RHODES UNIVERSITY
INVESTEC BUSINESS SCHOOL

THE IDENTIFICATION AND EVALUATION OF KEY SUSTAINABLE DEVELOPMENT INDICATORS AND THE DEVELOPMENT OF A CONCEPTUAL DECISION-MAKING MODEL FOR CAPITAL INVESTMENT WITHIN GOLD FIELDS LIMITED (GFL)

A dissertation submitted in partial fulfilment of the requirements of the degree of

MASTERS IN BUSINESS ADMINISTRATION

RHODES INVESTEC BUSINESS SCHOOL: RHODES UNIVERSITY

by

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to the Almighty who gave me the strength, courage and perseverance necessary to make a success of this study.

I am also greatly indebted to the many people who have helped me towards the completion of this study. I particularly want to thank the following persons:

1. To my family for their patience and continued support with special thanks to my wife Gail, daughter Megan and son Joshua for their inspiration and encouragement throughout this study.
2. To my friends, known to many as the inner circle due to their continuous show of attitude and tenacity, and without whom I would not have had such an eventful and enjoyable journey.
3. To my supervisor, Dr Kevin Whittington-Jones for his ongoing guidance and patience throughout the compilation of the thesis.

ABSTRACT

The current trends in sustainable development (SD) were examined in this study, which brought about the realisation that SD has become a business imperative. Mining, which is a highly impacting industry, is faced with the dilemma of implementing the principles of SD despite the realisation that its activities are severely limited by the finite nature of the resource it is capitalising on. This reality, however, does not detract from the non-negotiable requirement for the industry to meet the increasing pressures to act responsibly towards the environment and the community in which it operates.

Gold Fields has stepped up to the plate and has already taken several steps to achieve this end. These include the adoption of SD in its Vision, Values and strategies and the development and implementation of a SD framework to ensure the integration of the principles of SD into the business. Furthermore, Gold Fields has also entered into voluntary activities that further cement the commitment the company has towards SD. These other initiatives include, *inter alia*, its International Council on Mining and Metals membership, UN Global Compact participation, becoming a signatory to the cyanide code, ISO14001, and so on.

This study focussed on several indicator categories and the identification of a set of supporting sustainable development indicators (SDIs) for each, which included environmental, social, economic, technological, and ethics, legal and corporate governance (not in order of priority). These indicators were assessed by a carefully selected group of respondents whose collective wisdom and expertise were used to identify and weight supporting SDIs for each of the indicator categories. These supporting SDIs were in turn used to develop a model that is able to assist in the business's decision making processes when capital investment is being considered. A water treatment project that is currently being considered by Gold Fields was utilised to demonstrate how the decision making model can be applied to two different scenarios. The result clearly and successfully demonstrated that by proactively taking environmental, economic, social, technological, and ethics, legal and corporate governance considerations into account, a gold mining company is able to increase the level of SD of a capital investment project.

CHAPTER 1 – INTRODUCTION

Sustainable Development (SD) is a relatively old concept (Hedinger 2004) but needs to be clearly defined as it has no single blueprint (Hilson and Basu 2003) and because it forms the basis of this study. It is also the most recent paradigm in accordance with which society's environmental, social and economic requirements are balanced (Shields and Solar 2000). The traditional definition, which was taken from the Brundtland Report, "Our Common Future" and which is used most frequently (Hilson and Basu 2003, IISD 2008), says that: "Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Europa 2008). However, despite its frequent use, the Brundtland Report's definition does not explicitly explain the societal application nor does it provide any implementation guidance (Hilson and Basu 2003). Furthermore, historically, SD issues were usually related to specific components of the ecosystem (Rao 2000), a narrow approach which presents several challenges (Hilson and Basu 2003). Today the focus appears to be more intense and more integrated and has culminated in the form of what is called the "Triple Bottom Line" (Elkington 2005). For this study, the definition of SD in accordance with the Brundtland Report (Europa 2008; IISD 2008), has been adopted.

Given all the global pressures to minimise environmental and social impacts, from a business point of view, it would be irresponsible to ignore SD and its associated requirements. These pressures also include the requirement for good corporate governance and the maintenance of industry's license to operate. Post the publication of the King II Report these issues within the SD context, have become paramount to the success of any business (LexisNexis 2009). As a result many SD related initiatives are being pursued internationally and also in South Africa. These include an improvement in legislation relating to the environment, an increased focus on shareholder value, long term commercial survival, risk management, improvement of stakeholder relationships, and the improvement of reputation amongst governments and regulators (PricewaterhouseCoopers 2001; Azapagic 2004). When considering the manner in which SD has developed then the conclusion that is reached, given the above-mentioned, is that addressing SD issues has become a business imperative.

Mining has not been spared scrutiny and as an industry it currently faces challenges that relate directly to SD (Azapagic 2004). Mining in South Africa commenced in the mid 19th century (Antrobus 1986:1). Today, gold mining is regarded by many as being a sunset industry that is destined for closure in the next few decades as it is reliant on finite resources. However, it is often forgotten that mining has and continues to contribute to the GDP (Gill 2005) and accounts for about 21 per cent of the market capitalisation of the JSE (Gildenhuys 1994). It also consistently proves to be a safe haven for investors during times of financial crisis (Hamilton 2009) and has soared to unprecedented values of late.

Gold Fields (GFL) in its original form was established more than 120 years ago and is today the fourth largest unhedged gold producing mining company in the world (Gold Fields 2008). GFL has operations in Peru, Ghana, Australia and South Africa and has exploration sites across the globe. Its South African Operations are mainly deep gold mines, which extend to just less than 4km underground and have been the focus of this study. One of the areas in which GFL operates in South Africa is called the Far West Rand, an area with a steep mining history (Lednor 1986; Antrobus 1986). This area is characterised by its gold bearing geological formations and its abundance of subterranean water (Enslin 1964; Ramsden 1985; Werdmüller 1986). As a mining consequence the area has been impacted on through the formation of sinkholes (Swart, Stoch, van Jaarsveld and Brink 2003) and pollution, which has become evident in recent years through the intensive sampling regimes that have been introduced by the mines (Gold Fields internal 2009). Aside from the environmental impact the possibility of social impacts in the said area requires further investigation before it can be fully quantified. It is thus critical that the key factors that influence decision making are carefully contemplated so as to possibly internalise the full cost of mining and to address all associated issues for the benefit of our future generations.

Being a highly impacting industry (JSE 2008), gold mining presents challenges that, coupled with legacy issues, often require complex solutions. Legislation has also changed in the last decade and as a result, SD (and its social and environmental elements) has become a focal point (Acts Online 2009). The current macro-economic statistics paint a bleak picture for the South African economy (Statistics SA 2009), which highlights the fact that the industry can no longer operate in communities without accepting that there is a social responsibility inherent in the relationship that exists. The areas in which GFL operates have not been unaffected (WRDM 2009), which has been highlighted by an increase in activism in the area (Liefferink 2007). In fact the mining industry has come under serious scrutiny in recent times and has been accused of treating the communities and environment, in which they operate, irresponsibly (Hamann 2003). This highlights the need for well-informed strategic decisions to be made that will determine the way forward and links up with the concepts of weak and strong SD contemplated by Common and

Perrings (1992), Daly and Cobb (1989: 72 and 73), and Van Der Voet, Olsthoom, Kuik and Van Oers (2001). To this end, in terms of eventual closure and the strategy of moving towards strong SD, it is the GFL strategy to implement closure plans that will hopefully see an alternative mining-independent economy being left behind, post mine closure (Gold Fields internal 2009). The challenge, however, remains the actual implementation of SD on the ground and the measurement thereof.

One of the business activities that GFL could focus on to make a significant difference and to achieve the desired result in terms of SD implementation, is that of capital investment. The mining industry spends large amounts of money on capital investment on an annual basis and if planned correctly, the impact of the said investment could have a positive impact on the community and the environment. During the last financial year, GFL as a whole increased its capital expenditure from R1,016 million in previous financial year to R1,034 million (Gold Fields 2009b), which is a substantial amount of money. While it is accepted that not all of the said expenditure can be redirected to have a SD impact and that some projects will simply not be of relevance due to their technical nature (e.g. development underground), it is expected that an appropriate approach will still result in an acceptable contribution to the community and the environment. An example of such an approach is procurement from local enterprises so as to support the local economy, which is something that GFL is currently doing well (Gold Fields 2009 internal, Gold Fields 2009b).

It is therefore important that each capital project that presents itself within GFL is assessed according to a set of criteria, in the form of appropriate key performance indicators (KPIs), that will give an indication of the level of SD of the said project in addition to the traditional financial assessment techniques like Internal Rate of Return, Net Present Value, Payback Period, and so-on. These KPIs will be referred to as Sustainable Development Indicators (SDIs) as used by Hilson and Basu (2003). Formulating proper SDIs is critical in measuring the trend either towards or away from SD and can be used to set proper targets for improvement (Hilson and Basu 2003). It is also important in ensuring that the various aspects of SD are interrelated and interdependent (Hilson and Basu 2003) and creates a good mix of economic, environment and social indicators (Fricker 1998). The decision-making process that will enable this is perhaps best done using a set framework that will ensure consistency and comparability and which will allow senior management to make informed decisions that are based on a more holistic assessment. A capital project relating to the construction of a water treatment plant has been selected to demonstrate this. This process and its associated framework will be measured in terms of performance, using SDIs. These SDIs, in turn, are also potentially the basis upon which SD reporting and stakeholder engagement can be implemented (Azapagic 2004; Warhurst 2002) going forward.

It should be noted that a great deal of work has been done on SDIs in general and many companies utilise tools like, *inter alia*, the JSE SRI, Principles for Responsible Investment, and the Equator Principles. These SDIs are typically used to assess a company as a whole but can also be used to hone in on a specific project. This has been successfully demonstrated in specific projects that relate to water treatment, (Larsen and Gujer 1997; Hellström, Jeppson and Kärrman 2000; Hoffman, Nielsen, Elle, Gabriel, Eilersen, Henze and Mikkelsen 2000; Morrison, Fatoki, Zinn and Jacobsson 2001; Balkema *et al.* 2002; Larsen and Lienert 2003; Bracken 2005, and Neba 2006), which have enjoyed consideration in this study.

The goals of the current research are to:

(i) identify key SD Indicators (SDIs);
(ii) develop a decision-making model that will facilitate incorporation of sustainable development into capital investment decision-making process; and
(iii) to apply the developed model to a typical capital investment project within Gold Fields (GFL).

In order to achieve and demonstrate this, the proposed set of SD criteria will be applied to an actual water treatment capital investment project that is currently being considered within GFL so as to test its effectiveness in a real project situation. It should, however, be noted that despite the focus on water treatment, these SDIs will be transferable to other capital investment projects within the South African context.

CHAPTER 2 – LITERATURE REVIEW

2.1 SD – an historical perspective and its modern status

The mining and minerals industry currently faces challenges that relate directly to SD and that outweigh that of other sectors (Azapagic 2004). As a result there has been a change in focus and many initiatives are being pursued both internationally and in South Africa. These include an improvement in national and international legislation, an increased focus on shareholder value, long term commercial survival, risk management, improvement of stakeholder relationships, and the improvement of reputation amongst governments and regulators (Azapagic 2004; PricewaterhouseCoopers 2001).

SD has been an area of concern for hundreds of years, in one form or another. However, these concerns were usually related to specific components of the ecosystem (Rao 2000). Today the focus appears to be more intense and more integrated and has culminated in the form of what is commonly called the "Triple Bottom Line" (Elkington 2005), which hereinafter will be included in the SD concept for ease of discussion. Therefore, as clichéd as it may sound, SD (also often referred to as Sustainability), despite being a relatively old concept (Hedinger 2004), needs to be clearly defined.

The traditional definition says that:

> "Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Europa 2008).

This definition is taken from the Brundtland Report, "Our Common Future" and is used most frequently (IISD 2008). The advent of this definition was not in isolation and is associated with a long and steep history. The events that contributed to include (but are not limited to) the following events/occurrences:

- Malthus warned of severe resource shortages in 1798 (Rao 2000)
- the "Silent Spring" published by Rachael Carson in 1962 (NRCD 2008)
- the "Tragedy of the Commons" was published in 1968 (Hardin 1968)
- the launch of the United Nations Environment Programme (UNEP) in 1972 (UNEP 2008)

- the World Commission on Environment and Development and the publication of the Brundtland Report in 1987 (United Nations 2008, Rao 2000)
- the Earth Summit and the publication of Agenda 21 in 1989 (United Nations 2008)
- the Montreal Protocol in 1996 (United Nations 2008)
- the Kyoto Protocol in 1997 (United Nations 2008)
- the Millennium Summit and Development Goals in 2000 (United Nations 2008)
- the World Summit on Sustainable Development in 2002 (United Nations 2008)
- the Bali meeting in 2008 (IISD 2008a)

SD today goes beyond the traditional ecologically based conception of physical sustainability pointed out by Rao (2000) to the social and economic context of development (Adams 1990, Hamann 2003). The events depicted above have highlighted the global plight (Hedinger 2004) we face with regard to limited resources and have influenced our thinking and the way we approach things. However, it is difficult to change entrenched mindsets and therefore the process (albeit a concept agreed to by most) has been encouraged by the introduction of various protocols, policies, financial instruments, laws, and so on. In the current climate some of the main drivers (both compulsory and voluntary) have been:

- Principles of Responsible Investment (PRI 2008)
- SRI Indices (e.g. JSE, FTSE) (JSE 2008)
- Equator Principles (World Bank 2008)
- Protocols that translate into laws and regulations in countries that become signatories; Kyoto, Montreal, etc. (United Nations 2008)

These drivers have been (and continue to be) effective, especially when non-negotiable. An example of this is the Equator Principles which, if not adhered to will result in funding for large projects not being made available. This forces companies that require funding, to comply with the requirements as set out in the Equator Principles (World Bank 2008). Many banks especially those in a position to finance large investments are now adopting these principles (World Bank 2008), which limits the options available to companies that seek equity funding. The World Bank boasts at least twenty nine Financial Institutions that have adopted the Equator Principles (World Bank 2008). These requirements introduce an element of having to do the right thing which in turn introduces the concept of ethics whereby ecological economists would argue that the systems perspective demands an approach that the ecological system requirements are above that of the individual. This presumably ensures that the welfare of future generations is addressed as ethical judgements are required relating to the rights of the present generation versus that of the future generation and the behaviour change required (Pearce 1992). This is aligned with the argument of Norton (1987) that a stewardship ethic is sufficient for sustainability, since it implies that people would be less greedy and would take the cost that greed externalities have on other people, into account (Turner 2008). The conclusion that is thus reached, given the direction SD has taken, is that awareness in the SD arena has increased significantly over time.

Given all these global pressures, from a business point of view, it would be irresponsible to ignore SD and its associated requirements. This is particularly important if a company operates in the global market and hopes to continue doing so. Companies that fail to recognise the risk of ignoring SD are likely to impact on their social profiles and brand equity, miss opportunities, lose market share to their competition, suffer reduced profits, and finally, leave nothing for the generations to come. This will no doubt be unethical and morally sub-standard and will thus impact negatively on their respective social licenses to operate. The mining industry is not immune to these new pressures brought on by the SD agenda.

2.2 The modern business landscape in relation to SD

Globally, gold mining remains an intrusive activity and therefore presents challenges that, coupled with legacy issues, often require complex solutions. Gold mining activities in general impact on, *inter alia*, land, water and air quality, and is therefore considered to be a "high impact" industry (JSE 2008). Mining today is no longer as blind as it was historically and leading companies are now fully aware of their impacts. However, given its tainted history only an unbiased and objective approach to assessing the degree of sustainability will elucidate the efforts that have been made by the modern mining industry. Today there are many arguments in support of mining being sustainable based on the premise, *inter alia*, that the earth's crust has an abundance of minerals and that minerals like gold are not consumed (Hilson and Basu 2003). However, the truth is that by strict definition it is not (Hilson 2001b) simply because the definition fails to recognise the potentially positive operational phase contribution to socio-economic and environmental issues (Hilson and Basu 2003). In fact, if it is only the mineral resource that was focussed on then no mining operation will ever be sustainable (Hilson and Basu 2003). Therefore, in accordance with this adverse approach, mining continues being seen as unsustainable due to the mined resources being finite in nature (Hilson and Basu 2003). It should however be noted that a recent philosophy that has come to the fore is that mining can support the pillars of SD by contributing to environmental protection and socioeconomic improvements (Hilson 2001b). It is therefore possible that mining, albeit unsustainable by definition, can indeed implement the principles of SD through innovation and effort.

2.3 Mining as an economic contributor

Gold mining, particularly in South Africa, has long been regarded by many as being a sunset industry that is destined for closure in the next few decades as it is reliant on a finite resource. There are many reasons for this opinion like deep mines not being profitable, political constraints, and so on (Gill 2005). In essence this is true as the extraction of non-renewable resources cannot be sustained indefinitely (Hilson 2001b). However, minerals are essential to our lives as it provides the raw material for many products required on daily basis. These raw materials are required in several different industries that include, *inter alia,* construction, electronics, metal, paints, and so on (Azapagic 2004). Therefore mining is an important economic activity, particularly in Africa (Hilson 2001b) and it is often forgotten that until fairly recently gold production was also directly responsible for up to 12 per cent of the South African GDP (Gill 2005). When taking secondary industrial activities into account gold production contributes about 18 per cent of GDP.

Furthermore, gold remains an important role-player in South Africa's formal wealth creation structure, the Johannesburg Stock Exchange, and accounts for about 21 per cent of the market capitalisation of the JSE (Gildenhuys 1994). In South Africa the industry spends heavily on research and development aimed at improving the productivity and safety of mining operations. The industry as a whole also creates employment both nationally and regionally, for many. It has also provided a wealth of social benefits in the form of infrastructure (Hilson 2001b) like good quality housing for hundreds of thousands of respondents and, in addition, virtually all of these respondents are provided with water, electricity and access to telecommunications (Gildenhuys 1994). Adult Basic Education is a key component of the mining industry's training curriculum. When considering health care, the mining industry provides all of its employees with comprehensive medical facilities and treatment at hospitals which it operates. Today many of these provisions are supported by the legislative requirements that have, *inter alia*, taken the form of a Social and Labour Plan

(LexisNexis 2009). The mining industry continues to earn foreign exchange, and to build and sustain communities in which it operates. (Gildenhuys 1994). SD has therefore been historically practised in mining as these initiatives were conducted under the auspices of SD policies that were adopted as far back as the mid 1990s (Dashwood 2006).

Then there is the current global financial crisis that has once again proved that gold is still regarded as a safe haven for investors (Hamilton 2009). With the USA's Federal Reserve announcing the creation of over a trillion dollars to reduce US debt and the associated monetary inflation, it is no wonder that the price of gold has soared to unprecedented values. This is simply because it remains the best asset to own in inflationary times as it stays ahead of the rising inflationary tide (Hamilton 2009) and its all time high price that recently exceeded $1200 per fine ounce is testament to this (LMBA 2009). This increase in demand for gold has an increasing effect on the price of gold and benefits our South African mines since gold mines are price takers. This also results in a lowering demand for the United States dollar, which also has an added positive impact on the South African economy due to the associated strengthening of the South African Rand, which in turn decreases the cost of importing mining equipment. Therefore the global financial crisis has enabled the South African mining industry to continue contributing positively to the economy (Gold Fields internal 2009).

The landscape in which most mining companies operate has changed and presents several challenges. It is the opinion of GFL that this also presents opportunities (Gold Fields internal 2009). SD is today fully supported by the modern and robust legislative framework, which calls for implementation and the measurement thereof. It is this very framework that has resulted in national legislation being increasingly tailored towards promoting SD (Azapagic 2004).

The first area that needs to be acknowledged is the regulatory environment, the most important examples of which include:
Section 24 of the Constitution, which states that:

"Everyone has the right: to an environment that is not harmful to their health or well-being; and to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation; and secure ecologically SD and use of natural resources while promoting justifiable economic and social development."

(Acts Online 2009) This was one of the pivotal changes to the legislation post the political revolution in South Africa and is the main driver of environmental behaviour amongst industry.

Section eight of The Constitution, known as the "Bill of Rights", which gives individuals the right, where appropriate, to assert their rights against the state or individuals. This is perhaps the second driver of environmentally and socially responsible behaviour (Acts Online 2009).

The following legislation provides the premise upon which SD has been introduced into the mining industry, the details of which have not been expounded in this write-up.

i. The National Environmental Management Act 107 of 1998, which is a framework legislation and which replaced the Environment Conservation Act, incorporates the: (i) Sustainable Development, (ii) Preventive, (iii) Precautionary, and (iv) Polluter Pays Principles. These principles underlie all environmental related legislation that has subsequently been promulgated and is evident in the associated regulations that have been passed by Parliament.

ii. Minerals and Petroleum Resources Development Act 28 of 2002 (which was designed to replace the Minerals Act 50 of 1991)

iii. National Environmental Management: Air Quality Act 39 of 2004 (which was designed to replace the Atmospheric Pollution Prevention Act 45 of 1965)

iv. National Water Act 36 of 1998 (which was designed to replace the Water Act of 1956)

In terms of Economic, Social and Environmental requirements, the 2001 population census estimated that the South African population was about 44.8 million. In a mid – year census conducted in 2008 the estimated population was about 48.7 million (Statistics SA 2009). The current Consumer Price Index (CPI) was about 8.6% (year on year), its Producer Price Inflation (PPI) was about 7.3% (year on year), its Gross Domestic Product (GDP) was about 1.8% less (quarter on quarter), and the unemployment rate was about 21.9%, which was estimated during the fourth quarter of 2008. These statistics paint a bleak picture for the South African economy and highlights the fact that the industry can no longer operate in communities without accepting that there is a social responsibility inherent in the relationship that exists.

The level of activism by non-governmental organisations (NGOs) has also increased in this area over the last decade, and has been focussed on environmental degradation and social injustice (Liefferink 2007). This is further fuelled by a general level of scepticism with regard to the intentions of mining companies (Dashwood 2006). The environmental and social impact of gold mining is particularly acute and hence there has been a call on the part of numerous activists to reconsider the necessity of mining this metal when more supplies of gold are above than below ground. This is perhaps true since gold is eminently recyclable and is primarily used for ornamentation. However, the key issue with regard to the gold industry is that unlike most luxury commodities, the largest areas of gold consumption are in impoverished developing countries. Cultural factors play an important role in gold consumption and Western anti-mining activists are often tepid on this issue to avoid being blamed for lack of sensitivity. Yet, if developing countries are to accuse developed countries of over-consumption and resulting environmental impacts, they must also evaluate their own consumption patterns of gold (Saleem 2006). This study explores the ways in which these issues can be approached and measured as an integrated societal concern. By following these measures, both developed and developing countries can avoid breaking the "golden rule" of personal accountability and reduce the potential for conflict (Saleem 2006). The Far West Rand, in particular, has received a great deal of attention during the last few years. One activist in particular has been raising issues that relate to social injustice and environmental impacts including, inter alia, water pollution (Liefferink 2007). The level of activism has increased significantly over the years and has forced the mines in the area to, at the very least, get their monitoring and measurement updated. The result has been a renewed focus on the impacts associated with mining.

Bribery and corruption becomes critical when considering that any multinational company is not likely to explore the opportunities to do business in countries that do not have a sound ethical base. The failure to do this could lead to exposure to corrupt business practices. The case of Anglo Gold Ashanti (AGA) is a case in point, where AGA was forced to pay a bribe of about $8000. While the amount is not significant, the act contradicted all their principles of ethics and governance (Kapelus 2005). This is the point where overall risk management should play an important role so as to ensure a situation where all activities are consistently managed in a manner that meets ethical and moral requirements.

Environmental issues relate to the impacts caused by mining activities (Hilson 2001b), its prevention or mitigation, and finally closure (Gold Fields internal 2009). Land and water are important strategic issues for GFL (Gold Fields internal 2009). Thousands of hectares of land have been rendered unsafe due to the sinkhole formation and subsidence. In essence this has resulted in a loss of prime agricultural land. Water is as critical and with fresh water availability in South Africa being only about 984m^3 per capita compared to 16 114m^3 per capita in the Democratic Republic of the Congo (DRC), or 89 134m^3 per capita in Canada, it is clear that South Africa is a water stressed country (The World Bank 2006:57-195). Emissions (i.e. of CO_2) in South Africa is about 7.6 metric tons per capita, whereas the DRC's emissions are only 0.1 and Canada's emissions are only 0.6 metric tons per capita. This, while illustrating that South Africa is more industrialised than the DRC, is a serious concern when considering climate change and biodiversity. This is true despite the developmental status that S.A. currently enjoys. Environmental impacts in general (like dust fall out, water pollution, land degradation) have the potential to erupt in a spate of activism that could affect the bottom line directly or the share price through damage to company or organisational reputation. Reputation is one of the key issues for any mining company (Hamann 2003) and Non-Governmental Organisations are quick to highlight or draw attention to the lack of performance (Azapagic 2004). Again, as is the case with the issues mentioned above, environmental related issues will determine the long term closure success for any mining company and it is thus important that the environmental solutions being identified and put in place are supportive and supplementary to the closure initiatives being planned. This is another set of issues that need to be considered in an overall decision-making process.

2.4 A Historical perspective of the consequences of mining on the Far West Rand

In addition to the above-mentioned issues Gold Fields faces an additional set of issues related to a region in which it operates, called the Far Wet Rand. The areas in which GFL operates have been impacted on over many decades. Included in the Far West Rand is the district called the West Rand District Municipality WRDM which includes areas like Randfontein and Westonaria (WRDM 2009). In this area, not unlike the other settlements that are associated with mining, the unemployment rate and levels of poverty are exceptionally high. In Westonaria the recent unemployment rate was about 29.6% while in Randfontein it was 40.9% in 2005 (WRDM 2009) In fact, the situation is so dire that the provincial government has seen it fit to prioritise Bekkersdal, which is part of Westonaria, in terms of infrastructural development and poverty alleviation (Shilowa 2003). This emphasises the need for companies to make money in a sustainable manner so as to support the communities in which they operate. It also highlights the fact that this area is an exceptionally complex area both from an environmental and social perspective (Gold Fields internal 2009). To understand the complexity it is important to understand a bit of its history.

