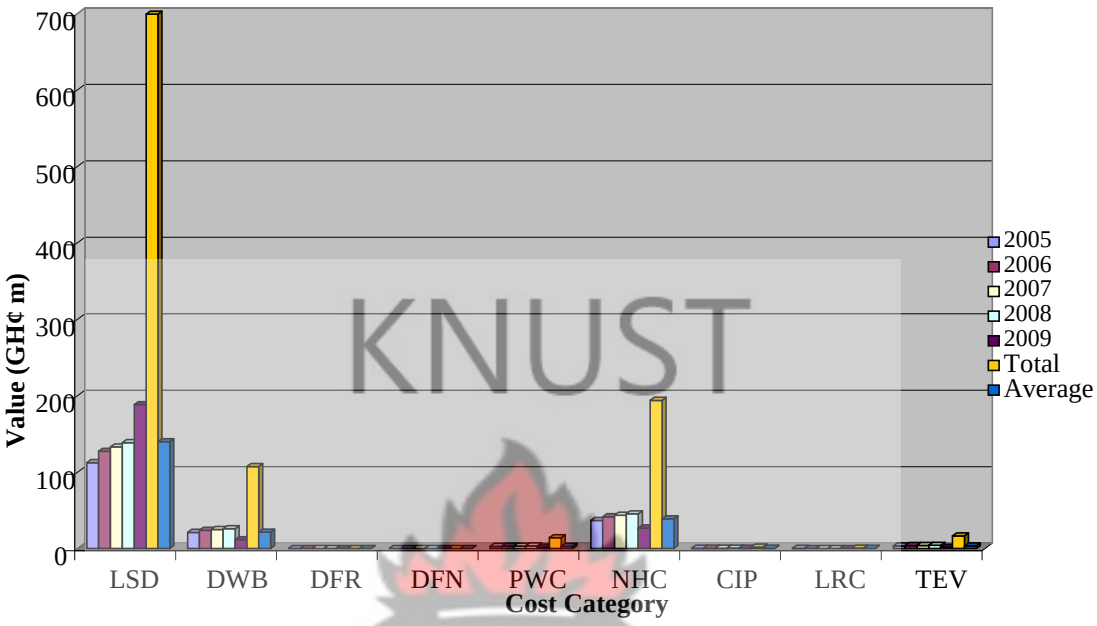
Source: Field Study, May 2010

The high proportion of the CLE benefit variable was accounted for by the relatively large number of mining servicing companies located in the district. Moreover, the year-to-year average benefits rose by 20.12%, 8.89%, 10.26%, and 8.11% between 2005-2006, 2006-2007, 2007-2008 and 2008-2009 respectively. In relation to the cost variables, LSD was the major one and recorded as high as 67.65% of all the cost variables in the district.

The others were: NHC, 18.76%; DWB, 10.38%; TEV, 1.60; PWC, 1.37%; CIP, 0.18%; NRC, 0.04%; DFR, 0.004 and DFN, 0.001%. The year-to-year average benefits rose by 13.01%, 4.54%, 4.26%1, and 5.87% between 2005-2006, 2006-2007, 2007-2008 and 2008-2009 correspondingly.

Appendices 7 and 8 report the data on cost and benefit variables respectively while the components are graphically presented in Figures 5.13 and 5.14.

Figure 5.14: Cost Components: Tarkwa Mining District (2005-2009)



Source: Field Study, May 2010

Net Benefits and Benefit-Cost Ratios Approaches: Tarkwa Mining District

Results of the net benefits (NET_B) analysis for 2005-2009 for Tarkwa Mining District are shown in Table 5.12 and Figure 5.15.

The Tarkwa Mining District recorded negative net benefits during the study period. The total and average net benefits values amounted to (GH¢ 607,415,136.74) and (GH¢121,483,027.35) respectively. The net benefits registered were (GH¢ 111,308,505.85), (GH¢ 121,130,839.37), (GH¢ 123,222,226.52), (GH¢ 123,320,168.08) and (GH¢ 128,433,396.92) for 2005, 2006, 2007, 2008 and 2009 in that order.

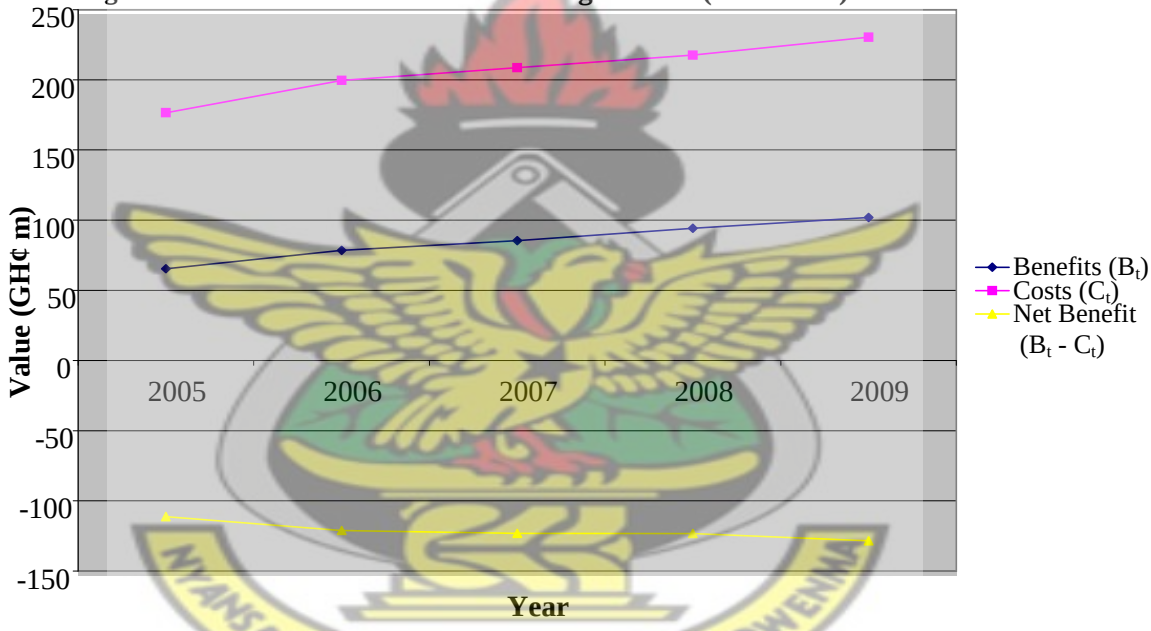
The relatively low BCR of 0.37, 0.39, 0.41, 0.43 and 0.44 recorded in the district signified a wider disparity between the benefits and cost values. In addition, the average BCR of 0.41 recorded also signifies that small-mining activities in the Tarkwa District were not worthwhile and indeed, not worth continuing with the existing mining activities in the Tarkwa Mining District.

Table 5.12: Net Benefits and Benefit-Cost Ratios: Tarkwa Mining District (in GH¢)

Year	Benefits (B_t)	Costs (C_t)	Net Benefit ($Bt - Ct$)	BCR
2005	65,332,240.25	176,640,746.10	-111,308,505.85	0.37
2006	78,491,661.09	199,622,500.46	-121,130,839.37	0.39
2007	85,457,713.30	208,679,939.82	-123,222,226.52	0.41
2008	94,245,031.74	217,565,199.82	-123,320,168.08	0.43
2009	101,910,171.12	230,343,568.04	-128,433,396.92	0.44
Total	425,436,817.51	1,032,851,954.24	-607,415,136.74	2.04
Average	85,087,363.50	206,570,390.85	-121,483,027.35	0.41

Source: Estimation, May 2010

Figure 5.15: Net Benefits: Tarkwa Mining District (2005-2009)



Source: Field Study, May 2010

Nominal Net Future Values Approach: Tarkwa Mining District

The average net benefit of (GH¢121,483,027.35) for 2005- 2009 in Table 5.12 was used to represent the present value or the value of the existing mining activities. To estimate the nominal NFVs, the average net benefit of (GH¢121,483,027.35) was compounded at rates of interest *r* of 10%, 26.54% and 50% for the optimistic, status quo and pessimistic scenarios respectively over a period of 11 years. Table 5.13 and Figure 5.16 present the nominal NPVs.

Table 5.13 Nominal Net Future Values: Tarkwa Mining District

Year	*t*	NFV *r* =10%	NFV *r* =26.54%	NFV *r* =50%
2005-2009	0	-121,483,027.35	-121,483,027.35	-121,483,027.35
2010	1	-133,631,330.09	-153,688,177.90	-182,224,541.03
2011	2	-146,994,463.09	-194,430,913.86	-273,336,811.54
2012	3	-161,693,909.40	-245,974,549.13	-410,005,217.31
2013	4	-177,863,300.34	-311,182,402.10	-615,007,825.96
2014	5	-195,649,630.38	-393,676,856.90	-922,511,738.94
2015	6	-215,214,593.42	-498,040,591.66	-1,383,767,608.41
2016	7	-236,736,052.76	-630,071,152.51	-2,075,651,412.61
2017	8	-260,409,658.03	-797,103,015.04	-3,113,477,118.92
2018	9	-286,450,623.84	-1,008,415,024.33	-4,670,215,678.38
2019	10	-315,095,686.22	-1,275,745,847.28	-7,005,323,517.57
2020	11	-346,605,254.84	-1,613,946,071.39	-10,507,985,276.35
Total		-2,597,827,529.75	-7,243,757,629.44	-31,280,989,774.36

Source: Estimation, March 2010

Note: r = nominal interest rate

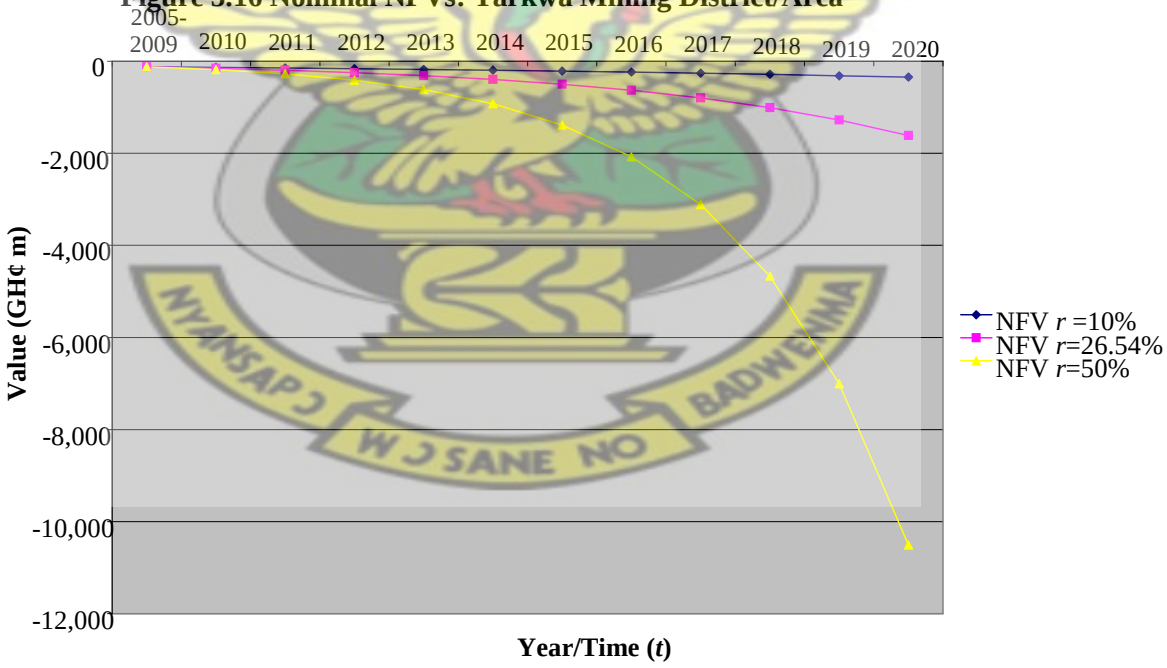
Optimistic Scenario: r = 10%

Status quo Scenario: r=26.54 which is the average of the actual interest rates of 27.37%, 26.95%, 25.12%, 23.78% and 29.48% for 2005, 2006, 2007, 2008 and 2009 respectively charged by GCB

Pessimistic Scenario: r = 50%

Value of existing mining activities in the district = (GH¢121,483,027.35) see Table 5.12

Figure 5.16 Nominal NPVs: Tarkwa Mining District/Area



Source: Estimation, March 2010

Note: r = nominal interest rate

Optimistic Scenario: r = 10%

Status quo Scenario: r=26.54 which is the average of the actual interest rates of 27.37%, 26.95%, 25.12%, 23.78% and 29.48% for 2005, 2006, 2007, 2008 and 2009 respectively charged by GCB

Pessimistic Scenario: r = 50%

The total nominal NFVs for 2010-2020 period amounted to (GH¢ 2,597,827,529.75), (GH¢7,243,757,629.44) and (GH¢31,280,989,774.36) the optimistic, status quo and pessimistic scenarios in that order. Again this result is consistent with the net benefit result observed by Bjorn, *et al.* (2005). The negative total NFVs recorded signifies that small-mining activities in the Tarkwa District were not worthwhile and indeed, not worth continuing with the existing mining activities in the Tarkwa Mining District.

