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Economic Cooperation

Balancing Competing Demands of Mining, Community and Environment to Achieve Sustainable Development in the Mining Sector

Final Report

APEC Mining Task Force
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FOREWORD (This will be used as an 'endorsement' form from the Project Overseer which a signature is required.)

Sustainable development for the mining sector has become an important issue to be considered for APEC region as its major world's mineral reserves and production. Mining sector has contributed economic development in many economies of the APEC. However, it is challenging APEC economies to balance the economic growth of mining sector along with the reducing of environmental impacts and increase the quality of life for the community.

The main objectives of this report are to evaluate competing sustainable development demands within the APEC mining sector through a network of experts in APEC economies, to exchange a wide range of information, including environmental regulations related to mining, case studies of the impacts from legacy mines and inappropriate mine closures, as well as mine reclamation technologies and leading sustainable development practices relating to mine closures, to provide recommendations on practical applications of sustainable development initiatives relating to mining and mine closures in developing economies, and to develop a reference database on the policies, regulations, standards, and technical guidelines related to mine rehabilitation, reclamation, and mine closure among APEC economies. The report also highlights the need for the effective policies, regulations and enforcement of the APEC economies to increase the level of sustainability in the mining sector.

MTF Korea (Mine Reclamation Corporation) hosted an APEC workshop on "Balancing competing demands of mining, community and the environment for sustainable development in the mining sector" on 31 August – 2 September 2010, in Seoul, Korea. The amended and updated report is intended to meet the goal of the project.

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Abbreviations

AHP	Analytical Hierarchy Process
APEC	Asia-Pacific Economic Cooperation
BFY	Budget Fiscal Year
CEAA	Canadian Environmental Assessment Act
DENR	Department of Environment and Natural Resources
EIA	Environmental Impact Assessment
EPI	Environmental Performance Index
EPs	Equator Principles
FMCDM	Fuzzy Multiple Criteria Decision Making
ERMITE	Environmental Regulation of Mine Waste in the European Union
ETFs	Exchange Trade Funds
GIST	Gwangju Institute of Science and Technology
ICMM	International Council on Mining and Metals
IFC	International Financial Corporation
IGOs	Intergovernmental Organizations
JOGMEC	Japan Oil, Gas and Metals National Corporation
HDI	Human Development Index
LME	London Metal Exchange
MCA	Minerals Council of Australia
MCDM	Multiple Criteria Decision Making
MIRECO	Korea Mine Reclamation Corporation
MTF	Mining Task Force
OECD	Organization for Economic Cooperation and Development
PPP	Purchasing Power Parity
SD	Sustainable Development
SDM	Sustainable Development for the Mining Sector
SDMI	Model of sustainable development evaluation for the mining sector
UNEP	United Nations Environment Programme
USGS	United States Geological Survey
WCED	World Commission on Environment and Development
WEF	World Economic Forum
WHO	World Health Organization
WNA	World Nuclear Association

EXECUTIVE SUMMARY

The mining, mineral and metal industries are very important to APEC member economies due to the fact that the majority of global trade and investment in these commodities occurs in the APEC region. As such, minimizing the possible adverse environmental impact along with a focus on socioeconomic conditions are important contributions for ensuring sustainable development.

A study on balancing the competing demands of mining, community and the environment to achieve sustainable development in the mining sector was performed with three main objectives. The first objective is to evaluate competing sustainable development demands within the APEC mining sector through a network of experts in APEC economies. The second is to exchange a wide range of information, including environmental regulations related to mining, case studies of the impacts from legacy mines and inappropriate mine closures, as well as mine reclamation technologies and leading sustainable development practices relating to mine closures. The third is to provide recommendations on practical applications of sustainable development initiatives relating to mining and mine closures in developing economies. The final objective is to develop a reference database on the policies, regulations, standards, and technical guidelines related to mine rehabilitation, reclamation, and mine closure among APEC economies. A questionnaire was used as the tool for collecting this data. Therefore, the study was conducted via a model for calculating a sustainable development index that can provide a quantitative assessment of sustainable development for the mining sector.

The results of this project provide a beneficial database of the policies, regulations, and technical guidelines for mining sectors among APEC economies. A sustainable development index was developed and recommendations on best practice applications for sustainable development were conducted. As a result of this initiative, a 3-day workshop on the topic "Balancing competing demands of mining, community and the environment for sustainable development in the mining sector" was organized in order to present the primary draft report and to a deeper consider the recommendations for practical applications pertaining to sustainable development initiatives in developing APEC economies based on advice from experts related to mine rehabilitation and reclamation technologies for sustainable development in the mining sector.

Keywords: Sustainable development, mining sector, APEC, 3-day workshop sustainable development index

1. BACKGROUND OF THE RESEARCH

1.1 Sustainable development

The term **Sustainable Development** from **Our Common Future**, also called *The Brundtland Report*, was released by the United Nations World Commission on Environment and Development (WCED) in 1987, and was applied to achieve economic development while preserving the environment based on recommendations of the Brundtland Commission. This report was published in six languages after a year of visiting capitals of major world economies and studying their economic, social, and environmental situations. Now, the term "sustainable development" is applied to sum up the conditions necessary for humankind to avoid impending crises at the end of the 20^{th} century.

Sustainable development is a model of development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This issue was further addressed at the Second Conference on the Environment and Development in Rio de Janeiro in 1992. Representatives of over 180 economies participated in the conference. The conference was held for seven days and dealt with discussions of conditions required in order to ensure that civilization created by humankind would overcome imminent crises, while continuing balanced sustainable development. A range of fundamental documents was adopted, with one of them being Agenda 21. The conference adopted a declaration referred to as the Rio Declaration on Environment and Development. It stated 27 principles for allowing countries to move towards a goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among economies, key sectors of societies and people, by working towards international agreements that respect the interests of all and protect the integrity of the global environment and to develop a system that recognizes the integral and independent nature of the Earth.

The definition of sustainable development mentioned in a final report entitled *Sustainable Development of Mining Sector in APEC 2009* describes sustainable development as the combination of economic, social, ecological approaches on local, national, regional and global levels that focuses on preserving the world's natural wealth for future generations.

The mining, mineral and metal industries are very important to APEC member economies, due to the fact that the majority of global trade and investment in these commodities occurs in this region. Some APEC members are significant producers and consumers of minerals and metals, and other APEC economies derive important economic and social benefits from the development, use, and trade of minerals and metals. Since 2000, the trend in developing the global mining industry has been gradually shifting towards the Asia-Pacific region—the APEC region. At the turn of the century a mining alliance emerged with its center constituted by Japan and China as the main producers of steel and consumers of raw and energy resources, Australia and Brazil as suppliers of raw materials and the USA being the main market for end products. In 2004, global steel production exceeded one billion tons for the first time in human history. In 2007, China alone produced over half a billion tons of steel. In the beginning of 2H 2008, however, the world did not have as much steel. The USA and Middle East, the main consumers of Chinese steel, dramatically reduced their consumption, and the mining industry immediately slid into a recession; steel and raw material prices in some cases fell below the profitability level. As such, the development and implementation of a new paradigm for global, regional, and national development at rate of sustainable development became defined by the 21^{st} century. Their conditions are especially critical for APEC economies, which have huge material and intellectual resources and thus the strongest potential for sustainable development despite current global crisis.

1.2 Positive and negative contributions of mining to sustainable development

Mining activities cause both positive and negative impacts across environmental, social, economic, and political boundaries. Broadly, mining activity generates essential goods and services, directly and indirectly provides employment opportunities, and is a source of wealth for companies, institutional and private investors and for government at all levels through the collection of taxes, royalties and levies. If the wealth generated from mining activities is invested in activities or outcomes that are sustainable, then the utilization of these materials is also sustainable, as it has taken on another form (Worrall *et al.*, 2009); for example, through the construction of essential infrastructure such as hospitals, universities, ports, roads, and provision for research and development funding sources and investment in alternative technologies. Moreover, mining may be viewed as more sustainable if the depletion rate of resources can be reduced, time is allotted for research development and technology to develop alternative materials, the recovery rate of resources is improved, recycling is improved and cleaner production techniques are adopted (Van Berkel, 2000). In other words, mining may be considered to be acceptable if the immediate negative impacts are offset by remediation and it achieves net social, economic, and environmental benefits (Kumah, 2006).

The primary focus on the negative contribution of mining is obviously about the use and depletion of non-renewable resources. Extraction by mining industries reduces opportunities for future generations to access the same resources. In part, it is also due to the fact that many types of mining activity have had a severe and lasting effect on the natural and social environment (Hilson, 2002). These impacts tend to be locally and sometimes regionally significant, including topographic modification, altered geological, geomorphological and hydrological conditions, vegetation removal, topsoil removal, and a change in fauna habitat conditions. Furthermore, mining can cause dust, noise, light, water and visual pollution, can increase traffic volume, and can produce significant quantities of waste material, contaminated water and gas emissions (including greenhouse gases like CH_4, CO_2, NO_x and SO_x) (Worrall *et al.*, 2009). As the world demand for raw materials continues to grow along with the global population, it is estimated that mining operations will occupy some 0.2% (37,000 km^2) of the total world land surface (Hilson, 2003). In Australia alone, there has been an exponential increase in waste production and a steady to significant increase in known economic resources over time, while the annual rate of rehabilitation has not kept pace with the rate of disturbance (Mudd, 2007). Therefore, the challenge for government, the mining industry, and the general population is to determine how to balance these socioeconomic and environmental issues in a way that maximizes their benefits and minimizes or eliminates the resultant harm and/or degradation of the environment (Worrall *et al.*, 2009).

1.3 Mining and environmental impact

Major environmental issues relating to mining activities include air emission, discharge of liquid effluent and the generation of large volumes of solid waste. Erosion, formation of sinkholes, loss of biodiversity, and contamination of soil, groundwater, and surface water by chemicals from mining processes are examples. In some cases, additional forest logging is done in the vicinity of mines to increase the available room required to store the tailings and debris created. Another source of environmental damage is contamination resulting from the leakage of chemicals, which affects the overall health of the local population. In general, the environmental impact of metals mining is likely to be greater than for other minerals, because of toxic chemicals often used in mineral separation (Azapagic, 2004).

Minerals are essential components of numerous daily products. They are also vital raw materials in a large number of industries, including ceramics, construction, cosmetics, detergents, drugs, electronics, glass, metals, paints, paper, and plastics. Extraction and processing of minerals are, however, associated with a number of sustainable development challenges, including various economic, environmental, and social issues. For example, the mining industry is an important source of employment and wealth creation. On the other hand, extractive operations invariably lead to a variety of environmental impacts, including depletion of non-renewable resources, disturbance of the landscape and above-average threats to the health and safety of workers and citizens (Azapagic, 2004). Achieving the goal of sustained development requires a systematic approach that enables the balancing of economic, environmental and social concerns through the following (Azapagic, 2003; Azapagic and Perdan, 2003):

- □ Identification of stakeholders and key sustainability issues;
- □ Programs and actions needed to address these issues;
- □ Development of sustainability indicators to enable performance measuring and monitoring;
- □ Progress evaluation to ensure continuous improvement of the triple bottom line (economy, social and environment); and
- □ Information sharing and communication with stakeholders

1.4 Governments' countermeasures on environmental impacts due to mining activities in major developed countries

Four major developed countries including the United Kingdom, Germany, Australia and the USA were studied to identify countermeasures they currently have in place related to mining activity. The UK and Germany are members of the European Union, which has endorsed and adopted principles of environmental protection and sustainable development. Australia and the USA are the members of APEC, which have a very strong policy and regulations about mining. Therefore, it is interesting to learn from their history and use of sustainability countermeasures.

1.4.1 The United Kingdom

1) History of mine and mine reclamation in the UK

Britain has one of the longest mining histories in the world. Underground flint mines dating from the Stone Age remain accessible at Grimes Graves in Norfolk. Bronze Age mines for tin and copper are to be found in Cornwall and Wales, respectively. The Romans certainly worked gold in Wales, and also smelted argentiferous galena from the Pennines to obtain silver (ERMITE, 2001).

Indeed, mining of all kinds was once a cornerstone of the British Industrial Revolution, with coal, slate, copper, iron, lead, gold, silver, and many other minerals being extracted from the ground in enormous quantities all over the country. Britain's minerals have been mined for thousands of years, with a number of prehistoric and roman tunnels still remaining. Due to this industrialization, however, we see a tremendous growth in British mining, from the 1700's, through the 1800's to the earlier part of the 1900's. The thousands of mines in operation, many of them truly vast, gave employment to countless workers that were producing raw materials that would eventually be sold around the world (http://www.mine-explorer.co.uk/about_mine _exploring.asp). The environmental impact of those early mining activities was probably relatively localized.

The wealth and power resulting from activities during war and post-war times depended heavily on the exploration of natural resources (Linehan, 1976). Due to the desire for increased profits and pressure from international markets, the mining industry explored ever cheaper and faster methods for mineral extraction (Cloke, 1996). As such, deep surface mining was slowly phased out, and by the early 1990's was completely taken out of production. Surface mining became the ideal method for mineral exploitation (Linehan, 1976).