According to Lednor (1986) John Henry Davis became the first person "with any geological knowledge" to prospect in what was known as the Transvaal around 1852 and to find gold at Paardekraal near Krugersdorp, close to the Wonderfonteinspruit headwaters. Relatively soon after the first agricultural settlement was established in 1838, gold mining struck its roots in the catchment and both occupations have persisted to this day. The farm Langlaagte was a farm on which gold in conglomerates was discovered by a pioneer called George Harisson in circa 1886. This happened more than 100 years ago and led to the discovery of the Witwatersrand goldfield, which prospered and grew into the mining we know today (Antrobus 1986: 1). This was paralleled by the developments in the West Rand and continued until 1932. This successful gold run was interrupted by the Anglo Boer War, World War I, severe droughts and the Great Depression. Mining companies then started undertaking sophisticated and large scale exploration programmes and with the backup of increasingly competent geological input and a greater knowledge of the Witwatersrand geology, improved geophysical techniques, improved drilling techniques and so on, things began to improve (Antrobus 1986: 2). Progress was once again interrupted by World War II but once this had passed and following several new reef discoveries, the gold mining industry started flourishing at a rapid rate (Antrobus 1986: 2).

Gold mining was possible and flourished in this region of South Arica due the high concentrations of gold present in the said geological formations. Coincidently, these same geological formations are also responsible for an abundance of water in the area due to the presence of dolomite and its associated subterranean water (Enslin, 1964). Proof of this was captured by the writings of Werdmüller, (1986) and Ramsden, (1985) and it was this very water filled karst characteristic of the area (Swart *et al.,* 2003) that also contributed to mining being stopped at one point until the cementation process was discovered (Swart *et al.,* 2003). Water was pumped out from underground at rates of about up to 61 mega-litres per day in order to allow mining to continue (Jordaan *et al.*, 1960). The support for this practice varied mainly due to differences in opinion relating to the possibility of the situation not being reversible without an even greater measure of risk (Mudd, 1964).

The ground movement incidences associated with this dewatering process resulted in the establishment of the Technical Committee on Sinkhole and Subsidence on the Far West Rand, which was later renamed the "State Co-ordinating Technical Committee on Sink-holes and Subsidence in Dolomitic Areas with special reference to the Far West Rand"

(STCC). This later led to the establishment of an administrative committee that would be known as the "Far West Rand Dolomitic Water Association" (FWRDWA) (Gibbs, 1964). The FWRDWA was duly constituted at its inaugural meeting held on the 6th July, 1964 (Tindall, 1964). Under the ambit of and through the influence of this committee, an area of nearly 500 km^2 in extent, where the sustained average volume of dolomitic water issuing from four sturdy fountains was 120 Ml/d, was impacted on from either a water supply or from a ground stability perspective (Jordaan *et al.,* 1960). At the time, given the largely uninhabited (Wessels et al, 1905) and expansive countryside, the initial primitive and shallow mining methods appeared to have had little impact on the environment. However, there were several unforeseen consequences associated with this dewatering process.

This pumping activity eventually resulted in the natural eyes no longer flowing as the subterranean water was being dewatered at a rate exceeding that of the recharge. Although sinkholes are a natural feature of some dolomitic landscapes, the increased rate of ground movement that followed the lowering of the water table as a consequence of the large-scale dewatering of specific dolomitic, compartments, appears to have been unexpected. A catastrophic sinkhole that occurred at the West Driefontein Mine on the 12th December 1962 with the loss of 29 lives (Wolmarans, 1985) was directly related to the dewatering process. Apart from the catastrophic sinkholes making international headlines at the time, the consequences of anthropogenic related ground-instability also affected local water infrastructure, such as irrigation canals of the Oberholzer Irrigation Board (OIB). Soon after dewatering commenced, the OIB canal traversing the Oberholzer compartment started to subside and partly collapsed into sinkholes. Although these canals had been built in 1924 and continued to transmit water without any problems until approximately 1958, the mines that were actively dewatering the groundwater compartments at the time, denied liability and responsibility for the phenomenon, notwithstanding the fact that boreholes in the Oberholzer Compartment were drying up (Bond, 1958).

The second consequence of dewatering and pollution, was raised by Stander (1964), who had warned the Department of Water Affairs and Forestry that pollution and not the lack of water, would be the most serious consequence of mining in respect of the Wonderfonteinspruit. The farmers in the Welverdiend area served by the Lower Oberholzer Irrigation Board canal, who were irrigating "heavier" soils, began noticing crop anomalies during the course of 1964 and started having the irrigation water analysed. The impact of the potential pollution was further expressed when a deputation of the Agricultural Union met the Deputy Minister of Water Affairs on the 3rd November, 1967 and submitted a

Memorandum that set out their dissatisfaction with the quality of the water, suggesting that there was a likelihood that the crop failures and anomalies experienced with the animals could be linked to the quality of the supplementary water being supplied by the mine (Retief and Stoch, 1967).

Many of these impacts have been externalised over many years, mainly due to the regulatory framework in which mining took place. The consequence of this was a change in the revenue generating activities and in a shift of wealth. In short, since the advent of mining on the Far West Rand during the 1930s a legacy that changed the socio-economic tenure of the area was created. As a result of the contention experienced in this regard, several studies have been commissioned and completed over the years to specifically look at the Far West Rand, which is today one of the best studied areas in the world. In practice the *ad hoc* studies resulted in many unrelated data sets that are housed in a variety of archives.

Today the situation is exacerbated by other issues like the substantial loss of institutional memory in Government Departments and in the Mining Industry. Another example is the access to this information, which is an indispensable prerequisite for sound decision-making and solution identification. Recent difficulties in the West Rand goldfield, where active mining had taken place for more than a century (1889 – 1995), to retrieve the most basic information needed to address severe post-closure impacts on the environment (Winde et al, 2005), illustrate how crucial reliable information and data are for a successful closure process and how easily these unique and valuable records are irretrievably lost within a few decades.

It is therefore evident that the industrial history of this area is steep and full of examples of alleged social and environmental impacts. Under these circumstances, the challenge is therefore retaining past knowledge and experience, learning from the mistakes made in the past and utilising the key factors in making decisions into the future. The truth is that water is a critical resource in this area and requires a broader consideration from an industry that has been around for a long time. The said broader consideration needs to be one of SD. It is thus critical that the key factors that influence decision making are carefully contemplated so as to internalise the full cost of mining and to address all associated issues for the benefit of our future generations. Gold Fields operates in this area and is therefore faced with having to address many of the issues related to the steep history mentioned above.

2.5 Gold Fields Limited (GFL) and the sustainable development agenda

Given the global SD landscape and the specific circumstances under which GFL operates, it is important to note that GFL also operates in the international arena. This in itself also brings with it a set of requirements that need to be met, some of which relate to multiple company listings and the varying environmental and social requirements related to those listings. GFL is a multinational mining company and is one of the world's largest unhedged producers of gold (Gold Fields 2008b). It is also one of the oldest mining companies in the world and has changed from one form to another over the years (Gold Fields 2007a:8). GFL has its core mines in South Africa but also has mines in other countries. Holistically, gold is sourced from a total of nine operating mines located in South Africa, Ghana, Australia and Peru. In South Africa the four mines are: Driefontein, Kloof, South Deep and Beatrix. The international mines include Tarkwa and Demang in Ghana, Agnew and St Ives in Australia, and Cerro Corona in Peru. GFL also has exploration activities across the globe. Since GFL operates in the area described above, is today a major industry role-player and can make and is making a difference in terms of SD in the area (Gold Fields internal 2009). Gold Fields has, in many respects, embraced the concept of SD (Hilson 2001b) and the issues that follow are recognized as important contributors towards this end.

Corporate Governance supports legal compliance and applies to all disciplines as it is cross-disciplinary. Since the GFL footprint is global it is forced to consider a range of international environmental laws, regulations and permit conditions as well as a more active stance by global and local environmentally focused organisations and community groups (Gold Fields 2008c). Compliance with existing and new regulatory requirements and ever-changing community expectations can potentially increase operational costs but it is recognised that the failure to do so could result in potential litigation. This too could impact negatively on cash-flows and earnings. Corporate governance is that aspect of the GFL business model that supports compliance and binds the elements of SD.

Reporting within the Organisation is done at regular intervals and published so that GFL's entire shareholder base is given an opportunity to scrutinise its performance. Reporting, where applicable, is also done in accordance with the "Global Reporting Initiative" (GRI) G3, which is a prime example of public reporting that satisfies public and stakeholder demands for transparency (Hamann 2003, Azapagic 2004). In general GFL is positioned as transparent and open. Good reporting practice and a firm ethical base is critical for the successful implementation of any SD project in the long run and needs to be embedded from an early stage.

GFL participates in the JSE-SRI index and has done well to date. When considering the latest "SRI Index Best Performers" Report then it is clear that the most recent assessment done by EIRIS has placed GFL in the top ten of all those companies that were assessed (JSE 2008). The 2009 assessment results were not available at the time when this study was finalised (Gold Fields internal 2009). This and the background that has been set gives an indication that GFL is certainly on the right track when it comes to SD and the issues associated with it. However, the challenge that remains is the full integration of the principles that fall within the SD ambit. To this end it becomes important that GFL is able to demonstrate this integration. This does not imply that there in not an inherent integration in this regard but the consistency of such integration and the application of a firm set of principles, through which the effectiveness of all initiatives becomes measurable and comparable, is still to be put in place. To date GFL has tackled the challenges presented by SD and has adopted a preventative stance to environmental, health and safety issues and has become extremely proactive in supporting the community and its other stakeholders (Hilson 2001b).

With regard to environmental issues, all GFL mines, both South African and international, are ISO14001 certified (Gold Fields 2009) and it is acknowledged that ISO14001 certification is becoming a key customer requirement (Hamann 2003). The Environmental Management Systems (EMSs) in this regard have added value to date and there has been a marked continual improvement in the overall site management over the last eight years. This is the area of responsibility where the Pigouvian Principle (Green and Sheshinski 1976), the Polluter Pays Principle, and the Precautionary Principle would be applied if necessary. It is also important to note that ISO14001 is inherently risk-based and therefore the risk element is addressed through existing processes.

A decision was taken to become a signatory to the International Cyanide Management Code ("Cyanide Code"), which is a stringent international best practice code that has cost GFL in the order of about R250 million (just for the GFL's South African mines) for full certification (Gold Fields internal 2009). However, this investment, from a SD and community safety point of view is expected to have positive returns in terms of a reduction of the potential environmental and social impacts and on the company's overall reputation. It will also serve to avoid a Baia Mare type catastrophe (Baia Mare Task Force 2000) going into the future.

GFL has also become a full member of the International Council on Mining and Metals (ICMM) (ICMM 2009), which is the successor of the International Council on Metals and the Environment (ICME) (Dashwood 2006) and has adopted the principles of the Global Compact (United Nations 2009). In order to achieve the associated requirements GFL has developed a SD framework and is in the process of implementation. While there is still a long way to go, this decision will address all the associated requirements. Through this participatory process GFL is focussing (i) Safety and Health, (ii) Human Rights, (iii) Ethics and Corporate Governance, (iv) Stakeholder Engagement, (v) Risk Management, (vi) Environmental Management, (vii) Community and Indigenous People, and (viii) Materials Stewardship and Supply Chain Management (Gold Fields internal 2009) From an environmental management point of view the focus is on biodiversity, land-use and climate change (Global Compact 2008). GFL's involvement with the ICMM also covers many other aspects of SD.

Activism, mostly by non-governmental organisations (NGOs), is as much a social issue as it is an environmental issue, which in principle demonstrates the integrated nature of SD and scrutiny in this regard has increased immensely (Hilson 2001). These NGOs have direct or indirect influence on companies and target mining companies from within the communities in which they operate (Dashwood 2006). In acknowledgement, GFL has recently adopted the principles of the AA1000 Stakeholder Engagement Standard and several programmes are being rolled out (Gold Fields internal 2009). It is expected that this approach will add value in the short and long term. Through its implementation, GFL expects the implemented AA1000SES (Accountability 2009) principles to improve its current relationships with stakeholder communities so as to remain fully inclusive, constructive and long-term in nature, which is in line with the process highlighted by Hamann (2003). Stakeholder engagement and respective concerns need to be accommodated for SD to be effective (Hilson and Basu 2003). In fact GFL currently applies the principles captured in this standard to address the high level of activism that has been experienced over the last five years or so. GFL also recognises the fact that stakeholders include employees, customers, affected communities and the general public, as articulated by Hamann (2003).

The Social and Labour Plans that were developed as part of the conversion process from old order to new order mining rights is integrated into the entire organisation (Gold Fields internal 2009). This demonstrates how efficiently an organisation can perform if it integrates the various functions into the entire organisation. It also addresses projects that lead to institutional development within the community. This too is an important aspect for long term closure as it is important that any mine, reaching closure, is able to leave behind some sort of economy that is not dependent on mining, which is a GFL belief (Gold Fields internal 2009). Of equal importance, during the operational phase of mining, acting in a responsible manner can be good for profits while ignoring the responsibility towards the community can impact negatively on the bottom line (Hamann 2003).

GFL is serious about SD and has even revised its vision and values to reflect this, which is to be a global leader in sustainable gold mining (Gold Fields 2009). The vision, in turn, is supported by a set of values, which includes responsibility towards the environment and the communities in which it operates. SD also forms part of the overall Group strategy. The strategy has three pillars; (i) to ensure the sustainable growth of its business (ii) by focusing on operational excellence, and (iii) securing its long-term future, by maintaining both our social and legal licences to operate (Gold Fields internal 2009). Furthermore, the issues related to SD are dealt with firstly at an Executive Level and then at Board Level for ratification. The final remark in this regard is that SD is important and if we are to keep on mining, this will need to be demonstrated. This is a requirement highlighted by Hamann 2003, albeit under the banner of Corporate Social Responsibility (CSR), who emphasises the need for companies to go beyond the philanthropic community investment and environmental mitigation to integrating SD into business processes. GFL has done this (Gold Fields 2009).

Furthermore, it is recognised by GFL that the SD approach is likely to present more business opportunities (Elkington 2005: 23; Porter and van der Linde 1999). This incentive added to the meeting of ethical standing in terms of "doing the right thing" as contemplated in Turner (2008) and Pearce (1992) changes the scene somewhat and allows for GFL to benefit on both fronts. In fact, SD is taken seriously to the point of it being incorporated in the company strategy. It is this approach that will see the various aspects required for effective closure, being brought together for ultimate success. This highlights the importance of incorporating SD criteria in the decision-making process that relates to capital expenditure.

Going forward, GFL needs to, despite having implemented systems that address issues like risk management and stakeholder relationships, focus on ensuring that any capital investment supports the principles of SD. This does not preclude other areas where SD principles (and the implementation thereof) are equally important. The SD agenda is becoming stronger. Therefore if a company is on the verge of making a substantial investment in the form of a capital project, which is expected to last for 20 years and longer, then it is important that the company ensures that the investment is acceptable both in terms of environmental and social impacts over the same period i.e. it must be sustainable environmentally, socially and financially. Capital investment is critical as the capital investments made often determine the direction in which a company, especially a capital intensive industry like gold mining, is moving. It is also usually a serious long term commitment and if not dealt with adequately, will culminate in a series of undesirable results due to bad decision-making processes. For the purposes of demonstrating how this can be done, the capital project that will be focussed on in this study will address water treatment.

2.6 A new approach to capital investment at GFL

In order to achieve the desired SD result, it is important that each capital project that presents itself within GFL is assessed according to a set of criteria that give an indication of the level of sustainability of the said project. Any company that wishes to embrace SD must determine whether or not a proposed project is acceptable from a SD point of view (Hilson and Basu 2003). This form of assessment is crucial in determining the level of SD (Azapagic 2004), which in turn is a prerequisite to promoting a sustainable society (Mitchell 1996). The decision-making process that will enable this is perhaps best done using a set framework that will ensure consistency and comparability. The said framework and its associated process needs to be measured or monitored in terms of performance using SD indicators (SDIs). These SDIs, in turn, are also potentially the basis upon which SD reporting and stakeholder engagement can be implemented (Azapagic 2004; Warhurst 2002).

An enormous amount of work has been done on broader (often country level) SDIs in attempt to address environmental, economic and social issues more holistically. These include, *inter alia,* the contribution to the GDP and wealth creation, distribution of revenues and wealth, resource use and availability, water use, bribery and corruption, employment creation, health and safety, and so on (Morrison, Fatoki, Zinn and Jacobsson 2001, Dunmade 2002, Azapagic 2003, Hilson 2001b, Hilson and Basu 2003, Parris and Kates 2003). Furthermore, in honing in on the project that has been used in this study, several more specific SDIs have been identified that relate to water treatment, (Larsen and Gujer 1997; Hellström, Jeppson and Kärrman 2000; Hoffman, Nielsen, Elle, Gabriel, Eilersen, Henze and Mikkelsen 2000; Morrison, Fatoki, Zinn and Jacobsson 2001; Balkema, Preisig, Otterpohl and Lambert 2002; Larsen and Lienert 2003; and Bracken 2005), which will be the focus of this study. Other methods have been considered in assessing the sustainability of water industry technologies and these include (i) economic analysis (Balkema *et al.* 2002), (ii) exergy (Hellström and Kärrman 1997), (iii) emergy (Björklund 2000), and general systems analysis (Hellström *et al.* 2000; Balkema *et al.* 2002). The approach that is being proposed in this study is, unlike the approach of allowing the needs and opportunities (Nijkamp and Vreeker 2000) to dictate the context (Hoffman *et al.* 2000) as in the above mentioned examples, to assess the overall sustainability as articulated by Pope, Annandale and Morrison-Saunders (2004). According to Pope *et al.* (2004), the approach of assessing overall SD results in SD being elucidated and in the development of associated indicator criteria that will serve to monitor performance, which is the desired end result of this study.

2.7 Strategy – going forward with new rules and a new approach

Given the description of weak and strong sustainability contemplated by Common and Perrings (1992) and Daly and Cobb (1989: 72 and 73) it is clear that GFL demonstrates a tendency towards strong sustainability. When considering the GFL Strategy (Gold Fields 2008c) it is clear that gold mining is likely to continue for several decades to come (dependent on economics). In fact, it should be noted that there is a difference between minerals sustainability whereby intergenerational sustainability is considered important (Hilson 2001) versus the application of the principles of SD. Gold mines are not aiming to minimise their production of minerals for the purpose of providing resources for future generations (Hilson 2001). Many gold mining companies are approaching SD differently by taking environmental and social aspects of their daily activities into account (Hilson 2001), while ensuring that the resource is mined efficiently. In terms of eventual closure, strategic plans are being developed that will see an alternative economy (i.e. an economy other than that of mining) being left behind, post mine closure. It is thus likely that GFL may not be mining gold in the long term, as it is likely to morph into another business form in order to meet its objective of leaving an alternative economy behind. Furthermore, Gold Fields recognises the non-substitutability of a gold resource, however, it also recognises the fact that its economy is dependent on the community in which it operates, which in turn is dependent on the environment in which is finds itself. It also recognises the fact that gold as a resource, while trapped in an almost inaccessible ore body, has no value until it is mined, which is what Gold Fields does. Therefore, the fact that Gold Fields, through accessing the value of a gold resource, creates employment and pays taxes, has local economic development projects within its impacted communities that are funded from its profits, and the fact that it has a trust fund to the value of billions of Rands, is evidence of Gold Fields leaning toward strong sustainability. Therefore, when considering Van Der Voet, Olsthoom, Kuik and Van Oers (2001) it would appear that GFL is an example of strong sustainability as it is likely to remain in existence for a relatively extended period, albeit possibly in a different form. It also highlights the need for GFL to carefully select and plan all long term capital expenditure. Finally, *ceteris paribus*, as mentioned earlier, SD has moved away from just being a concept to consider. It is now fast becoming an integral part of the business as well as a serious ethical issue.

CHAPTER 3 – RESEARCH METHODOLOGY

3.1 Research paradigm

The research paradigm that was applied was an inductive approach that was data driven. The ontological assumption was post positivist and the epistemological stance was an objectivist approach based on true findings from a questionnaire outcome analysis. The researcher's views did not interfere with the outcome of the research exercise (Babbie and Mouton 2006). The approach followed facilitated the gathering of data that is valid. In order to achieve the said goals, the following key theoretical concepts were explored in preparation:

- SD and its latest trends
- Triple bottom line – Financial, Social, Environment and Governance in support of its effective application
- Performance Measurement and the associated key Sustainable Development Performance Indicators (SDIs)

3.2 Data collection, population and sampling

Documents that relate to the key concepts were reviewed and included published and credible documentation like current scientific journals, promulgated legislation, internal GFL documents, and any other value-adding information. Current SD trends, best practice, applicable legislation, and the manner in which GFL will be best positioned to implement a SD framework, were identified. Data collection in general was purposive and data related to the selection of key SDIs were collected through the development and use of questionnaires (see Appendix A). The questionnaires were formulated using a range of potential SDIs covering all elements of SD (economic, environmental and social, with additional technological and ethics, legal and corporate governance SDIs). These SDIs were identified primarily from the literature survey and in particular work done by Neba (2006). These questionnaires were distributed to a carefully selected group of GFL and non-GFL respondents, the results of which were used to elicit opinions on the importance of each SDI for both the operational and post closure phases of mining. The main reason for this distinction is that the requirements for the two phases are expected to be different due to the fact that all mining activities cease after closure is obtained. This in itself presents a new set of circumstances and associated concerns that need to be dealt with, possibly very differently to the operational phase. Based on the expert opinion of both the internal and external stakeholders, who were approached to fill in the questionnaires, the individual weightings for the various SDIs were incorporated into a decision making model. This model was then applied to an actual GFL water treatment project that is currently being considered.

The questionnaire (see Appendix A) comprised several sections which are included in Table 3.1. Six sections were included to investigate the (i) integrated bottom line, (ii) financial, (iii) social, (iv) environmental, (v) technological, and (vi) ethical, legal and corporate governance indicator categories. Each of these sections or indicator categories included a series of related indicators, designed to further interrogate the judgement of the intended respondents with regard to sustainable development indicators (SDIs). These related SDIs have been captured in Table 3.2. It should be noted that the integrated bottom line indicators category section of the questionnaire was not an aggregation of the detailed SDIs sections that followed but was rather included to test the respondents' opinion with regard to the overall category before honing in on the detail of each respective category. The sum of the individual SDIs was therefore not expected to add up to the bottom line indicators category section of the questionnaire.

Table 3.1 Components of the questionnaire that were addressed in order to capture quantitative elements for the development of a Sustainable Development Indicator Framework

	Level of Assessment		
Section	**Objective**	**Operational Phase**	**Post-Closure**
Section 1	Weighting of Integrated Bottom line indicator categories	✓	✓
Section 2	Weighting of comprehensive financial SDIs	✓	✓
Section 3	Weighting of comprehensive social SDIs	✓	✓
Section 4	Weighting of comprehensive environmental SDIs	✓	✓
Section 5	Weighting of comprehensive technological SDIs	✓	✓
Section 6	Weighting of comprehensive ethical, legal and corporate governance SDIs	✓	✓

Table 3.2 Detailed list of Sustainable Development Indicators (SDIs) used in this study, divided per category

Financial Indicators	Social Indicators	Environmental Indicators	Technological Indicators	Ethics, Legal and Corporate Governance Indicators
Capital costs	Direct employment creation	Abiotic depletion	Ease of construction	Maintenance of company ethics levels
Operational costs	Indirect employment creation	Natural resource depletion	Flexibility/adaptability to future demands	Opportunity to go beyond standard ethics levels
Net Present Value	Secondary industry creation	Land area required	Susceptibility to mechanical failure	Current legal compliance
Internal Rate of Return	Safety	Ecotoxicity potential	Durability /life span of plant and parts	Ongoing legal compliance
Payback Period on capital invested	Health	Phytotoxicity potential	Process reliability	Positioning for future/anticipated legal compliance
Return on Investment	Retention opportunities	Energy depletion potential	Onsite / local solution	Maintenance of company corporate governance levels
Debt:Equity ratio	Remuneration	Global warming potential	Ease of Operation	Opportunity to go beyond standard company governance levels
Funding mechanism – level of leverage	Transformation	Acidification potential	Ease of maintenance or replacement of parts	Upholding of human rights
	Skills development / capacity building	Eutrophication potential	Local availability of system expertise/ technical know-how	Property rights
	Community's perception of the investment	Bioaccumulation potential	Clean Technology	
	Education and Training opportunities for the community	Ozone depletion potential	Renewable Energy	
	Maintenance of social structures	Photochemical oxidant creation potential	Availability of spare parts and equipment	
	Preservation of cultural heritage	Re-usability of raw materials	Reliance on labour force	
	Political stability	Generation of useful by-products	Level of automation	
	Institutional support	Type of waste produced and recycling potential	Effectiveness of treatment	
		Quantity of wastes produced	Robustness of technology	
		Toxicity of wastes produced	Efficiency of technology/ treatment process (i.e. any treatment process e.g. water, mineral)	
		Availability of special waste disposal facilities		
		Biodiversity		
		Attraction of pests/vermin potential		
		Toxicity/Hazard of raw materials		
		Aesthetics		
		Odour generation		
		Noise produced		

Questionnaires were completed by a small sample of respondents (i.e. about 22 experts and professionals with the required expertise deemed necessary). The total number of respondents was divided into two main categories, (i) GFL respondents and (ii) non-GFL respondents. The GFL respondents constituted 59%, while the non-GFL respondents constituted 41% of the total sample (Figure 3.1). These respondents were specifically targeted based on their technical expertise and served as the basic research tool in this study. The target audience (technical experts) were linked to the gold mining industry and included people who were regarded as being prominent in their areas of expertise and included representatives in environmental management, sustainable development, health, academic research, engineering (electrical, mechanical and civil), local government, regulation, conservation, community and social risk, metallurgy, and capital/project management (Figure 3.2). Figure 3.2 clearly illustrates that the majority of the respondents had expertise in environmental management, sustainable development, followed by health, academic research and engineering. This breakdown of respondents, due to there being a smaller number of respondents with expertise in the social issues associated with mining, may have resulted in a bias towards the environmental and financial components of the model.