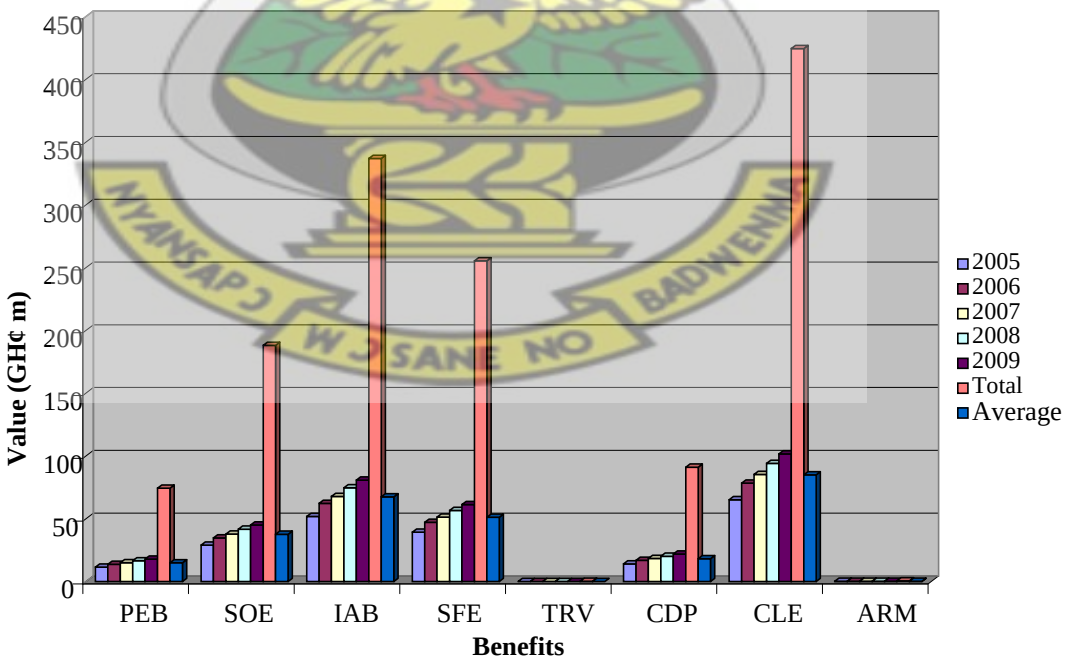
5.5.2 COMBINED TOTAL BENEFIT-COST ANALYSIS

This part provides an examination of all the four mining districts in the study area combined. It focuses on benefits and costs; net benefits approach; net future values and benefit-cost ratios approaches; and sensitivity analysis using inflation scenario of the combined total.

Benefits and Costs Approaches: Combined Total

The average total benefits rose by 20.14%, 8.87%, 10.29% and 8.13% between 2005-2006, 2006-2007, 2007-2008 and 2008-2009 respectively.

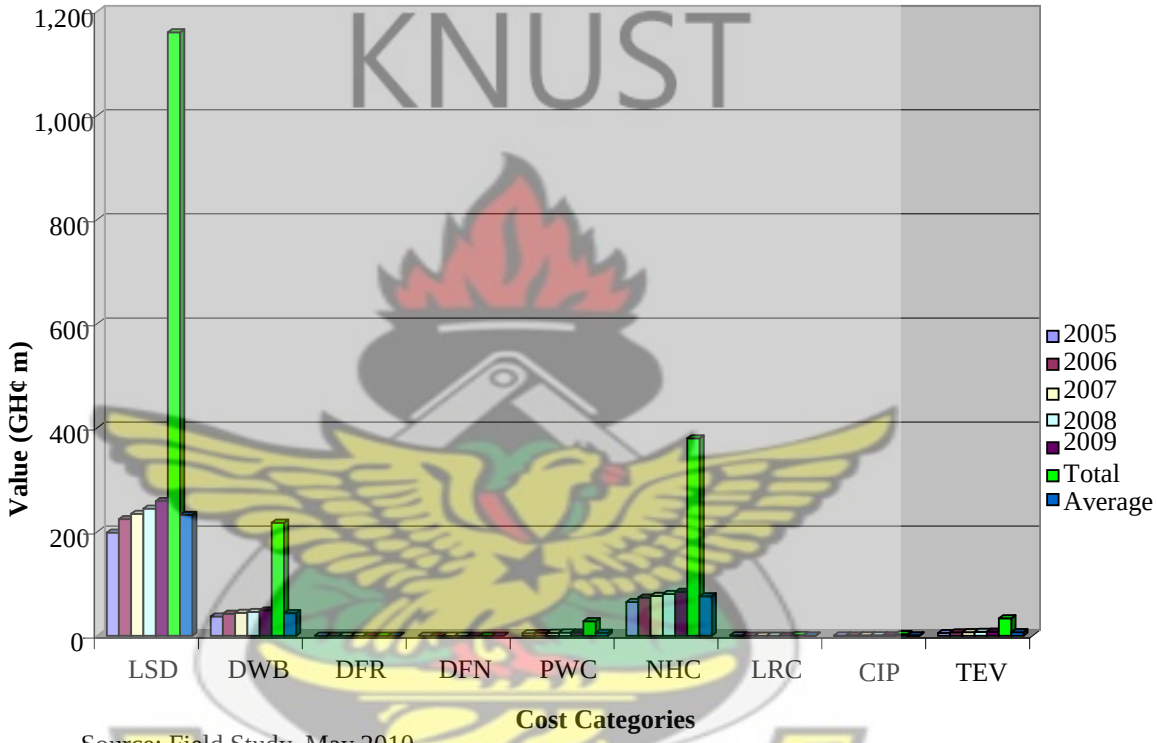
Figure 5.17: Benefit Components: Combined Total



Source: Field Study, May 2010

The benefit components from 2005-2009 suggested that CLE constituted the highest benefit which was 30.96% of the total benefits. It was followed by IAB, 24.59%; SFE 18.64%; SOE,13.72%; CPD, 6.64%; PEB, 5.42%; ARM, 0.03% and the least TRV, 0.01%. Appendices 9 and 10 provide the data on the benefits and costs respectively while Figures 5.17 and 5.18 present the corresponding benefit and cost components of the combined total.

Figure 5.18: Cost Components: Combined Total (2005-2009)



Source: Field Study, May 2010

In terms of significance of the various cost categories, LSD accounted for 63.65%. NHC was 20.81% while DWB, TEV, PWC, CIP, LRC, DFR and DFN recorded 11.93%, 1.84%, 1.53%, 0.17%, 0.06%, 0.005% and 0.001% respectively. Annual average costs increased by 13.15%, 4.54%, 4.26% and 5.89% between 2005-2006, 2006-2007, 2007-2008 and 2008-2009 in that order.

Net Benefits and Benefit-Cost Ratio Approaches: Combined Total

Results for net benefits showed declining negative values of (GH¢100,765,177.88) (GH¢99,311,990.33), (GH¢92,856,454.05), (GH¢80,212,930.98), (GH¢78,117,495.24) in 2005, 2006, 2007, 2008 and 2009 respective years as shown in Table 5.14 and

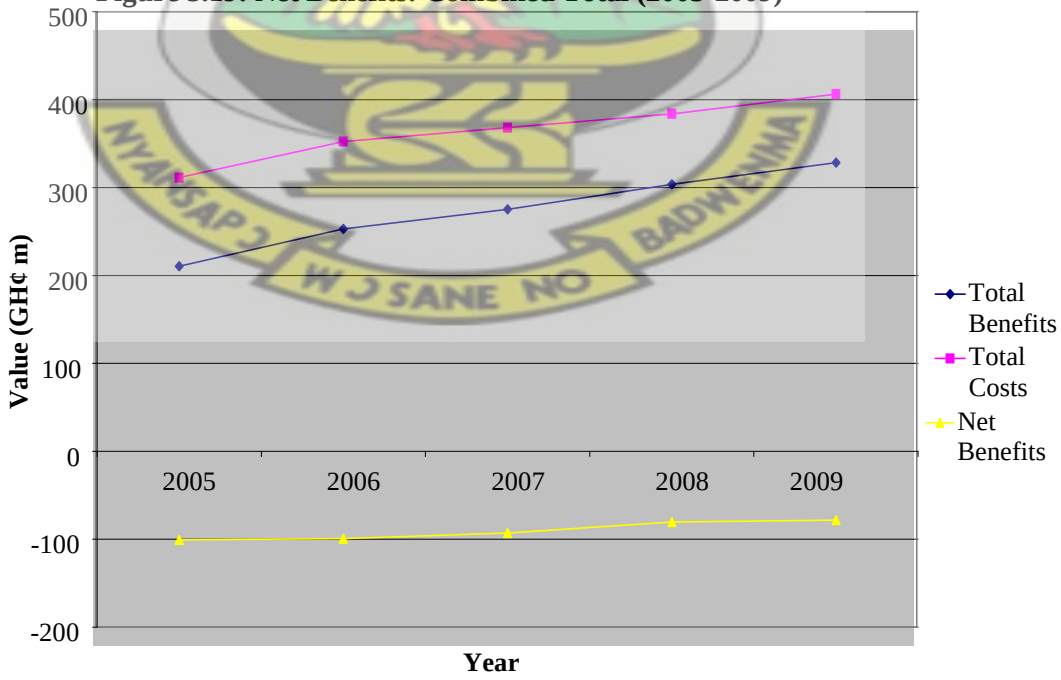
replicated in Figure 5.19. Again, the annual average BCR of 0.75 recorded for the entire study period (2005-2009) suggests that, taking into consideration the environmental, social and aggregate economic factors, small-scale mining activities in the four mining districts combined were not economically viable and therefore, not worth continuing with the existing mining activities. Landscape destruction, destruction of water bodies and negative health consequences were the major variables that accounted the net benefits depicting declining negative values.

Table 5.14: Net Benefits and Benefit-Cost Ratios: Combined Total

Year	Total Benefits (GH¢)	Total Costs (GH¢)	Net Benefits ($Bt - Ct$)	BCR
2005	210,503,312.54	311,268,490.42	-100,765,177.88	0.68
2006	252,903,537.43	352,215,527.76	-99,311,990.33	0.72
2007	275,340,804.28	368,197,258.33	-92,856,454.05	0.75
2008	303,661,581.11	383,874,512.09	-80,212,930.98	0.79
2009	328,358,992.73	406,476,487.97	-78,117,495.24	0.81
Periodic Total	1,370,768,228.09	1,822,032,276.57	-451,264,048.48	3.75
Average	274,153,645.62	364,406,455.31	-90,252,809.70	0.75

Source: Estimation, May 2010

Figure 5.19: Net Benefits: Combined Total (2005-2009)



Source: Field Study, May 2010

It must be emphasized that the negative net benefits indicated that the landscape destruction, destruction of water bodies and negative health consequences values reflect, at least in part, the real situation in the Ghanaian small-scale mining sub-sector.

Nominal Net Future Values Approach: Combined Total

The average net benefit of (GH¢ 90,252,809.70) for 2005- 2009 in Table 5.12 was used to represent the present value or the value of the existing mining activities. To estimate the nominal NFVs, the average net benefit of (GH¢ 90,252,809.70) was compounded at rates of interest *r* of 10%, 26.54% and 50% for the optimistic, status quo and pessimistic scenarios respectively over a period of 11 years. Table 5.15 and Figure 5.20 present the nominal NPVs

The total negative nominal NFVs of (GH¢1,929,991,693.41), (GH¢5,381,570,521.44) and (GH¢23,239,437,466.43) for the optimistic, status quo and pessimistic scenarios respectively in the period under consideration suggest that small- mining activities in the four mining districts combined are not worthwhile and consequently, not worth continuing with the existing mining activities. This result is consistent with the net benefit result observed by Bjorn, *et al.* (2005).

Table 5.15: Nominal Net Future Values: Combined Total

Year	*t*	NFV *r* =10%	NFV *r* =26.54%	NFV *r* =50%
2005-2009	0	-90,252,809.70	-90,252,809.70	-90,252,809.70
2010	1	-99,278,090.67	-114,178,829.55	-135,379,214.55
2011	2	-109,205,899.74	-144,447,637.27	-203,068,821.83
2012	3	-120,126,489.71	-182,740,705.90	-304,603,232.74
2013	4	-132,139,138.68	-231,185,267.04	-456,904,849.11
2014	5	-145,353,052.55	-292,472,481.33	-685,357,273.66
2015	6	-159,888,357.80	-370,006,936.13	-1,028,035,910.49
2016	7	-175,877,193.59	-468,095,774.90	-1,542,053,865.73
2017	8	-193,464,912.94	-592,187,964.83	-2,313,080,798.60
2018	9	-212,811,404.24	-749,176,994.31	-3,469,621,197.90
2019	10	-234,092,544.66	-947,783,815.50	-5,204,431,796.85
2020	11	-257,501,799.13	-1,199,041,304.98	-7,806,647,695.28
Total		-1,929,991,693.41	-5,381,570,521.44	-23,239,437,466.43