There are many severe side effects from mining. At a mining site like Cornwall, for example, every one ton of china clay extracted produces seven to eight tons of waste (Javurek, 1999). Large piles of mixed soil and larger debris were not leveled off—as is now required—leaving the landscapes in mining areas forever changed. In addition, huge pits were created that were sometimes used for holding water that is needed for the mining processes. Because of these and many other mining practices, severe soil erosion, nutrient loss, sedimentation, and water contamination (depending on the site), are characteristic environmental impacts at mine sites.

Many techniques used for reclaiming mines in England have been borrowed from common silvicultural practices used in forest management. The most commonly used techniques include site preparation, soil remediation, monitoring, and maintenance (Javulrek, 1999).

2) Background of legislation regarding mine reclamation laws

Considerable legal changes have taken place since 1994 in respect to mine water pollution in the UK. No statutory liability arose for merely "permitting" water to discharge from an abandoned mine; this oversight was changed in 1999, but only for mines abandoned after 31st December 1999. As such, this law would only apply to the few mines remaining, which may close at some time in the future.

In addition, new regulations were brought in that require operators to give at least 6 months notice to the Environment Agency of any proposed "abandonment". This notice was intended to allow time for all concerned to consider the likely impacts of closure and to seek to ensure appropriate measures could be put in place to deal with anticipated occurrences.

Perhaps the biggest change, however, was the introduction of the European Water Framework Directive, which is currently being transposed into the UK law. The directive is the most significant piece of legislation proposed related to the water environment in many decades. It is "all encompassing" in nature and requires that all bodies of water in the EU shall be of "good ecological quality" by 2015. Clearly, water impacted by mine water does not generally meet this requirement and therefore the objective must be to seek to treat discharges that lead to non-compliance within the timescale laid down. A further requirement of the directive is that no further degradation of watercourses from their current position should occur. This requirement puts added emphasis on the work needed to prevent new discharges from occurring (http://www.coal.gov.uk).

3) The government's countermeasures on environmental impacts due to mining activities

The main UK Government responsible for the environment is the Department for Environment, Food, and Rural Affairs. Within the UK, the key environmental regulators are the Environmental Agency (in England and Wales), the Northern Ireland Environment Agency (in Northern Ireland), and the Scottish Environment Protection Agency (in Scotland).

In England, the government has recently placed an increased importance on funding for various programs supporting restoration and reclamation projects of many previously mined lands. For example, it is supporting a program through the Countryside Commission that is restoring all types of lands (including mining) into Community Forests that spread throughout England. The emphasis of these projects is sustainability and education (Javulrek, 1999).

In terms of mine water pollution, the Environmental Agency (EA), the Scottish Environmental Protection Agency (SEPA) and the Coal Authority (CA) are the most active stakeholders in mine water management. The CA spends in excess of £8 million per annum on strategic pumping schemes, establishing treatment systems for the monitoring and maintenance of water in abandoned mines (ERMITE, 2001).

There is no regional government in England. In areas affected by mine water pollution, however, the Government Offices and the Regional Development Agencies may play some role.

At the policy-making level, the responsibility for mining issues and their environmental impact is spread among several ministries, including:

Department for Environment, Food, and Rural Affairs (DEFRA)

- in charge of water management, including water quality and contaminated land
- directly concerned with mine water pollution and mine waste management

Department of Transport, Local Government and Regions (DTLR)

- deals with mineral planning
- prepare mineral planning guidance documents including the mitigation of environmental effects of mineral extraction

Department of Trade and Industry (DTI)

- the interface between the government and the metalliferous and industrial mineral mining industries
- in charge of energy policy, which determines the fortunes of coal mining
- involved in policy-making as providers of expertise

Environment Agency (EA)

- responsible for the enforcement of pollution control legislation, water resources, waste management and fisheries in England and Wales

Scottish Environmental Protection Agency (SEPA)

- performs the same function as EA in Scotland

Coal Authority (CA)

- manages coal in Great Britain (which is still publicly-owned) on behalf of the state
- issuing licenses to private operators
- has a strict environmental policy to ensure legal compliance

- addresses historic legacies left by past coal mining activities

Mining industry in the UK

1. **UK Coal** is the largest mining company in the UK with 8,000 employees in 40 locations across the UK. It is also Europe's largest totally independently owned coal mining company.

2. **Scottish Coal** is a coal mining company with 2000 employees. It is mainly engaged in opencast mining at present, with only one deep mine (Longannet) which is still in production.

3. The **Mining Association of the United Kingdom (MAUK)** is subscribed by companies having interests in mining and exploration.

4. The **Mineral Industry Research Organization (MIRO)** is a research and information trade organization for the minerals industry. They are also involved in mine water research.

5. The **Institution of Mining and Metallurgy (IMM)** is the professional body representing mining and exploration geologists, engineers, and metallurgists in Britain and overseas.

6. The **British Geological Survey (BGS)** is the main Government agency in the Great Britain for undertaking national work in earth sciences. Its function is to recognize a national repository for geosciences data, carry out specialist functions for government departments and private companies, such as geochemical investigations and environmental geology studies in addition to producing the *BGS Directory of Mines and Quarries* and the *United Kingdom Minerals Yearbook.*

4) Financial supporter for mine reclamation

Public funding became increasingly available for metal mine closures during the 1980s and 1990s, and was initially focused on dealing with public health and safety issues at abandoned sites. From the 1990s, public funding has become increasingly available for developing infrastructure and capacity in the country for reversing post-industrial decline.

5) Special organization that handles mine reclamations in the UK

The **Post-Mining Alliance** (http://www.postmining.org) is an independent not-for-profit organization tasked with the mission to encourage and promote the regeneration of old mine sites for the sustainable benefit of the local community and the natural environment. Its funding from public and private sources includes:

- Anglo American;
- Carnegie Trust;
- Department for International Development, UK;
- Eden Project;
- English Partnerships;
- European Regional Development Fund, EU;
- Imerys;
- International Council on Mining and Metals; and
- Rio Tinto.

The aims of the Post-Mining Alliance are to:

- catalyze action on mining legacies—converting liabilities to opportunities;
- stimulate the uptake of good practice in integrated mine closure; and
- encourage solutions where risks, responsibilities and opportunities are shared.

There are a number of notable achievements in mine reclamation currently underway in the UK. The Eden Project in Cornwall is the most successful example of a post-mining regeneration project in the UK, with a strong socio-economic focus. Further information can be found at http://ww.edenproject.com.

6) Annual budget

The capital budget plan for year 2010–2011 in terms of total department expenditure is £393,400 million. Considering the environmental sector, a budget of £3,300 million has been allocated to the Department for Environment, Food, and Rural Affairs (DEFRA).

The Department for International Development, whose function is to provide funds for projects such as the Post-Mining Alliance, received about £7,800 million.

More information about the UK National Budget is at http://www.hm-treasury.gov.uk/budget2010_documents.htm.

7) Businesses eligible to get support from the government

The main discretionary incentive schemes to support capital investment in the UK are known as:

- In England: Grant for Business Investment;
- In Northern Ireland: Selective Financial Assistance;
- In Scotland: Regional Selective Assistance; and
- In Wales: the Single Investment Fund.

The schemes are designed to support domestic and overseas-owned companies that are considering opening a new facility, or expanding or modernizing an existing facility within an Assisted Area of the UK (http://www.uktradeinvest.gov.uk/).

Key eligibility criteria

In order to qualify for support, companies must meet a number of key criteria, including:

a) The project must be located in an Assisted Area;
b) The project must create or safeguard jobs;
c) The project must involve a capital expenditure;
d) The project must be viable and provide national and regional economic benefits;
e) The project must be mainly funded from the private sector;
f) The project must be located in an eligible sector;
g) The project must require grant assistance to proceed.

The European Commission restricts aid to certain sectors such as iron and steel, coal, synthetic fibers, vehicles, agriculture and fisheries. For a full list of ineligible sectors, applicant businesses should contact the relevant regional government organization (http://www.hm-treasury.gov.uk/d/mainest08_27_ukti.pdf).

In summary, there are a number of key criteria that must be met in order to succeed with an application for capital grants. Therefore, potential applicant businesses are strongly encouraged to contact the relevant regional government organization for detailed guidance (see http://www.businesslink.gov.uk/solutions).

According to the Grant for Business Investment Guideline provided by the Department for Business Enterprise and Regulatory Reform (BERR), eligible businesses that are able to receive financial assistance from the government can be summarized as follows:

Local consumer-type service activities	Projects that involve retailing or other local consumer-type activities will not normally qualify for assistance. This is because local consumer-type projects are not mobile, involve primarily routine low-risk investments, and do not provide significant regional or national benefits.
Mining and construction	Special care needs to be taken over the permanence of employment in mining and construction projects. Individual construction projects should not normally be assisted but a project to expand the workforce of a construction company on a permanent basis would be eligible.
Tourism	Tourism projects, for example B&B projects, hotels, etc. may qualify, though displacement considerations will frequently lead to ineligibility. Projects would not normally qualify where finance is still available under Section 4 of the Development of Tourism Act 1969. Applications are to be referred to the appropriate Tourist Board for market advice.
Charitable organizations	Activities undertaken by charitable organizations and other similar bodies may qualify providing they are of a commercial nature.
Franchise operations	By their nature, franchise operations will not normally qualify. The length of the franchise, viability, control over the business and displacement are among issues that need careful scrutiny. Legal advice should be sought if there is any uncertainty about the terms of the franchise agreement being compatible with the national policy objectives of the GBI scheme.
Health service	Applications involving hospital or medical services and residential care are ineligible for assistance. The primary health care sector is considered to be fully supplied by the National Health Service and its relationships with, and other funding for, private sector providers.
Defense	Applications for projects in the defense sector are normally ineligible for assistance. The defense sector is considered to be fully supplied by the Armed Services and their associated private sector providers.
Educational	Projects by schools or colleges are unlikely to qualify for assistance. The schools sector is considered to be fully

	supplied by the Department for Children, Schools and Families and its relationships with, and other funding for, private sector providers. Universities should be treated as private sector organizations.
Energy generation	These projects are unlikely to satisfy national GBI criteria. Energy markets are regulated and projects often serve only regional/local markets. There are also separate, substantial funding schemes for some segments; for example, for off-shore wind farms.
Tobacco	Projects involving the manufacture of tobacco related products are unlikely to qualify for GBI support as this market is considered to be fully supplied in Great Britain.

Further explanation pertaining to eligibility can be found in the *Grant for business investment_Dept. for Business Enterprise & Regulatory Reform* (http://www.bis.gov.uk/policies/regional-economic-development/regional-investment).

8) Portion of mining industry

The economic importance of individual industries in the UK, including the mining industry, to the national economy is measured by their contribution to the Gross Value Added (GVA) measure. This is a key economic indicator and refers to an increase in ability to produce goods and services. Value added is identified as the difference between the value of the output (e.g. sales revenue) and the cost of brought-in inputs used to produce it (fuel and other raw materials, but not labor). The GVA of mineral extractive industries as a whole is included in UK national accounts under the heading "Mining and quarrying", which includes the extraction of oil and gas (BGS, 2008).

Based on the GVA at current basic prices by industry, UK mining and quarrying has contributed about 2.1% to 2.8% among all industries. The estimated GVA of mining and quarrying in 2007 in the UK was £32,196 million, which decreased about 0.34% from £32,307 million in 2006 (Office for National Statistics, 2009).

9) Current status of impacts from mining activities

A major environmental problem from mining activity in the UK is mine water pollution. The impacts of mining on the water environment in the UK include five distinct phases of the mining life cycle (ERMITE, 2001).

1) Mineral processing operations, especially the disposal of tailings, caused major ecological and economical damages in the 18th and 19th centuries. Environmental problems from active processing have been increasing in the 20th and 21st centuries;
2) Dewatering;
3) Seepage of contaminated leachate from waste rock piles and tailings dams;
4) Flooding of workings after extraction;
5) Discharge of untreated water after flooding is complete.

Discharges of polluted water from old audits have long been a problem in the upland mining districts of England. It is only in recent decades that abandoned mine water discharges have begun to emerge from the major regional field of the British lowlands. The combined effects of metal mines and coal mines are currently estimated to adversely affect the ecology and water resources potential of some 600 km of watercourse in the UK, diminish water resources available for the water supply, impact the daily life of mining communities, hinder the economic redevelopment of former mining areas and require long-term funding for a problem that will simply not go away.

1.4.2 Germany

1) History of mine reclamation in Germany

There have been large and medium scale mining activities in the current territory of Germany for more than 1000 years; such activities can be traced back to the Neolithic and Bronze Age in the area which is now Germany. The beginning of mining can be dated back to the 10th century. Mining reached its peak in the Medieval Times (between the 12th and 14th centuries) and during the Renaissance (16th century). Recently, in the Federal Republic of Germany, active mining operations are conducted in the following sectors:

1) Hard coal and lignite
2) Quarry industry
3) Potash and mineral salt
4) Underground storage of oil and natural gas
5) Other resources, such as iron ore, fluorspar.

Hard coal and lignite are extremely important for the national economy in the medium and long term in order to satisfy the primary energy demand from indigenous raw materials. The exploitation of mineral oil and natural gas should also be mentioned, as well as the underground storage of hydrocarbon. Note that in the metal ore sector (e.g. iron, zinc, tin and silver) only one mine is still active.