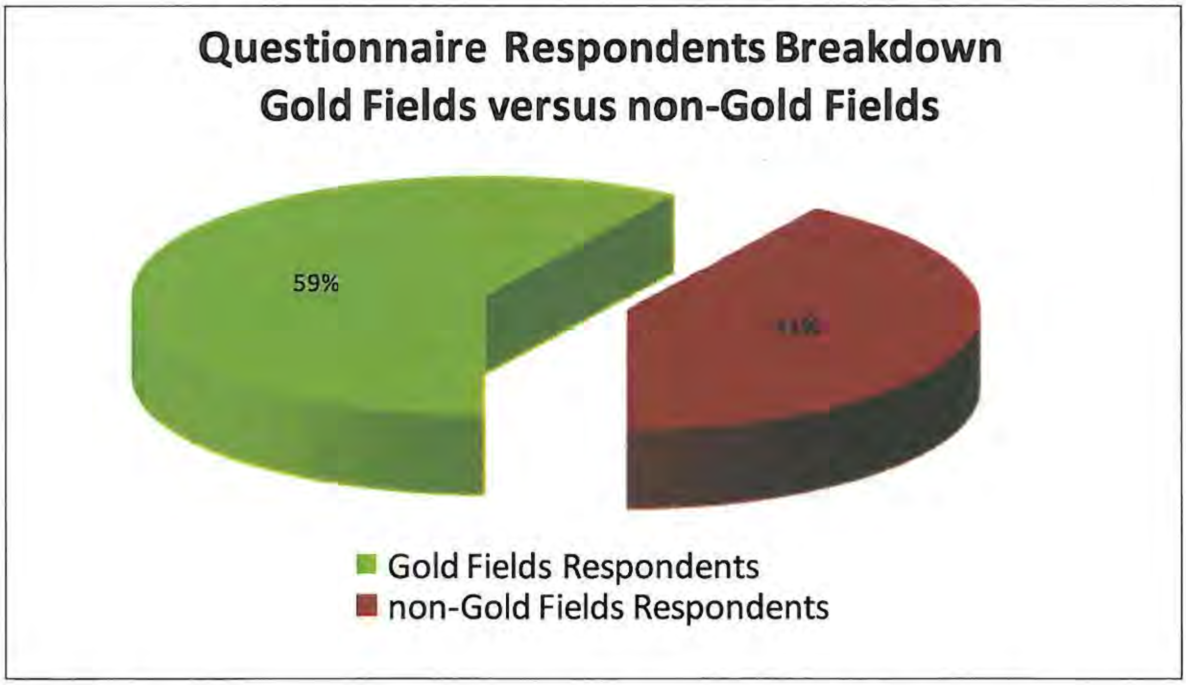

Figure 3.1 The breakdown of the number of respondents that were GFL respondents versus those who were non-GFL respondents. (GFL = Gold Fields; non-GFL = non-Gold Fields).

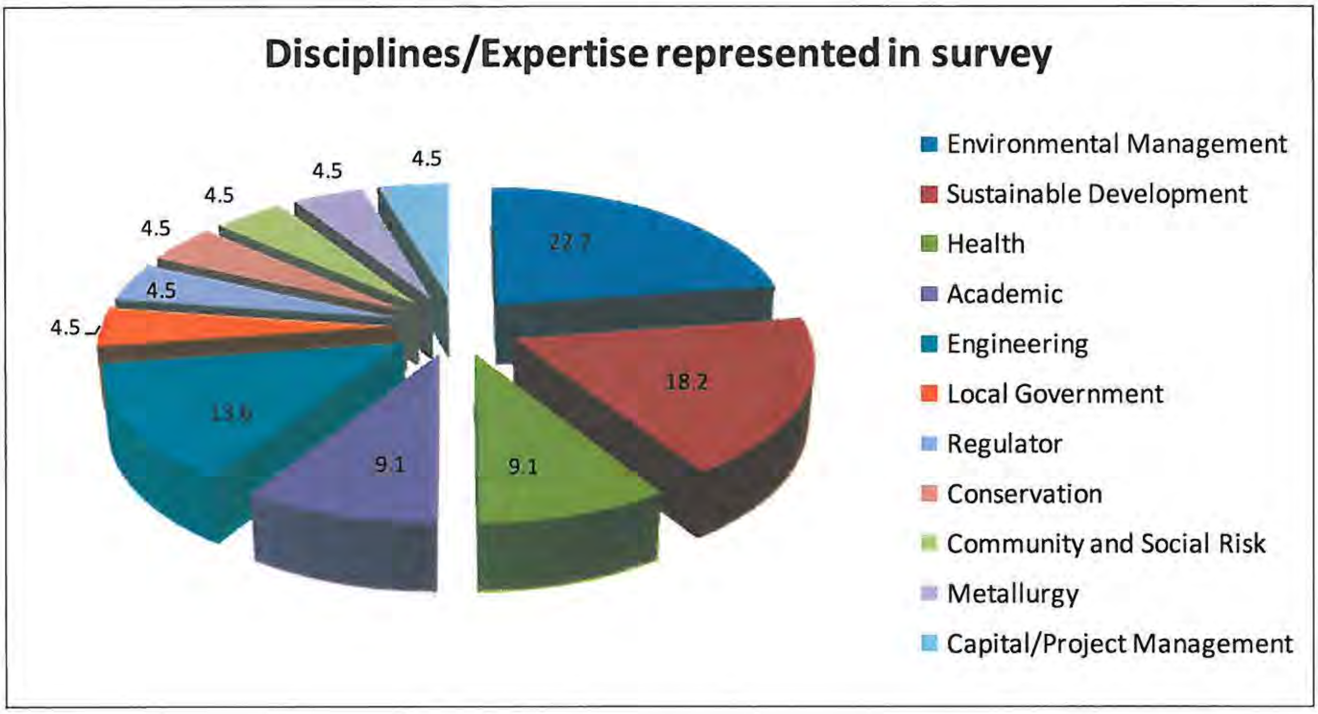

Figure 3.2 The breakdown of the different disciplines that were targeted in the questionnaire survey

The main reason for consulting several different role-players was that the views of different stakeholders were critical in avoiding potential decision-making conflicts (Bardos *et al.* 2000). The questionnaire investigation process was designed to gain insight into the respondent's thinking and understanding on the SDIs deemed relevant in relation to SD today. The questionnaire itself was designed to capture the quantitative sustainable development indicators (SDIs) for possible integration into a SDI Framework and to assess their respective weightings (Neba 2006), all of which have been identified from the literature (Larsen and Gujer 1997; Hellström *et al.* 2000; Hoffman *et al.* 2000; Lettinga 2001; Dunmade 2002; Larsen and Lienert 2003; Braken 2005; Neba 2006). The questionnaires were emailed to each of the respondents, with whom the author has a direct link through an existing working relationship, all of which were returned. Furthermore, the individual choices of all the respondents consulted, were captured using a Likert scale of 1-5. These individual choices were combined to formulate an overall ranking, which ensured an element of objectivity in the ranking process. Other data related to the testing of the identified SDIs and integration into a decision-making model was obtained through the use of (i) financial analysis (low level) and (ii) modelling.

3.3 Analysis of data

Neba (2006) found that the means and standard deviations of such a study did not adequately account for the wide degree of variation in the respondents' judgements of the importance of the SDIs. Therefore an importance index was calculated for each SDI identified in this study by dividing the mean weight allocated to the SDI by the associated standard deviation. The resultant value was then called the Actual Importance Index (AII) (Neba 2006) and was used to distinguish between what constitutes agreement on the importance of a SDI from a GFL perspective. In short, any AII score that was found to be higher than the mean weight for a particular SDI was deemed to be an indication of agreement, while those AII scores that were lower than the mean weight for a particular SDI was deemed to be an indication of disagreement. In effect, where the score for a particular indicator exhibited a high standard deviation i.e. where there was disagreement as to the suitable weighting for that particular indicator, the mean weighting would be reduced. The data analysis was both quantitative and qualitative and was subjected to describing, comparing, evaluating, and modelling. The data was also statistically tested using a One-way ANOVA (Scheffé Post Hoc test) statistical test (Neba 2006). This was done to test whether there is a significant difference between the SDIs based on the AII scores within and between the operational and post closure mining phases. All data was deemed to be credible, transferable, dependable and confirmable (Guba and Lincoln 1994).

3.4 Development and application of a decision making model

The sustainable development indicators (SDIs) that were developed and selected as being of high importance (Figure 5.2 to 5.18), were used to develop a decision making model (Table 5.10). Only the SDIs that were rated as being the most important SDIs within a given category, were incorporated into the decision making model. The classification of the most important SDIs was based on a requirement that the respective AII scores needed to be more than the Mean for the SDI to be selected. In addition, a cut-off of 50 was applied as a minimum outcome in terms of weighting. This was done as it represented the lower half of the score range, which was deemed to be less important, based on industry experience. This approach is acceptable since the operating environment in which different industry players find themselves is often different and hence each case is unique (Hilson 2001b). This approach is also supportive of the fact that the SDIs identified in this study were selected through a participatory process (through the careful selection of respondents) and were deemed to be representative of the circumstances in which GFL finds itself. These SDIs were then subjected to a weighting process (based on the AII) and incorporated into a Microsoft Office Excel based scoring model that was designed to produce a score in terms of the level of SD presented by the project being assessed (Table 5.10). This model was then applied to an actual project that GFL is currently considering. A water treatment project that involves different technology options and a variety of pricing possibilities was used to test the model as a means of demonstrating its effectiveness. Lastly, while the model allows the assessment of two different projects it also, as was the case in this study, allows a specific project to be assessed under different business scenarios.

CHAPTER 4 – RESULTS AND DISCUSSION

4.1 General

The questions in Table 4.1 served as qualifying questions and were included in the questionnaire with the main objective of identifying two groups of respondents and to ensure that all respondents had a good understanding of SD, notwithstanding that fact that they were expected to have a natural bias dependent on their respective levels and category of expertise. Table 4.1 depicts the results obtained during the survey.

Table 4.1 General questions included in the questionnaire that served as qualifying questions

Question posed	Percentage affirmative responses
1. Understanding of SD?	100% yes
2. SD - an important concept?	100% yes
3. SD - Business or Academic consideration?	100% business
4. Gold Fields (GFL) employee?	59% Gold Fields
5. Involvement with Gold Fields (GFL)?	66% involvement to some degree

It should be noted that all the respondents indicated that they had a good understanding of SD and that all the respondents agreed that sustainable development (SD) is both an important concept and a business imperative. Fifty nine percent (59%) of the respondents were GFL employees while the rest (i.e. 41%) were non-GFL employees with varying degrees of exposure to the manner in which GFL conducts its business. These results were deemed important as the targeted respondents needed to have an understanding of SD and also needed to be regarded as mature in their respective areas of expertise. In essence the questionnaire was designed with these biases in mind as the intention was to interrogate the aspects of SD and respondents without a clear understanding would only have skewed the results.

4.2 Integrated Bottom Line Indicators

Operational phase

The relative importance of the responses received from GFL and non-GFL respondents that relate to the selection of Integrated Bottom Line (IBL) indicator categories, applicable to the operational phase of mining, have been presented in Figure 4.1. The responses received from GFL respondents were initially kept separate from the non-GFL respondents for comparative purposes.

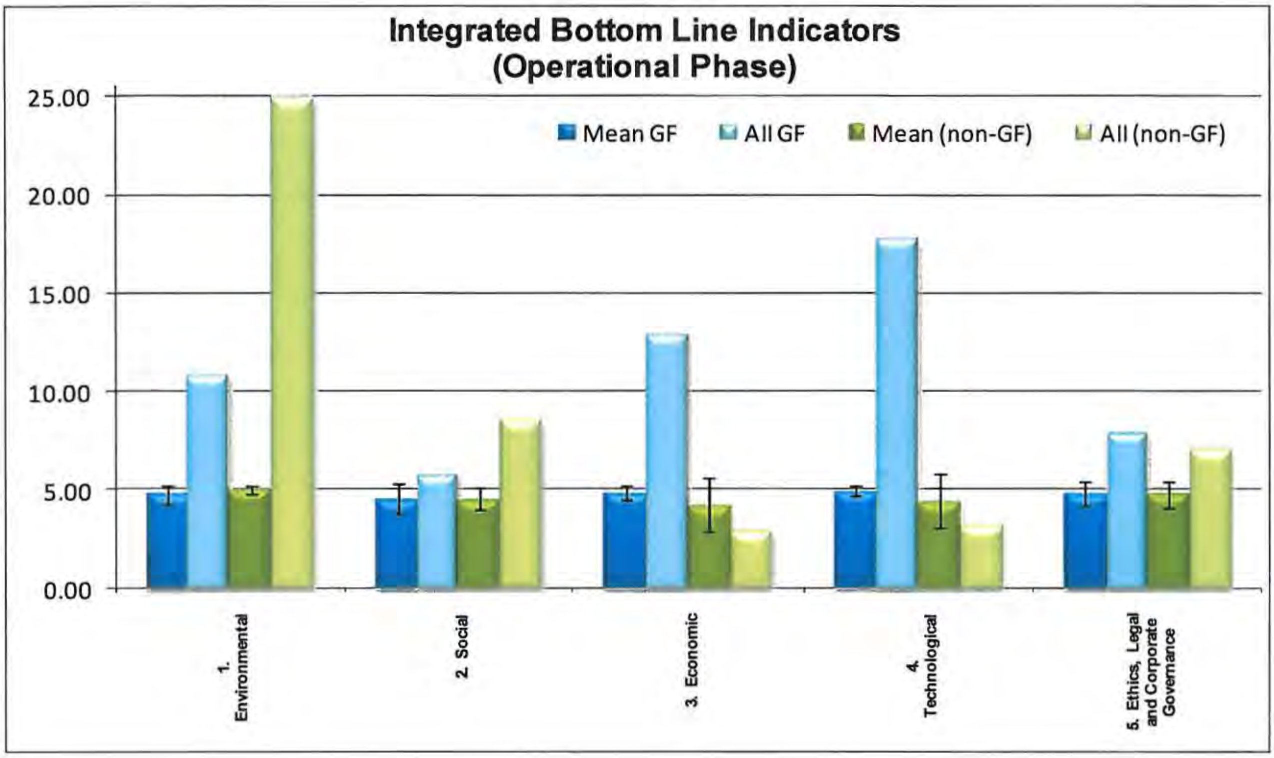

Figure 4.1 Integrated bottom line indicator categories relating to the operational phase, with a distinction between GFL and non-GFL respondents. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the IBL indicator categories for the operational phase of a mine, judged by Gold Fields (GFL) respondents, received high mean weights (4.5 to 4.9) (Figure 4.1). There was also a high degree of agreement between the respondents regarding the actual importance of the IBL indicator categories as indicated by the relatively low respective standard deviations (Figure 4.1). This translated into AII scores that were all higher than the mean weights, which indicate overall agreement that the said indicator categories were all deemed to be important. The calculated AII scores associated with the IBL indicator categories judged by the GFL respondents ranged from 4.9 to 17.8. When considering the AII scores calculated from the GFL respondents mean weights (Figure 4.1), it is evident that the indicator category that was rated as being the most important was the technological (AII = 17.8) indicator category, followed by the economic (AII = 12.9) and environmental (AII = 10.9) indicator categories. The indicator category that was rated the lowest in terms of relative importance but which was however still deemed important was the social category.

Most of the IBL indicator categories for the operational phase of a mine, judged by the non-GFL respondents, received high mean weights (4.2 to 5.0). There was a high level of agreement on the actual importance of the environmental and social indicator categories, as indicated by their relatively low respective standard deviations (Figure 4.1). This translated into relatively high AII scores for the said indicator categories. The calculated AII scores associated with the IBL indicator categories judged by the non-GFL respondents ranged from 3.0 to 25.0. When considering the responses from the non-GFL respondents (Figure 4.1), it is evident that the indicator category that was deemed to be the most important was the environmental (AII = 25) indicator category, followed by the social (AII = 8.6) and the ethics, legal and corporate governance (AII = 7.2) indicator categories. The indicator category that scored the lowest was the economic (AII = 3.0) indicator category, followed by the technological (AII = 3.3) indicator category.

When comparing the operational phase IBL indicator category responses of the GFL and non-GFL respondents, it was found that was no significant difference between the mean scores (ANOVA; df=1,3, p>0.05) and AII scores (ANOVA, df=1,3, p>0.05) of the two respondent categories.

Post closure phase

The relative importance of the responses received from GFL and non-GFL respondents that relate to the selection of Integrated Bottom Line (IBL) indicator categories, applicable to the post closure phase of mining, have been presented in Figure 4.2. The responses received from GFL respondents were initially kept separate from the non-GFL respondents for comparative purposes.

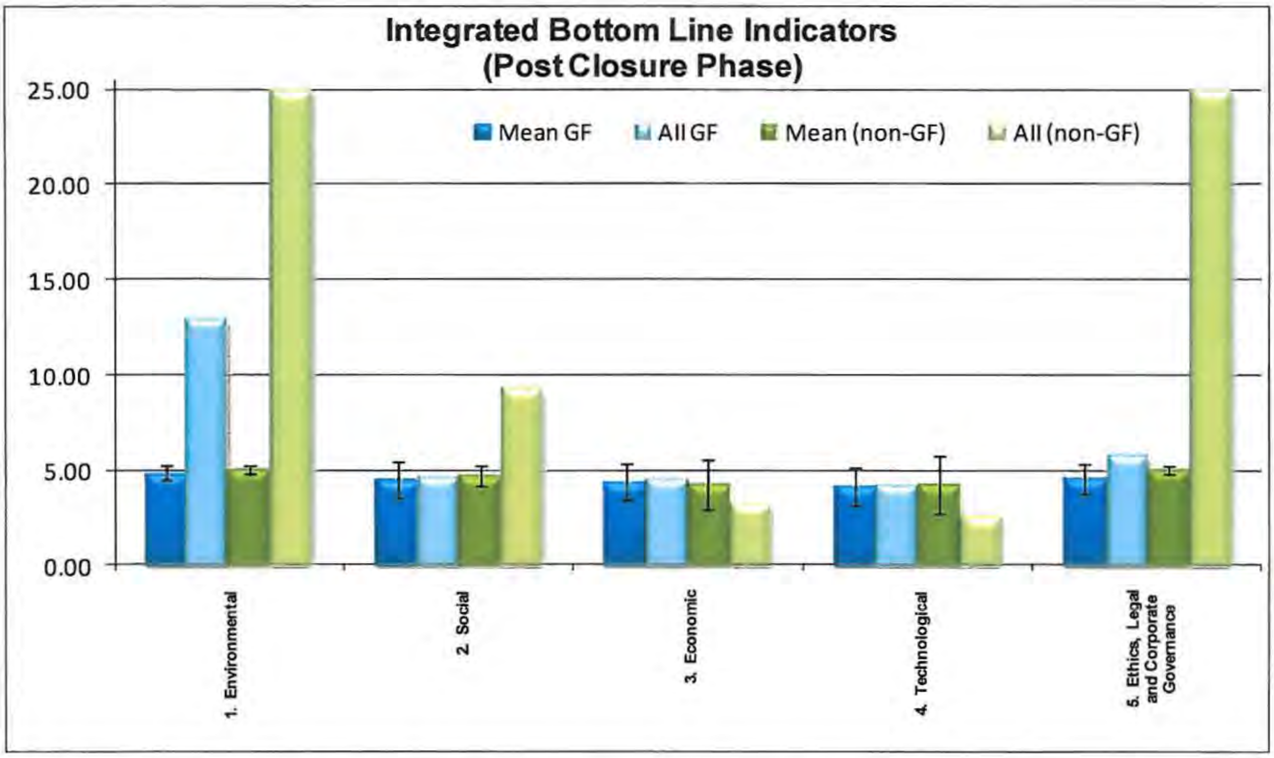

Figure 4.2 Integrated bottom line Indicators relating to the post closure phase, with a distinction between GFL and non-GFL respondents. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the IBL indicator categories for the post closure phase of a mine, judged by GFL respondents, received high mean weights (4.2 to 4.9) (Figure 4.2). There was also a high degree of agreement between the respondents regarding the actual importance of the IBL indicator categories as indicated by the relatively low respective standard deviations (Figure 4.2). This translated into AII scores that were all slightly higher than the mean weights, which indicate overall agreement that the said indicator categories were all deemed to be important. The calculated AII scores associated with the IBL indicator categories judged by the GFL respondents ranged from 4.3 to 12.9. When considering the AII scores calculated from the GFL respondents (Figure 4.2), it is evident that the indicator category that was rated as being the most important was the environmental (AII = 12.9) indicator category, followed by the ethics, legal and corporate governance (AII = 5.9) and the social (AII = 4.6) indicator categories. It is interesting that the environmental indicator category scores higher than the technological and economic SDIs during the post closure phase. This is likely due to the fact that the business is no longer a going concern during post closure and therefore the technological aspects would already have been taken care of. Furthermore, economic decisions pertaining to capital investments are less important, with the exception of the residual operational costs, during the post closure phase since the infrastructure would already have been built by then. The capitalisation of an investment is also only relevant while the business is generating revenue against which the investment is offset, which is important for a going concern. Lastly, the environmental state of the previously mined area is an important closure issue since the impacting activities of mining would have been ceased thus creating the expectation that rehabilitation would be done. The other indicator categories were generally similar (AII = 4.2 to 4.6). The indicator category that was rated the lowest in terms of relative importance was that covering the technology (AII = 4.2).

Most of the IBL indicator categories for the post closure phase of a mine, judged by the non-GFL respondents, received high mean weights (4.2 to 5.0) (Figure 4.2). There was a high level of agreement on the actual importance of most of the indicator categories like environment and ethics, legal and corporate governance, as indicated by the relatively low respective standard deviations for some of the indicator categories (Figure 4.2). This translated to relatively high AII scores for the said indicator categories. The calculated AII scores associated with the IBL indicator categories judged by the non-GFL respondents ranged from 2.7 to 25.0. When considering the responses from the non-GFL respondents (Figure 4.2), it is evident that the indicator category that was deemed to be the most important was the environmental (AII = 25) indicator category, followed by the social (AII = 8.6) and the ethics, legal and corporate governance (AII = 7.2) indicator categories. The indicator category that scored the lowest was the economic (AII = 3.0) indicator category, followed by the technological (AII = 3.3) indicator category.

When comparing the post closure phase IBL indicator category responses of the GFL and non-GFL respondents, it was found that there was no significant difference between the means (ANOVA, df=1,3, $p>0.05$) and AII scores (ANOVA, df=1,3, $p>0.05$) of the two respondent categories.

Combined response for operational and post closure phases

The relative importance of the responses received from both GFL respondents and non-GFL respondents that relate to the selection of Integrated Bottom Line (IBL) indicator categories, applicable to the operational and post closure phases of mining, were then combined and have been presented in Figure 4.3. The responses relating to the operational phase were kept separate from those relating to the post closure phase for comparative purposes.

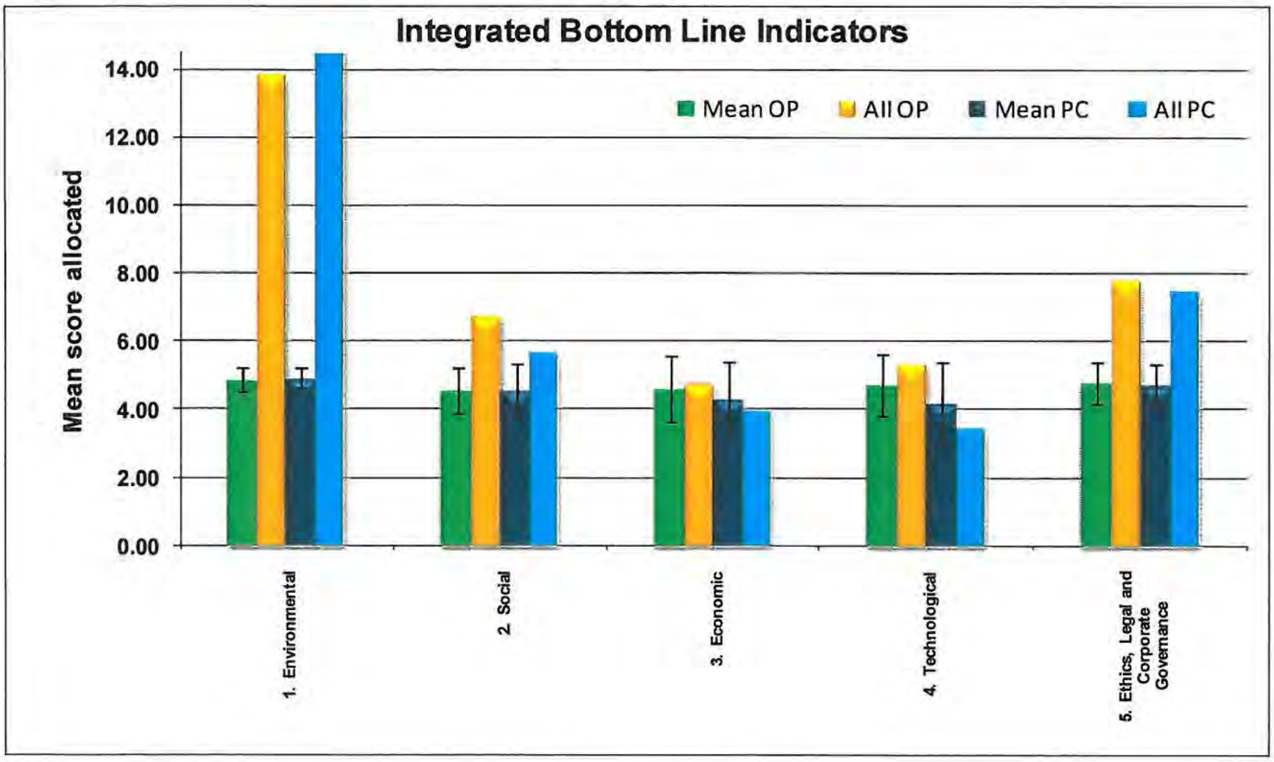

Figure 4.3 Integrated Bottom line Indicators relating to the operational and the post closure phases in mining. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the IBL indicator categories for the operational phase of a mine, judged by the total number of respondents, received high mean weights (4.6 to 4.9) (Figure 4.3). There was also a good degree of agreement between the respondents regarding the actual importance of the IBL indicator categories as indicated by the relatively high mean values (Figure 4.3). This translated into All scores that were all slightly higher than the mean weights, which indicate an overall agreement that the said indicator categories were all deemed to be important. The calculated combined All scores associated with the IBL indicator categories judged by the total number of respondents ranged from 4.8 to 13.9. When considering the All scores combined calculated from the total number of respondents (Figure 4.3), it is evident that the indicator category that was rated as being the most important was the environmental (All = 13.9) indicator category, followed by the ethics, legal and corporate governance (All = 7.8), social (All = 6.8), technological (All = 5.4) and economic (All = 4.8) indicator categories. The indicator category that was rated the lowest in terms of relative importance for the operational phase was the economic (AII = 4.8) indicator category.