Source: Estimation, March 2010

Note: r = nominal interest rate

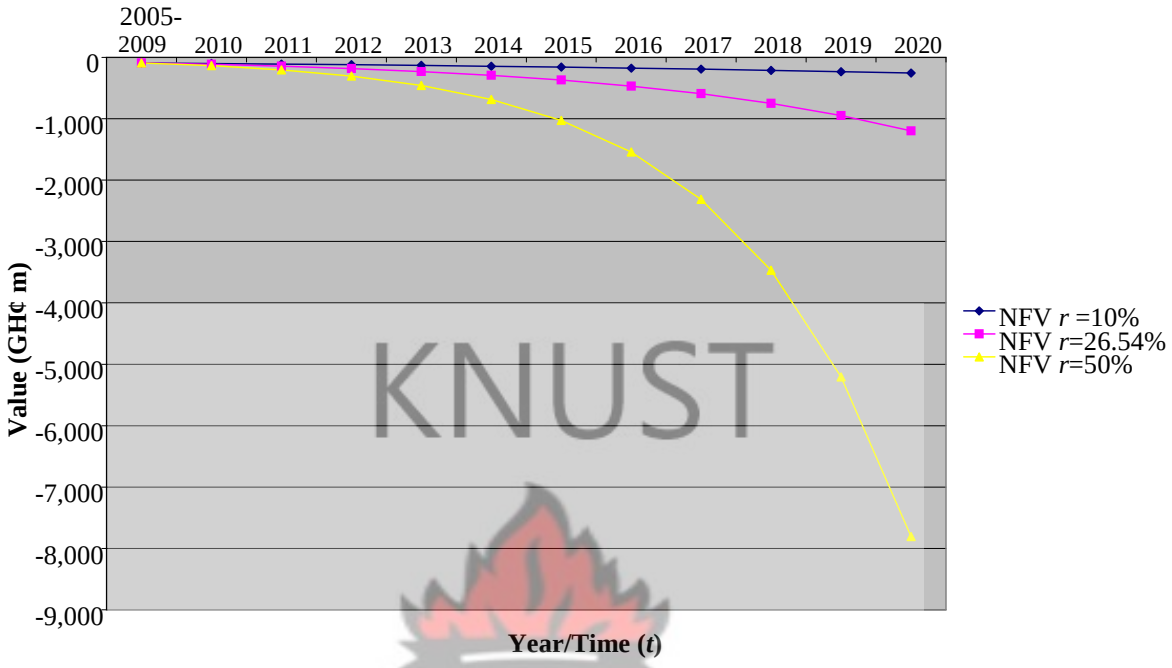
Optimistic Scenario: r = 10%

Status quo Scenario: r=26.54 which is the average of the actual interest rates of 27.37%, 26.95%, 25.12%, 23.78% and 29.48% for 2005, 2006, 2007, 2008 and 2009 respectively charged by GCB

Pessimistic Scenario: r = 50%

Value of existing mining activities in the combined districts = (GH¢-90,252,809.70 see Table 5.14

Figure 5.20 Nominal NFVs: Combined Total



Source: Estimation, March 2010
Note: r = nominal interest rate
Optimistic Scenario: r = 10%
Status quo Scenario: r=26.54 which is the average of the actual interest rates of 27.37%, 26.95%, 25.12%, 23.78% and 29.48% for 2005, 2006, 2007, 2008 and 2009 respectively charged by GCB
Pessimistic Scenario: r = 50%

5.5.3 PROFITABILITY INDEX ANALYSIS

The study carried out a profitability index analysis to find out (a) the column test for profitability and (b) the row test for profitability. Benefit-cost ratios were used to show the profitability index of operation between districts/areas and across the sectors. In other words, the study investigated whether there is any statistically significant difference between the means of equality classified by the row categories, (that is, the four mining areas/districts: namely, the Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining districts of the Minerals Commission of Ghana) and the means classified by the column categories across the sector variables, (which are made up of the physical environmental sector, social sector and aggregate economic sector).

A two-way ANOVA was employed to simultaneously, test for statistical interdependence between mining districts and across sector activity variables for enterprise profitability.

The study made use of the Statistical Package for Social Sciences (SPSS), version 16 for the analysis.

Hypotheses Testing

The following hypotheses of equality were tested.

- **Hypothesis I: Hypothesis testing of equality for profitability index of operation between the mining districts/areas**.

  The means of profitability index of operation across locations ie the four mining districts/areas (μ_1, μ_2, μ_3 and μ_4) are equal.

  H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

  H_1: $\mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4$

- **Hypothesis II: Hypothesis testing of equality for profitability index of operation across the activity sectors.**

  The means of profitability index of operation across the three sectors (μ_1, μ_2 and μ_3) are equal.

  H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

  H_1: $\mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4$

Data on benefit-cost ratios on profitability index of operation between districts/areas and across sectors and ANOVA results are reported in Tables 5.16 and 5.17 respectively.

In Hypothesis I, the study accepts (does not reject) the null hypothesis because the *F* statistic (F*) of 1.2564 was much less than the critical value of F which was 4.7571 at 0.05 level of significance as found in Table 5.17. The difference between the means of profitability index of operation between the mining districts/areas (μ_1, μ_2, μ_3 and μ_4) are really equal and show no significant difference.

This implies that the difference between the profitability index of operation in the mining districts/areas is not statistically significant. The study, therefore, suggests that location - Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining districts/areas does not matter much so far as profitability of operation is concerned.

Table 5.16: Profitability Index of Operation: Area/Sector Benefit-Cost Ratios

Sector / District/Area	Physical Environmental Benefit Cost Ratio	Social Benefit Cost Ratio	Aggregate Economic Benefit Cost Ratio
Bibiani	0.0622886792	1.4164649842	23.6312936318
Bolgatanga	0.1078417699	3.0443334374	40.6007418547
Dunkwa	0.0606027247	1.7878164700	20.4150856812
Tarkwa	0.0377977600	0.8426241695	12.8618604052

Source: Survey, June 2010

Table 5.17: Results of Profitability Index of Operation: Two-Way/Factor ANOVA

Source of Variation	*SS*	*df*	*MS*	*F**	*P-value*	*F crit*
Rows (Locations)	159.9941	3	53.3314	1.2564	0.3700	4.7571
Columns (Sectors)	1473.1352	2	736.5676	17.3529	0.0032	5.1433
Error	254.6787	6	42.4465			
Total	1887.8081	11				

Source: Survey, June 2010

Results in Table 5.17 show that the observed variance ratio (or computed *F*) F* is 17.3529 while the critical *F* at 0.05 level of significance is 5.1433. Since F* > F, we rejected the null hypothesis in Hypothesis II and accepted the alternative hypothesis that there is significant difference between the means of profitability index of operation across the activity sectors.

The rejection of the null hypothesis suggests that the differences between the profitability index of operation across the sectors is statistically significant. The study therefore, proposes that enterprise profitability of operation across the activity factors (namely, physical environmental, social and aggregate economic factors) matters much (so far as profitability of operation is concerned).

5.5.4 TEST OF STATISTICAL INDEPENDENCE AND THE CONTINGENCY TABLE

Testing statistical independence determines whether two or more observations across two populations are dependent on each other (that is, whether one variable helps to estimate the other). A chi-square test (χ^2) according to Corder *et al.* (2009) is a statistical test

commonly used for testing independence and goodness of fit. Chi-square test is important because it enables us to compare observed and expected frequencies objectively, since it is not always possible to tell just by looking at them whether they are "different enough" to be considered statistically significant. Statistical significance in this case implies that the differences are not due to chance alone, but instead may be indicative of other processes at work (Greenwood and Nikulin, 1996).

This study therefore, performed a Chi-Square (χ^2) test of independence to find out whether the benefit and cost variables between the mining districts and across sector activity are statistically significant or associated with each other. Thus the study assessed if there is any statistically significant relations between the row categories, namely: the Bibiani, Bolgatanga, Dunkwa and Tarkwa Mining districts and the column categories across the sector variables, which comprise of the physical environmental sector, social sector and aggregate economic sector.

The Predictive Analytics Software (PASW) version 16 was used for the analysis of the calculated Chi Square (χ^2).

Hypothesis Testing

The following hypotheses were tested.

- **Hypothesis I: Hypothesis testing of statistical independence with respect to benefits**.

  H_0: There is no association in benefits between the mining districts/areas and across sector activity variables.

  H_1: There is an association in benefits between the mining districts/areas and across sector activity variables.

- **Hypothesis II: Hypothesis testing of statistical independence with respect to costs**

  H_0: There is no association in costs between the mining districts/areas and across sector activity variables.

  H_1: There is an association in costs between the mining districts/areas and across sector activity variables

Data on the benefit variables are reported in Table 5.18

Table 5.18: Contingency Table on Benefits (in GH¢m)

Sector / District	Environmental Benefits fo	fe	Social Benefits fo	fe	Aggregate Economic Benefits fo	fe	Row Total
Bibiani	10	(11.31)	80	(94.50)	128	(112.19)	218
Bolgatanga	15	(21.33)	191	(178.16)	205	(211.51)	411
Dunkwa	16	(16.30)	145	(136.11)	153	(161.59)	314
Tarkwa	30	(22.06)	177	(184.23)	218	(218.71)	425
Column Total	71		593		704		1,368

Source: Survey June 2010

Note: Figures in parenthesis are expected frequency (fe) values with counterpart observed frequency (fo) values presented

Table 5.19 displays the result of the Chi-Square (χ^2) Test of Independence with respect to benefits.

Table 5.19: Result of Chi-Square (χ^2) Test of Independence on Benefits

	(χ^2) Calculated Value	Degree of Freedom (df)	(χ^2) Critical Value
Chi-Square (χ^2)	11.79885	6	12.60000
Likelihood Ratio	11.09000	6	
Number of Valid Cases	12		

Source: Survey, June 2010

In Table 5.19, the calculated Chi square (χ^2) value is 11.79885 while the critical Chi square $(\chi^2)_{0.05,6}$ value is 12.60000. Since the calculated Chi square (χ^2) value of 11.79885 is less than the critical Chi square (χ^2) value of 12.60000 given 6 degrees of freedom at 0.05 level of significance, the null hypothesis which states that, there is no association in benefits between the mining districts/areas and across sector activity variables is upheld. Hence, the row and column category variables are not associated.

This therefore, suggests that there is no statistical relationship between the kind of sector activity and the place of mining so far as benefits are concerned. Thus the benefit variables between the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts/areas and across sector activity, namely: environmental, social and aggregate economic are not statistically related or associated with each other. Table 5.20 shows data on the cost variables.

Table 5.20: Contingency Table on Costs (in GH¢m)

Sector / District	Environmental Cost fo fe	Social Cost fo fe	Aggregate Economic Cost Fo fe	Row Total
Bibiani	164 (170.80)	57 (50.98)	5 (4.22)	226
Bolgatanga	144 (160.22)	63 (47.82)	5 (3.96)	212
Dunkwa	263 (265.27)	81 (79.18)	7 (6.55)	351
Tarkwa	806 (780.70)	210 (233.02)	17 (19.28)	1,033
Column Total	1,377	411	34	1,822

Source: Survey, June 2010

Note: Figures in parenthesis are expected frequency (fe) values with counterpart observed frequency (fo) values presented

Table 5.21 presents the result of Chi square (χ^2) Test of Independence with respect to costs.

Table 5.21: Result of Chi-Square (χ^2) Test of Independence on Costs

	(χ^2) Calculated Value	Degree of Freedom (df)	(χ^2) Critical Value
Chi-Square (χ^2)	11.31708	6	12.60000
Likelihood Ratio	11.08800	6	
Number of Valid Cases	12		

Source: Survey, June 2010

Similarly, according to Table 5.21, the calculated Chi square (χ^2) value is 11.31708. Our critical Chi square $(\chi^2)_{0.05,6}$ value is 12.60000. There is no significant difference between the row and column category variables because the calculated Chi square (χ^2) value of 11.31708 is less than the critical Chi square (χ^2) value of 12.60000 given 6 degrees of freedom at 0.05 level of significance. The null hypothesis which states that there is no association in costs between the mining districts/areas and across sector activity variables is upheld.

This implies that there is no statistical relationship between the kind of sector activity and the place of mining (so far as costs are concerned). Thus the cost variables between the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts/areas and across sector activity, namely: environmental, social and aggregate economic are not statistically related or associated with each other.

5.5.5 SENSITIVITY ANALYSIS

The results and discussions on location benefit-cost analysis in section 5.5.1 were based on nominal or unadjusted values. The study therefore, used adjustments to obtain real NPVs' to augment the nominal values in order to again, determine whether small-scale mining activities in the four mining districts are economically viable and if it is worth continuing with the existing mining activities.

Scenario analysis was employed to establish the potential impact of changes in inflation rates on the nominal NFVs. Three inflation scenarios namely, optimistic, status quo and pessimistic were used (Shi Mingrel, *et al.*, 2005). For the status quo scenario, an inflation rate of 12.86% representing or constituting the average of the actual inflation rates of 15.2%, 10.5%, 10.7%, 11.5% and 16.4% for 2005, 2006, 2007, 2008 and 2009 correspondingly were used.

However, for the optimistic and pessimistic scenarios, 5% and 40% respectively were used. The study assumed that an optimistic scenario of 5% inflation rate for a developing country like Ghana is suitable for investment purposes and price stability. According to the Ghana Statistical Service, 40% inflation rate is the highest recorded rate of inflation in recent times, particularly, in 1996 and was used for the pessimistic scenario.

The optimistic, status quo and pessimistic scenarios, interest rates (r) of 10%, 26.54% and 50% respectively were divided or deflated by their counterpart inflation rates (i) of 5%, 12.86% and 40%.

Real interest rate is expressed as $(1+R) = \frac{1+r}{1+i}$ as in Boardman *et al.* (2006). Where; r is the nominal interest rate and i is the inflation rate.

Table 5.22 presents the nominal interest rates (r), inflation rates (i) and the computations of the real interest rates (R) of the three scenarios.

Table 5.22: Real Interest Rates for the Scenario Analyses

Scenario	Nominal Interest Rate (r) (in %)	Inflation Rate (i) (in %)	Real Interest Rate ($1+R$)
Optimistic[1]	10	5	1.0476
Status quo[2]	26.54	12.86	1.1212
Pessimistic[3]	50	40	1.0714

Source: Survey, June 2010

Note: [1]*= Assumed nominal interest rate of 10% and inflation rate of 5%*
[2]*= 26.54% is the average of the actual nominal interest rates from 2005-2009 and 12.86 is also average of the actual inflation rates from 2005-2009*
[3]*= Assumed nominal interest rate of 50% and inflation rate of 40%*

To obtain the real NFVs, the nominal NFVs in Tables 5.7, 5.9, 5.11, 5.13 and 5.15 were divided by their corresponding real interest rates (1+R) in Table 5.22. Tables 5.23, 5.24, 5.24, 5.25 and 5.26 report the real NFVs of the various scenarios for the Bibiani, Bolgatanga, Dunkwa, Tarkwa and combined total mining districts in that order.