Mining activities, i.e., exploitation and processing, have always had a considerable impact on the environment in the vicinity of the mining sites, depending on the intensity and the duration of the mining activities concerned. During the production phase, large quantities of overburden or waste rock are usually generated and relocated, while the processing of raw materials generates by-products and waste. All mining activities in Germany are regulated as case-to-case decisions within the Federal German Mining Law (Bundesberggesetz, BBergG as of 26th January 1998). These cases include the exploration, production and processing of mineral resources as well as the after-care phase and the recultivation of areas that are no longer used for mining. Depending on the different and concrete types of operation, the mining operator has the statutory duty to recultivate the land surface used for mining purposes after the operations have come to an end. The fundamental regulations contain quite long-lasting and strict obligations concerning the closure of mining companies in Germany.

2) Background of legislation regarding mine reclamation

Mining legislation in Germany consists of the Federal Mining Act of 1980, last amended in August 2002, and a number of Mining Ordinances on technical and procedural issues, e.g., the Federal General Mining Ordinance of 1995, the Health and Safety Mining Ordinance of 1991, the Ordinance on the Environmental Impact Assessment of Mining Projects of 1990. These provisions set up a uniform mining law for all important mineral resources in the form of a comprehensive law covering all aspects of mining, including health and safety, and environment, supervised by one single administration (a “one-stop” shop). This approach directly implements the challenges of the concept of sustainable development, taking into consideration the three pillars of environmental protection, social development and economic development, with each of these policy areas being mutually supportive of the others (http://www.un.org).

The Federal Mining Act and the Ordinance on the Environmental Impact Assessment for Mining Projects of 1990 integrated the environmental impact assessment (EIA) into a skeleton operations procedure plan with specific provisions for taking into account the dynamic character of mining activities. The Ordinance of 1990 contains a list of major mining projects that are subject to the EIA, e.g., opencast mining with a surface of 25 ha or more, and/or tips of an area of 10 ha or more. In order to guarantee the participation of both the public and all stakeholders, the approval of a skeleton operations plan via the EIA by the mining authority is subject to a formal plan approval procedure according to the general German Administrative Procedure Act, which includes a review of all involved parallel permits (one-stop shop). This procedure allows all issues involved to be examined by all administrations and stakeholders and gives the investor the necessary legal security. As regards the monitoring of all phases of mining operations (exploration, project development, mine operation, and mine closure), the German mining law contains a very dense system of mechanisms for compliance and monitoring, which is enforced by the mining authority through a differentiated system of administrative acts and regular controls (http://www.un.org).

3) Action on legislation and budget

All mining activities are regulated by mine management plans. The relevant authorities for all mining issues are the regional mining authorities (Bergamt). Although the permissions are formally given by the mining authorities, all decisions are based on cooperation with the authorities responsible for water and the environment at the local and regional levels. For the water used during the different mining phases, the authorities will note their decisions in the permitting procedure on the basis of the law and the relevant regulations (ERMITE, 2002).

As regards fiscal provisions, the German Federal Mining Act contains detailed rules on royalties for the extraction of mineral resources, setting them at a standard percentage of 10% of the market value. This percentage can be reduced or raised by Ordinance if so required in order to achieve any of the following aims, as set out in the Act: preventing an overall economic imbalance, preventing the risk of distortion of competition among the companies engaged in exploration and exploitation, assuring the adequate market supply of raw materials, improving the exploitation of deposits or protecting other interests of the national economy. Apart from this specific levy, taxes for the mining industry are, in principle, subject to the general provisions of the tax and revenue law (http://www.un.org).

In Germany, the Legislation, **Licensing and Fiscal regime** are the responsibility of **the local State Authority for Mining** of the federal states (http://www.ofd.niedersachsen.de/servlets/download?C=39688480&L=20) .

Further information can be found on the following websites:

- http://www.lbeg.niedersachsen.de for Lower Saxony, Hamburg, Bremen and Schleswig-Holstein
- http://www.bezreg-arnsberg.nrw.de/bergbau-und-energie for Nordrhein-Westfalen

- http://www.bergamt-mv.de for Mecklenburg-Vorpommern
- http://www.sachsen-anhalt.de/LPSA/index.php?id=15849 for Sachsen-Anhalt
- http://www.lbgr.brandenburg.de for Brandenburg and Berlin
- http://www.rp-darmstadt.hessen.de for Hessen
- http://www.saarland.de/7809.htm for Saarland
- http://www.lgb-rlp.de for Rheinland-Pfalz
- http://www.lgrb.uni-freiburg.de/lgrb for Baden-Württemberg
- http://www.stmwivt.bayern.de for Bayern
- http://www.tlba.de for Thüringen
- http://www.bergbehoerde.sachsen.de for Sachsen

Rules of the Mining Authority according to the Federal Mining Act include:

1) Ensuring the safety of mines/protecting third parties;
2) No installations without approval by the Mining Authority;
3) Government supervision includes:
    a. Operations planning procedures;
    b. Regular inspections of mining facilities;
    c. Law enforcement.
4) Power granted by the Federal Mineral Act;
    a. Section 71: Being authorized to command
    b. Section 72: Preventing unauthorized activities
    c. Section 73: Prohibiting the employment of unreliable or unsuitable individuals
    d. Section 74: Taking necessary steps in case of accidents
5) Monitoring of health and safety regulations;
6) Investigating accidents;
7) Fixing penalties in case of violations;
8) Decisions on dispensing permits.

More information can be found at http://www.ene.ttu.ee/maeinstituut/taiex/presentations/ THE% 20GERMAN% 20MINING%20AUTHORITIES.pdf.

4) Financial support for mine reclamation expense

Before the German reunification in 1990, the political and economical systems between the Western and Eastern parts of Germany were different. The mining industry in West Germany was in the hands of private companies that were obliged to properly re-cultivate the land used for mining and to obey the relevant measures with regard to other environmental matters, while the mining companies in East Germany were considered as state property. As the policy in East Germany was aimed at achieving a high degree of self-sufficiency by supplying indigenous raw materials wherever possible, the production of minerals was in most cases uneconomical, and the recultivation of land and the restoration of a proper water balance were of even lesser importance. After reunification, companies were founded for recultivation the closed down mines and for carrying out environmental measures (Wismut GmbH. LMBV, and GVV mbH). In West Germany, the costs for closing down mines have to be paid by the operator.

5) Special organizations carry out mine reclamation in Germany

Special companies have been set up for closing down opencast mines, which were closed down at a large scale.

1) Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft mbH (LMBV) (http://www.lmbv.de/) is a federally owned company. Its mission is to prepare and sell real estate on decommissioned lignite mining sites in eastern Germany as part of rehabilitation measures designed to ensure their successful future use. LMBV is one of four companies set up by the German Treasury to manage, develop, and market government-owned real estate. In doing so, LMBV concentrates on areas once used for opencast mining. The real estate business is locally run in departments of real estate properties in Lausitz and Central Germany. These areas include the rehabilitation of mining facilities with orientation to assure successful future utilization, recultivation, and creation of landscapes reclaimed from decommissioned lignite-mining operations, as well as real-estate development oriented to commercial and industrial use.

2) Wismut GmbH (http://www.wismut.de) is a federal government-owned company operating in Saxony and Thuringia. Its principal business is the decommissioning, cleanup, and rehabilitation of uranium mining and processing sites.

The company's sole shareholder is the Federal Republic of Germany, represented by the German Federal Ministry of Economics and Technology. Since its foundation in 1991, the company has been headquartered in Chemnitz/Saxony. The Wismut Project has emerged as an important international reference project for state-of-the-art remediation technologies for the rehabilitation of radioactively contaminated sites. The experience and know-how gained under this unique environmental restoration project are being applied by the WISUTEC subsidiary to rehabilitation projects in Germany and abroad.

Concluded between the German federal government and the Free State of Saxony in September 2003, an administrative agreement settled the funding of the rehabilitation of abandoned Wismut sites in Saxony. A total of €78m was spent on this undertaking by the year 2012. Wismut was the project executing organization for the task of rehabilitating abandoned uranium sites in Saxony. Under the terms of the administrative agreement, at least 50% of that total is to be outsourced to third parties by public invitation to tender a bid to give fresh impetus to regional development.

3) Gesellschaft zur Verwahrung und Verwertung von stillgelegten Bergwerksbetrieben mbH (GVV) (http://www.gvv-sondershausen.de/) is another federal company that handles the reclamation of minerals such as potash and spar-ore mines in eastern Germany. GVV has the task of being beneficiaries of the covenant, co-financed by the state of Saxony-Anhalt and Thuringia, focused after the cessation of potash production and spar-ore mines in eastern Germany.

6) Annual budget

Germany differs from other countries in that there are unusual constraints on government borrowing and an unusual reliance on countercyclical taxes and reserves. This is a direct result of Germany's history of extreme inflation. Detailed rules of the budgetary behavior are applied to particular circumstances to determine whether deficits of borrowing are permitted.

Federal budget and fiscal policy key figures, February 2010

(http://www.bundesfinanzministerium.de/nn_83222/DE/BMF__Startseite/Aktuelles/Monatsbericht__des__BMF/2010/03/federal-budget/1003161a1002.html?__nnn=true)

Table 1.1 Trends of the federal budget

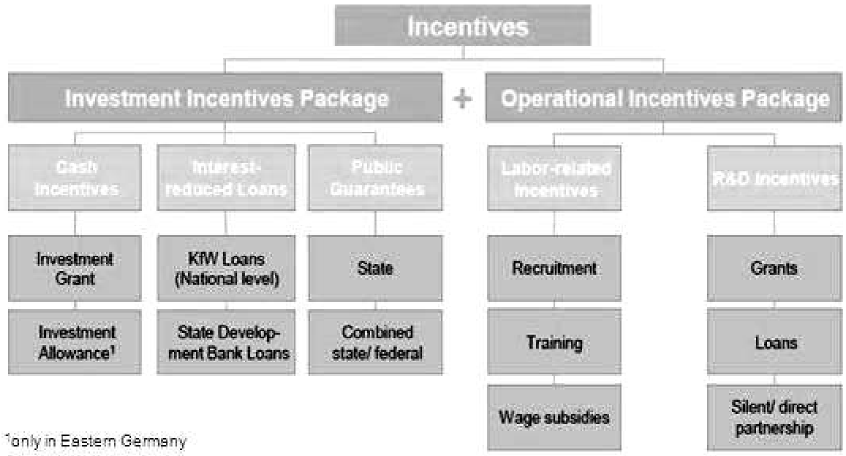
Trends in the federal budget (in million Euros)			
	Estimated 2010	**February 2010**	**February 2009**
Expenditure	319,500	60,455	57,615
Revenue	238,924	31,940	36,464
Tax revenue	211,887	28,383	32,912
Financial deficit	-80,576	-28,499	-21,152
Adjusted for revenue from coin	376	-115	-122
Net borrowing/current financial market balance	-80,200	-27,962	-1,513

The budget is not specific to the mining sector.

7) Businesses eligible to get support from the government

Incentives for investment in Germany (Germany Trade and Invest, 2009):
Germany offers numerous incentives to all investors—regardless of whether they are from Germany or otherwise. Incentives can be grouped into two packages:

1) An investment incentives package with different measures to reimburse investment costs.
2) An operational incentives package to subsidize expenditures after the investment has been settled.



Source: http://www.gtai.com/

Determining eligibility

Each incentives program defines both the industry as well as form of investment (e.g. Greenfield projects or expansions) eligible for funding. Foreign investors are subject to exactly the same conditions available to German investors.

Each program has a set of criteria (such as company size, planned investment project location, etc.) that determine individual investment project incentive levels.

Framework conditions of public funding

The legal and financial framework of public funding throughout Europe is provided by the European Union (EU)—meaning that public funding has to follow certain criteria applicable to all EU member states. The objectives of public funding are the overall advancement and maintenance of economic growth and development in different economic regions within the EU in the long term.

The federal government funds investment projects and supports employment in Germany in cooperation with the German states. A significant part of the funding comes from the EU, which supports regional economic development in its member states. Germany will receive EUR 25.5 billion until 2013 from the EU's two main financial instruments—the European Social Fund (ESF) and the European Regional Development Fund (ERDF)—which are co-financed from the German national and federal state budgets.

Most incentives programs offer the highest incentives rates to small and medium-sized enterprises (SMEs). Some programs may even specifically target SMEs (this is very often the case with R&D programs). Other criteria determining project eligibility may be defined subject to individual incentives programs and federal state regulations.

Cash incentives for investments

Investor production facility set-up costs can be significantly reduced using a number of different measures from Germany's investment incentives package. Cash incentives provided in the form of non-repayable grants typically make up the main components of this package. There are two major programs directing the allocation of these cash incentives:

1) The "Joint Task for the Promotion of Industry and Trade" or "Joint Task" *(Gemeinschaftsaufgabe, GRW).*
2) A special cash incentives program to promote investment activities in East Germany called the "Investment Allowance" *(Investitionszulage, IZ).*

Cash incentives are usually administered by the German states.

The Joint Task Program

The Joint Task Program is issued by the Ministry of Economics and Technology. It regulates the distribution of non-repayable grants for investment costs throughout Germany. Money available through this program is usually distributed in the form of cash payments that are based on either investment costs or assumed wage costs. The actual incentives amount granted varies from region to region, subject to the level of economic development. Regions with the highest incentives rates offer grants of up to 30% of eligible expenditures for large enterprises, up to 40% for medium-sized enterprises, and up to 50% for small enterprises. These higher incentive rate regions are mainly situated in East Germany.