Most of the IBL indicator categories for the post closure phase of a mine, judged by the total number of respondents, received high mean weights (4.2 to 4.9) (Figure 4.3). There was a high level of agreement on the actual importance of most of the indicator categories like environment, ethics and social, as indicated by the relatively low respective standard deviations for some of the indicator categories (Figure 4.3). This translated to relatively high AII scores for the said indicator categories. The combined calculated AII scores associated with the IBL indicator categories judged by the total number of respondents ranged from 3.4 to 16.7. When considering the responses from the total number of respondents (Figure 4.3), it is evident that the indicator category that was deemed to be the most important was the environmental (AII = 16.7) indicator category, followed by the ethics, legal and corporate governance (AII = 7.5) and social (AII = 5.7) indicator categories. The indicator categories that scored the lowest was the economic (AII = 4.0) and the technological (AII = 3.4) indicator categories.

When comparing all the responses relating to IBL indicator categories for both the operational phase and the post closure phase, it was found that there was no significant difference between the means (ANOVA, df=1,3, $p>0.05$) but that there was a significant difference between the AII scores (ANOVA, df=1,3, $p<0.05$) for the two mining phases.

The fact that the IBL indicator category mean values for both GFL and non-GFL respondents were relatively high is indicative of the fact that all respondents indicated that they had an understanding of SD. This is an important outcome as the target respondent population needed to have a good understanding of SD in order to add the necessary value towards the development of the decision making model. It should be noted though that the opinions of the respondents are not fully representative of the wider population, which would likely have ranked the social issues higher. The fact that the AII scores for the individual IBL indicator categories differed is indicative of the fact that the respondents emanated from different backgrounds and areas of expertise. This was also important as the second objective of the questionnaire and the selected respondents was to collate the best wisdom from the said disciplines in order to ultimately develop a robust model that is fully reflective of all the aspects of

SD. Furthermore, this was an expected outcome since the respondents were selected due to their potential value-add to the study in terms of expertise and due to the fact that the intention was to gain insights into their respective competencies.

The result of the assessment of the IBL indicator categories is that the GFL respondents place more emphasis on the technological, environmental and economic indicator categories. This is most likely due to the fact that GFL is business driven and its employees are keenly aware of the economic arena in which GFL operates. The emphasis on the environmental indicator category is likely a result of the ISO14001 drive that GFL embarked on more than eight years ago. The associated certification, which is now in its third certification cycle, has created a high level of awareness within the organisation and among the company's decision makers. While the social and ethics, legal and corporate governance indicator categories scored lower, they were highlighted as important as their AII scores were all above their respective means. This appreciation for the social and corporate governance requirements would most likely be the result the Company's Mining Charter requirements in South Africa and the Governance requirements associated with GFL's New York Stock Exchange listing.

The focus of the non-GFL respondents was mainly on environmental, social and ethics, legal and corporate governance indicator categories with lower ratings on the economic, and technological. This is expected due to the natural bias amongst respondents (e.g. academics) who are not exposed to the internal business requirements of a specific company like GFL and who tend to consider the issues at hand possibly from an emotional point of view.

When considering all the responses and the associated score of the combined expertise then the indicators that were deemed to be the most important by all the respondents were the (i) environment, (ii) ethics, legal and corporate governance, and (iii) social. It should be reiterated though, despite the reduced emphasis of the non-GFL respondents on the economic and technological indicators, when considering the combined effect of the two respondent categories, that all five IBL indicator categories were deemed to be important in terms of evaluating the level of SD of any capital investment.

While the above scoring provided important insights into the relative importance of the broad sustainability indicator groups, it was considered necessary to investigate the relative importance of the sub-components in greater detail. The results of this more detailed analysis are presented below.

4.3 Financial SDIs

Operational phase

The relative importance of the responses received from GFL and non-GFL respondents that relate to the selection of financial SDIs, applicable to the operational phase of mining, have been presented in Figure 4.4. The responses received from GFL respondents were initially kept separate from the non-GFL respondents for comparative purposes.

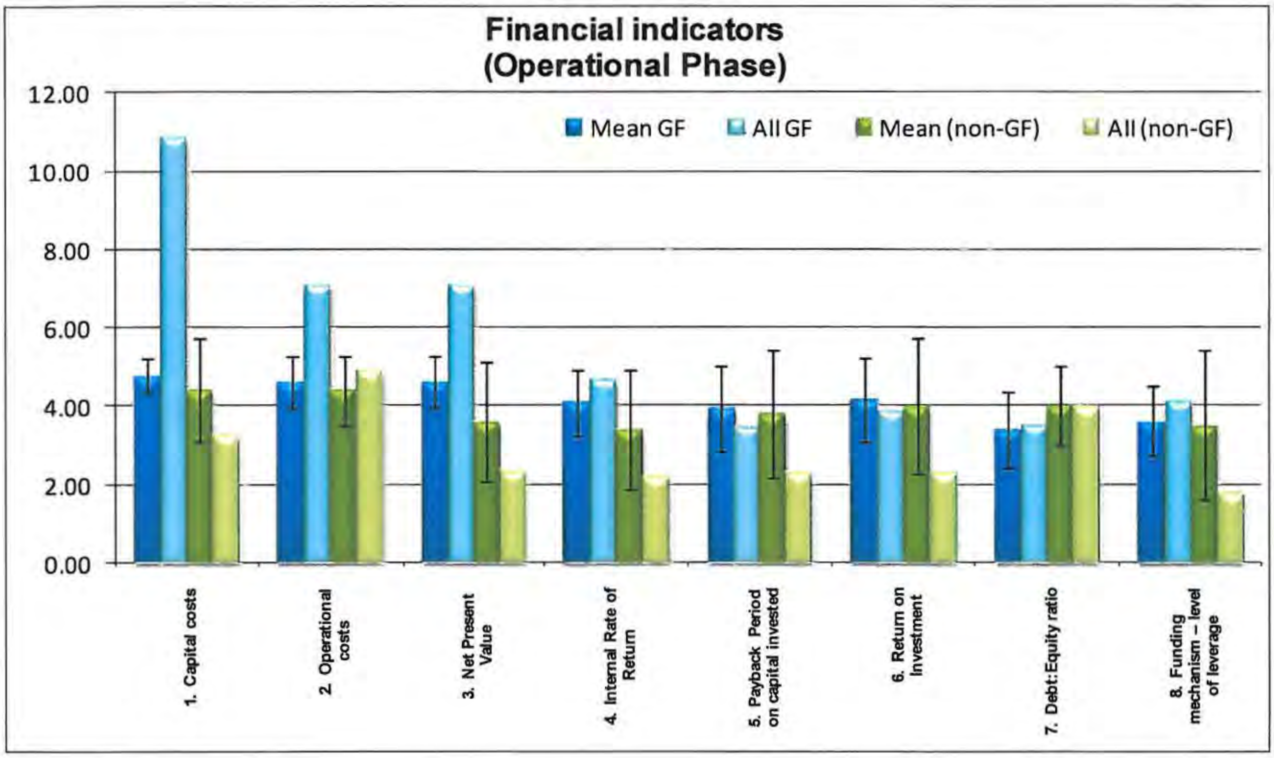

Figure 4.4 Financial SDIs relating to the operational phase, with a distinction between GFL and non-GFL respondents. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the financial SDIs for the operational phase of a mine, judged by the GFL respondents, received relatively high mean weights (3.4 to 4.8) (Figure 4.4). There was a high level of agreement on the actual importance of most of the SDIs like capital costs, operational costs, net present value, internal rate of return and the funding mechanism SDIs, as indicated by the relatively low respective standard deviations for some of the SDIs (Figure 4.4). This translated to relatively high AII scores for the said SDIs. The calculated AII scores associated with the financial SDIs judged by the GFL respondents ranged from 3.5 to 10.9. When considering the AII scores calculated from the GFL respondents (Figure 4.4), it is evident that the SDI that was rated as being the most important was the capital costs (AII = 10.9), followed by operational costs (AII = 7.1), net present value (AII = 7.1) and internal rate of return (AII = 4.7). The other SDIs were rated as less important. The SDIs that were rated the least important were the Debt:Equity ratio (AII = 3.5) and Payback period on the capital used (AII = 3.5) SDIs.

Most of the financial SDIs for the operational phase of a mine, judged by the non-GFL respondents, received relatively high mean weights (3.4 to 4.4) (Figure 4.4). There was a lower level of agreement on the actual importance of most of the SDIs with only the operational cost SDI being highlighted as being important. The other financial SDIs all scored lower on the AII, as indicated by the relatively low respective standard deviations for some of the SDIs (Figure 4.4). This translated to relatively low AII scores for the financial SDIs. The calculated AII scores associated with the financial SDIs judged by the non-GFL respondents ranged from 1.8 to 4.9. When considering the AII scores calculated from the non-GFL respondents (Figure 4.4), it is evident that the SDI that was rated as being the most important was the operational costs (AII = 4.9) SDI followed by the debt:equity ratio (AII = 4.0) SDI. The other SDIs were all rated as less important. The SDI that was rated the least important was the funding mechanism – level of leverage (AII = 1.8) SDI.

When comparing the operational phase financial SDI responses of the GFL and non-GFL respondents, it was found that was no significant difference between the means (ANOVA, df=1,6, $p>0.05$) and AII scores (ANOVA, df=1,6, $p>0.05$) of the two respondent categories.

Post closure phase

The relative importance of the responses received from GFL and non-GFL respondents that relate to the selection of financial SDIs, applicable to the post closure phase of mining, have been presented in Figure 4.5. The responses received from GFL respondents were initially kept separate from the non-GFL respondents for comparative purposes.

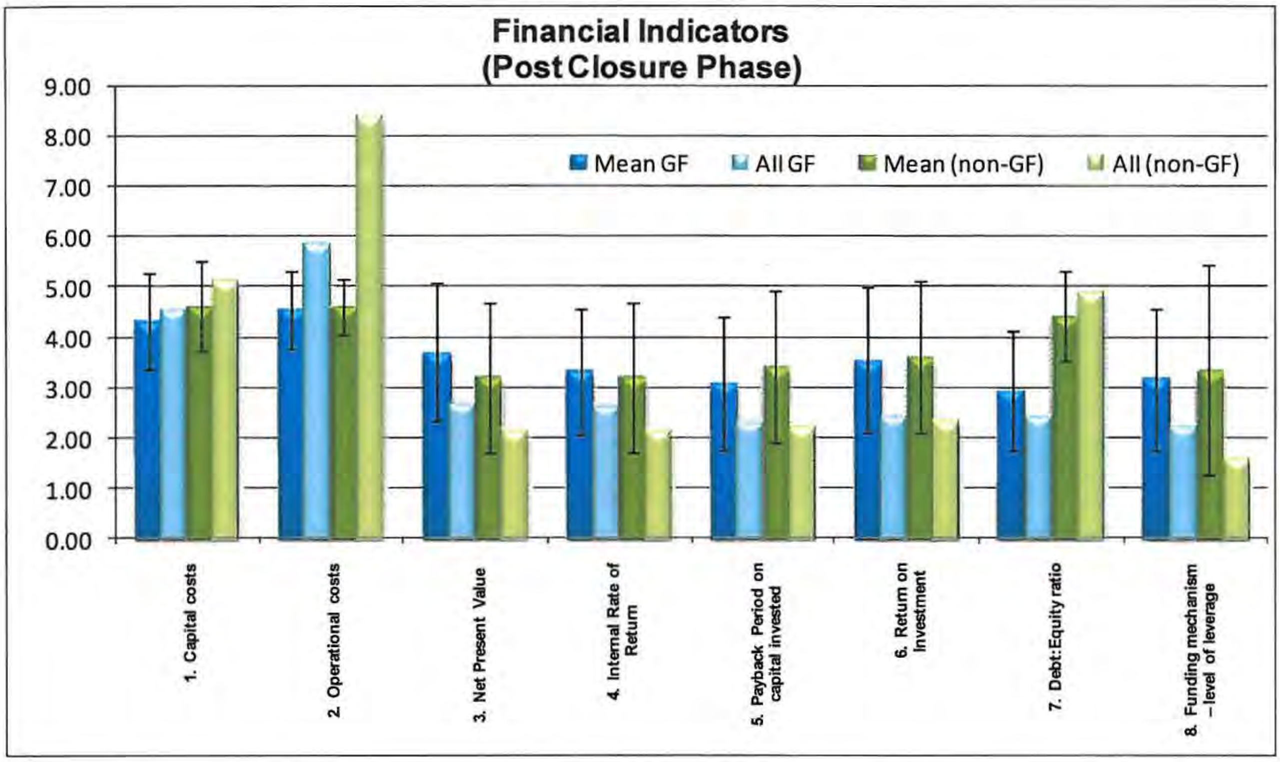

Figure 4.5 Financial SDIs relating to the post closure phase, with a distinction between GFL and non-GFL Respondents. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Some of the financial SDIs for the post closure phase of a mine, judged by the GFL respondents, received moderately high mean weights (2.9 to 4.5) (Figure 4.5). There was a lower level of agreement on the actual importance of most of the SDIs with the exception of the capital costs and the operational costs SDIs as indicated by their relatively low respective standard deviations (Figure 4.5). This translated to relatively higher AII scores for the said SDIs. The calculated AII scores associated with the financial SDIs judged by the GFL respondents ranged from 2.2 to 5.9. When considering the AII scores calculated from the GFL respondents (Figure 4.5), it is evident that the SDI that was rated as being the most important was the operational costs (AII = 5.9), followed by the capital costs (AII = 4.5) SDI. The other SDIs were rated as less important, with the funding mechanism – level of leverage (AII = 2.2) SDI being rated the lowest.

Most of the financial SDIs for the post closure phase of a mine, judged by the non-GFL respondents, received relatively high mean weights (3.2 to 4.6) (Figure 4.5). There was a lower level of agreement on the actual importance of most of the SDIs with the capital costs, operational costs and Debt:Equity ratio SDIs being highlighted as being important. The other financial SDIs all scored lower on the AII, as indicated by the relatively high respective standard deviations for some of the SDIs (Figure 4.4). This translated to relatively low AII scores for the financial SDIs. The calculated AII scores associated with the financial SDIs judged by the non-GFL respondents ranged from 1.6 to 8.4. When considering the AII scores calculated from the non-GFL respondents (Figure 4.5), it is evident that the SDI that was rated as being the most important was the operational costs (AII = 8.4) followed by the capital costs (AII = 5.1) and the debt:equity ratio (AII = 4.9) SDI. The other SDIs were all rated as less important. The SDI that was rated the least important was the funding mechanism – level of leverage (AII = 1.6) SDI.

When comparing the post closure phase financial responses of the GFL and non-GFL respondents, it was found that there was no significant difference between the means (ANOVA, df=1,6, $p>0.05$) but that there was a significant difference between the AII scores (ANOVA, df=1,6, $p<0.05$) of the two respondent categories.

Combined response for operational and post closure phases

The relative importance of the responses received from both GFL respondents and non-GFL respondents that relate to the selection of financial SDIs, applicable to the operational and post closure phases of mining, were then combined and have been presented in Figure 4.6. The responses relating to the operational phase were kept separate from those relating to the post closure phase for comparative purposes.

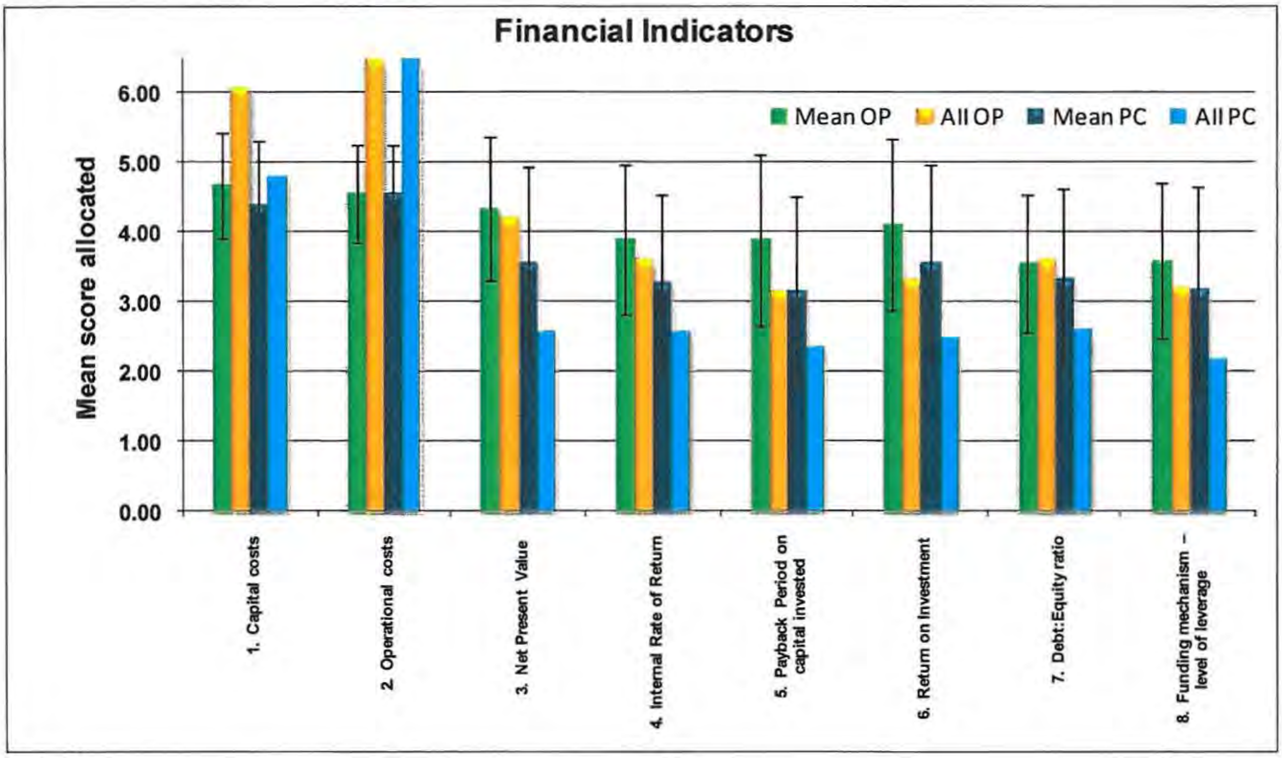

Figure 4.6 Financial SDIs relating to the operational and the post closure phases in mining. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the financial SDIs for the operational phase of a mine, judged by the total number of respondents, received high mean weights (3.6 to 4.7) (Figure 4.6). There was also a high degree of agreement between the respondents regarding the actual importance for the capital costs and operational costs SDIs as indicated by the relatively low respective standard deviations (Figure 4.6). This translated into All scores that were all higher than the mean weights, which indicate overall agreement that the said SDIs were all deemed to be important. The calculated All scores associated with the financial SDIs judged by all the respondents ranged from 3.2 to 6.5. When considering the combined All scores calculated from all the respondents (Figure 4.6), it is evident that the SDI that was rated as being the most important was the operational costs (All = 6.5), followed by the capital costs (All = 6.1) and net present value (All = 4.2) SDIs. The SDI that was rated the lowest in terms of relative importance was the payback period on capital investment (All = 3.1) SDI.

Some of the financial SDIs for the post closure phase of a mine, judged by the total number of respondents, received high mean weights (3.2 to 4.6) (Figure 4.6). There was a high level of agreement on the actual importance of SDIs like capital costs and operational costs, as indicated by the relatively low respective standard deviations for some of the SDIs (Figure 4.6). This translated to relatively high AII scores for the said SDIs. The calculated AII scores associated with the financial SDIs judged by the total number of respondents ranged from 2.2 to 6.5. When considering the responses (Figure 4.6), it is evident that the SDI that was deemed to be the most important was the operational costs (AII = 6.5) SDI, followed by the capital costs (AII = 4.8) SDI. The SDI that scored the lowest was the payback period (AII = 2.4) SDI.

When comparing the combined responses relating to financial SDIs for both the operational phase and the post closure phase, it was found that there was a significant difference between the means (ANOVA, df=1,6, $p<0.05$) and between the AII scores (ANOVA, df=1,6, $p<0.05$) of the two mining phases. This can be explained by the fact that the financial requirements from both a decision making and expenditure requirement point of view differs between the operational and post closure phases. During the operational phase you have a going concern that is able to operationalise or capitalise expenditure as per its business requirements while the post closure phase is most likely to be fully reliant on provisioning in the form of a trust fund. It is therefore expected that the opinions regarding the importance of the financial SDIs will differ between the two phases.

When considering the combined score of all the respondents the SDIs that were deemed to be the most important were the (i) capital costs, (ii) operational costs, and (iii) the net present value SDIs in terms of evaluating the level of SD of any capital investment (Figure 4.6). There was agreement between the respondents that the operational and capital costs were important for both the operational and post closure phases. The inclusion of the net present value SDI, despite being rated lower in term of its AII scoring, was included as per the outcome of the weighting exercise. These SDIs were included in the decision making model (Table 4.10). When considering these SDIs, deemed to be the most important by virtue of the associated scoring and weighting, it is clear that the ongoing nature of operational costs is critical. If any project is to be successful for long periods then it is important that those costs are affordable as the contrary will impact on the level of SD. Furthermore, the use of net present value as opposed to payback period is most likely linked to the fact that money invested today has to be compared to its future value as it is important that there is benefit in investing the money today as opposed to waiting for the associated issues to manifest at a later point. Lastly, the fact that these projects are long term projects (i.e. 20 years and longer), many of which are expected to continue long after the mine has closed its doors, renders the pay-back period less critical. Both net present value and payback period are also less critical in the post closure phase as the investment would have been made by then and the project is thus only sensitive to operational costs and the capital costs associated with keeping the infrastructure up to date and effective. .

4.4 Social SDIs

Operational phase

The relative importance of the responses received from GFL and non-GFL respondents that relate to the selection of social SDIs, applicable to the operational phase of mining, have been presented in Figure 4.7. The responses received from GFL respondents were initially kept separate from the non-GFL respondents for comparative purposes. The consideration of social SDIs, as opposed to the focus on conventional environmental issues, is being embraced by the gold mining industry and is making a marked difference (Hilson 2001). In fact it is the focus on stakeholders and their contribution to the overall result that is resulting in improved corporate strategy (Hilson 2001).

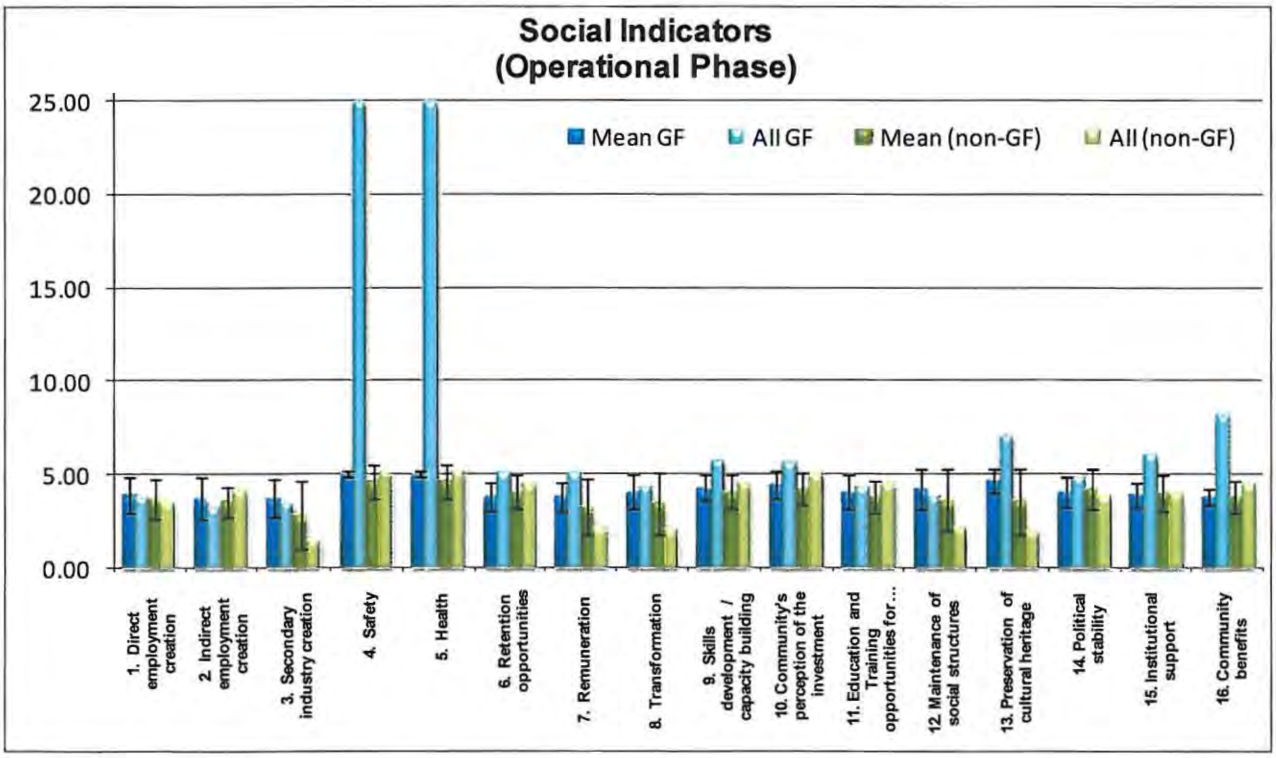

Figure 4.7 Social SDIs relating to the operational phase, with a distinction between GFL and non-GFL respondents. Weights The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the social SDIs for the operational phase of a mine, judged by the GFL respondents, received relatively high mean weights (3.7 to 5.0) (Figure 4.7). There was a high level of agreement on the actual importance of most of the SDIs like safety, health, preservation of cultural heritage SDIs, as indicated by the relatively low respective standard deviations for the said SDIs (Figure 4.7). This translated to relatively high AII scores for the said SDIs. The calculated AII scores associated with the social SDIs judged by the GFL respondents ranged from 3.3 to 25.0. When considering the AII scores calculated from the GFL respondents (Figure 4.7), it is evident that the SDIs that were rated as being the most important were the safety (AII = 25.0), health (AII = 25.0), community benefits (AII = 8.3), preservation of cultural heritage (AII = 7.1), skills development/ capacity building (AII = 5.8), Community perception of the investment (AII = 5.7), institutional support (AII = 6.1), and retention opportunities (AII = 5.2) SDIs. The other SDIs were rated as less important. The SDI that was rated the least important was the indirect employment creation (AII = 3.3), followed by the secondary industry creation (AII = 3.6) and the maintenance of social structures (AII = 3.9) SDIs.