Real NPVs for Bibiani Mining District/Area

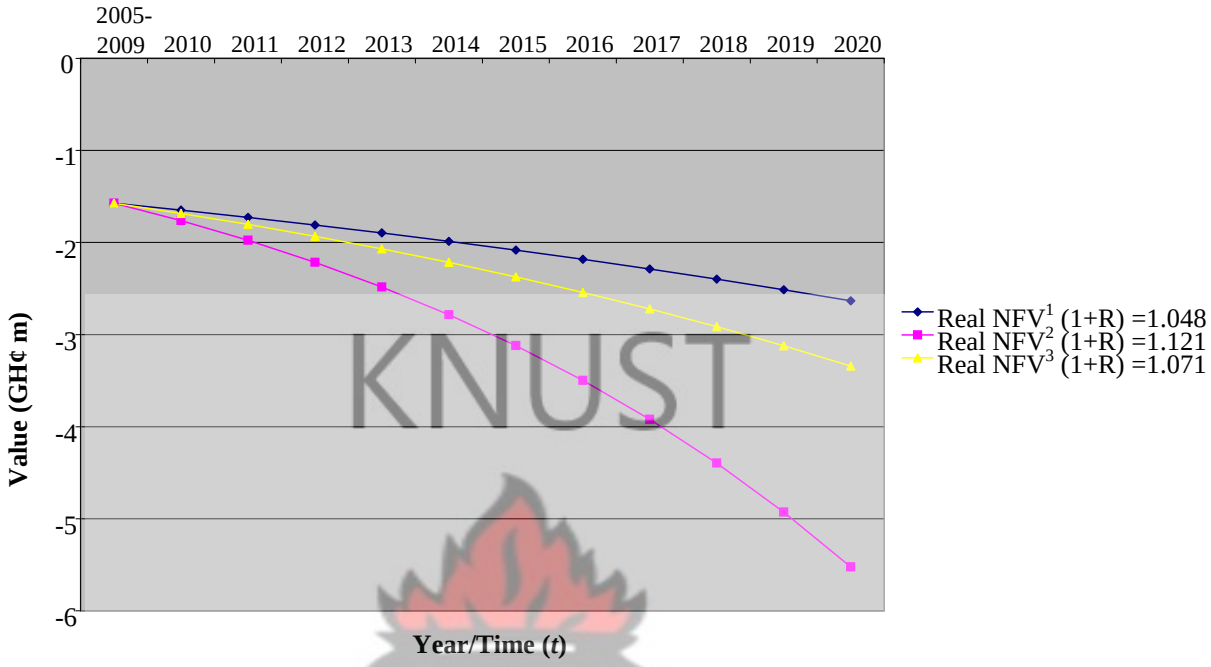
Table 5.23 records the real NFVs on the various scenarios of inflation rates in the Bibiani Mining District/Area.

Table 5.23: Real NFVs for Bibiani Mining District/Area

Year	t	Real NFV ($1+R^{*}$) =1.048	Real NFV ($1+R^{**}$) =1.121	Real NFV ($1+R^{***}$)=1.071
2005-2009	0	-1,572,088.66	-1,572,088.66	-1,572,088.66
2010	1	-1,647,548.92	-1,762,311.39	-1,683,706.95
2011	2	-1,726,631.26	-1,975,551.07	-1,803,250.15
2012	3	-1,809,509.56	-2,214,592.74	-1,931,280.91
2013	4	-1,896,366.02	-2,482,558.47	-2,068,401.85
2014	5	-1,987,391.59	-2,782,948.04	-2,215,258.39
2015	6	-2,082,786.39	-3,119,684.75	-2,372,541.73
2016	7	-2,182,760.14	-3,497,166.61	-2,540,992.19
2017	8	-2,287,532.62	-3,920,323.77	-2,721,402.64
2018	9	-2,397,334.19	-4,394,682.95	-2,914,622.23
2019	10	-2,512,406.23	-4,926,439.58	-3,121,560.40
2020	11	-2,633,001.73	-5,522,538.77	-3,343,191.19
Total		-24,735,357.31	-38,170,886.80	-28,288,297.30

Source: Field Study, August 2010
Note: (1+R) = Real interest rate
R^{*} = Optimistic scenario
R^{**} = Status quo scenario
R^{***} = Pessimistic scenario (see Table 5.22)

Figure 5.21: Trends in Real NPVs for Bibiani Mining District/Area



Source: Field Study, August 2010
Note: (1+R) = Real interest rate
R^{*} = Optimistic scenario
R^{**} = Status quo scenario
R^{***} = Pessimistic scenario (see Table 5.22)

The total real NFVs for 2010-2020 period amounted to (GH¢ 24,735,357.31), (GH¢38,170,886.80) and (GH¢28,288,297.30) the optimistic, status quo and pessimistic scenarios in that order. The negative total NFVs recorded confirmed the nominal NPVs that small-mining activities in the Bibiani Mining District were not worthwhile and in fact, not worth continuing with the existing mining activities in the district. Figure 5.21 presents the real NPVs of the Bibiani Mining District graphically.

Real NPVs for Bolgatanga Mining District/Area

Compared to the other mining districts such as Bibiani, Dunkwa and Tarkwa, the Bolgatanga Mining District looked promising with the positive total real NFVs recorded during the period (2010-2020). This suggests that in real terms, small-scale mining operations in that district were economically viable and it is worth continuing with the existing mining activities in the Bolgatanga district. Table 5.24 demonstrates that the

total real NFVs for the optimistic, status quo and pessimistic scenarios amounted to GH¢628,836,680.38, GH¢970,402,547.24 and GH¢719,161,593.04 respectively.

Table 5.24: Real NFVs for Bolgatanga Mining District/Area

Year	*t*	Real NFV $(1+R^{*})$ =1.048	Real NFV $(1+R^{**})$ =1.121	Real NFV $(1+R^{***})$=1.071
2005-2009	0	39,966,554.83	39,966,554.83	39,966,554.83
2010	1	41,884,949.46	44,802,507.96	42,804,180.22
2011	2	43,895,427.04	50,223,611.43	45,843,277.02
2012	3	46,002,407.53	56,300,668.41	49,098,149.69
2013	4	48,210,523.10	63,113,049.29	52,584,118.31
2014	5	50,524,628.20	70,749,728.25	56,317,590.72
2015	6	52,949,810.36	79,310,445.37	60,316,139.66
2016	7	55,491,401.25	88,907,009.26	64,598,585.57
2017	8	58,154,988.52	99,664,757.38	69,185,085.15
2018	9	60,946,427.96	111,724,193.02	74,097,226.19
2019	10	63,871,856.51	125,242,820.38	79,358,129.25
2020	11	66,937,705.62	140,397,201.65	84,992,556.43
Total		628,836,680.38	970,402,547.24	719,161,593.04

Source: Field Study, August 2010

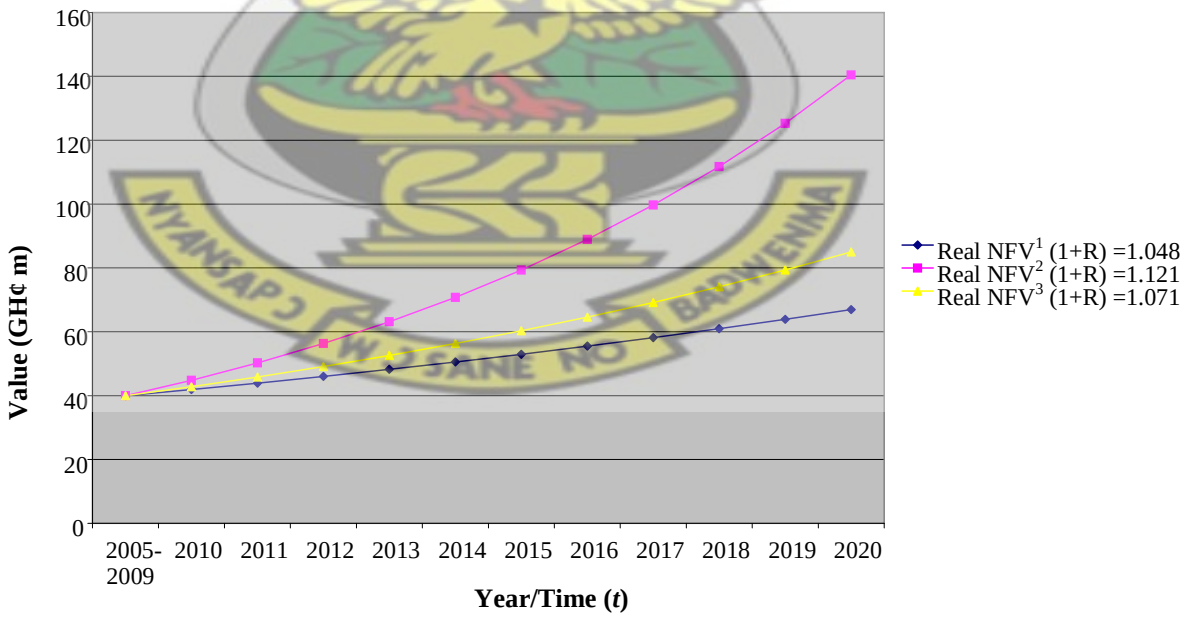
Note: (1+R) = Real interest rate

R^{*} = Optimistic scenario

R^{**} = Status quo scenario

R^{***} = Pessimistic scenario (see Table 5.22)

Figure 5.22: Components in Real NPVs for Bolgatanga Mining District/Area



Source: Field Study, August 2010

Note: (1+R) = Real interest rate

R^{*} = Optimistic scenario

R^{**} = Status quo scenario

R^{***} = Pessimistic scenario (see Table 5.22)

Real NPVs for Dunkwa Mining District/Area

Table 5. 25 displays the real NFVs of the Dunkwa Mining District.

Table 5.25: Real NFVs for Dunkwa Mining District/Area

Year	*t*	Real NFV $(1+R^{*})$ =1.048	Real NFV $(1+R^{**})$ =1.121	Real NFV $(1+R^{***})$=1.071
2005-2009	0	-7,588,627.13	-7,588,627.13	-7,588,627.13
2010	1	-7,952,881.23	-8,506,851.01	-8,127,419.66
2011	2	-8,334,619.53	-9,536,179.99	-8,704,466.45
2012	3	-8,734,681.27	-10,690,057.76	-9,322,483.57
2013	4	-9,153,945.97	-11,983,554.75	-9,984,379.90
2014	5	-9,593,335.38	-13,433,564.88	-10,693,270.88
2015	6	-10,053,815.47	-15,059,026.23	-11,452,493.11
2016	7	-10,536,398.62	-16,881,168.40	-12,265,620.12
2017	8	-11,042,145.75	-18,923,789.78	-13,136,479.15
2018	9	-11,572,168.75	-21,213,568.34	-14,069,169.17
2019	10	-12,127,632.85	-23,780,410.11	-15,068,080.18
2020	11	-12,709,759.22	-26,657,839.73	-16,137,913.87
Total		-119,400,011.17	-184,254,638.12	-136,550,403.18

Source: Field Study, August 2010

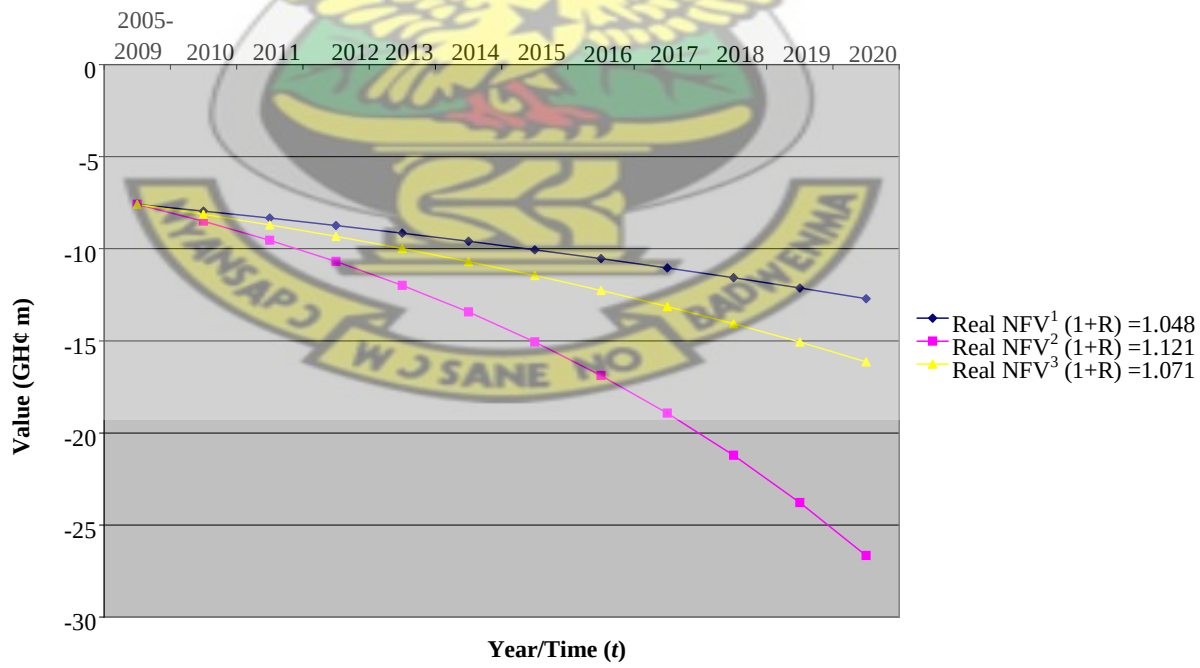
Note: (1+R) = Real interest rate

R^{*} = Optimistic scenario

R^{**} = Status quo scenario

R^{***} = Pessimistic scenario (see Table 5.22)

Figure 5.23: Trends in Real NPVs Dunkwa Mining District/Area



Source: Field Study, August 2010

Note: (1+R) = Real interest rate

R^{*} = Optimistic scenario

R^{**} = Status quo scenario and R^{***} = Pessimistic scenario (see Table 5.22)

The district recorded negative total real NFVs of (GH¢119,400,011.17), (GH¢184,254,638.12) and GH¢136,550,403.18) for the optimistic, status quo and pessimistic scenarios respectively. This supports the nominal NFVs that in real terms, small-scale mining operations in the Dunkwa district were not economically viable and worth continuing with the existing mining activities.