Several regions within the western parts of Germany and Berlin are also designated incentives regions, but at a lower incentive rate level than their eastern counterparts. In these regions, large enterprises can receive subsidy rates of up to 15%, medium-sized enterprises up to 25%, and small enterprises up to 35% of eligible project costs.

8) Portion of mining industry

Gross Domestic Product per capita of Germany declined 5% to $34,100 in 2009 from US$35,900 in 2008. The portion of mining industry in Germany is also mentioned in terms of Gross Value Added (GVA) as is the UK. Based on the GVA at current basic prices for all products and services, Germany's mining and quarrying has contributed about 0.14% to 0.23% among all products and services between 1995 and 2006 (Federal Statistical Office, 2009). In 2009, Germany's export-oriented manufacturing sector in particular suffered from the global collapse in demand. As such, the annualized gross output in this sector dropped by roughly 18% in real terms. This decline went hand-in-hand with a sharp drop in the transport and communication sectors, particularly due to a declining demand for transport services. In the mining and quarrying sector, the GVA decreased 15% from 2008. Overall, the services sector had a stabilizing effect on the economy since the public sector and private sector service providers attempted to expand their commercial activities (Federal Ministry of Economics and Technology, 2010).

9) Current status on impacts from mining activities

Germany has fundamental regulations based on their mining laws that contain lasting and strict obligations concerning the closure of mining companies, though the notable environmental problems for mining activities in Germany are from mines that are not governed by the mining control authority. Those mines were closed before the BBerG came into force or by mines that are closed in accordance with section 69(2) BBerG ("*Bergwerke die nicht der Bergaufscicht* *unterliegen*”). They are usually referred to as abandoned or closed mines, though other terms are also in use (UNEP & Chilean Copper Commission, 2001).

There are numerous untreated mine water discharges and drainage water effluents at German mine sites that pollute surface water on a local or regional scale. These are cases in which the authorities were or are not able to regulate mine water discharges because the mine was abandoned or was closed in accordance with former laws. Examples of these cases include polysulfide underground mines within the Freiberg/Saxony area, mercury mines in the Saar-Nahe-Basin, or the Mechernuch/Eifel lead-zinc mining area, which was disused before the commencement of the German Federal Mining Law. The environmental impact in the Freiberg region is caused by leaching of heavy metals from heaps and tailings and by acid mine drainage. The mine water is characterized by low pH values and a high content of heavy metals, including arsenic and cadmium (ERMITE, 2002).

The lead-zinc mine in Mechernich/Eifel was closed in 1957 because of economic change. The low metal content in the sandstone could only by economically extracted by an expanded mining area. Plumbiferous sand as a byproduct of ore processing was deposited in tailings and heaps; erosion processes of wind and water then distributed the plumbiferous sand within an area of several kilometers. Furthermore, mine water outflow from Burgfeyer Stollen, with high concentrations of zinc, cadmium, and nickel, discharges into Veybach and the river Erft. Every year, about 25 tons of zinc and 12 tons of nickel pollute the river. The problem is exacerbated by the fact that not all mine water discharges are treated according to existing environmental regulations (ERMITE, 2002).

An example of a mine that is not governed by the Mining Control Authority is the fluorspar mine Hohenwarte/Harz. In 1985, economic reasons caused the closure of the Hohenwarte fluorspar mine near Gernrode. The mine was closed with a requirement to use the mine’s drainage tunnel as water reservoir; at the end of utilization, the mine should finally be closed. As a result of the German reunification, however, the former mine owner disappeared, resulting in the mine being appropriated by the Federal State of Saxony-Anhalt. The mine water being discharged is highly conductive and has a high content of sulfur, iron, manganese, and zinc, which is now causing a decrease of the water quality of the neighboring rivers. No solution has been found yet, despite numerous discussions among the authorities and owners over the past several years (ERMITE, 2002).

1.4.3 Australia

1) History of mine and mine reclamation

Australia is one of the world's leading mineral resource nations. It is the world's largest refiner of bauxite and the fourth largest producer of primary aluminum. It is the largest producer of gem and industrial diamonds, lead and tantalum, and the mineral sands ilmenite, rutile and zircon. It is the fifth largest producer and largest exporter of black coal and the second largest producer of zinc, the third largest producer of gold, iron ore, and manganese ore, and the fourth largest producer of nickel. It is the fifth largest producer of copper and silver. It also has the world's largest resources of low-cost uranium.

Silver and later copper were discovered in South Australia in the 1840s, leading to the export of ore and the immigration of skilled miners and smelters. The first economic minerals in

Australia were silver and lead in February 1841 at Glen Osmond, now a suburb of Adelaide in South Australia. Mines including Wheal Gawler and Wheal Watkins opened soon after. In 1851, gold was found near Ophir, New South Wales. Weeks later, gold was found in the newly established colony of Victoria. Australian gold rushes, in particular the Victorian Gold Rush, had a major lasting impact on Victoria, and on Australia as a whole. The gold rush colored every aspect of Australian society and elements of it are still clearly visible today. The influx of wealth that gold brought soon made Victoria Australia's richest colony, and Melbourne the island's largest city (http://en.wikipedia.org/wiki/Mining_in_Australia).

In 1996, the Minerals Council of Australia launched the Australian Minerals Industry *Code for Environmental Management* (the Code) for adoption by signatory companies. This Code is intended to encourage minerals companies, wherever they operate, to implement effective environmental strategies during each phase of mineral development, from initial exploration to closure and final rehabilitation. Consistent with its *Multiple Land Use Policy,* the Minerals Council of Australia supports multiple and sequential land use. Rehabilitation, however, undertaken as part of the closure process, can only restore some—but not all—of the original environmental value.

However, innovative closure strategies, undertaken in close consultation with stakeholders, can provide end land use scenarios with many positive economic, social, and environmental benefits. (http://www.goodpracticemining.org/documents/jon/MCA_mineclosguidance.pdf).

Public awareness of the environmental problems associated with mining has increased significantly in the post-war years and extensive reclamation projects to clean up disturbed sites are now common in many mining operations. Cairns (1979) suggested three general options are available to industry: to abandon the site after mining is completed, to restore the mine site to its original condition, or to reclaim it to an ecologically viable condition. In recent years the limestone quarry at Marulan (located 2.5 km east of Goulburn) has expanded considerably and concern has been expressed regarding the implementation of methods needed to reduce its visual impact in the region, particularly when viewed from the Bungonia lookdown. In another location, in 2004, A.M. Mercuri, J.A. Duggin and C.D. Grant, studied the use of saline mine water and municipal wastes to establish plantations on rehabilitated open-cut coal mines, Upper Hunter Valley NSW, Australia. In 2007, B.G. Lottermoser, P.M. Ashley and N.C. Munksgaard utilized the biogeochemistry of Pb-Zn gossans for mineral exploration and mine site rehabilitation in northwest Queensland.

2) Background of legislation regarding mine reclamation laws

Despite being an important economic activity, mining causes substantial damage to the environment worldwide. Effective reclamation is therefore necessary, and if conducted properly, can restore scarred land to its former state, and support additional post-mining economic activities from a sustainable perspective.

Western Australia, an important mining region, is characterized by strict and comprehensive regulations (Mining Act, Soil and Land Conservation Act, Wildlife Conservation Act and Aboriginal Heritage Act). Here, a coordinated approach is used by government departments for an environmental assessment of mining prospects. Subsequent reclamation conditions are determined by the Mines Department and depend on the particular area where the mine site is situated. These conditions can be modified at any time.

3) Financial support for mine reclamation

In Australia, mine reclamation programs are supported by millions of dollars of funding from a series of environment organizations such as Environment Australia and National Environment Protection Measures, in addition to state/territory and local governments. More detailed information can be seen at http://www.environment.gov.au/about/international/oecd/publications/pubs/oecd.pdf and http://www.environment.gov.au/land/publications/pubs/wildlife.pdf.

4) Special organization for handling mine reclamation

Responsibility for mine closure issues, in particular for minerals industry regulation including mine closure requirements, rests primarily with the state and territory governments. Accordingly, while it is appropriate for the Minerals Council of Australia to work towards development of an industry position on mine closure regulations, the community will ultimately demand effective regulatory regimes. In developing such regulations, the needs of all stakeholders must be recognized.

5) Annual budget

The main cash budget aggregates for the Australian Government general government sector over the period 2007– 2010 are available at http://www.budget.gov.au.

6) Portion of mining industry

Australia has the potential to remain among the world's leading minerals exporters, and the minerals industry is one of the biggest contributors to Australia's export trade.

Key Industry Figures	2009	2010	
Industry Revenue	*169,755.8	XXXX	$ million
Revenue Growth	*27.8	XXXX	%
Industry Gross Product	*100,188	XXXX	$ million
Number of Establishments	*2,550	XXXX	Units
Number of Enterprises	*1,370	XXXX	Units
Employment	*131.5	XXXX	Persons
Exports	*135,594.4	XXXX	$ million
Imports	*22,079.9	XXXX	$ million
Total Wages	*14,035.8	XXXX	$ million

(Source: http://www.ibisworld.com.au/industry/default.aspx?indid=55**)**

The market share obtained from mineral resource exports was high, compared to the total shares obtained from all export sources. As this figure shows, the share of total exports varied from 50 to 60% of export earnings.

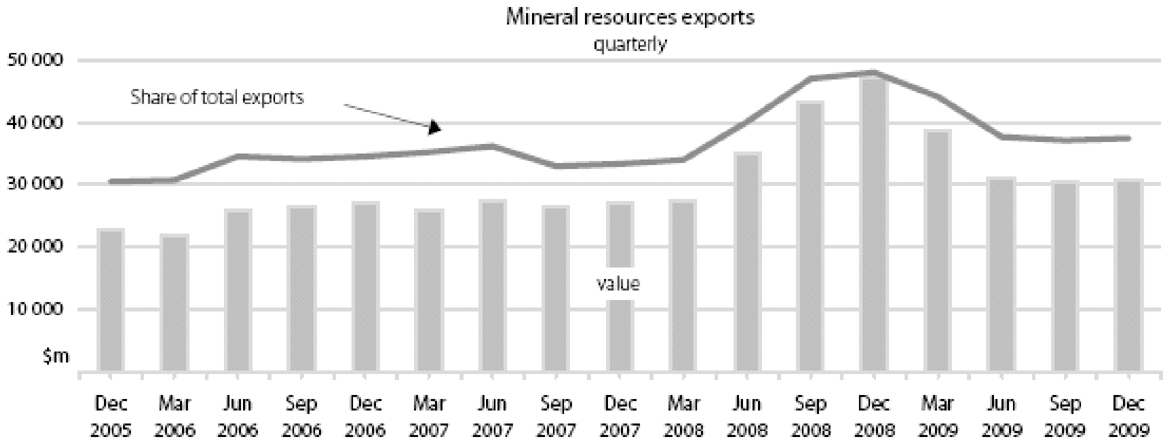


Figure 1.1 Share of mineral export of Australia (Source: http://www.abare.gov.au/publications _html/ams/ams_10/ams_mar10.pdf).

7) Current status of impacts from mining activities

The mining industry accounts for a small but vital contribution to the Australian economy. However, there are several issues of concern in this sector, including high rates of foreign ownership and control, unwelcome effects on the environment, rapid rates of extraction that may exhaust the reserves and the widespread but not universal neglect of simple reshipment processing in Australia.

Firstly, in terms of environment, Australia has specified the main impacts from mining, and has reported that the economy currently has a sufficient number of specific function organizations to handle unwelcome issues. Environmental impacts of mining are listed, such as 50,000 tons of coal dust, acid mine drainage (AMD) and heavy metal contamination, arsenic, mercury and lead, arsenic exposure from burning coal, from *The Source of Anthropogenic Heavy Metals in Fluvial Sediments of a Rural Catchment*. Further information can be seen at http://nonewcoal.greens.org.au/toxicity/ index-of-articles.

Secondly, as consequences of the aforementioned environmental problems, mining activities have caused a series of negative impacts on human beings—and especially for women. Though the impacts of mining operations are not gender neutral, women can experience the direct and indirect consequences of mining operations in different, and often more pronounced, ways than men. Many are mothers caring for children in households that deal with the daily reality of raising a family and putting food on the table. As such, when water and food supplies are polluted by mine waste, it is women who are most deeply and directly affected. Please refer this website for more information: http://www.oxfam.org.au/resources/filestore/originals/ OAus-MiningAndGender-1209.pdf.

9) Governments' countermeasures on environmental impacts due to mining activities

The Minerals Council of Australia's mandate is to represent Australia's exploration, mining, and minerals processing industry, nationally and internationally, in its contribution to sustainable development and society. The MCA has changed markedly, transitioning its focus from managing present environmental impacts (rehabilitation and reclamation) to longer-term sustainable ecosystems and biodiversity management.