Most of the social SDIs for the operational phase of a mine, judged by the non-GFL respondents, received relatively moderate-high mean weights (2.0 to 4.6) (Figure 4.7). There was a lower level of agreement on the actual importance of most of the SDIs with the safety and health SDIs being highlighted as being important. The other social SDIs all scored lower on the AII, as indicated by the relatively high respective standard deviations for most of the SDIs (Figure 4.7). This translated to relatively low AII scores for the social SDIs. The calculated AII scores associated with the social SDIs judged by the non-GFL respondents ranged from 1.6 to 5.1. When considering the AII scores calculated from the non-GFL respondents (Figure 4.7), it is evident that the SDI that was rated as being the most important was the safety (AII = 5.1), followed by the health (AII = 5.1) and the community's perception of the investment (AII = 5.0) SDIs. The other SDIs were all rated as less important.

When comparing the operational phase social responses of the GFL and non-GFL respondents, it was found that there was a significant difference between the means (ANOVA, df=1,14, p<0.05) and All scores (ANOVA, df=1,14, p=0.05) of the two respondent categories.

Post closure phase

The relative importance of the responses received from GFL and non-GFL respondents that relate to the selection of social SDIs, applicable to the post closure phase of mining, have been presented in Figure 4.8. The responses received from GFL respondents were initially kept separate from the non-GFL respondents for comparative purposes.

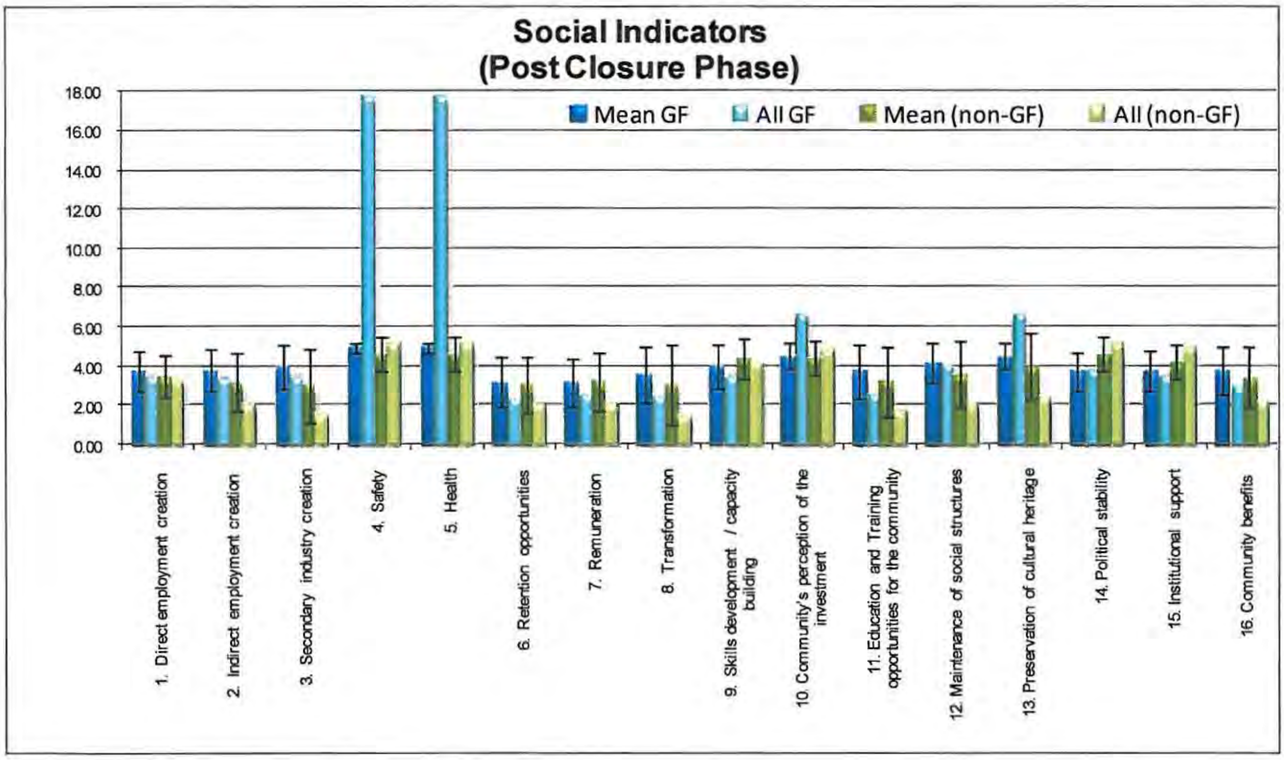

Figure 4.8 Social SDIs relating to the post closure phase, with a distinction between GFL and non-GFL respondents. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the social SDIs for the post closure phase of a mine, judged by the GFL respondents, received relatively high mean weights (3.2 to 4.9) (Figure 4.8). There was a high level of agreement on the actual importance of most of the SDIs like safety, health, preservation of cultural heritage and Community perceptions SDIs, as indicated by the relatively low respective standard deviations for some of the SDIs

(Figure 4.8). This translated to relatively high AII scores for the said SDIs. The calculated AII scores associated with the social SDIs judged by the GFL respondents ranged from 2.5 to 17.8. When considering the AII scores calculated from the GFL respondents (Figure 4.8), it is evident that the SDIs that were rated as being the most important were the safety (AII = 17.8), health (AII = 17.8), community perception of the investment (AII = 6.8), and the preservation of cultural heritage (AII = 6.8) SDIs. The other SDIs were rated as less important. The SDI that was rated the least important was the retention opportunities (AII = 2.5), followed by the remuneration (AII = 2.6) and transformation (AII = 2.5) SDIs.

Most of the social SDIs for the post closure phase of a mine, judged by the non-GFL respondents, received relatively high mean weights (3.0 to 4.6) (Figure 4.8). There was a lower level of agreement on the actual importance of most of the SDIs but with the safety and health SDIs being highlighted as being important. The other social SDIs all scored lower on the AII, as indicated by the relatively high respective standard deviations for most of the SDIs (Figure 4.7). This translated to relatively low AII scores for the social SDIs. The calculated AII scores associated with the social SDIs judged by the non-GFL respondents ranged from 1.5 to 5.1. When considering the AII scores calculated from the non-GFL respondents (Figure 4.7), it is evident that the SDIs that were rated as being the most important were the safety (AII = 5.1), health (AII = 5.1), and political stability (AII = 5.1), followed by the institutional support (AII = 5.0) and the community's perception of the investment (AII = 4.9) SDIs. The other SDIs were all rated as less important. The SDI that was rated the least important was the secondary industry creation (AII = 1.6) SDI.

When comparing the post closure phase social responses of the GFL and non-GFL respondents, it was found that there was a significant difference between the means (ANOVA, df=1,14, $p<0.05$) and AII scores (ANOVA, df=1,14, $p<0.05$) of the two respondent categories.

Combined response for operational and post closure phases

The relative importance of the responses received from both GFL respondents and non-GFL respondents that relate to the selection of social SDIs, applicable to the operational and post closure phases of mining, were then combined and have been presented in Figure 4.9. The responses relating to the operational phase were kept separate from those relating to the post closure phase for comparative purposes.

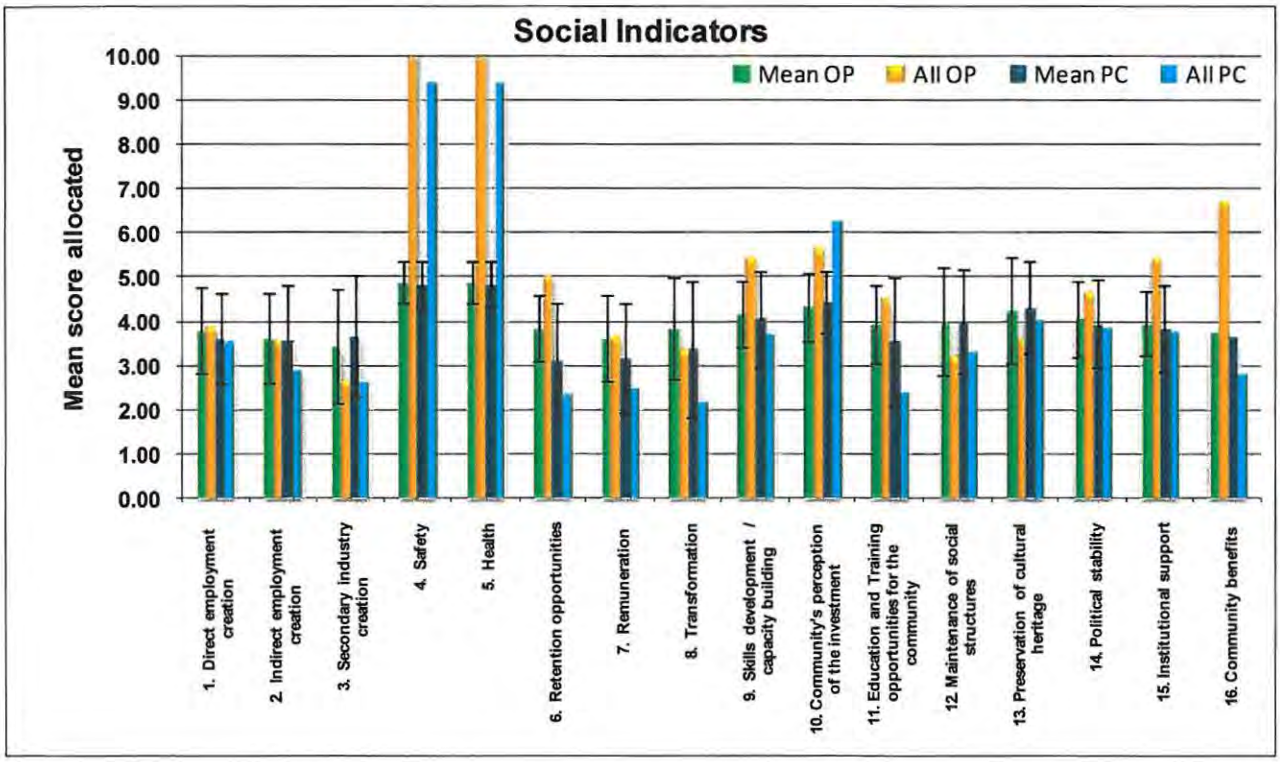

Figure 4.9 Social SDIs relating to the operational and post closure phases in mining. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the social SDIs for the operational phase of a mine, judged by the total number of respondents, received high mean weights (3.4 to 4.9) (Figure 4.9). There was also a relatively high degree of agreement between the respondents regarding the actual importance for the safety, health, community's perception of the investment, skills development/ capacity building and institutional support SDIs as indicated by the relatively low respective standard deviations (Figure 4.9). This translated into AII scores that were all higher than the mean weights, which indicate overall agreement that the said SDIs were all deemed to be important. The calculated AII scores associated with the social SDIs judged by the total number of respondents ranged from 2.7 to 10.4. When considering the combined AII scores calculated from the total number of respondents (Figure 4.9), it is evident that the SDIs that were rated as being the most important were the safety (AII = 10.4) and health (AII = 10.4) SDIs, followed by the community benefits (AII – 6.7), the community's perception of the investment (AII = 5.7), skills development/ capacity building (AII = 5.4), retention opportunities (AII = 5.0), direct employment (AII = 3.9) and remuneration (AII = 3.7) SDIs. The SDI that was rated the lowest in terms of relative importance was the indirect employment (AII = 2.7) SDI.

Some of the social SDIs for the post closure phase of a mine, judged by all the respondents, received high mean weights (3.1 to 4.8) (Figure 4.9). There was a lower level of agreement on the actual importance but some SDIs like safety, health and community perception were agreed on, as indicated by the relatively low respective standard deviations for some of the SDIs (Figure 4.9). This translated to relatively high AII scores for the said SDIs. The calculated AII scores associated with the social SDIs judged by the total number of respondents ranged from 2.2 to 9.4. When considering the responses (Figure 4.9), it is evident that the SDIs that were deemed to be the most important were the safety (AII = 9.4) and health (AII = 9.4) SDIs, followed by the community perception of the investment (AII = 6.3) SDI. The SDI that scored the lowest was the transformation (AII = 2.2) SDI.

When comparing all the responses relating to social SDIs for both the operational phase and the post closure phase, it was found that there was a significant difference between the means (ANOVA, df=1,13, $p<0.05$) and between the AII scores (ANOVA, df=1,13, $p<0.05$) of the two mining phases.

When considering the combined score of all the respondents the SDIs that were deemed to be the most important were the (i) safety, (ii) health, and (iii) community's perception of the investment, (iv) Skills development/ capacity building, (v) Political stability, (vi) retention opportunities (vii) education and training opportunities for the community, (viii) preservation of cultural heritage, (ix) institutional support, and (x) community benefits SDIs in terms of evaluating the level of SD of any capital investment (Figure 4.9). There was agreement between the respondents that the safety, health, community's perception of the investment SDIs were important for both the operational and post closure phases. These SDIs were included in the decision making model (Table 4.10). Safety and health are issues that have become very prominent in the industry today due to the statistics associated with mining at close to 4000m underground. The inclusion of the community's perception is indicative of the fact that mining companies can no longer mine in any area without taking the affected community into account. Gone are the days when a mining company was allowed to do anything without the associated accountability. Indirect employment was not deemed important, which is likely due to the fact that indirect employment and its associated mine dependency, is one of the reasons why communities expand in the vicinity of a mine and are then forced to close once the mine closes. These SDIs are also critical in encouraging a more equitable distribution of benefits and in improving the quality of life of the surrounding community and in so doing maintaining GFL's social license to operate (Hilson and Basu 2003, Azapagic 2004).

4.5 Environmental SDIs

Operational phase

The relative importance of the responses received from GFL and non-GFL respondents that relate to the selection of environmental SDIs, applicable to the operational phase of mining, have been presented in Figure 4.10. The responses received from GFL respondents were initially kept separate from the non-GFL respondents for comparative purposes. Mining is inherently associated with environmental destruction unless mitigation is implemented proactively (Hilson 2001b) simply because some of these problems are not preventable form the onset (Hilson and Basu 2003). It should be noted that, according to Hilson (2001), the prevention of environmental impacts from the onset is likely to contribute to the overall successful implementation of SD. This is supportive of the identification and use of suitable environmental SDIs. A mining operation that is serious about SD must minimise its environmental impacts (Hilson and Basu 2003) and to do so it is necessary to monitor in the form of SDIs.

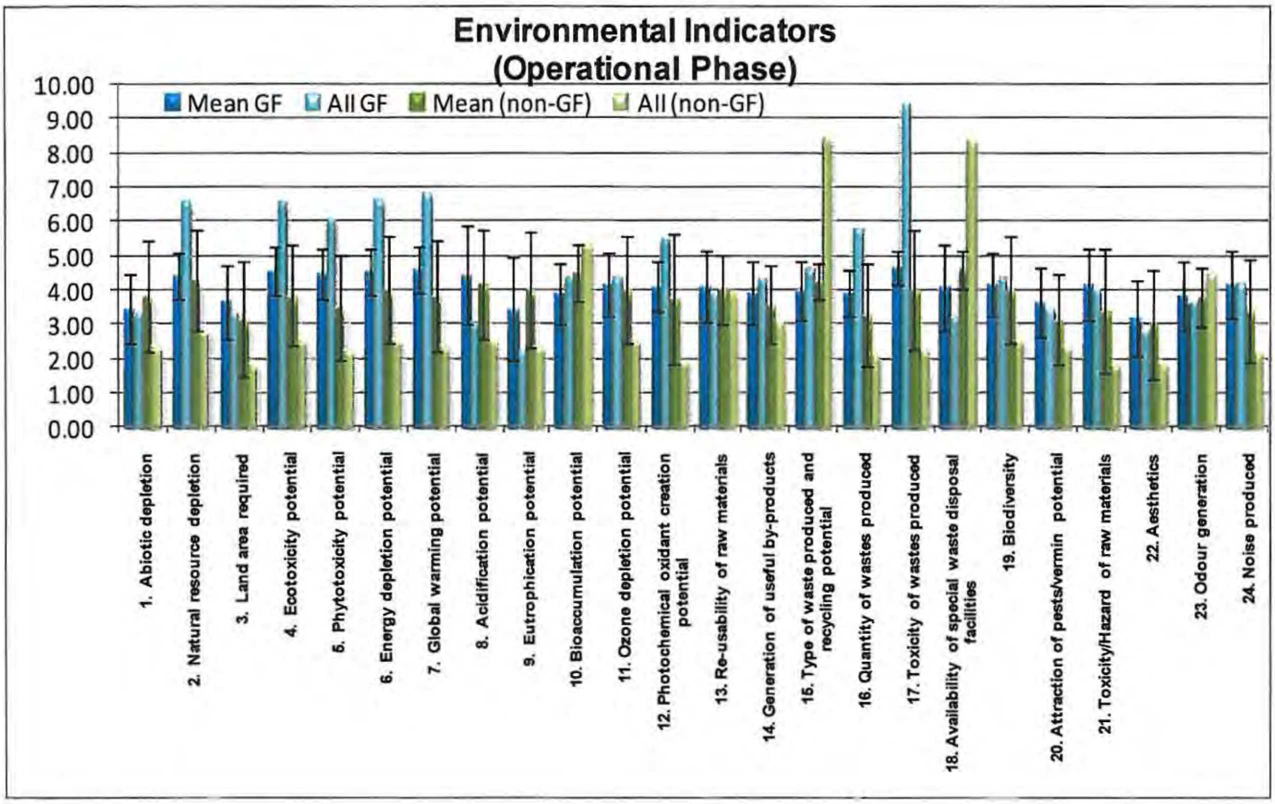

Figure 4.10 Environmental SDIs relating to the operational phase, with a distinction between GFL and non-GFL respondents. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the environmental SDIs for the operational phase of a mine, judged by the GFL respondents, received relatively high mean weights (3.2 to 4.7) (Figure 4.10). There was a high level of agreement on the actual importance of most of the SDIs like toxicity, global warming, energy depletion, natural resources, ecotoxicity, phytotoxicity, quantity of waste, and photochemical SDIs, as indicated by the relatively low respective standard deviations for some of the SDIs (Figure 4.10). This translated to relatively high AII scores for the said SDIs. The calculated AII scores associated with the environmental SDIs judged by the GFL respondents ranged from 2.3 to 9.5. When considering the AII scores calculated from the GFL respondents (Figure 4.10), it is evident that the SDIs that were rated as being the most important were the toxicity of wastes produced (AII = 9.5), global warming potential (AII = 6.9), energy depletion potential (AII = 6.7), natural resource depletion (AII = 6.6), ecotoxicity potential (AII = 6.6), phytotoxicity potential (AII = 6.1), quantity of wastes produced (AII = 5.9), photochemical oxidant creation potential (AII = 5.6) SDIs. The other SDIs were rated as less important. The SDI that was rated the least important was the eutrophication potential (AII = 2.3) SDI.

Most of the environmental SDIs for the operational phase of a mine, judged by the non-GFL respondents, received relatively high mean weights (3.1 to 4.3) (Figure 4.10). There was a lower level of agreement on the actual importance of most of the SDIs but with the odour, bioaccumulation, disposal facilities and type of waste SDIs being highlighted as being important. The other environmental SDIs all scored lower on the AII, as indicated by the relatively high respective standard deviations for most of the SDIs (Figure 4.10). This translated to relatively low AII scores for the environmental SDIs. The calculated AII scores associated with the environmental SDIs judged by the non-GFL respondents ranged from 1.9 to 8.5. When considering the AII scores calculated from the non-GFL respondents (Figure 4.10), it is evident that the SDIs that were rated as being the most important were the type of waste produced and recycling potential (AII = 8.5), availability of special waste disposal facilities (AII = 8.4), bioaccumulation potential (AII = 6.4), followed by the odour generation (AII = 4.5) SDI. The other SDIs were all rated as less important. The SDI that was rated the least important was the land area required (AII = 1.9) SDI.

When comparing the operational phase Environmental responses of the GFL and non-GFL respondents, it was found that was no significant difference between the means (ANOVA, df=1,22, $p>0.05$) and AII scores (ANOVA, df=1,22, $p>0.05$) of the two respondent categories.

Post closure phase

The relative importance of the responses received from GFL and non-GFL respondents that relate to the selection of environmental SDIs, applicable to the post closure phase of mining, have been presented in Figure 4.11. The responses received from GFL respondents were initially kept separate from the non-GFL respondents for comparative purposes.

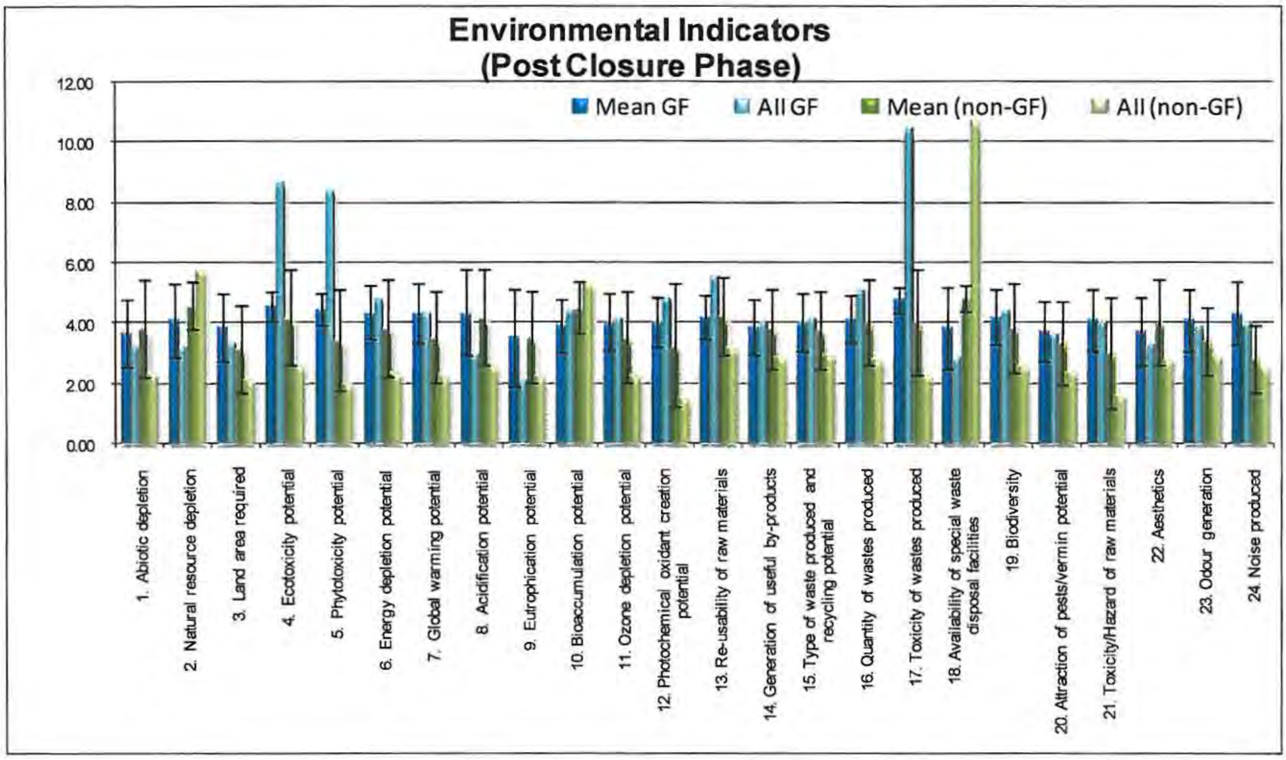

Figure 4.11 Environmental SDIs relating to the post closure phase, with a distinction between GFL and non-GFL respondents. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the environmental SDIs for the post closure phase of a mine, judged by the GFL respondents, received relatively high mean weights (3.5 to 4.8) (Figure 4.11). There was a high level of agreement on the actual importance of some of the SDIs like toxicity, global warming, energy depletion, ecotoxicity, phytotoxicity, quantity of waste, and photochemical SDIs, as indicated by the relatively low respective standard deviations for some of the SDIs (Figure 4.11). This translated to relatively high AII scores for the said SDIs. The calculated AII scores associated with the social SDIs judged by the GFL respondents ranged from 2.2 to 10.5. When considering the AII scores calculated from the GFL respondents (Figure 4.11), it is evident that the SDIs that were rated as being the most important were the ecotoxicity potential (AII = 8.7), phytotoxicity potential (AII = 8.4), re-usability of raw materials (AII = 5.6), quantity of wastes produced (AII = 5.2), photochemical oxidant creation potential (AII = 4.9), energy depletion potential (AII = 4.9), global warming potential (AII = 4.4), bioaccumulation potential (AII = 4.5), ozone depletion potential (AII = 4.2), generation of useful by-products (AII = 4.1), biodiversity (AII = 4.4), type of waste produced and recycling potential (AII = 4.2) SDIs. The other SDIs were rated as less important. The SDI that was rated the least important was the eutrophication potential (AII = 2.2) SDI.

Most of the environmental SDIs for the post closure phase of a mine, judged by the non-GFL respondents, received relatively high mean weights (1.6 to 4.8) (Figure 4.11). There was a lower level of agreement on the actual importance of most of the SDIs but with the availability of special waste facilities, natural resources and bioaccumulation SDIs being highlighted as being important. The other environmental SDIs all scored lower on the AII, as indicated by the relatively high respective standard deviations for most of the SDIs (Figure 4.11). This translated to relatively low AII scores for the environmental SDIs. The calculated AII scores associated with the environmental SDIs judged by the non-GFL respondents ranged from 1.6 to 10.7. When considering the AII scores calculated from the non-GFL respondents (Figure 4.11), it is evident that the SDIs that were rated as being the most important were the availability of special waste disposal facilities (AII = 10.7), natural resource depletion (AII = 5.8), and bioaccumulation potential (AII = 5.4) SDIs. The other SDIs were all rated as less important. The SDIs that were rated the least important were the photochemical oxidant creation potential (AII = 1.6) and toxicity of wastes produced (AII = 1.6).

When comparing the post closure phase Environmental responses of the GFL and non-GFL respondents, it was found that there was no significant difference between the means (ANOVA, df=1,22, $p>0.05$) and AII scores (ANOVA, df=1,22, $p>0.05$) of the two respondent categories.

Combined response for operational and post closure phases

The relative importance of the responses received from both GFL respondents and non-GFL respondents that relate to the selection of environmental SDIs, applicable to the operational and post closure phases of mining, were then combined and have been presented in Figure 4.12. The responses relating to the operational phase were kept separate from those relating to the post closure phase for comparative purposes.