Real NPVs for Tarkwa Mining District/Area

The average real NFVs for the optimistic, status quo and pessimistic scenarios in this district amounted to (GH¢127,557,178.72), (GH¢ 130,953,978.20) and (GH¢170,076,238.29) correspondingly as illustrated in Table 5.26 and Figure 5.24. Like the Bibiani and Dunkwa Mining districts the negative total NFVs recorded mean that small-scale mining operations in the Tarkwa district were not economically viable and it is not worth continuing with the existing mining activities in the district.

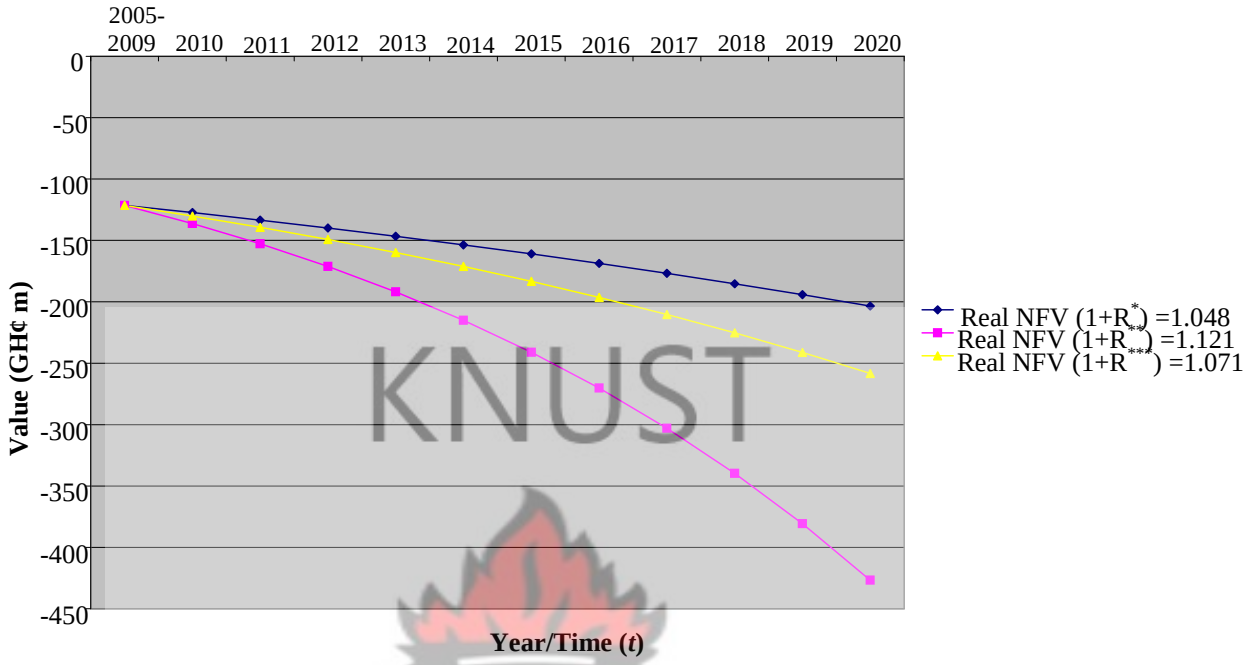
Table 5.26: Real NFVs for Tarkwa Mining District/Area

Year	*t*	Real NFV $(1+R^{*})$ =1.048	Real NFV $(1+R^{**})$ =1.121	Real NFV $(1+R^{***})$=1.071
2005-2009	0	-121,483,027.35	-121,483,027.35	-121,483,027.35
2010	1	-127,314,212.66	-136,182,473.66	-130,108,322.29
2011	2	-133,425,294.87	-152,660,552.97	-139,346,013.17
2012	3	-139,829,709.02	-171,132,479.88	-149,239,580.11
2013	4	-146,541,535.06	-191,839,509.95	-159,835,590.30
2014	5	-153,575,528.74	-215,052,090.65	-171,183,917.21
2015	6	-160,947,154.12	-241,073,393.62	-183,337,975.33
2016	7	-168,672,617.52	-270,243,274.25	-196,354,971.58
2017	8	-176,768,903.16	-302,942,710.43	-210,296,174.56
2018	9	-185,253,810.51	-339,598,778.39	-225,227,202.96
2019	10	-194,145,993.41	-380,690,230.58	-241,218,334.37
2020	11	-203,465,001.10	-426,753,748.48	-258,344,836.10
Total		-1,911,422,787.52	-2,949,652,270.22	-2,185,975,945.33

Source: Field Study, August 2010

Note: (1+R) = Real interest rate
R^{*} = Optimistic scenario
R^{**} = Status quo scenario
R^{***} = Pessimistic scenario (see Table 5.22)

Figure 5.24: Trends in Real NPVs for Tarkwa Mining District/Area



Source: Field Study, August 2010

Note: (1+R) = Real interest rate
R^{*} = Optimistic scenario
R^{**} = Status quo scenario
R^{***} = Pessimistic scenario (see Table 5.22)

Real NPVs for the Four Mining Districts/Areas Combined

The positive total real NFVs recorded by the Bolgatanga Mining District were insignificant enough to offset the negative total real NFVs recorded by the Bibiani, Dunkwa and Tarkwa Mining districts. As a result, the four mining districts combined registered negative total NFVs all over the study period.

The total real NFVs in terms of the optimistic, status quo and pessimistic scenarios amounted to (GH¢ 1,420,044,271.71), (GH¢ 2,191,371,180.25) and (GH¢ 1,624,016,747.91) in that order as displayed in Table 5. 27 and Figure 5.25. This also implies that in real terms, small-scale mining operations in the mining districts were not economically viable.

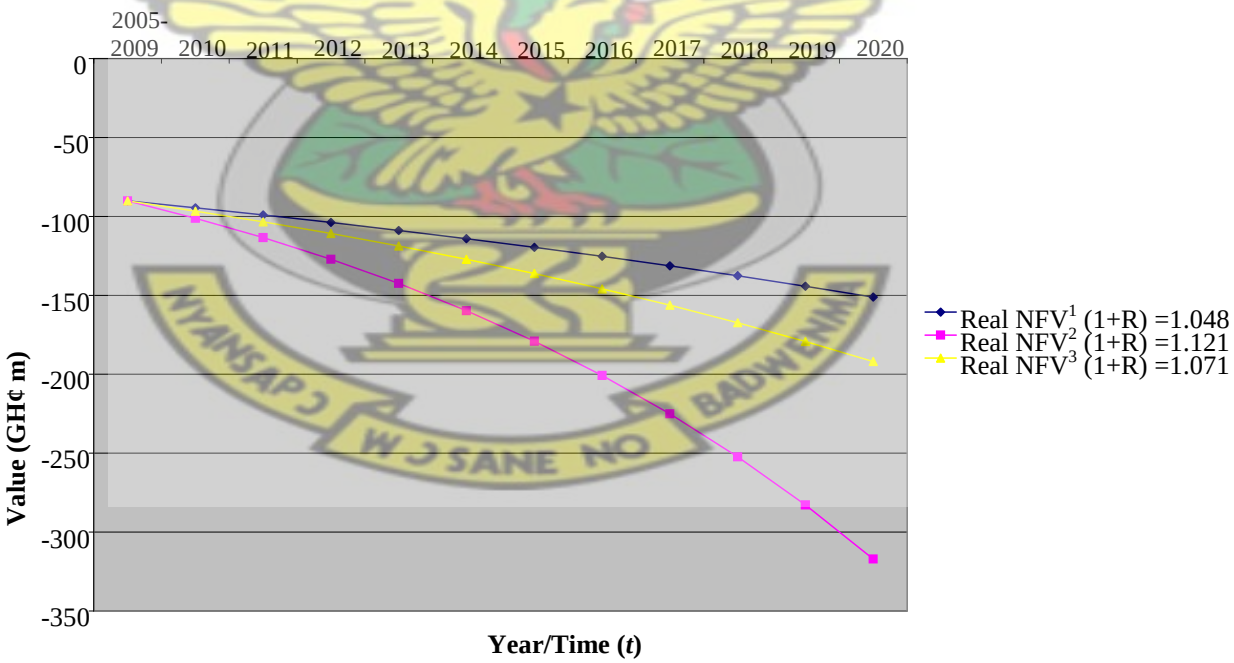
Table 5.27: Real NFVs for Combined Mining Districts/Areas

Year	*t*	Real NFV $(1+R^{*})$ =1.048	Real NFV $(1+R^{**})$ =1.121	Real NFV $(1+R^{***})$=1.071
2005-2009	0	-90,252,809.70	-90,252,809.70	-90,252,809.70
2010	1	-94,584,944.57	-101,173,399.67	-96,660,759.19
2011	2	-99,125,021.90	-113,415,381.03	-103,523,673.09
2012	3	-103,883,022.96	-127,138,642.14	-110,873,853.88
2013	4	-108,869,408.06	-142,522,417.84	-118,745,897.51
2014	5	-114,095,139.64	-159,767,630.40	-127,176,856.23
2015	6	-119,571,706.35	-179,099,513.67	-136,206,413.02
2016	7	-125,311,148.25	-200,770,554.83	-145,877,068.35
2017	8	-131,326,083.37	-225,063,791.96	-156,234,340.20
2018	9	-137,629,735.37	-252,296,510.79	-167,326,978.35
2019	10	-144,235,962.67	-282,824,388.60	-179,207,193.82
2020	11	-151,159,288.88	-317,046,139.62	-191,930,904.58
Total		-1,420,044,271.71	-2,191,371,180.25	-1,624,016,747.91

Source: Field Study, August 2010

Note: (1+R) = Real interest rate
R = Optimistic scenario*
*R** = Status quo scenario*
*R***= Pessimistic scenario (see Table 5.22)*

Figure 5.25: Trends in Real NPVs for Combined Mining Districts/Areas



Source: Field Study, August 2010

Note: (1+R) = Real interest rate
R^{*} = Optimistic scenario
R^{**} = Status quo scenario
R^{***} = Pessimistic scenario (see Table 5.22)

5.6 CONCLUSIONS AND RECOMMENDATIONS

The results show that while mining activities in the Bolgatanga Mining District promises to be economically viable and worth continuing with the existing mining activities, they are not in the other three mining districts (Bibiani, Dunkwa and Tarkwa). Small-scale mining activities in all the four mining districts (Bibiani, Bolgatanga, Dunkwa and Tarkwa) combined are also not economically viable and therefore, not worth continuing with the existing mining activities.

The analysis of variance indicates that enterprise profitability of operation across the activity sectors, which are physical environmental, social and aggregate economic, matters much, though, location of (namely, Bibiani, Bolgatanga, Dunkwa and Tarkwa) mining districts/areas does not matter much so far as profitability of operation is concerned. The Chi square test indicates that both the benefit and cost variables between the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts/areas and across sector activity, namely: environmental, social and aggregate economic, are not statistically related or associated with each other.

The results of the nominal values were not different statistically from the real values in the respective mining districts. The results of the nominal and real NFVs were also categorical in terms of the viability of the mining activities in each of the four mining districts.

The study suggests that attention should be paid to the high negative environmental, social and aggregate economic impacts or costs. An integrated approach involving all stakeholders aimed at improving health and safety standards, environmental management, improving access to technology, finance, information and support services; strengthening the political-will; providing adequate human and technical capacity to support the sector; and enforcing the existing laws and regulations will have a lasting impact on small-scale mining operations in Ghana.

Guidelines that aim at promoting efficiency in mining operations; minimizing the negative environmental, social and aggregate economic costs or impact, promoting high health and safety standards; and promoting obligations for all stakeholders should be developed. These guidelines should be developed by carrying out field exercises and bringing together mining and environmental experts, social scientists and miners, to review existing techniques and identify constraints. In order to improve acceptability, the guidelines should be prepared in consultation with stakeholders such as miners, relevant government institutions, rural development experts, local communities, NGOs, the private sector, international development agencies and other interested parties.