The Australian Environment Portal is the primary environmental organization. Each state and territory also has a department dealing with the environment (New South Wales, Queensland, Victoria, Western Australia, South Australia, Tasmania, Northern Territory, Australian Capital Territory). More information can be found at:

Australian Environment Departments
Department of Environment, Water, Heritage and the Arts (DEWHA)
www.ea.gov.au/about/library/govtdepts.html

Individual Agencies with Environmental Concerns:

- Department of Climate Change (http://www.climatechange.gov.au) is tasked with reducing carbon pollution.
- Arid Lands Environment Centre (ALEC) has campaigned on a wide range of local, regional, and national environmental issues including: urban water and energy conservation, ecologically sustainable pastoral land management, weed and feral animal management, nuclear issues, threatened species conservation and waste minimization (http://www.alec.org.au/). Some of ALECs on-ground outcomes include the establishment of the Centre for Sustainable Arid Towns (CSAT), a consultancy specializing in sustainable urban water, energy and waste management, working to oppose uranium mining, nuclear energy and waste in central Australia.
- Centre for Plant Biodiversity Research and Australian National Herbarium (http://www.anbg.gov.au/cpbr)
- Environment Protection and Heritage Council (EPHC) (http://www.ephc.gov.au)
- Land & Water Australia (http://lwa.gov.au)
- National Climate Change Research Strategy for Primary Industries (CCRSPI) (http://ccrspi.com.au)
- National Pollution Inventory (NPI) (http://www.npi.gov.au)
- National Water Commission (http://www.nwc.gov.au)
- National Land and Water Resources Audit (http://www.nlwra.gov.au)
- Safe Work Australia (http://safeworkaustralia.gov.au)

1.4.4 USA

1) History of mining and mine reclamation

The United States produces a wide variety of commodities from gold to coal. It is the world's second largest producer of copper and gold, exports over US$26 billion worth of minerals and material produced from minerals each year and its mining industry employs over 3 million people directly and indirectly.

The USA has a long history of mining that even pre-dates the country's split from Britain. The coal industry, for instance, dates back to 1,000 AD when the Hopi Indians, living in what is now Arizona, used coal to bake pottery made from clay. The history of coal is summarized in a timeline produced by the American Coal Foundation.

Other important dates in the US mining history can be summarized as followings (http://www.infomine.com/countries/SOIR/USA/):

- 1705 - the first copper mine was opened in Branby, Connecticut.
- 1748 - the first recorded commercial US coal production in the Manakin area, what is now Richmond, Virginia
- 1844 - iron ore was discovered in Negaunee, Michigan. Mining commenced in 1846, grew steadily, and has continued to the present time.
- 1848 – the California Gold Rush began.
- 1859 – oil production began in northwestern Pennsylvania.
- 1870's – gold was first discovered in Southeast Alaska. Alaska's first big gold strike came in Juneau in 1880.
- 1879, 1887 - the first oil wells were drilled in California and Texas, respectively.

2) Background of legislation regarding mine reclamation laws

Most of laws and acts for all aspects of mining and exploration industry in the USA are set up for the land acquisition, exploitation and environmental control.

There are several mining laws and acts that had been enacted to follow the acquisition and exploitation of land for exploration, mining and reclamation. They are separate laws and acts depending on upon the material being extracted from the ground. The Mining Law of 1872 only covers hard rock ores such as gold and copper. The Mineral Leasing Act of 1920 is used for leases for the development of deposits of industrial minerals such as coal and potash. The surface mining of coal is governed by the Surface Mining Control and Reclamation Act (SMCRA).

As environmental concern grew in the 1970s, a public demand for mine reclamation was developed. The Surface Mining Control and Reclamation Act (SMCRA) was enacted in 1977 after the US Congress recognized the need to regulate mining activity, rehabilitate abandoned mines, and protect society and the environment from the adverse effects of mining operations. Before 1977, surface coal mining landowners had abandoned 1.1 million coal mine sites in the United States. The SMCRA directed owners of coal mines to contribute bonds for land rehabilitation and environmental damages caused by mining activities. The flow of collected funds went into the *Abandoned Mine Reclamation Fund* to finance restoration of abandoned sites. The act established the Office of Surface Mining Reclamation and Enforcement; it controls surface mining operations, reviews and approves state programs, and conducts enforcement when necessary. The SMCRA did not prohibit mountaintop coal mining, an activity that steadily increased after 1977. The Abandoned Mine Reclamation Act of 1990 amended this act and extending funding operations through 1995 (http://www.eoearth.org/article/Surface_Mining_Control_and_Reclamation_Act_of_1977,_United_States).

The preservation of the land in the US is a major concern when it comes to mining. The Federal Land Policy and Management Act (FLPMA) requires that the public lands be managed in a manner that protects the quality of scientific, scenic, historical, ecological, environmental, air, atmospheric, water, and archeological resources. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) authorize the President to respond to releases or threatened releases of hazardous substances into the environment. The primary emphasis is the cleanup of hazardous substance releases. Other important acts to follow include The Endangered Species Act and The National Historic Preservation Act.

3) Governments' countermeasures on environmental impact due to mining activities
The United States Environmental Protection Agency (EPA) provides the various environmental laws and regulations for the environmental protection and what to do in case of an accident in a mine or exploration setting.

A number of laws serve as EPA's foundation for protecting the environment and public health. However, most laws do not have enough detail to be put into practice right away. EPA is called a regulatory agency because it has been authorized by the Congress to write regulations that explain the critical details necessary to implement environmental laws. In addition, a number of Presidential Executive Orders (EOs) play a central role in EPA activities. List of laws and regulations those are administered by EPA can be found in http://www.epa.gov/lawsregs/laws/index.html.

For the enforcement of regulations, EPA has civil, cleanup, and criminal enforcement programs work with the Department of Justice, state, and Tribal governments to take legal actions in both federal and state courts that bring polluters into compliance with federal environmental laws. The Agency emphasizes those actions that reduce the most significant risks to human health or the environment, and consults extensively with states and other stakeholders in determining risk-based priorities. More description about the programs is available in http://www.epa.gov/compliance/index-e.html.

4) Financial supporter for mine reclamation
To be eligible for SMCRA funding, sites to be reclaimed must have been mined or affected by mining processes and abandoned or left in an inadequate reclamation status prior to August 3, 1977, (or prior to August 28, 1974, for the US Forest Service-administered lands; or prior to November 26, 1980, for the US Bureau of Land Management administered lands).

SMCRA-funded sites can only be those that are truly abandoned where there is no one who can be held responsible for the needed reclamation. One statutory eligibility criteria is that there must be no continuing reclamation responsibility under state or federal laws on the part of owners, operators, or others connected to past mining operations on the site. Also, a proposed SMCRA reclamation site cannot be within an area that has been designated for remedial action under the federal uranium control law or under the federal Superfund law.

In limited instances, coal mining sites that were operated after 1977 until November 24, 1990, may be eligible for SMCRA-funded reclamation. These are the situations where funds available from a bond, financial guarantee or other source were insufficient for adequate reclamation. Also, some sites may benefit from SMCRA funds if a coal company surety became insolvent between August 4, 1977, and November 5, 1990, and the funds available from bankruptcy proceedings were not sufficient for adequate reclamation. Other than these two limited exceptions, a privately owned site must have been abandoned prior to August 3, 1977, to be reclaimed with SMCRA funds.

5) Special organization for handling mine reclamation
The Office of Surface Mining Reclamation and Enforcement (OSM) is a bureau within the United States Department of the Interior. OSM is responsible for establishing a nationwide program to protect society and the environment from the adverse effects of surface coal mining

operations, which OSM is charged with balancing the nation's need for continued domestic coal production with protection of the environment. The Bureau was created in 1977 when the Congress enacted the Surface Mining Control and Reclamation Act. OSM works with State and Indian Tribes to assure that citizens and the environment are protected during coal mining and that the land is restored to beneficial use when mining is finished.

In its beginning, OSM directly enforced mining laws and arranged cleanup of abandoned mine lands. Recently, most coal States have developed their own programs to do those jobs themselves, as Congress envisioned. OSM focuses on overseeing the State programs and developing new tools to help the States and Tribes get the job done (http://www.osmre.gov).

6) Annual budget
The Department of the Interior (DOI) is in charge of protection and management of the Nation's natural resources and cultural heritage; provide scientific and other information about those resources; and honor its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities. The President's 2011 Budget provides $12 billion to DOI. In 2009, $164 million was spent to the Office of Surface Mining while it has been estimated to $181 million in 2010 and $190 million in 2011. However, the budget which is functionally for the natural resources and environment was $57,393 million or 1.40% of National budget. The budget from 2010 has been reduced to $39,520 million or 1.09% of total National budget and it has been estimated to be gradually decreased until 2020 (http://www.gpoaccess.gov/usbudget/fy11/index.html#budget).

7) Businesses eligible to get support from the government
In May 2007, The White House has issued a new "Open Economies" policy statement and press release which includes the new Invest in America initiative at the US Department of Commerce within the International Trade Administration (ITA). This is a major change in the US policy. *Invest in America®* is the primary US Government mechanism to manage foreign direct investment promotion. The mission of this program is to promote and support foreign direct investment in the United States, contributing to the US job creation, innovation and competitiveness (http://www.investamerica.gov).

Federal, state and local governments offer a wide range of financing programs to help small businesses start and grow their operations. These programs include low-interest loans, venture capital, and scientific and economic development grants.

There are many groups of organizations that are eligible to apply for government grants. Typically, most grantee organizations fall into the categories below.

Government Organizations
: State Governments
: Local Governments
: City or Township Governments
: Special District Governments
: Native American Tribal Governments (federally recognized)
: Native American Tribal Governments (other than federally recognized)

Educational Organizations
: Independent School Districts
: Public and State Controlled Institutions of Higher Education

: Private Institutions of Higher Education

Public Housing Organizations
: Public Housing Authorities
: Indian Housing Authorities

Non-Profit Organizations
: Nonprofits having a 501(c)(3) status with the IRS, other than institutions of higher education
: Nonprofits that do not have a 501(c)(3) status with the IRS, other than institutions of higher education

For-Profit Organizations (other than small businesses)

Small Businesses
Small business loans and small business grants may be awarded to companies that meet the size standards that the US Small Business Administration (SBA) has established for most industries in the economy. The most common size standards are as follows:

: 500 employees for most manufacturing and mining industries
: 100 employees for all wholesale trade industries
: $6 million for most retail and service industries
: $28.5 million for most general & heavy construction industries
: $12 million for all special trade contractors
: $0.75 million for most agricultural industries

It could be noted that about one-fourth of industries have a size standard that is different from these levels. They vary from $0.75 million to $28.5 million for size standards based on average annual revenues and from 100 to 1500 employees for size standards based on number of employees. With few exceptions, all federal agencies, and many state and local governments, use the size standards established by SBA (http://www.grants.gov/help/exitdisclaimer.jsp).

More than 1,000 grant programs are offered by the 26 federal grant-making agencies, and these programs fall into 21 categories. Some agencies may be listed in multiple grant categories.

: Agriculture
: Arts
: Business and commerce
: Community development
: Disaster prevention and relief
: Education
: Employment, labor and training
: Energy
: Environmental quality
: Food and nutrition
: Health
: Housing
: Humanities
: Information and statistics
: Law, justice and legal services

: Natural resources
: Recovery Act
: Regional development
: Science and technology
: Social services and income security
: Transportation

More information of specific grants can be found in
http://www.grants.gov/aboutgrants/grant_categories.jsp

8) Current status of impacts from mining activities
Acidic mine drainage from coal and mineral mining operations is a difficult and costly problem. In the eastern USA, more than 7,000 km of streams are affected by acid drainage from coal mines. In the western USA, the Forest Service estimates that between 20,000 and 50,000 mines are currently generating acid on Forest Service lands, and that drainage from these mines is impacting between 8,000 and 16,000 km of streams. In addition to the acid contribution to surface waters, AMD may cause metals such as arsenic, cadmium, copper, silver and zinc to leach from mine wastes. According to the Forest Service, the metal load causes environmental damage, and is of greater concern than the acidity in environmental terms (US EPA, 1994). The EPA (1991) has prepared National Priorities List (NPL) Site Summary Reports for the mining sites on the NPL.

Mine subsidence is one of important environmental problems of active as well as abandoned mining operations in the USA. The damages range from simple land settlement to severe structural damage and have experienced in both rural and urban areas across 30 states. The areas of the country that already have been affected by subsidence are shown in Table 1.2. Over 90% of all subsidence recorded in the USA arises from underground coal mining (Karmis *et al.*, 1982). Subsidence caused by underground mining is generally acknowledged to be a primary cause of groundwater resource effects (Zipper *et al.*, 1997) since groundwater is the main water supply in the USA (USGS).

Table 1.2 Mining states with subsidence damage (Karmis *et al.*, 1982)

Serious	*Remote*	*Minor*
Pennsylvania (coal)	Arizona	Alaska
Kansas (zinc, limestone)	Idaho	California
Missouri (zinc, lead, limestone)	Kentucky	Connecticut
Oklahoma (zinc)	Michigan	Georgia
Montana (copper)	Minnesota	Illinois
New Jersey (iron)	New Mexico	Iowa
Washington (coal)	South Dakota	Maryland
	West Virginia	Nevada
		New York
		North Carolina
		Ohio
		Oregon
		Tennessee
		Wisconsin
		Wyoming

1.5 Mining and community impact

The impact of mining activities on communities can be considered as health, employment, and public relationship. There are a number of health concerns related to working in mining areas where workers are exposed. These concerns include chronic occupational diseases due to dust inhalation during mineral extraction (particularly silicates, asbestos, and uranium). The most common diseases in the mining industry are pneumoconiosis and lung cancer, though non-occupational health issues, such as HIV/AIDS also have a significant impact on the workforce in some countries. For example, 20% of coal and 30% of gold miners in South Africa are HIV-positive and it is predicted that 5–10% will start to die in the next five years (World Bank International Finance Corporation, 2001). Local communities can also become exposed to health and safety risks from mining activities, such as extraction activities or production of mineral products, or both. These risks can include health effects from local air pollution, accidental release of toxic chemicals and the toxicity of products. In addition, active open pits with no access protection can pose safety risks for citizens (Azapagic, 2003).