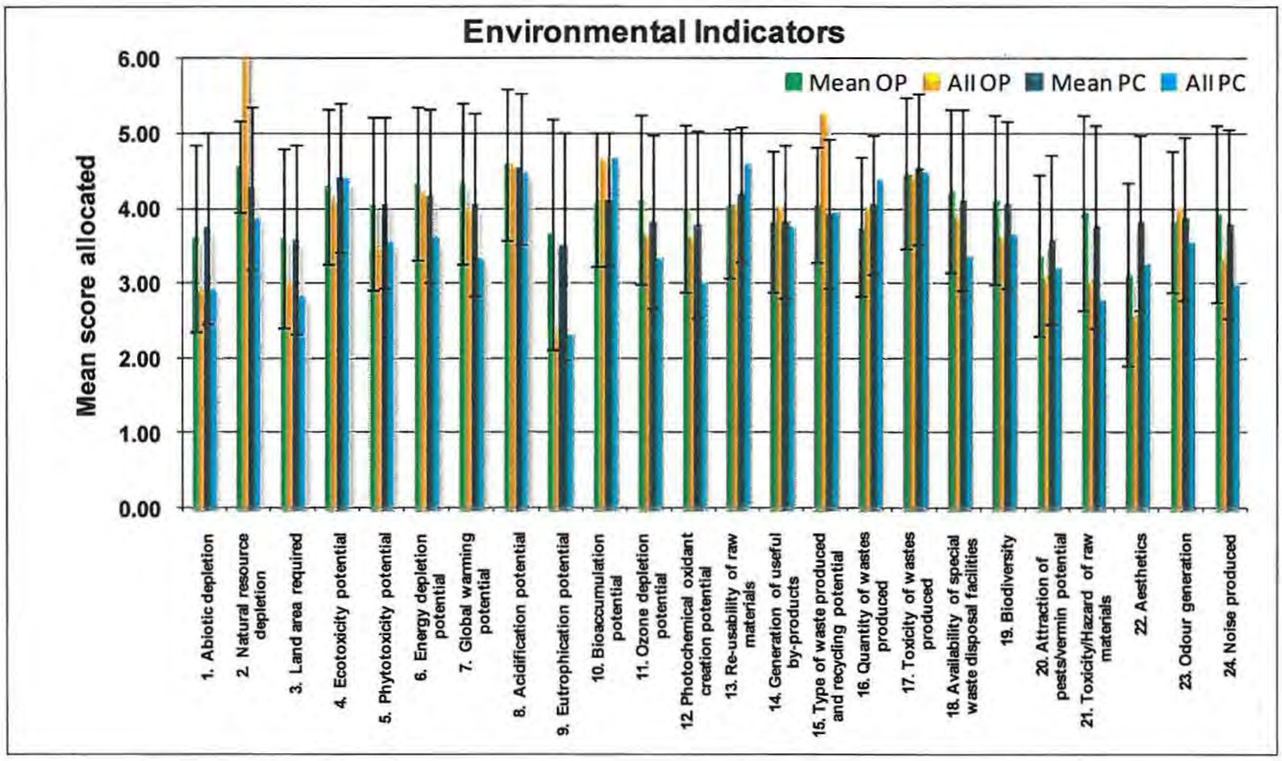

Figure 4.12 Environmental SDIs relating to the operational and the post closure phases in mining. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the environmental SDIs for the operational phase of a mine, judged by the total number of respondents, received high mean weights (3.1 to 4.6) (Figure 4.12). There was also a relatively high degree of agreement between the respondents regarding the actual importance for the natural resource depletion, bioaccumulation, reusability, and quantity waste produced SDIs as indicated by the relatively low respective standard deviations (Figure 4.12). This translated into AII scores that were all higher than the mean weights, which indicate overall agreement that the said SDIs were all deemed to be important. The calculated AII scores associated with the environmental SDIs judged by the total number of respondents ranged from 2.4 to 7.4. When considering the combined AII scores calculated from the total number of respondents (Figure 4.12), it is evident that the SDI that was rated as being the most important was the natural resource depletion (AII = 7.4) SDI, followed by the type of waste produced and recycling potential (AII = 5.2), bioaccumulation potential (AII = 4.7), reusability (AII = 4.1) and quantity of waste produced (AII = 4.0) SDIs. The SDI that was rated the lowest in terms of relative importance was the eutrophication potential (AII = 2.4) SDI.

Some of the environmental SDIs for the post closure phase of a mine, judged by all the respondents, received high mean weights (3.6 to 4.5) (Figure 4.12). There was a lower level of agreement on the actual importance but some SDIs like ecotoxicity, bioaccumulation, reusability and quantity of waste were agreed on, as indicated by the relatively low respective standard deviations for some of the SDIs (Figure 4.12). This translated to relatively high AII scores for the said SDIs. The calculated AII scores associated with the social SDIs judged by the total number of respondents ranged from 2.3 to 4.7. When considering the responses (Figure 4.12), it is evident that the SDIs that were deemed to be the most important were the ecotoxicity potential (AII = 4.4), followed by the bioaccumulation potential (AII = 4.7), reusability of raw materials (AII = 4.6) and quantity of wastes produced (AII = 4.4) SDIs. The SDI that scored the lowest was the eutrophication (AII = 2.3) SDI.

When comparing all the responses relating to environmental SDIs for both the operational phase and the post closure phase, it was found that there was a significant difference between the means (ANOVA, df=1,22, $p<0.05$) and between the AII scores (ANOVA, df=1,22, $p<0.05$) of the two mining phases.

When considering the combined score of all the respondents the SDIs that were deemed to be the most important were the (i) natural resource depletion, (ii) ecotoxicity, (iii) acidification potential, (iv) bioaccumulation, (v) re-usability of raw materials, (vi) quantity of wastes produced, (vii) energy depletion potential, (viii) generation of useful by-products, (ix) type of waste produced, and (x) odour generation SDIs in terms of evaluating the level of SD of any capital investment (Figure 4.9). There was agreement between the respondents that the ecotoxicity potential, followed by the bioaccumulation potential, reusability of raw materials and quantity of wastes produced were important for both the operational and post closure phases, which is supported by Atkinson and Hamilton (1996) as being some of the critical environmental SDIs. These SDIs were included in the decision making model (Table 4.10). Ecotoxicity and bioaccumulation are issues that are currently enjoying a high level of attention in the area in which GFL operates. The potential for acid mine drainage to manifest and the fact that it has done so in other areas (Hilson 2001b), as well as the fact that the legacy that is more than 100 years old in the area, all contribute to the importance of these SDIs. The focus on reusability of raw materials and the quantity of waste produced are equally important due to the history of badly selected water treatment solutions (Gold Fields internal 2009) that create more harm than good.

4.6 Technological SDIs

Operational phase

The relative importance of the responses received from GFL and non-GFL respondents that relate to the selection of technological SDIs, applicable to the operational phase of mining, have been presented in Figure 4.13. The responses received from GFL respondents were initially kept separate from the non-GFL respondents for comparative purposes.

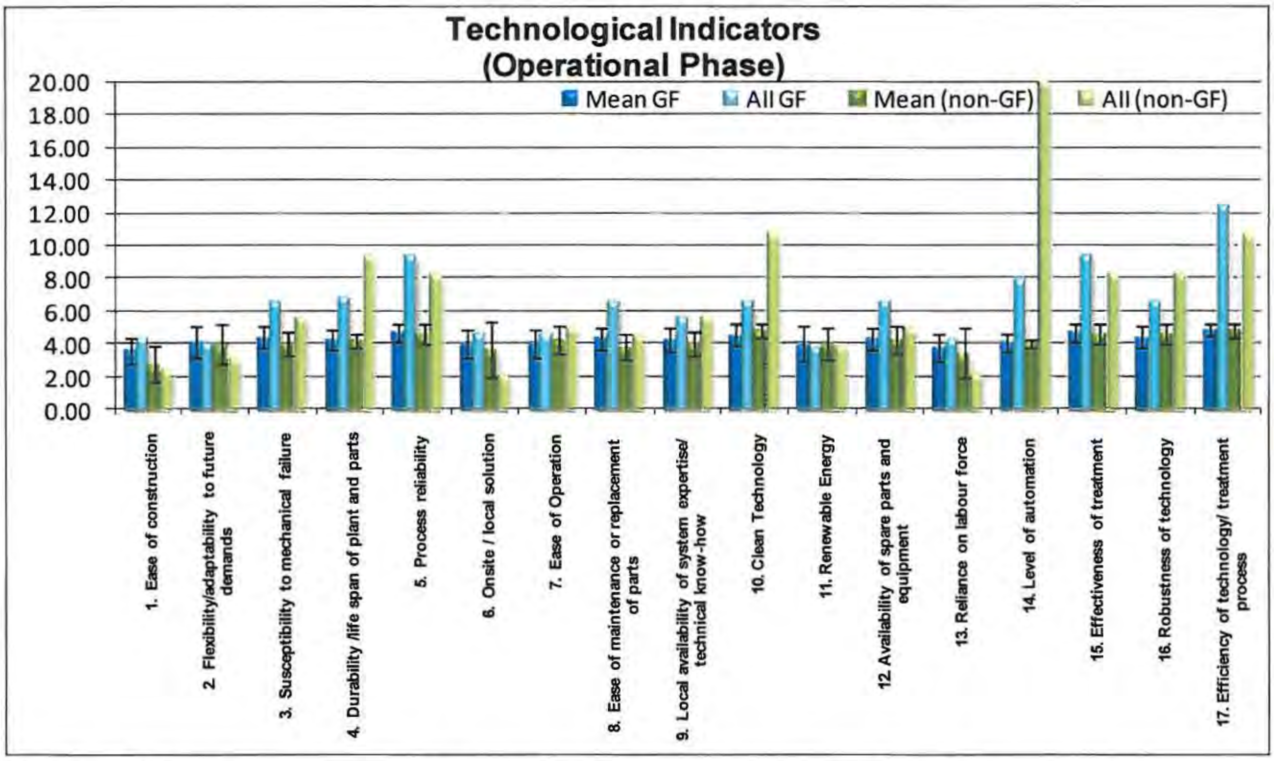

Figure 4.13 Technological SDIs relating to the operational phase, with a distinction between GFL and non-GFL respondents. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the technological SDIs for the operational phase of a mine, judged by the GFL respondents, received relatively high mean weights (3.6 to 4.8) (Figure 13). There was a high level of agreement on the actual importance of most of the SDIs like efficiency of treatment, robustness of technology, effectiveness, level of automation SDIs and so on, as indicated by the relatively low respective standard deviations for some of the SDIs (Figure 4.13). This translated to relatively high AII scores for the said SDIs. The calculated AII scores associated with the technological SDIs judged by the GFL respondents ranged from 4.1 to 12.4. When considering the AII scores calculated from the GFL respondents (Figure 4.13), it is evident that the SDIs that were rated as being the most important were the effectiveness of treatment (AII = 9.5) and process reliability (AII = 9.5), SDIs followed by the level of automation (AII = 7.9), durability/ lifespan of plant and parts (AII = 6.7), clean technology (AII = 6.7), ease of maintenance or replacement of parts (AII = 6.7) and susceptibility to mechanical failure (AII = 6.6) . The other SDIs were rated as less important. The SDI that was rated the least important was the flexibility/ adaptability to future demands (AII = 4.1) SDI.

Most of the technological SDIs for the operational phase of a mine, judged by the non-GFL respondents, received relatively high mean weights (2.8 to 4.8) (Figure 4.13). There was a lower level of agreement on the actual importance of most of the SDIs with the level of automation, efficiency of technology/ treatment process, robustness of technology, effectiveness of treatment, clean technology, durability/ lifespan of plant and parts, and process reliability being highlighted as important. The other social SDIs all scored lower on the AII, as indicated by the relatively high respective standard deviations for most of the SDIs (Figure 4.13). This translated to relatively low AII scores for the other social SDIs. The calculated AII scores associated with the technological SDIs judged by the non-GFL respondents ranged from 2.2 to 20.0. When considering the AII scores calculated from the non-GFL respondents (Figure 4.13), it is evident that the SDIs that were rated as being the most important were the level of automation (AII = 20.0), efficiency of technology/ treatment process (AII = 10.7), clean technology (AII = 10.7), durability/ lifespan of plant and parts, (AII = 9.4) robustness of technology (AII = 8.4), effectiveness of treatment (AII = 8.4), and process reliability (AII = 8.4) SDIs. The other SDIs were all rated as less important. The SDI that was rated the least important was the onsite/ local solution (AII = 2.2) SDI.

When comparing the operational phase technological responses of the GFL and non-GFL respondents, it was found that was a significant difference between the means (ANOVA, df=1,15, $p<0.05$) and AII scores (ANOVA, df=1,15, $p<0.05$) of the two respondent categories.

Post closure phase

The relative importance of the responses received from GFL and non-GFL respondents that relate to the selection of technological SDIs, applicable to the post closure phase of mining, have been presented in Figure 4.14. The responses received from GFL respondents were initially kept separate from the non-GFL respondents for comparative purposes.

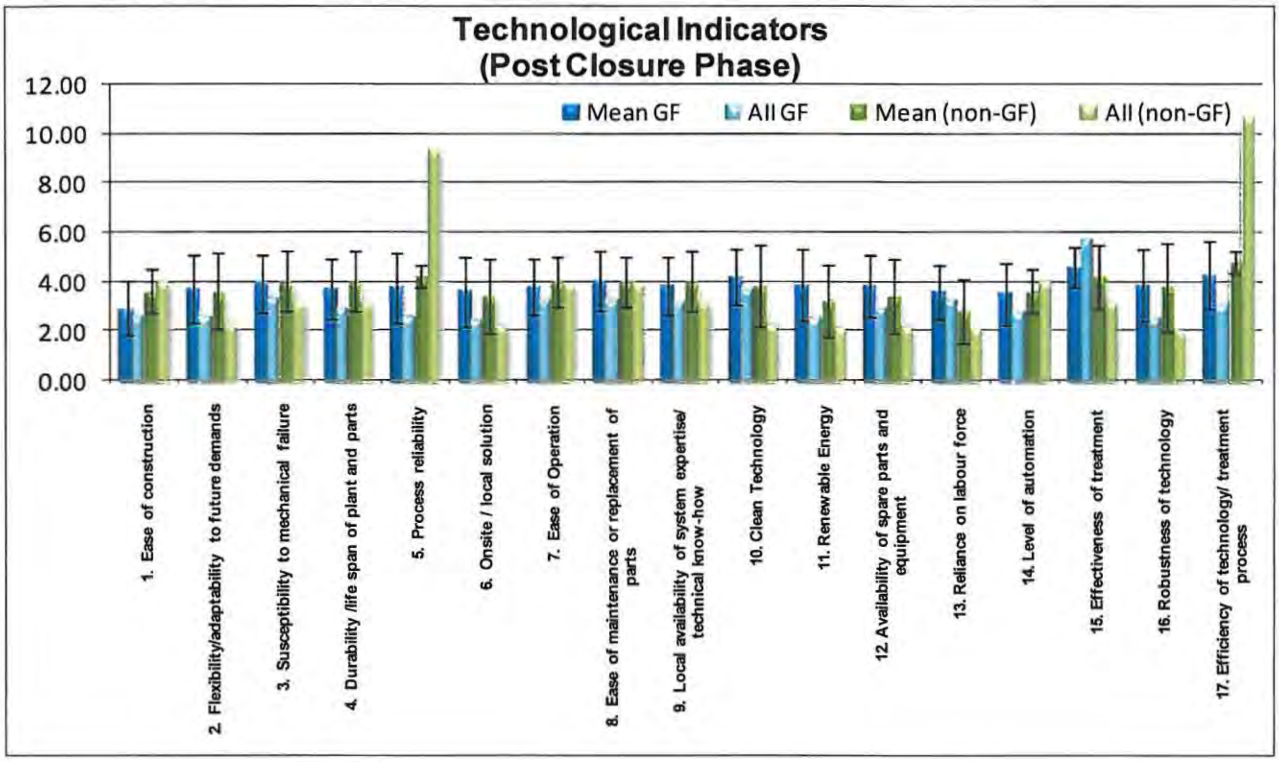

Figure 4.14 Technological SDIs relating to the post closure phase, with a distinction between GFL and non-GFL respondents. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the technological SDIs for the post closure phase of a mine, judged by the GFL respondents, received relatively high mean weights (2.9 to 4.6) (Figure 4.14). There was a lower level of agreement on the actual importance of most of the SDIs, with the exception of the effectiveness SDI, as indicated by its relatively high respective standard deviation (Figure 4.14). This translated to relatively low AII scores for the said SDIs. The calculated AII scores associated with the technological SDIs judged by the GFL respondents ranged from 2.5 to 5.8. When considering the AII scores calculated from the GFL respondents (Figure 4.14), it is evident that the only SDI that was rated as being important was the effectiveness of treatment (AII = 5.8) SDI. The other SDIs were all rated as less important. The SDI that was rated the least important was the onsite/ local solution (AII = 2.5) SDI.

Most of the technological SDIs for the post closure phase of a mine, judged by the non-GFL respondents, received relatively high mean weights (2.8 to 4.8) (Figure

4.14). There was a lower level of agreement on the actual importance of most of the SDIs but with the process reliability and efficiency of technology/ treatment process SDIs being highlighted as being important. The other technological SDIs all scored lower on the AII, as indicated by the relatively high respective standard deviations for most of the SDIs (Figure 4.14). This translated to relatively low AII scores for the technological SDIs. The calculated AII scores associated with the technological SDIs judged by the non-GFL respondents ranged from 2.1 to 10.7. When considering the AII scores calculated from the non-GFL respondents (Figure 4.14), it is evident that the SDIs that were rated as being the most important were the efficiency of technology/ treatment process (AII = 10.7), process reliability (AII = 9.4), ease of construction (AII = 4.0) and level of automation (AII = 4.0) SDIs. All the other SDIs were all rated as less important. The SDI that was rated the least important was the robustness of technology (AII = 2.5) SDI.

When comparing the post closure phase technological responses of the GFL and non-GFL respondents, it was found that there was a significant difference between the means (ANOVA, df=1,15, $p<0.05$) but that there was no significant difference between the AII scores (ANOVA, df=1,15, $p>0.05$) of the two respondent categories.

Combined response for operational and post closure phases

The relative importance of the responses received from both GFL respondents and non-GFL respondents that relate to the selection of technological SDIs, applicable to the operational and post closure phases of mining, were then combined and have been presented in Figure 4.15. The responses relating to the operational phase were kept separate from those relating to the post closure phase for comparative purposes.

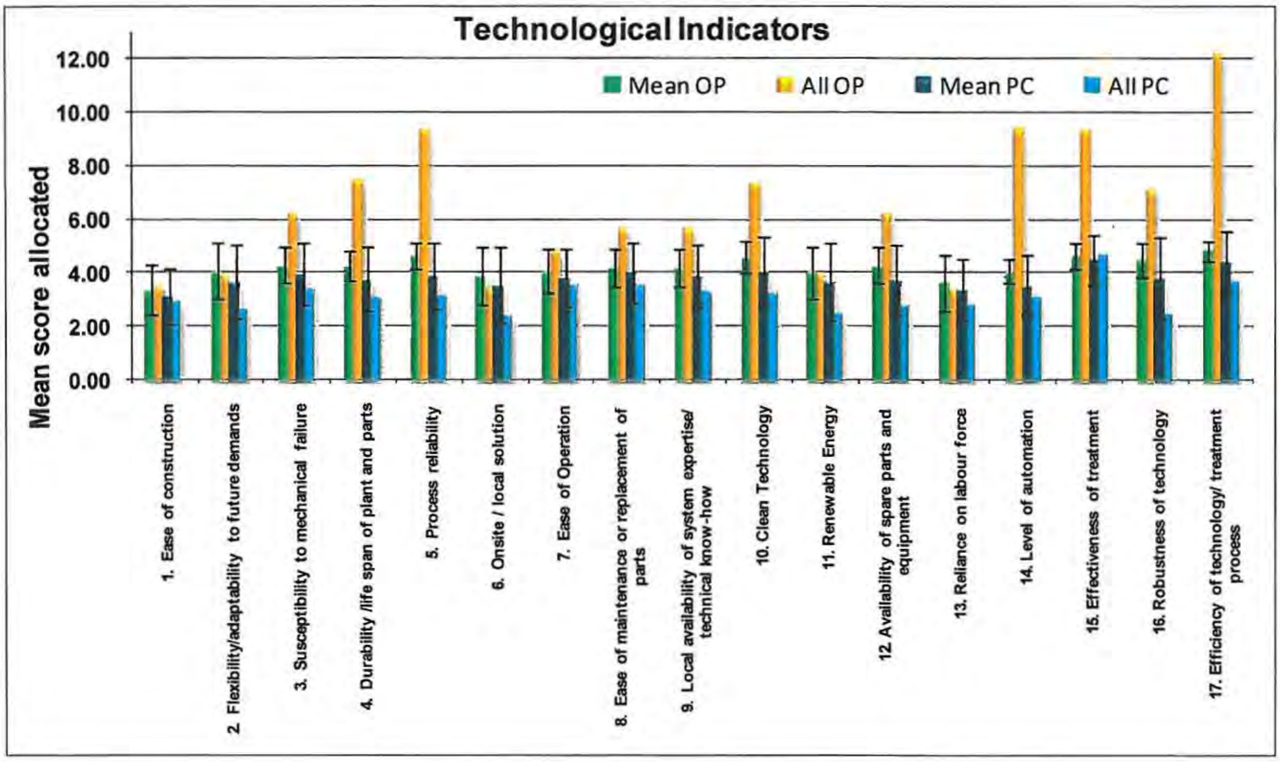

Figure 4.15 Technological SDIs relating to the operational and the post closure phases in mining. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the technological SDIs for the operational phase of a mine, judged by the total number of respondents, received high mean weights (3.4 to 4.8) (Figure 4.15). There was also a relatively high degree of agreement between the respondents regarding the actual importance for the efficiency of technology/ treatment process, robustness of technology, effectiveness of treatment, level of automation, availability of spare parts and equipment, clean technology, process reliability SDIs and so on, as indicated by the relatively low respective standard deviations (Figure 4.15). This translated into AII scores that were all higher than the mean weights, which indicate overall agreement that the said SDIs were all deemed to be important. The calculated AII scores associated with the technological SDIs judged by the total number of respondents ranged from 3.5 to 12.3. When considering the combined AII scores calculated from the total number of respondents (Figure 4.15), it is evident that the SDIs that were rated as being the most important were the efficiency of technology/ treatment process (AII = 12.3), level of automation (AII = 9.5), effectiveness of treatment (AII = 9.4), process reliability (AII = 9.4), durability/ lifespan of plant and parts (AII = 7.5), clean technology (AII = 7.4), robustness of technology (AII = 7.2), availability of spare parts and equipment (AII = 6.3), and susceptibility to mechanical failure (AII = 6.3), SDIs. The SDIs that were rated the lowest in terms of relative importance were the onsite / local solution (AII = 3.5) and the reliance on labour force (AII = 3.5) SDIs.

Some of the technological SDIs for the post closure phase of a mine, judged by all the respondents, received high mean weights (3.1 to 4.5) (Figure 4.15). There was a lower level of agreement on the actual importance with the exception of effectiveness of treatment, as indicated by its relatively low respective standard deviations (Figure 4.15). This translated to relatively low AII scores for the said SDIs. The calculated AII scores associated with the technological SDIs judged by the total number of respondents ranged from 2.5 to 4.7. When considering the responses (Figure 4.15), it is evident that the SDI that was deemed to be the most important was the effectiveness of treatment (AII = 4.7) SDI. The SDIs that scored the lowest were the robustness of treatment (AII = 2.2), renewable energy (AII = 2.5), and onsite/ local solution (AII = 2.5) SDIs.

When comparing all the responses relating to technological SDIs for both the operational phase and the post closure phase, it was found that there was a significant difference between the means (ANOVA, df=1,15, $p<0.05$) and between the AII scores (ANOVA, df=1,15, $p<0.05$) of the two mining phases.

When considering the combined score of all the respondents the SDIs that were deemed to be the most important were the (i) efficiency of technology/ treatment process, (ii) effectiveness of treatment, (iii) process reliability, (iv) level of automation, (v) durability/ lifespan of plant and parts, (vi) clean technology, (vii) availability of spare parts and equipment, (viii) robustness of technology, (ix) susceptibility to mechanical failure (x) ease of operation, and (xi) ease of maintenance or replacement of SDIs in terms of evaluating the level of SD of any capital investment (Figure 4.15). There was agreement between the respondents that the effectiveness of treatment was important for both the operational and post closure phases. Those SDIs deemed important were included in the decision making model (Table 4.10). The effectiveness of treatment was deemed to be important as it is critical that the solution is effective under circumstances determined by both the operational and post closure phases. Many solutions in the past have been ineffective and therefore any new solution will be treated with suspicion (Gold Fields internal 2009). Furthermore, the treatment technology needs to be robust enough to reliably continue long after the mine has closed its doors. Mechanical failure, complex technical operational requirements and the lack of easily obtainable spares would render any solution ineffective and therefore the identified SDIs are critical to the level of SD of any capital investment project.

4.7 Ethics, Legal and Corporate Governance SDIs

Operational phase

The relative importance of the responses received from GFL and non-GFL respondents that relate to the selection of ethics, legal and corporate governance SDIs, applicable to the operational phase of mining, have been presented in Figure 4.16. The responses received from GFL respondents were initially kept separate from the non-GFL respondents for comparative purposes.