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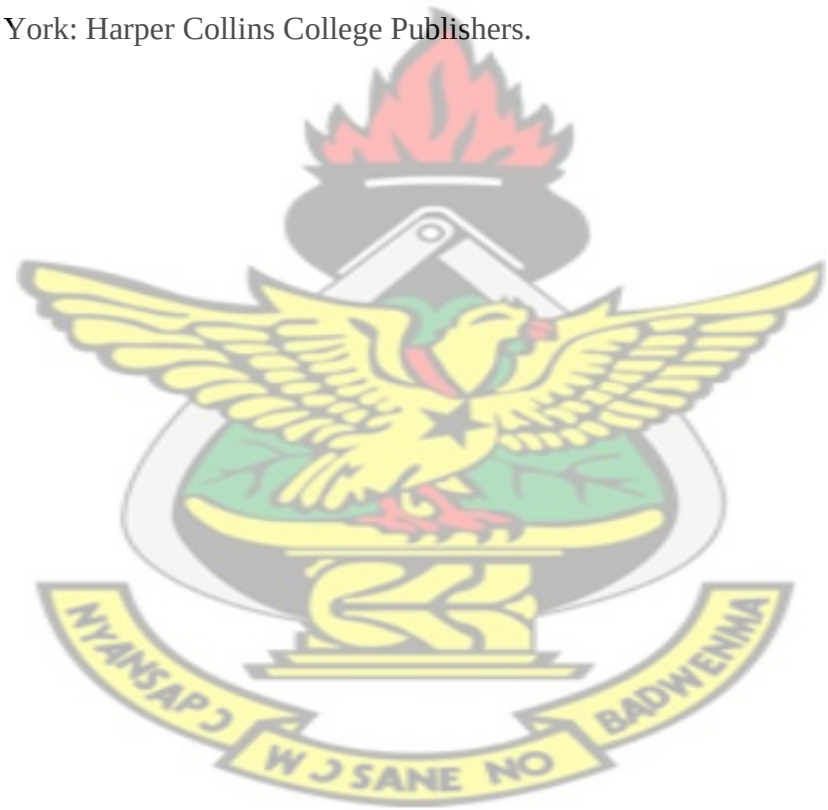

CHAPTER SIX

GENERAL SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY AND CONCLUSIONS

Major findings of the three essays are summarized as follows:

In essay one, the findings are that:

- Gold production from small-scale mining operations has increased substantially over the years. Between 2000 and 2008, production rose by 203.30% and its relative contribution to GDP also increased by 181.93%.
- Small-scale gold mining operations in Ghana have a substantial degree of adverse environmental, social and aggregate economic impact or cost in Ghana.
- The main challenges of small-scale mining operations in Ghana are environmental, occupational health and operational constraints.

From the second essay, the major conclusions are that:

- The Tarkwa mining district had the highest output and contributed 54.35% of the total volume of gold production in the four mining districts while Bibiani mining district produced the least of approximately 8.70% of total production volume.
- Large numbers (40.89%) of licensed operators/concessions in the study area are located in the Tarkwa Mining District while the Bolgatanga district recorded the least of 12.00%.
- The results of the two-way or factor ANOVA showed that both location (mining districts) and time (years) matter much so far as production is concerned because the observed variance ratio (or computed *F*) F* is 10.284 while the critical *F* at 0.05% level of significance is 3.862.
- Similarly, the two-way ANOVA showed that both location (mining districts) and time (years) matter much so far as the number of licensed operators/concession is concerned as the observed F statistic (F*) is 16.697 while the critical *F* value was 3.862.
- However, with respect to employment levels, (distance mining districts) matters much, although, time (years) does not matter. The reason was that the observed

variance ratio or F statistic of 6.197 was greater than the critical *F* value was 3.862.

- Managerial structures, choice of technology and profitability are among the factors or issues that explain the extent of differences in the mining districts.
- The more the miners use mechanized methods in production, the more the environment is destroyed.
- The small-scale mining sub-sector should be recognised as a significant generator of rural livelihoods that has the potential to alleviate poverty and for sustainable rural development if it is well developed.

The major findings in the third essay are as follows:

- Results of the benefit-cost analysis showed that mining activities in the Bolgatanga Mining District promise to be economically viable, as it recorded total real NFVs of GH¢628,836,680.38, GH¢970,402,547.24 and GH¢719,161,593.04 respectively for the optimistic, status quo and pessimistic scenarios respectively for the study period. Hence it is worth continuing with the existing mining activities in the District. Though, mining activities in the other three mining districts (Bibiani, Dunkwa and Tarkwa) are not the economically viable and consequently, not worth continuing with the existing mining activities in these districts.

- Small-scale mining activities in all the four mining districts (Bibiani, Bolgatanga, Dunkwa and Tarkwa) combined however, are not economically viable. The four mining districts combined recorded negative total NFVs of (GH¢ 1,420,044,271.71), (GH¢ 2,191,371,180.25) and (GH¢ 1,624,016,747.91) for the optimistic, status quo and pessimistic scenarios in that order during the 2010-2020 period.
- The analysis of variance indicates that enterprise profitability of operation between location (mining districts/areas) does not matter much so far as profitability of operation is concerned because the *F* statistic (F*) of 1.2564 was much less than the critical value of F which was 4.7571 at 0.05 level of significance but across the activity sectors matters much since the observed

variance ratio (or computed *F*) F* is 17.3529 greater than the critical *F* of 5.1433.at 0.05 level of significance as found in Table 5.16.

- The Chi square test (χ^2) indicates that both the benefit and cost variables between the Bibiani, Bolgatanga, Dunkwa and Tarkwa mining districts/areas and across sector activity, namely: environmental, social and aggregate economic are not statistically related or associated with each other since the calculated Chi square (χ^2) values of 11.79885 and 11.31708 for the benefits and costs respectively are less than the critical Chi square (χ^2) value of 12.60000 given 6 degrees of freedom at 0.05 level of significance.

In general, small-scale mining operations in Ghana are receiving increasing attention because of the increasing number of people seeking a livelihood through mining and dwindling rural livelihood choices in marginal mining communities. Although various governments have made efforts to improve the efficiency of operations, certain challenges principally, environmental, social and aggregate economic impacts; avoidable accidents and land-use conflicts continue to emerge and are attracting much attention.

It is therefore, imperative that measures are taken immediately to address these pressing sector-specific environmental problems. The essays share the views of Hilson (2001) that irrespective of one's perception of whether or not the sector is a net contributor to sustainable development, the fact remains that small-scale mining activities in Ghana continue and will continue as long as poverty persists. It is therefore, essential that efforts be made to maximize the benefits from and minimize or mitigate the costs involved in small-scale mining.

6.2 SPECIFIC POLICY RECOMMENDATIONS

The following specific recommendations are based on the major findings.

- The government should adopt a discriminatory policy to stimulate production volumes (output) and the number of licensed small-scale mining operators in all the mining districts (Bibiani, Bolgatanga, Dunkwa and Tarkwa) in view of the fact that the means of production volumes (output) and the number of licensed operators between the mining districts are not the same or identical.

- However, with respect to employment levels, the government should adopt a non discriminatory policy to influence small-scale mining operations since the means of employment levels between the mining districts (Bibiani, Bolgatanga, Dunkwa and Tarkwa) are the same or identical.

- The Minerals Commission of Ghana and the Environmental Protection Agency should embark on policies that aim at minimizing the physical environmental, social and aggregate economic costs, especially, in the Bibiani, Dunkwa and Tarkwa mining districts whose operations are not economically viable.

- It is recommended also that the government should also adopt a non discriminatory policy to stimulate enterprise profitability in small-scale mining operations in all the four mining districts because the means of the enterprise profitability of operations (profitability index) between the mining districts (Bibiani, Bolgatanga, Dunkwa and Tarkwa) are equal or homogeneous.

6.3 GENERAL POLICY RECOMMENDATIONS

The following recommendations which are in conformity with suggestions made by international organizations such as the ILO (1999) and ECA (2000) will go along a way to improve small-scale scale mining operations in Ghana to become a sustainable economic activity.

Government

Government should develop a mining policy that incorporates a poverty reduction dimension in small-scale mining strategies and recognizes small-scale mining as a potential economic sector with clear identification of constraints and potential. It is necessary to adopt a policy that recognizes small-scale mining as a distinct sector, notes its different categories, and proposes objectives and strategies aimed at decreasing poverty and improving livelihoods in small-scale mining communities in a sustainable manner. Mining policy design should be done in a participatory manner. Consultations should involve different stakeholders including miners, relevant government institutions,

rural development experts, local communities, NGOs, the private sector, international development agencies and other interested parties.

To make small-scale mining attractive and enable it achieve its full potential, the government should have the political will and commitment to enforce the Minerals and Mining Act 2006, (Act 703) and also provide support services and access to information and technology to sustain small-scale mining operations in the country.

Government should strengthen or develop schemes that will enable miners to have access to finance. Financial empowerment of small-scale miners is a prerequisite for the success of the overall development strategy of the sector. This requires the establishment of special financing schemes, such as government/donor-supported financing programmes, revolving loans, equity-based schemes, hire/lease/purchase schemes, buyers' credits, group schemes and others.

Fiscal incentives aimed at reducing the cost of acquiring small-scale mining equipment and technology should be devised and accorded to miners and suppliers of such technology. Reduction in import duties on capital equipment, which is commonly accorded to large-scale miners in most countries, should also be provided to small-scale miners and this could go a long way in facilitating access to technology by small-scale miners. Incentives for acquisition of raw materials required by manufacturers and fabricators of equipment and tools are also necessary for building local capacity to produce the required technology.

The minerals marketing systems in the country should be liberalized through simplification of licensing procedures for private mineral dealers. The marketing of minerals in Ghana is under the control of the Precious Minerals Marketing Corporation (PMMC). The PMMC determines and sets prices that are not reflective of the world mineral market prices. As a result, illegal traders seize the opportunity to offer the miners prices that are more attractive, thus denying the government foreign exchange earnings. Liberalization of mineral markets through simplification of licensing procedures for private mineral dealers would lead to most miners trading through legal channels. Processing of mineral marketing licenses and monitoring of the trade should be carried

out by the small-scale mining district centres. This will enable the authorities to know their clients well.

Donors, International Organizations and NGOs

Donors, international organizations and NGOs should assist small-scale mining by making more resources available; providing training and technical assistance to the sector. Resources such as the purchase of appropriate equipment and tools, including small-scale processing plants and environmental monitoring equipment; the support of projects to improve local infrastructure; providing better access to credit; determining the economic viability of mineral deposits; and the preparation of mining plans should be made available to small-scale miners. Donors, international organizations, specialized agencies of the United Nations such as UNEP, UNIDO, and ILO and companies could do more to assist in the formation and strengthening of small-scale mining associations and work with them by facilitating communication and cooperation and disseminating examples of best practice to raise standards.

Minerals Commission of Ghana/Inspection Division of Ministry of Lands, Forestry and Mines

More training centres for miners and mine inspectors that focus on safety and health, environmental issues and improved mining techniques must be provided and resourced in all the mining districts. Mines inspectors should intensify extension services to small-scale miners. Mobile training facilities that would enable training to be brought to the workplace and thus reach many more people should be established and funded.

Education on the use of retorts instead of mercury in the gold amalgamation process must be intensified. There is also a need for management training for mine owners and entrepreneurs. Seminars, workshops and study tours are important facets of training. Training materials and equipment should be appropriate for both the type of mining being carried out and the educational level of the trainees. Visual, practical, rather than oral or written training materials should be developed and used. Awareness should be intensified on the need to (i) avoid child labour at the mining sites and (ii) work or mine at the blocked out area reserved for small-scale mining purposes by the Minerals Commission of Ghana.

Technical assistance should be sought in a variety of areas to help improve small-scale gold mining in Ghana including: improving the social protection of mineworkers; reviewing, updating and harmonizing mining laws and regulations, with a particular focus on health, safety and the environment; encouraging the local manufacture of tools and equipment for small-scale mining; increasing awareness of environmental issues; consolidating responsibility for small-scale mining in a single agency; and studying how to limit any adverse impact of small-scale mining on local communities, especially the indigenous people (ILO, 1999; and Mining Journal,1998).

To improve small-scale mining operations in Ghana, there should be a collaborative or coordinated effort or approach by all levels of government, industry, and the civil society. The approach taken should be appropriate to local, social, cultural, and economic circumstances

Universities and Research Institutions

The universities and research institutions should focus on finding out the answer to specific problems of small-scale mining. Thus research should be directed at learning from existing experience (problems/challenges and successes) of small-scale mining and the best practices that will make the small-scale mining sector contribute positively towards community as well as national development (Economic Commission for Africa, 2002).

Large Scale Mining Companies

To make the mining industry attractive to investors, there should be a cordial relationship between the large mining companies and the small-scale mining operators. The large mining companies should recognize small-scale mining operators as partners in the development of the mining industry. Large mining companies should help small-scale miners to work in a more sustainable fashion by providing technical advice, support or collaborate with the government and the NGOs. Large-scale mining companies can offer direct employment to small-scale miners, if they qualify, and, where necessary, find alternative employment for them. Large mining companies should refrain from retaining large tracts of land which they cannot mine on commercial basis.

Small-Scale Miners

Licensed small-scale mining operators should pull resources together (form co-operatives) in order to form large-scale mining company or companies for sustainable mining.

Small-scale miners need to be alerted to the effects of their activities on the physical environment and the water bodies and encouraged to take measures to mitigate or reduce the negative impacts. Where possible, this should be enforced through government intervention. Small-scale miners need to be conscious about the dangers of indiscriminate mining and adopt appropriate safety techniques and practices. Small-scale miners should obtain the necessary mining permits or license and avoid illegal mining.

They should also refrain from encroaching on the concessions of large-scale mining companies and concentrate on the blocked out areas reserved for them by the Minerals Commission of Ghana. Although raising awareness is primarily the responsibility of government, all actors can assist in this effort.

Small-Scale Miners' and Mining Communities' Organizations and Associations

Small-scale miners' and mining communities' organizations and associations should be strengthened and supported. Miners and mining communities' organizations or associations such as WACAM provide a single voice that can help both the mining communities and the miners in conducting negotiations, mobilize assistance programmes (e.g., training, finance, etc.) and conduct awareness campaigns among its members. For it to be trusted and representative, the process of formation of such associations should be led and owned by the miners and the mining communities with little or no intervention from government.

The above-mentioned policy recommendations will help make small-scale mining in Ghana attractive and enable it achieve its full potential.