One primary employee-related issue pertaining to mining activity is the occupational health and safety of underground metalliferous mines, which have a high incidence of fatalities. The gold industry was found to have the highest average fatality ratio (IIED and WBCSD, 2002).

Numerous studies have mentioned that mining industries are facing a big challenge in attracting high-quality people, mainly because of their negative image. Therefore, another impact relating to employment is related to education and skills development. Mining companies can improve recruiting and relating top-quality staff, which is needed in order to be more competitive. Mining-related activities can bring wealth and prosperity to communities, though they can also cause a considerable disruption in terms of social life and structure. An increasing trend of outsourcing or contracting out due to the lack of a locally available skilled workforce means that local communities are less likely to directly benefit from getting jobs and opportunities (Azapagic, 2004).

Mining operations have been seen by environmentalists and conservationists alike as causing varying degrees of environmental damage in mining areas, which are often located in remote regions. In urban, suburban, and rural settings of agricultural communities, operators of rock quarries, gravel pits, and certain industrial mines have been considered as more visible and significant offenders. Indeed, much of the concern has been focused on the concurrent and subsequent physical and aesthetic effects that their operations have had on the land as a basic resource. Mining is only a temporary occupier of the land surface and, hence, is of a transient nature. Although active mines at any particular time are not as widespread as other land uses, they dramatically change the landscape and tend to leave evidence of their past use. Therefore, results of abandonment or closure become quite conspicuous to the general public.

There have been continuous confrontations between citizen groups, governmental agencies and members of the mining industry. The degree of conflict and its nature usually depends on current land use and estimated consequences of proposed disturbances. Typically, the conflicts are centered on the following issues;

- Destruction of landscape
- Degradation of visual environment
- Disturbance of watercourses
- Destruction of agricultural and forest lands

- □ Damage to recreational lands
- □ Noise pollution
- □ Dust
- □ Truck traffic
- □ Sedimentation and erosion
- □ Land subsidence
- □ Vibration from blasting and air blasts

Recently, it has become very important to get community acceptance prior to operating a mine. This social acceptance is commonly an intangible, informal approval by the community. It is non-permanent, so, a mining company must firstly earn it and continue to maintain it. Especially due to the fact that communities will forever live with the mine after closure, it has a legitimate right to be concerned (Garcia, 2008). However, in addressing sustainability, the mining and minerals industry also faces a number of challenges. Following the Brundtland definition of sustainable development (WCED, 1987), the main challenge for the mining sector is to clearly demonstrate that it contributes to the welfare and well-being of the current generation, without compromising the potential of future generations for a better quality of life (IIED and WBCSD, 2002).

1.6 Mining and gender impact

According to the definitions adapted from the Australian Agency for International Development (AusAID)'s *Guide to Gender and Development*, gender refers to the socially constructed roles and relationships between women and men. These are learned, change over time, and vary within and between countries and cultures according to social, religious, historical, and economic factors. Gender contrasts with sex, which describes a set of biological differences between men and women. As such, gender roles and responsibilities affect both women's and men's ability and incentive to participate in developmental activities, and often lead to different project impacts (http://www.ausaid.gov.au).

Gender equality refers to equal rights, responsibilities and opportunities for women, men, girls, and boys. Equality does not mean that women and men are the same, but rather that people's rights, responsibilities, and opportunities do not depend on whether they are born male or female. Gender equality implies that the interests, needs, and priorities of women and men are taken into consideration, recognizing the diversity among different groups of women and men. Equality between women and men is a human right, and a precondition for—and an indicator of—sustainable people-centered development (http://www.oxfam.org.au/explore/mining).

The impacts of mining operations are not gender neutral. Women can experience the direct and indirect consequences of mining operations in different, and often more pronounced, ways than men. Most campaigns to change destructive mining practices typically focus on either protecting the natural environment or the labor rights of workers. In both cases, gender is usually subsumed within one or both of the broader categories, namely environmental rights and human rights. Gender concerns tend to become invisible. As a consequence, the solutions proposed for the problems generated by mining operations frequently fail to adequately address the needs of women, which are often quite different from those of men (http://www.earthrights.org/publication/mining-gender-and-environment).

Worldwide, between eighty and one hundred million people are directly and indirectly dependent upon non-industrial forms of mining for their livelihoods. Of these, about 30% are women (International Labour Organization, 1999). For this reason, gender equity is an essential building block in sustainable development; the pillars of sustainable development cannot be achieved without finding solution to the problem of gender inequity (Earth Summit, 2002). In addition, it was suggested that increasing women's participation in the industry and enhancing women's access to power and decision-making have a direct bearing on the way the industry currently operates. Studies have also pointed to areas where there is an opportunity to support women's advancement, such as through a policy of proactive recruitment, promotion and skills building, which should be implemented in order to contribute to sustainable development (Nayak and Mishra, 2007). Moreover, mounting evidence now shows that women, due to gendered forms of socioeconomic discrimination, do not generally benefit from mining operations. Rather, women bear a much greater proportion of the negative impact in nearly all cases. To address this persistent problem, gender concerns should be more fully taken into account when designing and implementing mining activities (www.earthrights.org/publication/mining-gender-and-environment).

1.7 Challenging environmental laws as a tool for achieving sustainable development

Sustainable development necessitates the balancing the interests and concerns of both the environment and the economy. The importance of the environmental laws as a tool to balance these potentially conflicting interests is increasing (Halbert and Erbguth, 1999).

Mining companies typically conduct exploration projects in far-reaching corners of the globe, in countries with varying governmental regulations and standards for mine closure. Though some countries have established closure requirements as part of their operational permits, most countries, especially developing countries, currently have few or no mine closure requirements. However, even though there are no international regulatory agencies, financial institutions have stated to emphasize the importance of closure for socially conscious and fiscally safe banking purposes. To date, 60 financial institutions have adopted the Equator Principles (EPs) guidelines, which require that the financial institutions assess and manage social and environmental risk as part of the project financing. EPs require that the borrower should conduct a social and environmental assessment process to address the relevant impacts and to identify risks to the proposed project. The EPs do not cover the technical aspects of due diligence.

The World Bank has been involved in mining since 1955, mainly through grants from its International Bank for Reconstruction and Development, with the Multilateral Investment Guarantee Agency (MIGA) offering political risk insurance. Between 1955 and 1990 it provided about $2 billion to 50 mining projects, broadly categorized as reform and rehabilitation, Greenfield mine construction, mineral processing, technical assistance, and engineering. These projects have been criticized since 1981; particularly the Ferro Carajas project of Brazil. The bank established mining codes intended to increase foreign investment, and in 1988 solicited feedback from 45 mining companies on how to increase their involvement.

In 1992, the bank began to push for privatization of government-owned mining companies with a new set of codes, beginning with its report *The Strategy for African Mining*. In 1997, Latin America's largest miner Companhia Vale do Rio Doce (CVRD) was privatized. These and other movements such as the Philippines 1995 Mining Act led the World Bank to publish a third report *Assistance for Minerals Sector Development and Reform in Member Countries*, which endorsed mandatory environment impact assessments and attention to locals. The codes based on this report have been influential in the legislation of developing nations; these new codes were intended to encourage development through tax holidays, zero custom duties, reduced income taxes, and related measures. The results of these codes were analyzed by a group from the University of Quebec in 2003, which concluded that the codes promote foreign investment but "fall very short of permitting sustainable development". The observed negative effect of natural resources on economic development is known as the resource curse (http://en.wikipedia.org/wiki/Mining).

For APEC economies like the United States, the environmental laws, policies, and management techniques are fundamental in making pollution prevention a key component of sustainable mining operations. Indeed, Environmental Impact Assessments (EIAs) are gaining great popularity in the Americas as a tool for preventing the environmental impacts of mining.

In Chile, the most important tool for environmental management and pollution prevention is the environmental impact evaluation system. The system, which is applied to all productive sectors, became mandatory in April 1997, although many mining operations were already preparing EIAs pursuant to requirements imposed in connection with the financing of their operations. In accordance with Law 19300 (Art. 10, LBMA) and its regulations, eight mining development projects, including prospecting activities, susceptible to causing environmental impacts in any of their phases, must be submitted to the EIA system.

In Canada, the federal or a provincial government, or both, may require EIA of proposed mining projects. Federal assessments, under the Canadian Environmental Assessment Act (CEAA) are triggered if there is a requirement for federal approval for a mining activity to proceed, if the undertaking is on federal lands, or if it is to receive federal funding.

In Mexico, an environmental impact statement *(Manifestación de Impacto Ambiental)* is generally required prior to commencing exploration and mining activities (LGEEPA Art. 28, Para. III). However, there may be some exceptions to this requirement in the future. Mexico's general environmental law (LGEEPA) states that the implementing regulations (currently under development) may identify works or activities that are exempt from an environmental evaluation because their location, size, characteristics or reach cannot cause significant environmental impacts, nor exceed the limits and conditions established in the legal norms about preservation of the ecological equilibrium and the protection of the environment (Art. 28).

Pollution prevention should be a strategic management principle for the hard rock mining industry. It offers an opportunity to avoid or minimize the significant environmental impacts of hard rock mining while also identifying and promoting economical and efficient principles in the design and operation. It enhances the recovery of minerals while at the same time helping to minimize impacts on the surrounding environment and preventing the creation of long-term environmental hazards and risks. Environmental laws, policies, and management techniques are fundamental to make pollution prevention as a key component of sustainable mining operations. Note that a variety of legal and policy approaches can require the identification and integration of pollution prevention into the conditions for commencing metallic mineral mining operations.

1.8 Environmental Regulation of Mine Waste in European Union (ERMITE)

A concern of the European Union pertaining to water pollution from mine waste was raised since there were several cases of large-scale aquatic pollution due to mining activities (e.g. Aznalcóllar in Spain, 1998; Baia Mare in Romania, 2000). These two accidents in tailings pond dam failures are of concern to the policy makers of the EU. Accordingly, these two cases have prompted a critical re-evaluation of European policies in relation to mining accidents in general and mine water pollution in particular.

The first European environmental policy was adopted in 1967, providing guidelines on the classification, packaging and labeling of dangerous substances. The Helsinki European Council in December 1999 invited the European Commission to "prepare a proposal for a long-term strategy dovetailing policies for economically, socially and ecologically sustainable development" in time for the Gothenburg European Council in June 2001. The newly proposed Sixth Environmental Action Plan (EAP) 2001–2010 established the objectives for the next 10 years of environmental action by the EU. It included four major priority areas: climate change, nature and biodiversity, health and environment, and natural resource and waste—which specifically included the topic of water. The Sixth EAP was the first to introduce policy action in the mining sector to take place at EU level.

Environmental**,** industrial, regional development and research policies are all relevant to the multifaceted impact of mining. With respect to regional development and use of European Commission (EC) funding, mining sector has been a beneficiary of such funding, especially in the regions subject to EC aid (basically Structural Funds and Cohesion Funds). A recent review of the regional development programmes and projects under the sustainability angle, including the "polluter pays principle", may influence future fund allocations. EU research policy also plays an important role through the Framework R&D Programmes; the Fifth Framework (FP5) is currently supporting projects dealing with metal pollution and mining.

Environmental liability and mining law in Europe

In Europe, environmental damage resulting from mining operations is regulated under states' common law rules, Civil Codes or specific statutes and administrative public laws. A number of jurisdictions have been studied, and of these a number of comparisons may be made. For example, many countries have a system of strict liability for damage caused by mining operations. In most occasions, this strict liability regime operates in conjunction with general actions in tort law; it is generally the case that the mining operator and/or license holder is the person or corporate body found liable for such damage. A number of states make provisions to lessen the claimant's burden of litigation. However, while the burden upon the claimant remains a disincentive to pursue claims, most significant is the cost involved in taking action in private law. With the claimant's interests in mind, a number of states offer supporting measures ranging from statutory presumptions of causation, to more procedural support such as access to technical advisory bodies that aid the claimant in the establishment of causation.

Legal systems of mining in some countries have been set up to financial security, by compulsory contributions of the operators to a Compensation Fund or by back-up liability of the State (with right of recourse against operators). The scope of the recoverable damage varies in that some regimes do not cover personal injury, some cover material loss and all have law to cover property damage. In terms of access to justice for interest groups, in the majority of states, NGOs do not have explicit legal standing. However, in most states, the system provides for those who can show a “sufficient interest” to be granted legal access. Most regimes accept a form of limited retrospectively in so far as damage resulting from events before the entry into force of the regime does not become known until after that date; the concept of continuous nuisance is pertinent in this context.