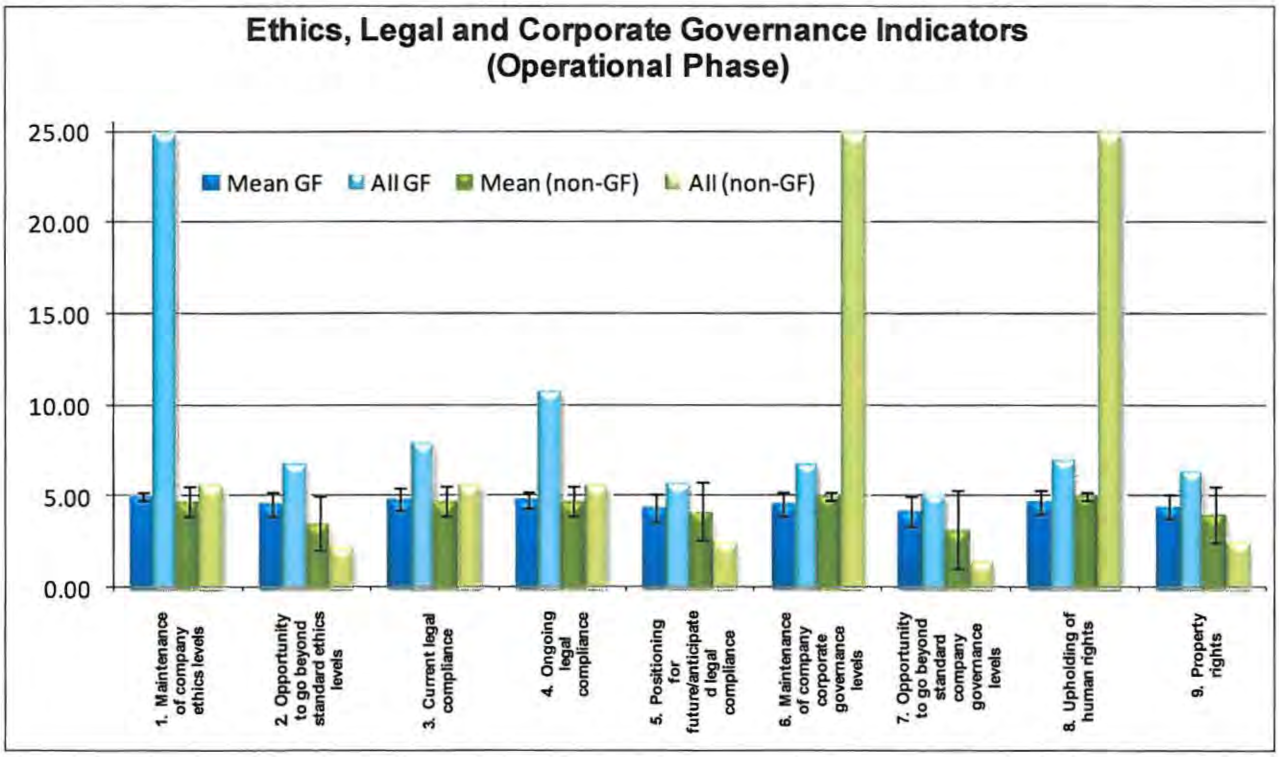

Figure 4.16 Ethics, Legal and Corporate Governance SDIs relating to the operational phase, with a distinction between GFL and non-GFL respondents. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the ethics, legal and corporate governance SDIs for the operational phase of a mine, judged by the GFL respondents, received relatively high mean weights (4.2 to 5.0) (Figure 4.16). There was a high level of agreement on the actual importance of most of the SDIs like the maintenance of company ethics levels, ongoing legal compliance, current legal compliance, upholding of human rights, property rights, maintenance of company corporate governance levels SDIs and so on, as indicated by the relatively low respective standard deviations for some of the SDIs (Figure 4.16). This translated to relatively high AII scores for the said SDIs. The calculated AII scores associated with the ethics, legal and corporate governance SDIs judged by the GFL respondents ranged from 5.2 to 25.0. When considering the AII scores calculated from the GFL respondents (Figure 4.16), it is evident that the SDIs that were rated as being the most important were the maintenance of company ethics levels (AII = 25.0), ongoing legal compliance (AII = 10.9), current legal compliance (AII = 9.0), upholding of human rights (AII = 7.1), property rights (AII = 6.5), maintenance of company corporate governance levels (AII = 6.9), opportunity to go beyond the standard ethics levels (AII = 6.9), and the positioning for future/ anticipated legal compliance (AII = 5.8) SDIs. The other SDIs were rated as less important. The SDI that was rated the least important was the opportunity to go beyond standard company governance levels (AII = 5.2) SDI.

Most of the ethics, legal and corporate governance SDIs for the operational phase of a mine, judged by the non-GFL respondents, received relatively high mean weights (3.2 to 5.0) (Figure 4.16). There was a lower level of agreement on the actual importance of most of the SDIs with the upholding of human rights, maintenance of company corporate governance levels, ongoing legal compliance, current legal compliance, maintenance of company ethics levels SDIs being highlighted as being important. The other ethics, legal and corporate governance SDIs all scored lower on the AII, as indicated by the relatively high respective standard deviations for most of the SDIs (Figure 4.16). This translated to relatively low AII scores for most of the ethics, legal and corporate governance SDIs. The calculated AII scores associated with the ethics, legal and corporate governance SDIs judged by the non-GFL respondents ranged from 1.6 to 5.1. When considering the AII scores calculated from the non-GFL respondents (Figure 4.16), it is evident that the SDI that was rated as being the most important was the upholding of human rights (AII = 25.0), followed by the maintenance of company corporate governance levels (AII = 25.0), ongoing legal compliance (AII = 5.7), current legal compliance (AII = 5.7), and maintenance of company ethics levels (AII = 5.7) SDIs. The other SDIs were all rated as less important. The SDI that was rated the least important was the opportunity to go beyond standard company governance levels (AII = 1.5) SDI.

When comparing the operational phase ethics, legal and corporate governance responses of the GFL and non-GFL respondents, it was found that there was no significant difference between the means (ANOVA, df=1,7, p>0.05) and All scores (ANOVA, df=1,7, p>0.05) of the two respondent categories.

Post closure phase

The relative importance of the responses received from GFL and non-GFL respondents that relate to the selection of ethics, legal and corporate governance SDIs, applicable to the post closure phase of mining, have been presented in Figure 4.17. The responses received from GFL respondents were initially kept separate from the non-GFL respondents for comparative purposes.

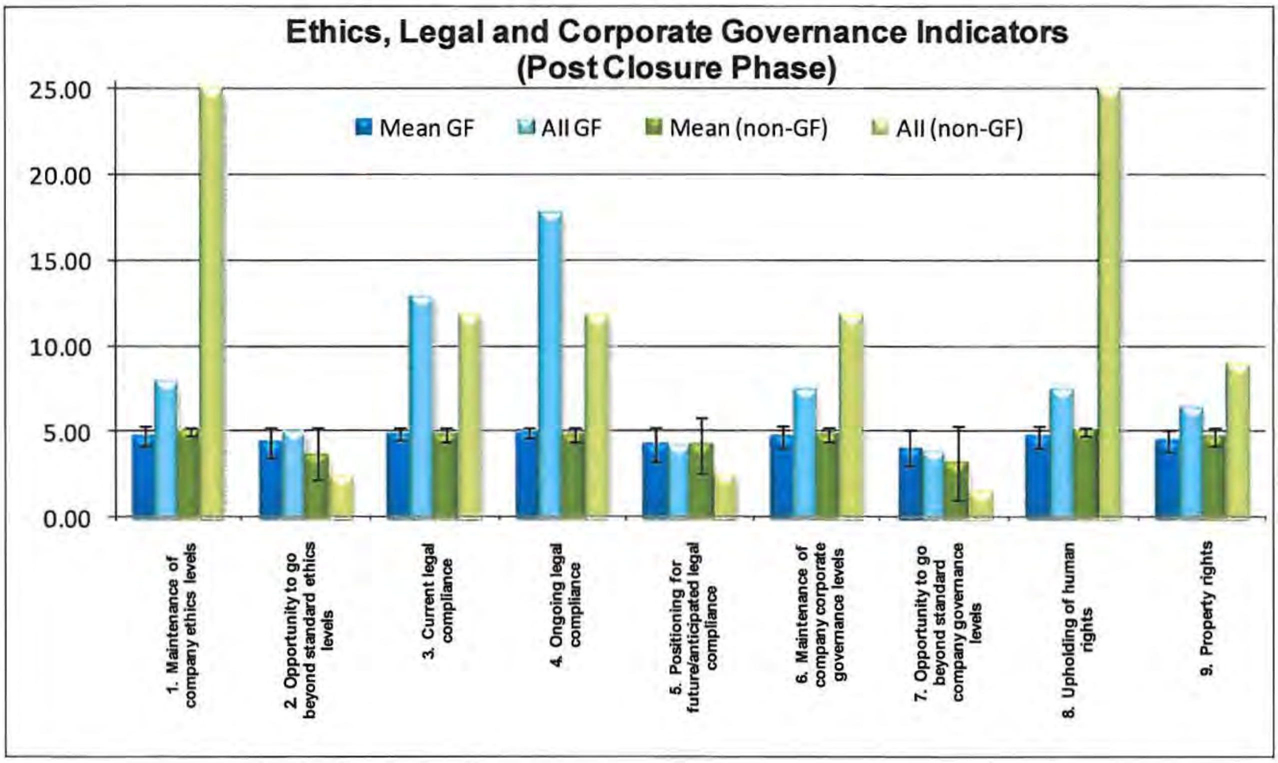

Figure 4.17 Ethics, legal and Corporate Governance SDIs relating to the post closure phase, with a distinction between GFL and non-GFL respondents. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the ethics, legal and corporate governance SDIs for the post closure phase of a mine, judged by the GFL respondents, received relatively high mean weights (4.1 to 4.9) (Figure 4.17). There was a high level of agreement on the actual importance of most of the SDIs like ongoing legal compliance, current legal compliance, maintenance of company ethics levels, and maintenance of company corporate governance levels SDIs, as indicated by the relatively low respective standard deviations for some of the SDIs (Figure 4.17). This translated to relatively high AII scores for the said SDIs. The calculated AII scores associated with the ethics, legal and corporate governance SDIs judged by the GFL respondents ranged from 3.9 to 17.8. When considering the AII scores calculated from the GFL respondents (Figure 4.17), it is evident that the SDIs that were rated as being the most important were the ongoing legal compliance (AII = 17.8), current legal compliance (AII = 12.9), maintenance of company ethics levels (AII = 8.0), and maintenance of company corporate governance levels (AII = 7.4). The other SDIs were rated as less important. The SDIs that were rated the least important were the opportunity to go beyond standard company governance levels (AII = 3.9) and the positioning for future/ anticipated legal compliance (AII = 4.2) SDIs.

Most of the ethics, legal and corporate governance SDIs for the post closure phase of a mine, judged by the non-GFL respondents, received relatively high mean weights (3.2 to 5.0) (Figure 4.17). There was a lower level of agreement on the actual importance of most of the SDIs but with the maintenance of company ethics levels, upholding of human rights, current legal compliance, ongoing legal compliance, maintenance of company corporate governance levels, property rights SDIs being highlighted as being important. The other ethics, legal and corporate governance SDIs all scored lower on the AII, as indicated by the relatively high respective standard deviations for some of the SDIs (Figure 4.17). This translated to relatively low AII scores for some of the ethics, legal and corporate governance SDIs. The calculated AII scores associated with the ethics, legal and corporate governance SDIs judged by the non-GFL respondents ranged from 1.5 to 25.0. When considering the AII scores calculated from the non-GFL respondents (Figure 4.17), it is evident that the SDIs that were rated as being the most important were the maintenance of company ethics levels (AII = 25.0), upholding of human rights (AII = 25.0), current legal compliance (AII = 11.8), ongoing legal compliance (AII = 11.8), maintenance of company corporate governance levels (AII = 11.8), and property rights (AII = 9.0) SDIs. The other SDIs were all rated as less important. The SDIs that were rated the least important were the opportunity to go beyond standard company governance levels (AII = 1.5), opportunity to go beyond standard ethics levels (AII = 2.4) and positioning for future/ anticipated legal compliance (AII = 2.6) SDIs.

When comparing the post closure phase ethics, legal and corporate governance responses of the GFL and non-GFL respondents, it was found that there was a significant difference between the means (ANOVA, df=1,7, $p<0.05$) but that there was no significant difference between the AII scores (ANOVA, df=1,7, $p>0.05$) of the two respondent categories. The significant difference highlighted in this section possibly relates to the fact that GFL is subject to King II and the Companies Act (LexisNexis 2009) due its JSE Stock Exchange listing and to the Sarbaines Oxley Act due to its New York Stock Exchange listing (Gold Fields internal 2009). The non-GFL respondents typically work for the State or academic institutions which are not typically governed in such a stringent manner. This possibly explains the difference in opinion highlighted in this section.

Combined response for operational and post closure phases

The relative importance of the responses received from both GFL respondents and non-GFL respondents that relate to the selection of ethics, legal and corporate governance SDIs, applicable to the operational and post closure phases of mining, were then combined and have been presented in Figure 4.18. The responses relating to the operational phase were kept separate from those relating to the post closure phase for comparative purposes.

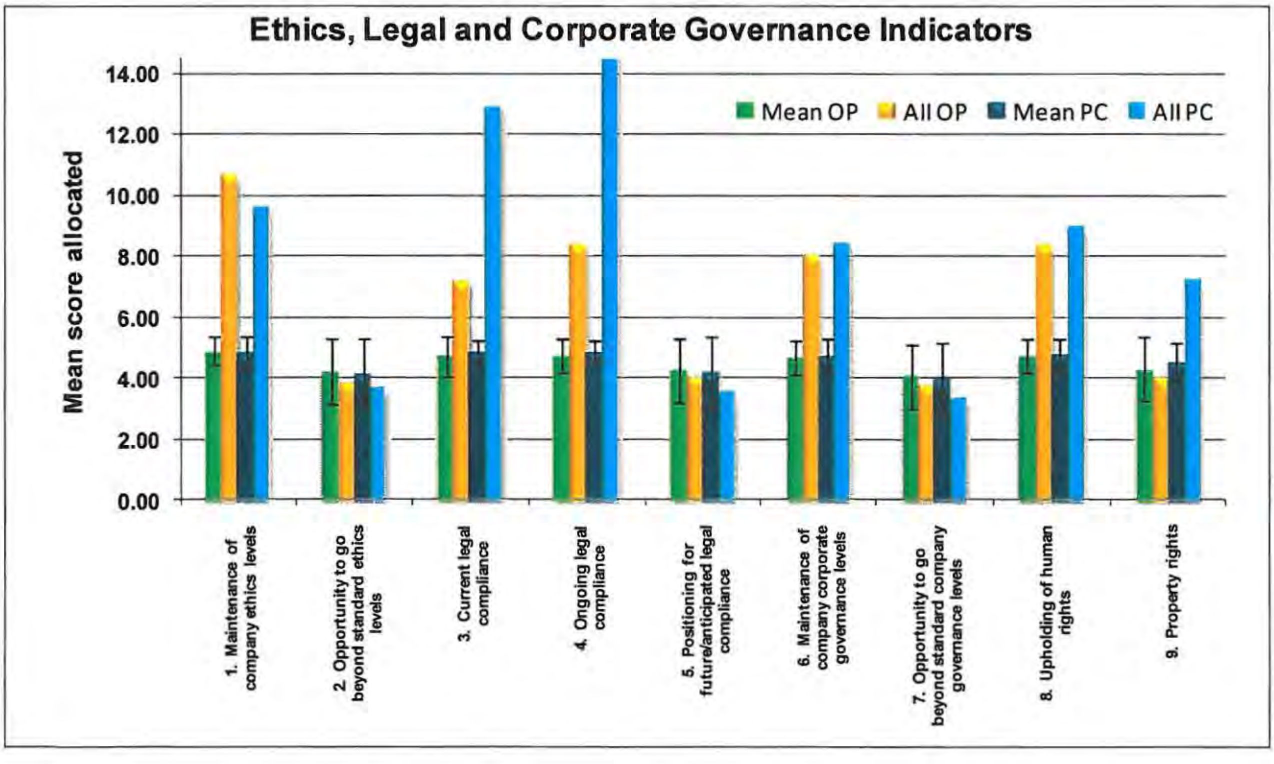

Figure 4.18 Ethics, Legal and Corporate Governance SDIs relating to the operational and the post closure phases in mining. The line bars represent the standard deviation of each data set. (GFL = Gold Fields; non-GFL = non-Gold Fields).

Most of the ethics, legal and corporate governance SDIs for the operational phase of a mine, judged by the total number of respondents, received high mean weights (4.1 to 4.9) (Figure 4.18). There was also a relatively high degree of agreement between the respondents regarding the actual importance for the ongoing legal compliance, current legal compliance, maintenance of company ethics levels, upholding of human rights, and property rights SDIs, as indicated by the relatively low respective standard deviations (Figure 4.18). This translated into AII scores that were mostly higher than the mean weights, which indicate overall agreement that the said SDIs were all deemed to be important. The calculated AII scores associated with the ethics, legal and corporate governance SDIs judged by the total number of respondents ranged from 3.8 to 10.7. When considering the combined AII scores calculated from the total number of respondents (Figure 4.18), it is evident that the SDIs that were rated as being the most important were the ongoing legal compliance (AII = 15.5), current legal compliance (AII = 12.9), maintenance of company ethics levels (AII = 9.7), upholding of human rights (AII = 8.9), maintenance of company corporate governance levels (AII = 8.4), and property rights SDIs (AII = 7.3) SDIs. The SDIs that were rated the lowest in terms of relative importance were the opportunity to go beyond standard company corporate governance levels (AII = 3.4) and the opportunity to go beyond standard ethics levels (AII = 3.7) SDIs.

Some of the ethics, legal and corporate governance SDIs for the post closure phase of a mine, judged by all the respondents, received high mean weights (4.0 to 4.9) (Figure 4.18). There was a high level of agreement on the actual importance with some SDIs like the maintenance of company ethics levels, ongoing legal compliance, maintenance of company corporate governance levels, upholding of human rights, and current legal compliance SDIs being agreed on, as indicated by the relatively low respective standard deviations for some of the SDIs (Figure 4.18). This translated to relatively high AII scores for the said SDIs. The calculated AII scores associated with the ethics, legal and corporate governance SDIs judged by the total number of respondents ranged from 3.4 to 15.5. When considering the responses (Figure 4.18), it is evident that the SDIs that were deemed to be the most important were the maintenance of company ethics levels (AII = 10.7), ongoing legal compliance (AII = 8.4), upholding of human rights (AII = 8.4), maintenance of company corporate governance levels (AII = 8.0), and current legal compliance being (AII = 7.3) SDIs. The SDIs that scored the lowest were the opportunity to go beyond standard ethics levels (AII = 3.9) and the opportunity to go beyond standard company governance levels (AII = 3.8) SDIs.

When comparing all the responses relating to ethics, legal and corporate governance SDIs for both the operational phase and the post closure phase, it was found that there was a significant difference between the means (ANOVA, df=1,7, $p<0.05$) between the AII scores (ANOVA, df=1,7, $p<0.05$) of the two mining phases.

When considering the combined score of all the respondents the SDIs that were deemed to be the most important were the (i) ongoing legal compliance, (ii) maintenance of company ethics levels, (iii) current legal compliance, (iv) maintenance of company corporate governance, (v) upholding of human rights, (vi) property rights, (vii) and positioning for future/ anticipated, legal compliance SDIs in terms of evaluating the level of SD of any capital investment (Figure 4.18). There was agreement between the respondents that the maintenance of company ethics levels, ongoing legal compliance, upholding of human rights, maintenance of company corporate governance levels, and current legal compliance SDIs were important for both the operational and post closure phases. The most important SDIs were included in the decision making model (Table 4.10). The ethics, legal and corporate governance SDI category and its specific SDIs is generally accepted as being important for any modern day business as it is a non-negotiable on a global scale. GFL is listed on the JSE stock exchange in South Africa but also the New York Stock exchange, which requires compliance with the Sarbaines Oxley Act (Gold Fields 2008b). The said Act has a specific set of corporate governance requirements that all listed companies need to meet. Furthermore, with the King Report (KCCG 2002) in support, any company that desires to operate in the global arena has no choice but to act ethically and within the legal and corporate governance parameters that applies to it.

4.8 Actual Importance Index (AII) Analysis

The sustainable development indicators (SDIs) that were identified and selected as being of high importance and used to develop a decision making model are captured in Figures 4.2 to 4.8. Those SDIs that were rated as being the most important were included in the decision making model. It is highlighted by Hilson (2001b) that mines are able to achieve improved levels of SD through enhanced community development and stakeholder engagement, partnership formation, clean technology implementation and improved environmental management. Hilson (2001b) also highlights the fact that each case is unique due to different regulatory, economical, technological circumstances. This is fully supportive of the approach that was taken in this study whereby the SDIs that are relevant to the GFL's set of circumstances were taken into account. It also provides a good basis upon which performance can be measured and improvements made (Azapagic 2004).

Table 4.2 depicts the Actual Importance Index (AII) score ranges and the assigned weightings that were used to formulate the decision making model. The lowest and highest weightings achievable were 10 and 150, respectively. Tables 4.2 to 4.8 depict the selected SDIs and their respective allocated weightings for both the operational and post closure phases..

Table 4.2 List of the Actual Importance Index (AII) score ranges and their respective weightings (Neba 2006)

Actual Importance Index Score	Assigned Weight
<2	10
>2-4	25
>4-6	50
>6-8	75
>8-10	100
>10-12	125
>12	150

Table 4.3 Detailed list of Integrated Bottom Line SDIs used in this study and their respective resultant SDI weights

Integrated Bottom Line Indicator categoriess	Weight	
	OP	PC
Environment	150	150
Social	75	50
Economic	50	25
Technological	50	25
Ethics, legal, corporate governance	75	75
Total Score	**400**	**325**

Table 4.4 Detailed list of financial SDIs used in this study and their respective resultant SDI weights

Financial SDIs	Weight	
	OP	PC
Capital costs	75	50
Operational costs	75	75
Net Present Value	50	25
Internal Rate of Return	25	25
Payback Period on capital invested	25	25
Return on Investment	25	25
Debt:Equity ratio	25	25
Funding mechanism – level of leverage	25	25
Total Score	**325**	**275**

Table 4.5 Detailed list of social SDIs used in this study and their respective resultant SDI weights

Social SDIs	Weight	
	OP	PC
Direct employment creation	25	25
Indirect employment creation	25	25
Secondary industry creation	25	25
Safety	125	75
Health	125	75
Retention opportunities	50	25
Remuneration	25	25
Transformation	25	25
Skills development / capacity building	50	50
Community's perception of the investment	50	75
Education and Training opportunities for the community	50	25
Maintenance of social structures	25	25
Preservation of cultural heritage	25	50
Political stability	50	50
Institutional support	50	25
Community benefits	25	75
Total Score	**750**	**675**

Table 4.6 Detailed list of environmental SDIs used in this study and their respective resultant SDI weights

Environmental SDIs	Weight	
	OP	PC
Abiotic depletion	25	25
Natural resource depletion	75	25
Land area required	25	25
Ecotoxicity potential	50	50
Phytotoxicity potential	25	25
Energy depletion potential	50	25
Global warming potential	25	25
Acidification potential	50	50
Eutrophication potential	25	25
Bioaccumulation potential	50	50
Ozone depletion potential	25	25
Photochemical oxidant creation potential	25	25
Re-usability of raw materials	50	50
Generation of useful by-products	50	25
Type of waste produced and recycling potential	50	25
Quantity of wastes produced	50	50
Toxicity of wastes produced	50	50
Availability of special waste disposal facilities	25	25
Biodiversity	25	25
Attraction of pests/vermin potential	25	25
Toxicity/Hazard of raw materials	25	25
Aesthetics	25	25
Odour generation	50	25
Noise produced	25	25
Total Score	**900**	**750**

Table 4.7 Detailed list of technological SDIs used in this study and their respective resultant SDI weights

Technological SDIs	Weight	
	OP	PC
Ease of construction	25	25
Flexibility/adaptability to future demands	25	25
Susceptibility to mechanical failure	50	25
Durability /life span of plant and parts	75	25
Process reliability	100	25
Onsite / local solution	25	25
Ease of Operation	50	25
Ease of maintenance or replacement of parts	50	25
Local availability of system expertise/ technical know-how	50	25
Clean Technology	75	25
Renewable Energy	25	25
Availability of spare parts and equipment	75	25
Reliance on labour force	25	25
Level of automation	100	25
Effectiveness of treatment	100	50
Robustness of technology	75	25
Efficiency of technology/ treatment process	150	25
Total Score	**1075**	**450**

Table 4.8 Detailed list of ethics, legal and corporate governance SDIs used in this study and their respective resultant SDI weights

Ethics, legal and corporate governance SDIs	Weight	
	OP	PC
Maintenance of company ethics levels	125	100
Opportunity to go beyond standard ethics levels	25	25
Current legal compliance	75	150
Ongoing legal compliance	100	150
Positioning for future/anticipated legal compliance	50	25
Maintenance of company corporate governance levels	100	100
Opportunity to go beyond standard company governance levels	25	25
Upholding of human rights	100	100
Property rights	50	75
Total Score	**650**	**750**

4.9 Weight Filtered SDIs

Only the SDIs that were rated as being the most important SDIs within a given category, were incorporated into the decision making model. These SDI's have been included in Table 4.9. A score of 50 was used as a cut-off score i.e. 25s were ignored. The assumption made was that if you do not take issues into account during the operational phase, you will not be able to retrofit during the post closure phase. Therefore the post closure scores were used as qualifiers i.e. 25 scored under operational phase was converted to the higher post closure score, where applicable.

Table 4.9 Summary of the top ranked SDIs to be considered when the level of Sustainable Development of a capital investment is being determined (Weight ≥ 50).

IBL Indictor categroies	Financial SDIs	Social SDIs	Environmental SDIs	Technological SDIs	Ethics, legal and corporate governance SDIs
Environment	Capital costs	Safety	Natural resource depletion	Efficiency of technology/ treatment process	Ongoing legal compliance
Ethics, legal and corporate governance	Operational costs	Health	Ecotoxicity potential	Effectiveness of treatment	Maintenance of company ethics levels
Social	Net Present Value	Community's perception of the investment	Acidification potential	Process reliability	Current legal compliance
Technological		Skills development / capacity building	Bioaccumulation potential	Level of automation	Maintenance of company corporate governance levels
Economic		Political stability	Re-usability of raw materials	Durability /life span of plant and parts	Upholding of human rights
		Retention opportunities	Quantity of wastes produced	Clean Technology	Property rights
		Education and Training opportunities for the community	Toxicity of wastes produced	Availability of spare parts and equipment	Positioning for future/anticipated legal compliance
		Preservation of cultural heritage	Energy depletion potential	Robustness of technology	
		Institutional support	Generation of useful by-products	Susceptibility to mechanical failure	
		Community benefits	Type of waste produced and recycling potential	Ease of Operation	
			Odour generation	Ease of maintenance or replacement of parts	

4.10 Sustainable Development Scoring Model

The identified SDIs and associated weights were incorporated into an Excel based scoring model that was designed to produce a score in terms of the level of SD presented by the project being assessed (Table 4.10). This model was intended to also serve as a decision making tool for GFL. The key elements of the model are shown in Table 4.10.