6.4 LIMITATIONS OF THE STUDY

The study was confined to four (4) out of the seven (7) mining districts of the Mineral Commission of Ghana. The districts are Bibiani, Bolgatanga, Dunkwa and Tarkwa. Appendix 12 shows the map of the study area. The study did not cover remote areas in the districts where road accessibility to reach the miners for information is very difficult. Furthermore, only official figures obtained from the four small-scale mining district offices mentioned above and other sources as shown in Table 5.3 were used.

The following additional limitations were recognized.

- The perceptions of the miners that researchers and other government agencies interfering in their activities and the influence they expected from their peers affected the willingness of some respondents to give information.
- Moreover, the study did not estimate all the variables identified by Hentschel, Hruschka and Priester (2002) due to time constraints.
- Finally, the benefit-cos t analysis performed in the third essay in chapter five did not include the estimation of the cost of death (loss of human life) which is frequent at some mining sites in recent times.
- These limitations suggest the need for further studies into small-scale mining activities in Ghana.

6.5 SUGGESTIONS/DIRECTIONS FOR FUTURE RESEARCH

The study suggests three key directions for future research as follows:

- A study on small-scale gold mining operations in the Ghana: Its multiplier effects on GDP within the framework of regression analysis.
- A study on the use of marginal productivity concept to measure the value of human life lost in small-scale mining operations in Ghana.
- A study on commercial benefit-cost analysis in small-scale mining operations in Ghana.

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APPENDICES

APPENDIX 1: BENEFIT COMPONENTS: BIBIANI MINING DISTRICT (IN GH¢)

Sector	Env. Benefit	Social Benefit			Aggregate Economic Benefit						
Benefit Item / Year	PEB (GH¢)	SOE (GH¢)	IAB (GH¢)	ARM (GH¢)	SFE (GH¢)	TRV (GH¢)	CPD (GH¢)	CLE (GH¢)	Total (GH¢)	Average (GH¢)	Percentage (%)
2005	1,815,917.89	4,599,357.49	2,224,369.44	6,247,838.60	8,241,660.63	3,379.87	10,378,387.47	10,993.54	33,521,904.92	4,190,238.12	
2006	2,181,685.66	5,525,774.23	2,672,408.78	7,506,297.47	9,901,721.28	4,060.65	12,468,834.20	13,207.89	40,273,990.14	5,034,248.77	20.14
2007	2,375,241.92	6,016,013.60	2,909,501.35	8,172,246.24	10,780,188.87	6,796.90	13,575,052.66	4,875.67	43,839,917.20	5,479,989.65	8.85
2008	2,619,552.59	6,634,803.75	3,208,764.43	9,012,820.39	11,889,008.63	4,875.60	14,971,344.20	15,858.73	48,357,028.31	6,044,628.54	10.30
2009	1,234,311.20	9,188,540.00	1,911,606.79	4,264,985.10	17,940,000.00	5,983.20	17,720,000.00	24,577.14	52,290,003.43	6,536,250.43	8.13
Total	10,226,709.25	31,964,489.06	12,926,650.79	35,204,187.79	58,752,579.42	25,096.22	69,113,618.52	69,512.96	218,282,844.00	27,285,355.50	
Average	2,045,341.85	6,392,897.81	2,585,330.16	7,040,837.56	11,750,515.88	5,019.24	13,822,723.70	13,902.59	43,656,568.80	5,457,071.10	
Percentage	4.69%	14.64%	5.92%	16.13%	26.92%	0.01%	31.66%	0.03%	100.00%		

Source: Field Study, March 2010

APPENDIX 2: COST COMPONENTS: BIBIANI MINING DISTRICT (IN GH¢)

Sector	Environmental Cost				Social Cost			Aggregate Economic Cost				
Cost Item / Year	LSD (GH¢)	DWB (GH¢)	DFR (GH¢)	DFN (GH¢)	PWC (GH¢)	NHC (GH¢)	CIP (GH¢)	LRC (GH¢)	TEV (GH¢)	Total (GH¢)	Average (GH¢)	Percentage
2005	24,551,776.36	4,600,702.81	1,853.14	458.11	591,219.43	8,029,143.90	73,662.22	253,416.45	723,834.65	38,826,067.07	4,314,007.45	
2006	27,781,536.30	5,205,920.35	2,096.92	518.38	668,993.72	9,085,369.20	83,352.40	30,977.70	819,054.32	43,677,819.30	4,853,091.03	12.50%
2007	29,042,119.65	5,442,138.27	2,192.07	541.90	699,349.22	9,497,616.56	87,134.51	32,636.34	856,218.80	45,659,947.30	5,073,327.48	4.54%
2008	30,278,686.92	5,673,855.86	2,285.40	564.97	729,126.39	9,902,009.97	90,844.56	34,025.95	892,675.24	47,604,075.26	5,289,341.70	4.26%
2009	17,951,822.09	13,636,600.00	4,953.23	1,848.19	1,260,135.69	15,738,126.40	9,844.29	258,726.50	1,513,322.00	50,375,378.39	5,597,264.27	5.82%
Total	129,605,941.31	34,559,217.29	13,380.76	3,931.55	3,948,824.45	52,252,266.02	344,837.98	609,782.93	4,805,105.01	226,143,287.32	25,127,031.92	
Average	25,921,188.26	6,911,843.46	2,676.15	786.31	789,764.89	10,450,453.20	68,967.60	121,956.59	961,021.00	45,228,657.46	5,025,406.38	
Percentage	57.31%	15.28%	0.01%	0.002%	1.75%	23.11%	0.15%	0.27%	2.12%	100.00%		

Source: Field Study, March 2010

APPENDIX 3: BENEFIT COMPONENTS: BOLGATANGA MINING DISTRICT (IN GH¢)

Sector	Env. Benefit	Social Benefit			Aggregate Economic Benefit						
Benefit Item / Year	PEB (GH¢)	SOE (GH¢)	IAB (GH¢)	ARM (GH¢)	SFE (GH¢)	TRV (GH¢)	CPD (GH¢)	CLE (GH¢)	Total (GH¢)	Average (GH¢)	Percentage
2005	3,438,145.77	8,708,136.86	15,604,246.66	4,211,482.49	11,829,268.26	6,399.24	19,649,792.10	20,814.48	63,468,285.85	7,933,535.73	
2006	4,130,667.67	10,462,156.58	18,747,302.04	5,059,772.25	14,211,955.87	7,688.18	23,607,713.68	25,006.99	76,252,263.26	9,531,532.91	20.15%
2007	2,375,241.92	11,390,345.25	20,410,537.84	5,508,668.54	15,472,821.77	10,746.27	25,702,158.77	27,225.58	80,897,745.94	10,112,218.24	6.09%
2008	4,959,697.63	12,561,923.97	22,509,908.07	6,075,274.62	17,064,312.48	9,231.22	28,345,810.16	30,025.93	91,556,184.08	11,444,523.01	13.18%
2009	590,429.40	15,441,580.00	23,920,000.00	10,021,102.25	10,060,243.88	3,988.80	38,930,000.00	35,289.70	99,002,634.03	12,375,329.25	8.13%
Total	15,494,182.40	58,564,142.65	101,191,994.62	30,876,300.15	68,638,602.27	38,053.71	136,235,474.71	138,362.67	411,177,113.17	51,397,139.15	
Average	3,098,836.48	11,712,828.53	20,238,398.92	6,175,260.03	13,727,720.45	7,610.74	27,247,094.94	27,672.53	82,235,422.63	10,279,427.83	
Percentage	3.77%	14.24%	24.61%	7.51%	16.69%	0.01%	33.13%	0.03%	100.00%		

Source: Field Study, March 2010

APPENDIX 4: COST COMPONENTS: BOLGATANGA MINING DISTRICT (IN GH¢)

Sector	Environmental Cost				Social Cost			Aggregate Economic Cost				
Cost Item / Year	LSD	DWB	DFR	DFN	PWC	NHC	CIP	LRC	TEV	Total	Average	Percentage
2005	23,088,689.95	4,326,538.30	1,742.71	430.81	555,987.56	7,550,672.15	NA	NA	3,221.48	35,527,282.96	3,947,475.88	
2006	26,125,982.44	4,895,689.79	1,971.96	487.49	629,127.13	8,543,955.00	NA	NA	770,245.34	40,967,459.16	4,551,939.91	15.31%
2007	27,311,445.26	5,117,831.04	2,061.44	509.61	657,673.68	8,931,635.77	NA	NA	805,195.12	42,826,351.92	4,758,483.55	4.54%
2008	28,474,323.17	5,335,740.15	2,149.21	531.30	685,676.38	9,311,930.62	NA	NA	839,479.04	44,649,829.88	4,961,092.21	4.26%
2009	8,587,205.19	10,397,550.00	3,427.55	841.89	1,473,116.37	24,279,002.60	NA	NA	2,632,271.50	47,373,415.10	5,263,712.79	6.10%
Total	113,587,646.01	30,073,349.28	11,352.87	2,801.1	4,001,581.12	58,617,196.14	NA	NA	5,050,412.48	211,344,339.02	23,482,704.34	
Average	22,717,529.20	6,014,669.86	2,270.57	560.22	800,316.23	11,723,439.23	NA	NA	1,010,082.50	42,268,867.80	4,696,540.87	
Percentage	53.75%	14.23%	0.01%	0.001%	1.89%	27.74%			2.39%	100.00%		

Source: Field Study, March 2010

APPENDIX 5: BENEFIT COMPONENTS: DUNKWA MINING DISTRICT (IN GH¢)

Sector	Env. Benefit	Social Benefit			Aggregate Economic Benefit						
Benefit Item / Year	PEB	SOE	IAB	ARM	SFE	TRV	CPD	CLE	Total	Average	Percentage
2005	2,610,010.53	6,610,635.61	11,845,701.36	3,197,076.09	8,979,990.01	4,857.87	14,916,809.12	15,800.96	48,180,881.54	6,022,610.19	
2006	3,135,726.88	7,942,170.17	14,231,698.97	3,841,040.99	10,788,767.23	5,836.35	17,921,398.71	18,983.64	57,885,622.93	7,235,702.87	20.14%
2007	3,413,924.41	8,646,788.99	15,494,316.46	4,181,813.06	11,745,932.36	8,730.15	19,511,361.46	20,667.84	63,023,534.72	7,877,941.84	8.88%
2008	3,765,071.03	9,536,173.26	17,088,018.05	4,611,942.53	12,954,085.76	7,007.73	21,518,244.95	22,793.68	69,503,336.98	8,687,917.12	10.28%
2009	3,020,810.20	11,765,916.00	20,930,000.00	5,051,967.59	13,591,007.42	8,775.36	20,760,000.00	27,707.62	75,156,184.19	9,394,523.02	8.13%
Total	15,945,543.04	44,501,684.03	79,589,734.84	20,883,840.24	58,059,782.78	35,207.46	94,627,814.24	105,953.73	313,749,560.36	39,218,695.04	
Average	3,189,108.61	8,900,336.81	15,917,946.97	4,176,768.05	11,611,956.56	7,041.49	18,925,562.85	21,190.75	62,749,912.07	7,843,739.01	
Percentage	5.08%	14.18%	25.37%	6.66%	18.51%	0.01%	30.16%	0.03%	100.00%		

Source: Field Study, April 2010

APPENDIX 6: COST COMPONENTS: DUNKWA MINING DISTRICT (IN GH¢)

Sector	Environmental Cost				Social Cost			Aggregate Economic Cost				
Cost Item / Year	LSD	DWB	DFR	DFN	PWC	NHC	CIP	LRC	TEV	Total	Average	Percent-age
2005	38,202,582.36	7,158,697.02	2,883.49	712.82	919,937.88	12,493,353.90	114,618.47	255,321.09	1,126,287.26	60,274,394.29	6,697,154.92	
2006	43,228,091.25	8,100,415.96	3,262.81	806.60	1,040,954.73	14,136,841.26	129,696.40	33,230.69	1,274,449.14	67,947,748.84	7,549,749.87	12.73%
2007	45,189,559.88	8,467,971.21	3,410.86	843.19	1,088,187.90	14,778,298.47	135,581.36	34,889.33	1,332,277.09	71,031,019.29	7,892,335.48	4.54%
2008	47,113,659.48	8,828,523.96	3,556.09	879.10	1,134,521.21	15,407,534.92	141,354.20	36,374.87	1,389,003.33	74,055,407.15	8,228,378.57	4.26%
2009	43,934,663.55	12,869,550.00	4,887.69	985.52	1,632,851.88	17,781,714.80	155,235.90	9,844.29	1,994,392.80	78,384,126.43	8,709,347.38	5.85%
Total	217,668,556.52	45,425,158.15	18,000.94	4,227.23	5,816,453.60	74,597,743.35	676,486.32	369,660.27	7,116,409.63	351,692,696.01	39,076,966.22	
Average	43,533,711.30	9,085,031.63	3,600.19	845.45	1,163,290.72	14,919,548.67	135,297.26	73,932.05	1,423,281.93	70,338,539.20	7,815,393.24	
	61.89%	12.92%	0.01%	0.001%	1.65%	21.21%	0.19%	0.11%	2.02%	100.000		

Source: Field Study, April 2010

APPENDIX 7: BENEFIT COMPONENTS: TARKWA MINING DISTRICT (IN GH¢)