The summarized results of the ERMITE project pertaining to mining and mine water of 33 countries in Europe are shown in Table 1.3. To date, no comprehensive mine water inventory for Europe has been made, even though it is known that, in some areas, water streams are or were heavily contaminated by mine water discharge (e.g., Rio Tinto Spain; Erft River Germany; Vistula and Odra Rivers Poland; Odra River Czech Republic; Elmet River Turkey; Avoca River Ireland; Religious Creek France; River Don United Kingdom). All EU member states are aware of mine water issues and its potential to contaminate receiving water streams. For example, in 1998, Poland listed 150 million m^3 of mine water and the Czech Republic spent 369 million CZK in 2001 on projects related to the polluted mine water. Notably, the Polish statistics assumed that at least 5–10 billion m^3 of polluted mine water is being discharged into European water courses.

Table 1.3 Summarized results of the 33 countries studied concerning mining laws and mine water classification: (-) no mine water problems known; (+) mine water problems known; (++) severe mine water pollution recorded; and (?) no information available (ERMITE, 2002).

Country	Degree of mine water problems	Mining Law	Does the mining Law cover mine water issues	Is mine water categorized as waste water	Is there a special mine water law
1 – Albania	++	Yes	No	No	No
2 – Austria	+	Yes	Yes	?	No
3 – Belgium	-	No	-	-	No
4 – Bosnia and Herzegovina	++	Yes	No	No	No
5 – Bulgaria	++	No	-	?	No
6 – Croatia	++	Yes	No	No	No
7 – Cyprus	++	Yes	?	?	No
8 – Czech Republic	++	Yes	Yes	No	No
9 – Denmark	-	No	-	-	No
10 – Estonia	++	Yes	No	No	No
11 – Finland	+	Yes	No	Yes	No
12 – France	+	Yes	?	?	No
13 – Germany	+	Yes	Yes	No	No
14 – Greece	?	Yes	?	?	No
15 – Hungary	++	Yes	Yes	?	No
16 – Ireland	+	Yes	No	No	No
17 – Italy	+	Yes	?	?	No
18 – Latvia	-	Yes	No	?	No
19 – Lithuania	-	Yes	No	No	No
20 – Luxembourg	-	No	-	-	No
21 – Macedonia	++	Yes	No	No	No
22 – Malta	-	No	-	-	No
23 – Netherlands	+	Yes	?	?	No
24 – Poland	++	Yes	No	Yes	No
25 – Portugal	+	Yes	?	?	No
26 – Romania	++	Yes	?	No	No
27 – Slovakia	++	Yes	?	?	No
28 – Slovenia	+	Yes	?	?	No
29 – Spain	++	Yes	No	?	No
30 – Sweden	+	Yes	No	No	No
31 – Turkey	++	Yes	Yes	Yes	No
32 – United Kingdom	+	Yes	Yes	Yes	Yes
33 – Serbia and Montenegro	++	Yes	No	No	No

Considering mine water issues, European countries do not have many things in common. This applies to both the extent of mine water problems and the legislative regulations of mine waters. Countries that suffer from polluted mine waters (e.g. Serbia and Montenegro) do not necessarily have the most comprehensive regulations and vice versa. As such, the regulation of mine water issues differs substantially, with the only countries that explicitly address mine water in legislative framework are the United Kingdom, Czech Republic (Section 40 of the Mining Law), and Austria (Section 106 of the Mineral Resource Act). Nevertheless, a country having no explicit "Mine Water Legislation" does not necessarily imply that mine water is not regulated. On the contrary, countries with a long lasting mining history and environmental liability regulate mine water within existing mining and water legislation (e.g., Germany, the UK, and Austria). However, a problem that establishing a common European mine water legislation might face to the different responsibilities concerning water or environmental issues. Mining and mine water related subjects are not necessarily managed in the same ministries or authorities. Referring to Table 1.3, in many potential EU member states, even if the polluter pay principles are applied or an EIA has to be conducted prior to mining, there is still a lack of a strong administrative body to control pollution. Indeed, there are only a few cases in which legal standards have been used to regulate mine effluents (e.g., Czech Republic, Poland), while others use guidelines only (e.g. Germany). However, most countries do take into account the nature of mining, with different geological or mineralogical conditions in every single case, and base mine water discharge values on case-to-case decisions.

Guideline of mine closure in Europe

Closure aspects for mining facilities in Europe are closely linked with the conditions of planning permission for the mine. Closure of waste disposal facilities is covered by the European Union (EU) Mining Waste Directive (EU, Directive 2006/21/EC, 2006). This includes requirements for the establishment of a closure plan for the waste facilities (Article 12) and allocation of a financial bond to cover the estimated costs of closure and rehabilitation (Article 14). A partnership of international organizations prepared a closure guideline for South-eastern and Eastern Europe, Central Asia and Caucasus as part of its mission to advance and protect peace and the environment (United Nations et al, 2005). The document makes a particular point of the economic development of nations in central and Eastern Europe being linked to ongoing and new mining efforts. A primary objective of the document is to provide guidance for either re-opening the mine or redeveloping the site for other economic uses. Historic mines are being revisited in many countries as commodity prices increase and mining technology improves (or in some cases, the political stability of the area allows for private investment) (Garcia, 2008).

Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries

Various countries in Europe have regulations covering rehabilitation of sites after the cessation of a range of industrial activities. The European Union (EU), as the central regulatory body for Europe, is trying to produce a unifying regulation or directive to regulate the management of waste from the mining and quarrying industries. The primary driver for this move is the recognition of the dangers posed to human health by mismanaged chemical wastes. The directive is known as the European Community Draft Directive on the Management of Waste from the Extractive Industry.

The European Union has introduced measures to prevent or minimize any adverse effects on the environment and resultant risks to health resulting from the management of waste from the extractive industries, such as tailings and displaced material.

This Directive applies to waste resulting from the extraction, treatment and storage of mineral resources and the working of quarries. Waste covered by this Directive no longer falls within the scope of Directive 1999/31/EC on the landfill of waste.

This particular extractive waste must be managed in specialized facilities in compliance with specific rules. In accordance with Directive 2004/35/EC, operators of such facilities are subject to liability in respect of environmental damage caused by their operation. Member States shall take every precaution to limit risks to public health and the environment related to the operation of extractive waste processing facilities, *inter alia* by applying the concept of "best available techniques". The followings are the summary of this Directive.

Extractive industry waste facilities

No extractive industry waste facility may operate without a permit issued by the competent authorities. In order to obtain this type of authorization, the operator of the facility must comply with the provisions of this Directive.

The competent authorities must inform the public of applications for permits that are submitted. This provision enables the public to submit comments and to participate in the assessment procedure for authorisation requests.

When a new waste facility is built or an existing one modified, the competent authority must ensure that the following measures are taken:

- the facility must be suitably located;
- its physical stability must be ensured and soil, air and water pollution prevented;
- it must be monitored and inspected by competent persons;
- arrangements must be made for the closure of the facility, the rehabilitation of the land and the after-closure phase.

Operators of waste facilities presenting a potential risk for public health or for the environment (Category A) must draw up:

- a policy for preventing major accidents;
- a safety management system;
- an internal emergency plan specifying the measures to be taken on-site in the event of an accident.

For facilities in Category A, the competent authority must also draw up an external emergency plan specifying the measures to be taken off-site in the event of an accident. These two types of emergency plan (produced by the operator and the competent authority) are intended to reduce the potential impact of major accidents on health and the environment and ensure the restoration of the environment following such an accident. They must provide for participation by the public and for account to be taken of the opinions submitted.

Waste facility operators must provide a financial guarantee before the beginning of operations so as to ensure that the Directive's obligations are covered and to ensure the existence and availability of funds to restore the site when the facility is closed.

A waste facility is regarded as finally closed when the competent authority has carried out a final inspection, assessed the reports submitted by the operator, confirmed that the site has been restored and given its approval. After closure, the operator must maintain and monitor the site for as long as the competent authority considers necessary. The costs of these measures are, in principle, borne by the operator.

Management measures for extractive industry waste

Member States must ensure that waste facility operators draw up a waste management plan, to be reviewed every five years. The objectives of the plan must be as follows:

- to prevent or reduce the generation of waste and/or its harmful nature;
- to encourage waste recovery through recycling, re-use or reclaiming.
- to encourage the short and long-term safe disposal of waste.

The plan must include at least the following:

- a description of the waste and its characterization (chemical, physical, geological, etc.), a description of the substances used to process the mineral resources, methods used to transport and process the waste;
- the control and monitoring procedures;
- where applicable, the classification of the waste facility (Category A);
- planned measures for the closure of the facility and after-closure monitoring;
- measures for the prevention of water and soil pollution.

The competent authority must satisfy itself that waste facility operators have taken the measures necessary to prevent **water and soil contamination**, in particular by:

- evaluating leachate generation (leachate means any liquid percolating through the deposited waste, including polluted drainage);
- preventing leachate generation and preventing surface water or groundwater from being contaminated by the waste;
- treating contaminated water and leachate in order to ensure their discharge.

The Directive also introduces specific measures aimed at limiting cyanide concentrations in tailings ponds and waste waters when cyanide is used to extract minerals.

Inspections, records and reports

The competent authority must inspect waste facilities at regular intervals, including after their closure. Operators are required to keep up-to-date records of all waste management operations and to make them available for inspection by the competent authority.

Every three years, Member States must send the European Commission a report on the implementation of the Directive. The Commission must publish a report within nine months of receiving the information from the Member States.

Member States must ensure that an inventory of closed waste facilities, including abandoned waste facilities, located on their territory which cause serious negative environmental impacts or have the potential of becoming in the medium or short term a serious threat to human health or the environment is drawn up and periodically updated.

1.9 Sustainability indicators for mining

Sustainable development practices have become an integral part of most major mining companies' business activities (Worrall *et al.*, 2009). The purpose of sustainability indicators for industry is to assist a company's economic, environment and social performance and to provide information on how it contributes to sustainable development (Azapagic, 2004). While the concept of sustainable development is now widely accepted by policy makers and the broader community, achieving it implies the definition of goals and ways to measure progress towards the goals.

Across several resource sectors with numerous policies making groups, a widely adopted mechanism for measuring progress is the use of criteria and indicator frameworks for sustainability measurement. Principles, criteria, and indicator frameworks are versatile because of their thematic structure, and thus are able to be used for a wide range of applications at different scales or for specific sustainability issues.

Principles are general conditions for achieving sustainability, which may be seen as the ultimate goal. They should be formulated as a general objective to be achieved. Simply, principles may be reviewed as the three fundamental pillars of sustainability including environmental, social, and economic principles.

Criteria describe the broad values that society seeks in order to sustain goals. They are specific objectives that are more concrete than principles, and therefore easier to assess and link to indicators (Van Cauwenbergh *et al.*, 2007). Criteria serve as the basis for assessment and assist in ordering individual indicators within a framework.

Indicators provide measures of change in the criteria over time. They are the descriptive tools that enable assessment. Indicators help to summarize data and make measurement outputs more meaningful. Indeed, an indicator's significance can extend beyond what is actually measured to larger phenomena of interest. Indicators should be easy to measure, be cost effective, accommodate changing conditions, be scientifically sound, and be based on functional ecological relationships (Worrall *et al.*, 2009). In this way, they can provide information for policy makers and aid in decision making (Niemeijer and de Groot, 2008).

1.10 Sustainable development evaluation

There have been a number of publications regarding to evaluate sustainable development index in individual aspects of sustainability such as environmental, social, and economic sustainability.

Firstly, to measure environmental sustainability, studies include the pilot environmental performance index (WEF, 2002), index of environmental friendliness (Statistics Finland, 2003) and eco-indicator 99 (Pre Consultants, 2001). For example, in WEF (2002) a Pilot Environmental Performance Index (EPI) was constructed to measure current environmental results at a national scale. The results-oriented EPI provided a valuable counterpoint to their Environmental Sustainability Index (ESI), which covered a much broader range of conditions aimed at measuring long-term environmental prospects. However, it did not consider any contribution of economic and social factors into the environmental sustainability trend.

Secondly, to measure economic sustainability, researchers have shown interest in the internal market index (JRC, 2002), composite leading indicators (OECD, 2002) and index of sustainable and economic welfare (Daly and Cobb, 1989). During which time, the OECD (2002) designed composite leading indicators (CLIs) to provide early signals of turning points (peaks and troughs) between the expansions and slowdowns of economic activity. CLIs provide an important aid for short-term forecasts (6–12 months) of changes in the direction of an economy. However, CLIs are but one instrument of analysis and are no substitute for quantitative or long-term forecasts based on econometric models (OECD, 2002).

Lastly, in the Human Development Index (HDI) (UNDP, 1990–2003), overall health system attainment (Murray *et al.*, 2001) was studied to evaluate social sustainability. The HDI is a summary measure of human development used to measure the average achievement in a country in terms of three basic dimensions of human development: 1) a long and healthy life, as measured by life expectancy at birth; 2) knowledge, as measured by the adult literacy rate and the combined primary, secondary and tertiary gross enrollment ratio; and 3) a decent standard of living, as measured by the GDP per capita. HDI is not an exhaustive indicator of a country's development, however, which is vital for a more complex assessment of the human development level of a country.

Therefore, one definite need has been identified—to develop a comprehensive framework of sustainability criteria for one country in general and for performance of the mining sector in particular.