Table 4.10 Decision making model derived from the scoring of the top ranked Sustainable Development indicators, with modified scoring

	Weight OP	Weight PC	Weight OP+PC	Highest possible score	Score	Status 0,1 or 2
Triple Bottom Line Indicator Categories						
Environment	150	150	300	600		
Ethics, Legal, CG	75	75	150	300		
Social	75	50	125	250		
Technical	50	25	75	150		
Total score and % SD compliance for this category	250	175	425	1450		
Financial SDIs						
Operational costs	75	75	150	300		
Capital costs	75	50	125	250		
Net Present Value	50	25	75	150		
Total score and % SD compliance for this category	125	75	200	700		
Social SDIs						
Safety	125	75	200	400		
Health	125	75	200	400		
Community's perception of the investment	50	75	125	250		
Skills development / capacity building	50	50	100	200		
Political stability	50	50	100	200		
Retention opportunities	50	25	75	150		
Education and Training opportunities for the community	50	25	75	150		
Preservation of cultural heritage	25	50	75	150		
Institutional support	50	25	75	150		
Community benefit	75	25	100	200		
Total score and % SD compliance for this category	525	400	925	2250		
Environmental SDIs						
Natural resource depletion	75	25	100	200		
Ecotoxicity potential	50	50	100	200		
Acidification potential	50	50	100	200		
Bioaccumulation potential	50	50	100	200		
Re-usability of raw materials	50	50	100	200		
Quantity of wastes produced	50	50	100	200		
Toxicity of wastes produced	50	50	100	200		
Energy depletion potential	50	25	75	150		
Generation of useful by-products	50	25	75	150		
Type of waste produced and recycling potential	50	25	75	150		
Odour generation	50	25	75	150		
Total score and % SD compliance for this category	500	400	900	2000		
Technological SDIs						
Efficiency of technology/ treatment process	150	25	175	350		
Effectiveness of treatment	100	50	150	300		
Process reliability	100	25	125	250		
Level of automation	100	25	125	250		
Durability /life span of plant and parts	75	25	100	200		
Clean Technology	75	25	100	200		
Availability of spare parts and equipment	75	25	100	200		
Robustness of technology	75	25	100	200		
Susceptibility to mechanical failure	50	25	75	150		
Ease of Operation	50	25	75	150		
Ease of maintenance or replacement of parts	50	25	75	150		
Local availability of system expertise/ technical know-how	50	25	75	150		
Total score and % SD compliance for this category	800	300	1100	2550		
Ethics, Legal and Corporate Governance SDIs						
Ongoing legal compliance	100	150	250	500		
Maintenance of company ethics levels	125	100	225	450		
Current legal compliance	75	150	225	450		
Maintenance of company corporate governance levels	100	100	200	400		
Upholding of human rights	100	100	200	400		
Property rights	50	75	125	250		
Positioning for future/anticipated legal compliance	50	25	75	150		
Total score and % SD compliance for this category	500	550	1050	2600		
Scoring						
Highest possible score						
Final Score						
% Overall Compliance						

Each category/ group of indicators was calculated as a separate section and therefore the columns will not add up. The scoring calculation is captured within the Excel algorithm and is essentially based on the status score, namely, 0, 1 or 2. The highest possible score for each line option is the sum of the weight of the operational phase, post closure phase and the combination/sum of the operational and post closure phase. Therefore, as an example, the environmental category has an operational phase weighting of 150, a post closure weighting of 150 and a combination of 300. The sum of all three is thus 600. The status of 0, 1 or 2 is thus measured against the said highest possible score. In the event of a 0 status (indication that the indicator had not been addressed) being selected, the total score becomes zero. In the event of a 1 status (indication that the indicator had been partially addressed) being selected, the total score becomes 300. Lastly, in the event of a 2 status (indication that the indicator had been fully addressed) being selected, the total score becomes 600. In this manner each of the individual indicators have been measured against their respective weightings and highest possible score.

In order to use the model to make informed decisions a cut-off score would need to be applied. It is recommended that 50% be used as a cut-off. This means that any project that is assessed and that score lower than 50% will be deemed inappropriate in terms of it level of sustainability. Those projects that score higher than 50% wil thus be deemed appropriate. Given this threshold, a higher the score will give an indication of the level of sustainability of the assessed project. Therefore the closer the score is to 100%, the more appropriate it will be. Likewise, if two projects are being compared and both score higher than 50% then the project with the higher score will be selected.

CHAPTER 5 – APPLICATION OF THE MODEL

The decision making model depicted in Table 4.10 was applied to a recently proposed GFL water treatment project. The said water treatment project involves different technology options and a variety of pricing possibilities. It also takes into account a variety of operational costs, which is dependent on informed decision making. The model was used to provide an indication of the likely sustainability of the proposed project, as a means of demonstrating the effectiveness of this sustainability assessment tool.

The said GFL project relates to the treatment of water that is used and therefore contaminated during the mining process. It entails the utilisation of a combination of modular treatment solutions, including ion exchange and reverse osmosis technologies, strategically placed within the company's reticulation system. The said modules will be used to either treat what is called process water by removing heavy metals and salts, or to soften naturally occurring fissure water by removing magnesium and calcium (Gold Fields internal 2009). The GFL process of approving a project of this nature, which is exceptionally costly, requires a holistic assessment. This implies that economic, environmental, social, technological, and ethics, legal and corporate governance issues are considered upfront.

The results of the model after being applied to the said project are captured in Table 6.1. The status scores applied were subjectively applied by considering each SDI as being (i) not addressed, (ii) partially addressed, or (iii) fully addressed. Therefore if a SDI was deemed to be addressed as part of the project planning and assessment process it would be given a status score of 2. Likewise, if the SDI was not addressed or taken into account, the status score would have been 0. Having applied this rationale to the said water treatment project, the resultant score is a 73% level of compliance to SD principles. The model also highlights areas where GFL could possibly improve and in so doing achieve a higher overall level of compliance. This provides invaluable information and insight regarding the individual SD components. By applying a cut-off score (for example 50%) Gold Fields will thus be able to make informed decisions as to the appropriateness of a proposed project. The model could therefore be used to both assess a project but to also help identify opportunities beyond the traditional economic and technological options.

Table 5.1 Decision making model applied to a GFL capital investment project

	Weight OP	Weight PC	Weight OP+PC	Highest possible score	Score	Status 0,1, or 2
Triple Bottom Line Indicator Categories						
Environment	150	150	300	600	300	1
Ethics, Legal, CG	75	75	150	300	300	2
Social	75	50	125	250	125	1
Technical	50	25	75	150	150	2
Total score and % SD compliance for this category	250	175	425	1450	1025	70.69%
Financial SDIs						
Operational costs	75	75	150	300	300	2
Capital costs	75	50	125	250	250	2
Net Present Value	50	25	75	150	150	2
Total score and % SD compliance for this category	125	75	200	700	700	100.00%
Social SDIs						
Safety	125	75	200	400	400	2
Health	125	75	200	400	400	2
Community's perception of the investment	50	75	125	250	125	1
Skills development / capacity building	50	50	100	200	100	1
Political stability	50	50	100	200	0	0
Retention opportunities	50	25	75	150	75	1
Education and Training opportunities for the community	50	25	75	150	0	0
Preservation of cultural heritage	25	50	75	150	0	0
Institutional support	50	25	75	150	0	0
Community benefit	75	25	100	200	100	1
Total score and % SD compliance for this category	525	400	925	2250	1200	53.33%
Environmental SDIs						
Natural resource depletion	75	25	100	200	200	2
Ecotoxicity potential	50	50	100	200	200	2
Acidification potential	50	50	100	200	200	2
Bioaccumulation potential	50	50	100	200	200	2
Re-usability of raw materials	50	50	100	200	200	2
Quantity of wastes produced	50	50	100	200	200	2
Toxicity of wastes produced	50	50	100	200	100	1
Energy depletion potential	50	25	75	150	0	0
Generation of useful by-products	50	25	75	150	150	2
Type of waste produced and recycling potential	50	25	75	150	75	1
Odour generation	50	25	75	150	0	0
Total score and % SD compliance for this category	500	400	900	2000	1525	76.25%
Technological SDIs						
Efficiency of technology/ treatment process	150	25	175	350	175	1
Effectiveness of treatment	100	50	150	300	300	2
Process reliability	100	25	125	250	125	1
Level of automation	100	25	125	250	0	0
Durability /life span of plant and parts	75	25	100	200	100	1
Clean Technology	75	25	100	200	200	2
Availability of spare parts and equipment	75	25	100	200	200	2
Robustness of technology	75	25	100	200	100	1
Susceptibility to mechanical failure	50	25	75	150	75	1
Ease of Operation	50	25	75	150	0	0
Ease of maintenance or replacement of parts	50	25	75	150	75	1
Local availability of system expertise/ technical know-how	50	25	75	150	75	1
Total score and % SD compliance for this category	800	300	1100	2550	1425	55.88%
Ethics, Legal and Corporate Governance SDIs						
Ongoing legal compliance	100	150	250	500	500	2
Maintenance of company ethics levels	125	100	225	450	450	2
Current legal compliance	75	150	225	450	450	2
Maintenance of company corporate governance levels	100	100	200	400	400	2
Upholding of human rights	100	100	200	400	400	2
Property rights	50	75	125	250	250	2
Positioning for future/anticipated legal compliance	50	25	75	150	150	2
Total score and % SD compliance for this category	500	550	1050	2600	2600	100.00%
Scoring						
Highest possible score	11550					
Final Score	8475					
% Overall Compliance	73					

CHAPTER 6 – CONCLUSIONS

Sustainable Development is an old concept (Hedinger 2004) and the most commonly used definition is the one taken from the Brundtland Report, "Our Common Future", which is non-prescriptive. This means that despite its frequent use, SD still needs to be clearly defined. In this regard, the challenge facing individual companies is the task of translating the concept of SD into something tangible, which can be applied practically within the business context.

Mining is a highly impacting industry and the areas in which Gold Fields operates have been impacted on in the form of land degradation and water pollution as well as a range of potential social impacts that can be traced back to more than 120 years of mining activity. However, despite the negative connotations to mining, it should also be noted that mining continues to contribute to the economic wealth of the country as part of the Gross Domestic Product (GDP), employment creation, building of infrastructure, and still serves as a financial safe-haven in times of financial crisis.

The picture portrayed is in the process of changing, however, the change process is not an easy one as it requires a change to entrenched mindsets. The process has been encouraged by the introduction of various protocols, policies, financial instruments, laws, and so on. In this regard some of the main drivers, *inter alia*, have been

(i) Requirements like:

- Principles of Responsible Investment (PRI 2008)
- SRI Indices (e.g. JSE, FTSE) (JSE 2008)
- Equator Principles (World Bank 2008)
- Protocols that translate into laws and regulations in countries that become signatories; Kyoto, Montreal, etc. (United Nations 2008)

(ii) Changes to the South African regulatory framework in which the mining industry operates.

(iii) An increase in the levels of awareness of local communities to the extent that activism has increased significantly during the last decade.

(iv) Increased international scrutiny in search of contraventions related to bribery, corruption, human rights, corporate governance, and so on.

(v) Increased scrutiny in relation to environmental degradation.

In short, the days of externalising costs onto the surrounding communities in the form of environmental and social transgressions is over and the mining industry has now been called to account for its actions and to bring about positive change. For mining companies this process presents many challenges, which will take some careful planning going forward. Despite the challenges, there is no doubt that we have reached a point of no return and that change will be had.

Gold Fields recognised the dilemma that mining faces in that its finite activity cannot be regarded as sustainable. Instead of resigning to this eventuality, Gold Fields has responded by embracing the SD concept and reviewing its *modus operandi*. To date Gold Fields has amended its Vision, Values and company strategy to clearly reflect the principles of SD and in so doing has embarked on a process of developing and implementing a SD framework to ensure that all the principles of SD are integrated into its business processes (Gold Fields internal 2009). This, in essence, means that Gold Fields will interact, while running an economically viable business, with the environment and the community in a responsible manner. Gold Fields has responded further by (i) introducing corporate governance systems, (ii) reporting in a transparent and honest manner, (iii) certifying all its operations in accordance with ISO14001 and developing Environmental Management Programmes, (iv) becoming a member of the International Council on Mining and Metals, (v) becoming a signatory of the International Cyanide Management Code, (vi) becoming an active participant of the United Nations Global Compact, (vii) adopting the principles of the AA1000 Stakeholder Engagement Standard, and (viii) developing Social and Labour Plans to address community needs (Gold Fields internal 2009). However, despite all these efforts and initiatives there still appears to be something missing, which this study aims to address i.e. by creating a tool that could facilitate the incorporation of SD into capital projects.

In order to achieve the level of process customisation that Gold Fields requires to fully implement the principles of SD, SD was examined in its current form with a focus on the trends that are being observed both internationally and locally. The concept of the Triple Bottom Line was considered and incorporated in an effort to identify performance measures in the form of sustainable development indicators (SDIs) and to develop a decision making model that will serve as a decision making tool for Gold Fields. This study was designed to achieve this and to apply the concept and rationale to Gold Fields as a mining company, in the South African context.

The study has demonstrated the following learning points:

(i) Through the successful identification of appropriate SDIs and through adopting a collaborative approach, a gold mining company is able to develop a decision making model that is applicable to its own set of circumstances. The decision making model in turn can be used effectively to proactively evaluate capital investment projects, since capital investment constitutes a large percentage of a gold mine's annual expenditure, so as to ensure that the manner in which it is implemented contributes to the company's SD efforts.

(ii) It should be noted that since GFL is an international company, operating in South Africa, Australia, Ghana and Peru, it is faced with a varying circumstances relating to economic, environmental and social issues. Therefore it is possible that the current model has not necessarily been designed to apply to all Gold Fields' operations. This highlights the need to evaluate and adapt the current model to suit the rest of GFL. In doing so, GFL will ensure that the overall SD principles that are being applied will be appropriate to the differing circumstances of each GFL region.

(iii) Gold Fields has recognised that the SD approach is likely to present more business opportunities (Elkington 2005: 23). This is evident in the results obtained from the implementation of the model, which not only gives an overall SD score but also allows the user to hone in on the individual SDIs and to understand the individual components. By including this in the decision making process it becomes possible to make informed decisions from a SD point of view. Add this to the notion of achieving ethical standing in terms of "doing the right thing" as contemplated in Turner (2008) and Pearce (1992), and the result is an opportunity for GFL to benefit on several fronts. This further highlights the importance of incorporating SD criteria into business processes that relate to expenditure.

(iv) The model that has been developed is certainly intended to add value to GFL but admittedly it would need to be tested in the workplace before it is proven to be entirely effective. This is important since the task of developing a model of this nature represents the easy part. Implementing and testing the model in a real situation is what will contribute the most value. It is also only through a rigorous testing process such as that being proposed, within the day-to-day business process, that any shortcomings and biases will become apparent. Hence it is important to introduce a proper testing phase.

(v) Furthermore, it should be noted that, as highlighted earlier, many of the identified SDIs were identified as being important by a small but carefully selected group of respondents. It is therefore important that the model be kept updated and be reviewed regularly so as to continually improve to system. Further research possibly targeted at a larger audience, may be necessary going forward but more importantly, further research is required to determine the value that each of the SDIs contribute to the project. Placing a value on these SDIs, particularly those that could easily have been classified as externalities, will improve the financial assessment by fully integrating the social and environmental contributions. It is also likely to effect a positive change to any project's net present value calculation as the benefits will be accounted for upfront.

These suggestions will ensure that Gold Fields, in the South African context to begin with, will have an appropriate and ongoing means of determining its contribution to SD and of evaluating the opportunities presented in its capital expenditure from a SD point of view. Finally, in conclusion, the objectives set for this study are deemed to have been met.

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APPENDICES

Appendix A – Questionnaire template used to with each respondent during the study.

QUESTIONNAIRE

1. **Introduction**

   The following questionnaire is designed to highlight business aspects that the respondent deems to be important in the effective implementation of sustainable development. The responses will be used to identify the most critical aspects and to apply an appropriate weighting. These weighted aspects will then be used to develop a model through which any capital investment can be assessed in terms of its level of sustainability. The model will apply specifically to the Gold Fields South African Operations and respondents are encouraged to bear this in mind when considering each of the questions that follow. The questions that follow are divided up into categories. Some of the questions within these categories are open-ended, in which case the respondent is free to include any type of answer. Others are limited to a specific set of responses, in which case the respondent is expected to use an "X" to mark the preferred selection. Please note that in some questions respondents are also expected to make a selection for both the "Operational" and the "Post Closure" phases of mining and that the scale of 1-5 is designed to highlight the respondent's opinion on the level of importance relating to the aspect being assessed.

   All responses will be treated with the strictest level of confidentiality. Furthermore, all respondents are thanked in anticipation for their time and their willingness to share their opinions.

2. Please give an indication of the field in which you work (e.g. Environmental Management, Engineering, Academic, Financial, Regulatory, etc:

3. Please indicate what level of expertise you have in the following disciplines. Using a scale of 1 to 3 (1 indicating a zero level, 2 indicating an average level, and 3 indicating a high level of expertise/familiarity) please indicate your choice using an "X".

Discipline		Level of Expertise		
1.	Environment	**1**	**2**	**3**
2.	Social	**1**	**2**	**3**
3.	Economic	**1**	**2**	**3**
4.	Technical (e.g. engineering)	**1**	**2**	**3**
5.	Ethics, Legal or Corporate Governance	**1**	**2**	**3**

4. General Considerations

	Parameter
1.	What is your understanding of Sustainable Development (SD)?
2.	Do you consider SD to be an important concept and why?
3.	Do you believe that SD should be an important business consideration or is it simply an academic theory?
4.	Are you a Gold Fields employee?
5.	If not, have you been involved with Gold Fields in any way in the last 5 years, so as to give you some insight into the manner in Gold Fields approaches issues related to SD?
	In your opinion, has Gold Fields embraced SD?

5. Integrated Bottom Line Considerations

When considering capital investment (like the construction of a water treatment plant), on a scale of 1-5 (where 1 = not important, 5 = extremely important), how important do you or would you consider the following sustainability aspects? Please mark your choice with an "X").

PARAMETER		OPERATIONAL PHASE					POST CLOSURE				
1.	Environment	1	2	3	4	5	1	2	3	4	5
2.	Social	1	2	3	4	5	1	2	3	4	5
3.	Economic	1	2	3	4	5	1	2	3	4	5
4.	Technical	1	2	3	4	5	1	2	3	4	5
5.	Ethics, Legal and Corporate Governance	1	2	3	4	5	1	2	3	4	5
6.	Others (please specify)										
		1	2	3	4	5	1	2	3	4	5
		1	2	3	4	5	1	2	3	4	5
		1	2	3	4	5	1	2	3	4	5

6. Financial Considerations

When considering capital investment (like the construction of a water treatment plant), on a scale of 1-5 (where 1 = not important, 5 = extremely important), how important do you or would you consider the following financial aspects? Please mark your choice with an "X").

PARAMETER		OPERATIONAL PHASE					POST CLOSURE				
1.	Capital costs	1	2	3	4	5	1	2	3	4	5
2.	Operational costs	1	2	3	4	5	1	2	3	4	5
3.	Net Present Value	1	2	3	4	5	1	2	3	4	5
4.	Internal Rate of Return	1	2	3	4	5	1	2	3	4	5
5.	Payback Period on capital invested	1	2	3	4	5	1	2	3	4	5
6.	Return on Investment	1	2	3	4	5	1	2	3	4	5
7.	Debt:Equity ratio	1	2	3	4	5	1	2	3	4	5
8.	Funding mechanism – level of leverage	1	2	3	4	5	1	2	3	4	5
9.	Others (please specify)										
		1	2	3	4	5	1	2	3	4	5
		1	2	3	4	5	1	2	3	4	5
		1	2	3	4	5	1	2	3	4	5
		1	2	3	4	5	1	2	3	4	5
		1	2	3	4	5	1	2	3	4	5

7. Social Considerations

When considering capital investment (like the construction of a water treatment plant), on a scale of 1-5 (where 1 = not important, 5 = extremely important), how important do you or would you consider the following social aspects? Please mark your choice with an "X").

PARAMETER		OPERATIONAL PHASE					POST CLOSURE				
1.	Direct employment creation	1	2	3	4	5	1	2	3	4	5
2.	Indirect employment creation	1	2	3	4	5	1	2	3	4	5
3.	Secondary industry creation	1	2	3	4	5	1	2	3	4	5
4.	Safety	1	2	3	4	5	1	2	3	4	5
5.	Health	1	2	3	4	5	1	2	3	4	5
6.	Retention opportunities	1	2	3	4	5	1	2	3	4	5
7.	Remuneration	1	2	3	4	5	1	2	3	4	5
8.	Transformation	1	2	3	4	5	1	2	3	4	5
9.	Skills development / capacity building	1	2	3	4	5	1	2	3	4	5
10.	Community's perception of the investment	1	2	3	4	5	1	2	3	4	5
11.	Education and Training opportunities for the community	1	2	3	4	5	1	2	3	4	5
12.	Maintenance of social structures	1	2	3	4	5	1	2	3	4	5
13.	Preservation of cultural heritage	1	2	3	4	5	1	2	3	4	5
14.	Political stability	1	2	3	4	5	1	2	3	4	5
15.	Institutional support	1	2	3	4	5	1	2	3	4	5
16.	Community benefits (other than those	1	2	3	4	5	1	2	3	4	5
17.	Others (please specify)	1	2	3	4	5	1	2	3	4	5
18.	Others (please specify)										
		1	2	3	4	5	1	2	3	4	5
		1	2	3	4	5	1	2	3	4	5

Employment: Retention, Benefits, Remuneration, Transformation, Performance management, Skills development

Health and Safety: Silicosis, Noise Induced Hearing Loss (NIHL), Tuberculosis, HIV/AIDS

Community benefit: Local economic development, Poverty alleviation, Partnerships, Resettlement, Contractor and supplier management, Closure, Local employment

8. Environmental Considerations

When considering capital investment (like the construction of a water treatment plant), on a scale of 1-5 (where 1 = not important, 5 = extremely important), how important do you or would you consider the following environmental aspects? Please mark your choice with an "X").

Parameter		Operational Phase					Post Closure				
1.	Abiotic depletion	1	2	3	4	5	1	2	3	4	5
2.	Natural resource depletion	1	2	3	4	5	1	2	3	4	5
3.	Land area required	1	2	3	4	5	1	2	3	4	5
4.	Ecotoxicity potential	1	2	3	4	5	1	2	3	4	5
5.	Phytotoxicity potential	1	2	3	4	5	1	2	3	4	5
6.	Energy depletion potential	1	2	3	4	5	1	2	3	4	5
7.	Global warming potential	1	2	3	4	5	1	2	3	4	5
8.	Acidification potential	1	2	3	4	5	1	2	3	4	5
9.	Eutrophication potential	1	2	3	4	5	1	2	3	4	5
10.	Bioaccumulation potential	1	2	3	4	5	1	2	3	4	5
11.	Ozone depletion potential	1	2	3	4	5	1	2	3	4	5
12.	Photochemical oxidant creation potential	1	2	3	4	5	1	2	3	4	5
13.	Re-usability of raw materials	1	2	3	4	5	1	2	3	4	5
14.	Generation of useful by-products	1	2	3	4	5	1	2	3	4	5
15.	Type of waste produced and recycling potential	1	2	3	4	5	1	2	3	4	5
16.	Quantity of wastes produced	1	2	3	4	5	1	2	3	4	5
17.	Toxicity of wastes produced	1	2	3	4	5	1	2	3	4	5
18.	Availability of special waste disposal facilities	1	2	3	4	5	1	2	3	4	5
19.	Biodiversity	1	2	3	4	5	1	2	3	4	5
20.	Attraction of pests/vermin potential	1	2	3	4	5	1	2	3	4	5
21.	Toxicity/Hazard of raw materials	1	2	3	4	5	1	2	3	4	5
22.	Aesthetics	1	2	3	4	5	1	2	3	4	5
23.	Odour generation	1	2	3	4	5	1	2	3	4	5
24.	Noise produced	1	2	3	4	5	1	2	3	4	5
25.	Others (please specify)										
		1	2	3	4	5	1	2	3	4	5
		1	2	3	4	5	1	2	3	4	5
		1	2	3	4	5	1	2	3	4	5
		1	2	3	4	5	1	2	3	4	5

9. Technological Considerations

When considering capital investment (like the construction of a water treatment plant), on a scale of 1-5 (where 1 = not important, 5 = extremely important), how important do you or would you consider the following technological aspects? Please mark your choice with an "X").

PARAMETER		OPERATIONAL PHASE					POST CLOSURE				
1.	Ease of construction	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
2.	Flexibility/adaptability to future demands	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
3.	Susceptibility to mechanical failure	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
4.	Durability /life span of plant and parts	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
5.	Process reliability	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
6.	Onsite / local solution	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
7.	Ease of Operation	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
8.	Ease of maintenance or replacement of parts	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
9.	Local availability of system expertise/ technical know-how	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
10.	**Clean Technology**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
11.	**Renewable Energy**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
12.	Availability of spare parts and equipment	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
13.	Reliance on labour force	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
14.	Level of automation	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
15.	Effectiveness of treatment	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
16.	Robustness of technology	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
17.	Efficiency of technology/ treatment process	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
18.	Others (please specify)										
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**

10. Ethics, Legal and Corporate Governance Considerations

When considering capital investment (like the construction of a water treatment plant), on a scale of 1-5 (where 1 = not important, 5 = extremely important), how important do you or would you consider the following ethics, legal and corporate governance aspects? Please mark your choice with an "X").

PARAMETER		OPERATIONAL PHASE					POST CLOSURE				
1.	Maintenance of company ethics levels	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
2.	Opportunity to go beyond standard ethics levels	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
3.	Current legal compliance	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
4.	Ongoing legal compliance	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
5.	Positioning for future/anticipated legal compliance	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
6.	Maintenance of company corporate governance levels	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
7.	Opportunity to go beyond standard company governance levels	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
8.	Upholding of human rights	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
9.	Property rights	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
10.	Others (please specify)										
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**

Ethics: Human rights, diversity, bribery and corruption, corporate governance, Confidentiality

Human Rights: Forced labour, Child labour, Freedom of expression, Freedom of association, Political affiliation, Cultural choice, Freedom of religion