Sector	Env. Benefit	Social Benefit		Aggregate Economic Benefit							
Benefit Item / Year	PEB	SOE	IAB	ARM	SFE	TRV	CPD	CLE	Total	Average	Percentage
2005	3,539,118.20	8,963,879.86	16,062,516.55	4,335,166.49	12,176,673.53	6,587.17	20,226,872.69	21,425.76	65,332,240.25	8,166,530.03	
2006	4,251,978.28	10,769,412.12	19,297,878.06	5,208,369.06	14,629,336.57	7,913.97	24,301,031.63	25,741.40	78,491,661.09	9,811,457.64	20.12%
2007	4,629,208.16	11,724,860.10	21,009,960.24	5,670,448.66	15,927,231.94	10,992.09	26,456,986.96	28,025.15	85,457,713.30	10,682,214.16	8.89%
2008	5,105,355.42	12,930,846.07	23,170,985.36	6,253,694.98	17,565,461.99	9,502.33	29,178,277.86	30,907.74	94,245,031.74	11,780,628.97	10.26%
2009	12,942,011.40	8,656,308.00	17,940,000.00	4,803,813.94	33,283,566.92	14,359.68	24,250,000.00	20,111.18	101,910,171.12	12,738,771.39	8.11%
Total	30,467,671.46	53,045,306.15	97,481,340.20	26,271,493.13	93,582,270.95	49,355.24	124,413,169.14	126,211.23	425,436,817.51	53,179,602.19	
Average	6,093,534.29	10,609,061.23	19,496,268.04	5,254,298.63	18,716,454.19	9,871.05	24,882,633.83	25,242.25	85,087,363.50	10,635,920.44	
Percentage	7.16%	12.47%	22.91%	6.18%	22.00%	0.01%	29.24	0.03%	100.00%		

Source: Field Study, May 2010

APPENDIX 8: COST COMPONENTS: TARKWA MINING DISTRICT (IN GH¢)

Sector	Environmental Cost				Social Cost			Aggregate Economic Cost				
Cost Item / Year	LSD	DWB	DFR	DFN	PWC	NHC	CIP	LRC	TEV	Total	Average	Percent-age
2005	112,264,045.41	21,036,910.01	8,473.57	2,094.74	2,703,376.10	36,713,603.20	336,823.64	265,654.60	3,309,764.84	176,640,746.10	19,626,749.57	
2006	127,032,260.64	23,804,293.04	9,588.26	2,370.30	3,059,002.34	41,543,238.48	381,132.42	45,454.12	3,745,160.86	199,622,500.46	22,180,277.83	13.01%
2007	132,796,331.79	24,884,409.53	10,023.32	2,477.85	3,197,804.14	43,428,257.14	398,426.26	47,112.76	3,915,097.02	208,679,939.82	23,186,659.98	4.54%
2008	138,450,588.43	25,943,948.11	10,450.10	2,583.36	3,333,961.56	45,277,363.27	415,390.61	49,118.76	4,081,795.62	217,565,199.82	24,173,911.09	4.26%
2009	188,228,613.80	11,573,950.00	6,258.10	1,151.54	1,863,580.95	26,804,323.00	362,217.10	16,407.15	1,487,066.40	230,343,568.04	25,593,729.78	5.87%
Total	698,771,840.08	107,243,510.69	44,793.35	10,677.79	14,157,725.09	193,766,785.09	1,893,990.03	423,747.39	16,538,884.74	1,032,851,954.24	114,761,328.25	
Average	139,754,368.02	21,448,702.14	8,958.67	2,135.56	2,831,545.02	38,753,357.02	378,798.01	84,749.48	3,307,776.95	206,570,390.85	22,952,265.65	
Percentage	67.65%	10.38%	0.004%	0.001%	1.37%	18.76%	0.18%	0.04%	1.60%	100.00%		

Source: Field Study, May 2010

APPENDIX 9: BENEFIT COMPONENTS: COMBINED TOTAL (IN GH¢)

Sector*	Year / Benefit Item	2005 (GH¢)	2006 (GH¢)	2007 (GH¢)	2008 (GH¢)	2009 (GH¢)	Total (GH¢)	Average (GH¢)	Percentage (%)
a	PEB	11,403,192.38	13,700,058.48	14,915,509.52	16,449,676.67	17,787,562.20	74,255,999.26	14,851,199.85	5.42%
b	SOE	28,882,009.81	34,699,513.10	37,778,007.94	41,663,747.05	45,052,344.00	188,075,621.89	37,615,124.38	13.72%
b	IAB	51,754,125.20	62,178,600.35	67,695,003.41	74,657,920.11	80,730,000.00	337,015,649.07	67,403,129.81	24.58%
b	A R M	69,034.73	82,939.92	80,794.23	99,586.06	107,685.60	440,040.55	88,008.11	0.03%
b	SFE	39,233,770.39	47,136,357.14	51,318,232.31	56,596,680.63	61,199,803.32	255,484,843.78	51,096,968.76	18.64%
c	TRV	21,224.15	25,499.16	37,265.42	30,616.87	33,107.04	147,712.63	29,542.53	0.01%
c	CPD	13,968,094.50	16,781,591.07	18,270,431.60	20,149,676.55	21,788,490.57	90,958,284.30	18,191,656.86	6.64%
c	C LE	65,171,861.37	78,298,978.21	85,245,559.85	94,013,677.17	101,660,000.00	424,390,076.60	84,878,015.32	30.96%
	Total	210,503,312.54	252,903,537.43	275,340,804.28	303,661,581.11	328,358,992.73	1,370,768,228.09	274,153,645.62	100.00%
	Average	26,312,914.07	31,612,942.18	34,417,600.54	37,957,697.64	41,044,874.09	171,346,028.51	34,269,205.70	

Source: Field Study, May 2010

*Note *: a = Environmental Benefits*
b = Social Benefits
c = Aggregate Economic Benefits

APPENDIX 10: COST COMPONENTS: COMBINED TOTAL (IN GH¢)

Sector*	Year / Cost Item	2005 (GH¢)	2006 (GH¢)	2007 (GH¢)	2008 (GH¢)	2009 (GH¢)	Total (GH¢)	Average (GH¢)	Percentage (%)
a	LSD	198,107,094.08	224,167,870.64	234,339,456.58	244,317,258.01	258,702,304.64	1,159,633,983.94	231,926,796.79	63.65%
a	DWB	37,122,848.14	42,006,319.15	43,912,350.04	45,782,068.04	48,477,650.00	217,301,235.37	43,460,247.07	11.93%
a	DFR	14,952.91	16,919.95	17,687.69	18,440.80	19,526.57	87,527.92	17,505.58	0.005%
a	DFN	3,696.49	4,182.76	4,372.55	4,558.73	4,827.14	21,637.67	4,327.53	0.001%
b	PWC	4,770,520.98	5,398,077.91	5,643,014.95	5,883,285.55	6,229,684.89	27,924,584.27	5,584,916.85	1.53%
b	NHC	64,786,773.15	73,309,403.94	76,635,807.94	79,898,838.78	84,603,166.80	379,233,990.62	75,846,798.12	20.81%
b	LRC	777,613.61	109,662.51	114,638.43	119,519.58	36,095.73	1,157,529.86	231,505.97	0.06%
c	CIIP	525,104.32	594,181.23	621,142.12	647,589.37	776,179.50	3,164,196.54	632,839.31	0.17%
c	TEV	5,159,886.74	6,608,909.67	6,908,788.03	7,202,953.24	7,627,052.70	33,507,590.38	6,701,518.08	1.84%
	Total	311,268,490.42	352,215,527.76	368,197,258.33	383,874,512.09	406,476,487.97	1,822,032,276.57	364,406,455.31	100.00%
	Average	34,585,387.82	39,135,058.64	40,910,806.48	42,652,723.57	45,164,054.22	202,448,030.73	40,489,606.15	

Source: Field Study, May 2010

APPENDIX 11: CALCULATION OF CHI SQUARE $(\chi)^2$ VALUES

Benefits

fo		fe	fo-fe	$(fo-fe)^2$	$[(fo-fe)^2]/fe$
10	(218*71)/1368	11.31	-1.31433	1.72746	0.15268
15	(411*71)/1368	21.33	-6.33114	40.08334	1.87910
16	(314*71)/1368	16.30	-0.29678	0.08808	0.00540
30	(425*71)/1368	22.06	7.94225	63.07936	2.85974
80	(218*593)/1368	94.50	-14.49854	210.20760	2.22445
191	(411*593)/1368	178.16	12.83991	164.86335	0.92537
145	(314*593)/1368	136.11	8.88743	78.98636	0.58030
177	(425*593)/1368	184.23	-7.22880	52.25557	0.28364
128	(218*704)/1368	112.19	15.81287	250.04672	2.22884
205	(411*704)/1368	211.51	-6.50877	42.36411	0.20029
153	(314*704)/1368	161.59	-8.59064	73.79915	0.45670
218	(425*704)/1368	218.71	-0.71345	0.50901	0.00233
				$(\chi)^2$ calculated	**11.79885**
				$(\chi)^2$ crit [i.e. $(\chi)^2_{0.05,6}$	**12.60000**

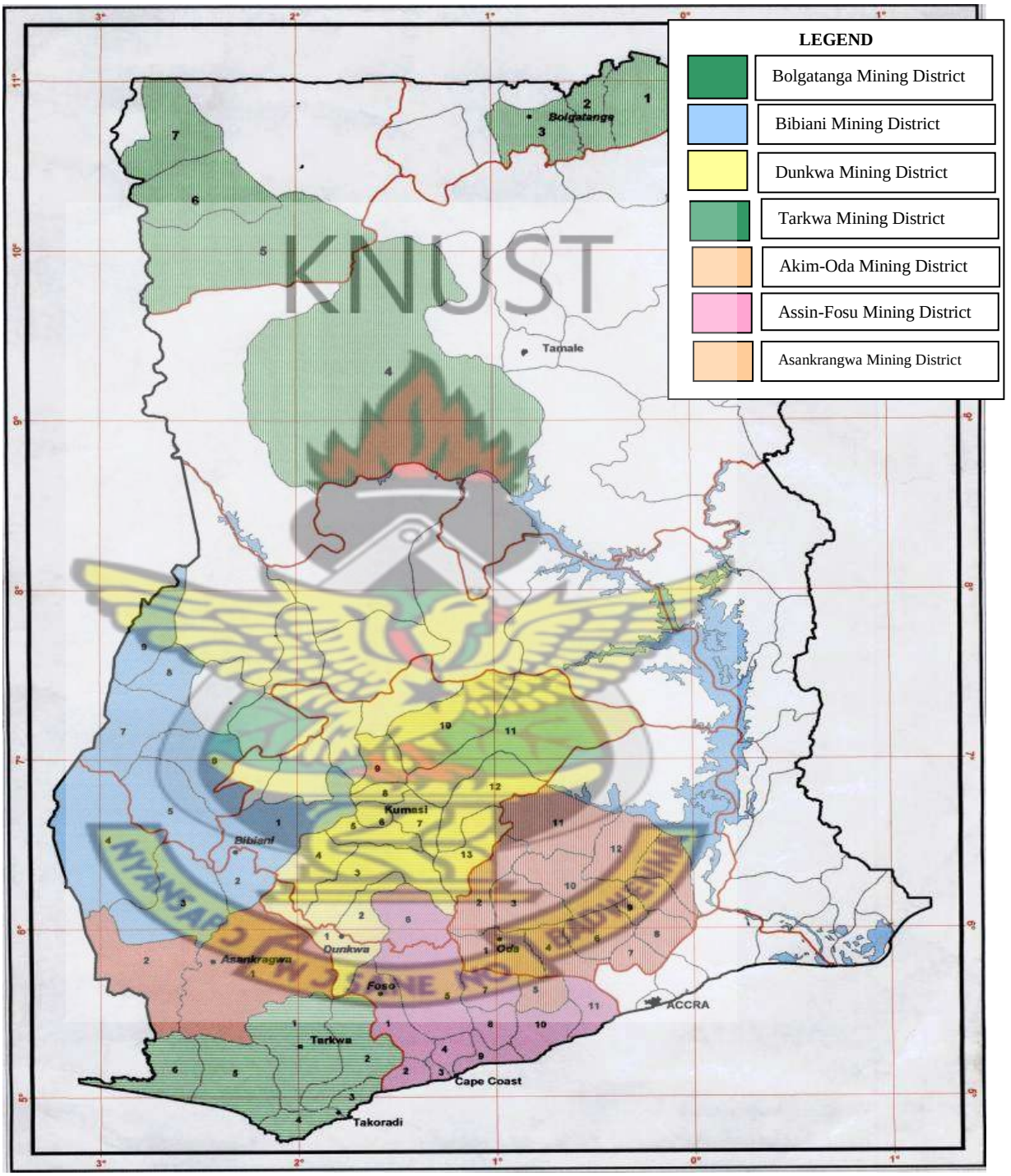
Source: Estimation, August 2010

Costs

fo		fe	fo-fe	$(fo-fe)^2$	$[(fo-fe)^2]/fe$
164	(226*1377)/1822	170.80	-6.80241	46.27285	0.27091
144	(212*1377)/1822	160.22	-16.22173	263.14467	1.64238
263	(351*1377)/1822	265.27	-2.27278	5.16552	0.01947
806	(1033*1377)/1822	780.70	25.29693	639.93449	0.81969
57	(226*411)/1822	50.98	6.01976	36.23749	0.71081
63	(212*411)/1822	47.82	15.17783	230.36642	4.81715
81	(351*411)/1822	79.18	1.82272	3.32232	0.04196
210	(1033*411)/1822	233.02	-23.02031	529.93455	2.27420
5	(226*34)/1822	4.22	0.78266	0.61255	0.14525
5	(212*34)/1822	3.96	1.04391	1.08974	0.27546
7	(351*34)/1822	6.55	0.45005	0.20255	0.03092
17	(1033*34)/1822	19.28	-2.27662	5.18299	0.26887
				$(\chi)^2$ calculated	**11.31708**
				$(\chi)^2$ crit [i.e. $(\chi)^2_{0.05,6}$	**12.60000**

Source: Estimation, August 2010

APPENDIX 12: MAP OF THE STUDY AREA



Source: Minerals Commission of Ghana