1.10.1 Analytical Hierarchy Process (AHP)

Multiple criteria decision making (MCDM) is *"the study of methods and procedures by which concerns about multiple conflicting criteria can be formally incorporated into the management planning process*, as defined by the *International Society on Multiple Criteria Decision Making"*. In its most basic form, MCDM assumes that a decision maker is to choose from among a set of alternatives whose objective function values or attributes are known with certainty. At the decision-maker (DM) level, a useful method for solving MCDM problems must thereby take into account opinions made under uncertainty and based on distinct criteria with different importance.

One of the most popular and powerful methods for MCDM is the analytical hierarchy process (AHP) established by Saaty in 1977. AHP has been used as a widespread decision-making analysis tool for modeling unstructured problems in areas such as political, economic, social, and management sciences (Yu, 2002). The basic idea of AHP is to decompose the decision problem into a hierarchy of more easily comprehended sub-problems, each of which can then be independently analyzed. Once the hierarchy is built, the DM evaluates the various elements of the hierarchy by comparing them to one another two at a time (Saaty, 2008). The AHP consists of three main operations including hierarchy construction, priority analysis and consistency verification.

1.10.2 AHP applications for sustainable development issue

With a strong foundation in mathematics, psychology and philosophy, AHP has been successfully applied to thousands of multidisciplinary projects in both the public and private sectors worldwide since its creation in the 1980s (Wong and Li, 2008; Srdjevic and Jandric, 2007; Ho, 2008). Notably, in sustainable development problems, there have been three studies to date that employ AHP models, and each faced the common limitations of the AHP model.

Firstly, Glavic *et al.* (2005) employed AHP to determine the impact of individual indicators on the overall sustainability of a company. The model used normalized social, environmental, and economic indicators and incorporated them into a unique measure of performance. The objective of the work was to design a model for obtaining a composite sustainable development index (I_{CSD}) in order to track integrated information pertaining to the economic, environmental, and social performance of the company with time.

Secondly, AHP was adopted in the study, as it offered a logical and representative way of structuring the decision problem and deriving priorities (Singh *et al.*, 2007). AHP explicitly ranked tangible and intangible factors against each other to resolve conflict and/or set priorities. The objective of this paper was to introduce sustainability and to present a conceptual decision model, using AHP to assist in evaluating the impact of an organization's sustainability performance.

Lastly, Haipu *et al.* (2010) proposed methods for calculating the weight of each index and its environmentally sustainable capability based on the AHP method. From an analysis of environmental pollution from coal mining and the increasing need for raw coal, this paper established an environmental evaluation system, covering the environmental situation, resource protection, and economic benefit, to determine the potential for sustainable development in coal mining. They then demonstrated the validity of the index system by applying it to a coal mine in Qijiang, Western China, which was subsequently used as a reference for engineering applications at other mining sites.

Although AHP is one of the most outstanding MCDM approaches (Saaty, 2001), and has been applied successfully in many practical decision-making problems (Saaty, 1988). This method is often criticized because of its inability to handle uncertain and imprecise decision-making problems (Cheng, 1999).

In primitive forms of the AHP methods, experts' comparisons about criteria and alternatives are represented in the form of exact numbers. However, in many practical cases, experts' preferences are rather uncertain and thus are reluctant or unable to make numerical comparisons. In fact, it is unrealistic to expect that the decision-maker has either complete information or a full understanding of all aspects of the problem (Boender *et al.*, 1989; Nurmi, 1981). In addition, many researchers have also noted that fuzziness and vagueness are characteristics of many decision-making problems (Levary, 1998; Ribeiro, 1996; Ruoning *et al.*, 1992; Zimmermann, 1987). Hence, it has been inferred that good decision-making models and decision-makers must tolerate vagueness or ambiguity and be able to function in such situations. This problem of generating such a priority vector in an uncertain pair-to-pair comparison environment is referred to as a fuzzy AHP problem.

1.10.3 Fuzzy Analytical Hierarchy Process (FAHP)

It has been widely recognized that most decisions made in the real world take place in an environment in which there are goals and constraints. Because their complexity is not precisely known, the problems cannot be exactly defined or definitively represented as a crisp value (Bellman and Zadeh, 1970). To deal with qualitative, imprecise information or even ill-structured decision problems, Zadeh (1965) suggested employing fuzzy set theory as a modeling tool for complex systems that can be controlled by humans, though are hard to exactly define. In these cases, the fuzzy AHP method has been used to determine the final weights of alternatives. To evaluate the alternatives of multi-criteria problems, different attribute weights play an important role in the decision-making process; for more details, please refer to the proposed fuzzy AHP model presented in Farahani *et al.* (2010).

1.10.4 FAHP applications

Fuzzy set theory has now been applied to problems in engineering, business, medical and related health sciences, and the natural sciences. Over the years, there have been a number of successful applications and implementations of fuzzy set theory in MCDM. As a result, MCDM is one branch in which fuzzy set theory has found a wide application area (Kahraman, 2008).

The earliest work in fuzzy AHP appeared in a report by van Laarhoven and Pedrycz (1983), which compared fuzzy ratios described by triangular membership functions. Buckley (1985) then determined fuzzy priorities of the membership functions of trapezoidal comparison ratios. Stam *et al.* (1996) explored how recently developed artificial intelligence techniques can be used to determine or approximate the preference ratings in AHP. They concluded that the feed-forward neural network formulation appears to be a powerful tool for analyzing discrete alternative multi-criteria decision problems with imprecise or fuzzy ratio-scale preference judgments (Kahraman, 2008). Chang (1996) introduced a new approach for handling fuzzy AHP, with the use of triangular fuzzy numbers for pair-wise comparison scale of fuzzy AHP and the use of the extent analysis method for the synthetic extent values of the pair-wise comparisons. Moreover, Kahraman *et al.* (1998) used a fuzzy objective and subjective method to obtain the weights from AHP to make a fuzzy weighted evaluation. More recently, Cheng *et al.* (1999) proposed a new method for evaluating weapons systems via an analytical hierarchy process based on linguistic variable weights, and Zhu *et al.* (1999) discussed an extent analysis method and its relevant applications in fuzzy AHP.

Recently, Farahani *et al.* (2010) has proposed a fuzzy MCDM approach for evaluating alternative options with respect to the user's preference orders. Fuzzy MCDM was proposed as a means of solving the MCDM problem; fuzzy AHP was applied to determine the relative weights of the evaluation criteria. The research team also provided some empirical results, and that compared to the results from other papers, shown that their proposed method is feasible for obtaining weighting criteria and alternatives with respect to the overall goal. They stated that when the performance ratings are vague and imprecise, fuzzy MCDM can be used to determine the preferred solution.

Because of the imprecise and fuzzy data in MCDM problems, fuzzy decision-making is a powerful tool for decision-making (Farahani *et al.*, 2010). Fuzzy set approaches are suitable for use when the modeling of human knowledge is necessary and when human evaluations are needed. Hence, fuzzy set theory is recognized as an important problem modeling and solution technique.

1.11 Importance and necessity of the project

The concept of sustainable development has become an important objective of policy makers in the mining sector in APEC economies since the meeting in July 1996 in the Philippines. Even though most developing countries already have environmental standards for emissions, effluent, and groundwater contamination in place, as well as hazardous and toxic waste management guidelines, mining industries still do not comply with the standards due to weak law enforcement, lack of monitoring capability, and a lack of skilled human resources. The exchange of information related to the mining sector among APEC economies is an alternative to improve the sustainability development level.

Measuring sustainable development using indicators is increasingly being recognized as a useful tool for policy making and public communication in terms of conveying information on countries' performance in environmental, economical, social, and technical development (Singh *et al.*, 2009). The project "Sustainability Development of Mining Sector in APEC" (2009) identified the key positive and adverse factors facilitating/hindering sustainable development in the APEC mining sector. The report ranked APEC economies according to their sustainability index in the mining sector by applying a thermodynamics model. Therefore, it is essential to provide meaningful information with an evaluation of sustainability level to decision makers of each country, and thereby assist them in determining which actions should or should not be taken in an attempt to effectively improve the sustainability development of the mining sector.

One of the challenges of our project is that multiple factors regarding sustainability were considered and quantified into an integrated sustainability index at a country-level scale. Here, development of a model for obtaining a composite sustainable development index was performed in order to track integrated information pertaining to the economical, environmental, and social performance of APEC economies. Moreover, sub-indices including economy, environment, and society will also be compared via sustainability indices. It is a challenging task to identify appropriate indicators for a national-level sustainability index for the mining sector, as it also requires opinion from the experts and decision makers. However, the development of an informative database on policies, regulations, standards, and technical guidelines related to mine rehabilitation, reclamation, and mine closure among APEC economies along with a workshop can be a capacity building for developing countries to pursue sustainable development in the mining sector.

2. OBJECTIVE

This project was performed according to the following objectives;

1) To evaluate competing sustainable development demands within the APEC mining sector through a network of experts in APEC economies and exchange a wide range of information including environmental regulations related to mining, case studies of impacts from legacy mines and inappropriate mine closure, as well as mine reclamation technologies and leading sustainable development practices related to mine closure.

2) To consider recommendations on practical applications of sustainable development initiatives related to mining and mine closure in developing economies.

3) To develop a reference database on policies, regulations, standards, and technical guidelines related to mine rehabilitation, reclamation, and mine closure among APEC economies.

3. RESEARCH ACTIVITIES AND METHODOLOGIES

3.1 Survey of data

In this project, a questionnaire (Appendix A) was used as the tool to collect data from APEC economies. Questions were aimed at obtaining information related to sustainable development demands within APEC economies. The questionnaire was first tested to ensure that it was comprehensive and practical. A preliminary draft report with recommendations was made with the agreement of experts through the survey and analysis of relevant data obtained from APEC economies. The survey was mainly a desktop review exercise to collate international best-practice mine closure standards. Application of these standards throughout the APEC region was then assessed through contacts within the proponent organization as well as through contacts, experience, and staff consulting groups representing relevant countries in the region.

The proposed questionnaire was divided into six parts, as follows:

1) General information
2) Economic aspects
3) Environmental aspects
4) Social aspects
5) Technology

3.2 Data analysis tool

The obtained data was analyzed by application of a model in order to obtain a composite sustainable development index (I_{CSD}) for tracking integrated information pertaining to the economic, environmental, and social performance of the country as a function of time.

To improve the limitations of previous research evaluating sustainable development, we employ the concept of AHP to create a specific sustainability framework of indicators for the mining sector, based on the three criteria of economic, environmental, and social conditions at a national scale. We then employ fuzzy AHP to determine the importance of each indicator towards sustainability in the mining sector, using triangular and linguistic fuzzy numbers for the first time; thus, we can assess the impacts from mining activities on the economy, environment, and society, and evaluate the integrated sustainability index for the mining industry in some developed and developing countries, before subsequently providing some necessary recommendations on the practical applications of sustainable development initiatives related to mining, mine closure ,and mine rehabilitation.

3.3 AHP, Fuzzy theory and Fuzzy AHP

3.3.1. Analytic Hierarchy Process

AHP consists of three main operations, including hierarchy construction, priority analysis, and consistency verification.
In more detail, this approach can be described as follows:

i. Firstly, decision makers need to break down complex multiple-criteria decision problems into their component parts, of which every possible attribute is arranged into multiple hierarchical levels.
ii. Then, decision makers have to do pairwise comparisons at the same level of hierarchy, using Saaty's scale of absolute numbers, which is used to assign numerical values to both quantitative and qualitative judgments (Table 3.1, Hafeez *et al.*, 2002).

Table 3.1 Comparison scales of analytic hierarchy process.

Comparison scale of analytic hierarchy process (Hafeez et al., 2002)

Factor of preference, p	Importance definition
1	Equal importance
3	Moderate importance of one over another
5	Strong or essential importance of one over another
7	Very strong or demonstrated importance of one over another
9	Extreme importance of one over another
2, 4, 6, 8	Intermediate values
Reciprocal, $1/p$	Reciprocal for inverse comparison

The results of these comparisons are recorded in an *(n × n) positive reciprocal matrix A*, where the diagonal $a_{ii} = 1$ and the reciprocal property: $a_{ji} = (1/a_{ij})$, i, j = 1, . . . ,n.

$$A = \begin{pmatrix} 1 & . & . & . & \\ . & 1 & a_{ij} & & \\ . & 1/a_{ij} & .... & & \\ . & & & 1 & \\ & & & & 1 \end{pmatrix}, \qquad \text{where i, j= 1, 2, 3… n.}$$

Note that it is understood that since the comparisons are carried out through personal or subjective judgments, some degree of inconsistency may occur.

iii. To guarantee the judgments are consistent, the final operation, referred to as consistency verification (regarded as one of the primary advantages of AHP), is incorporated in order to measure the degree of consistency among the pairwise comparisons by computing the consistency ratio.
If it is found that the consistency ratio exceeds the limit, the decision makers should review and revise the pairwise comparisons. Once all pairwise comparisons are carried out at every level, and are proved to be consistent, the judgments can then be synthesized to determine the priority ranking of each criterion and its attributes.

However, it has been widely recognized that most decisions made in the real world take place in an environment in which there are goals and constraints, because of their complexity, are not precisely known, thus the problem cannot be exactly defined or precisely represented in a crisp value (Bellman and Zadeh, 1970). To deal with these kinds of qualitative, imprecise information or even ill-structured decision problems, Zadeh (1965) suggested employing fuzzy set theory as a modeling tool for complex systems that can be controlled by humans, though are hard to exactly define.

3.3.2 Fuzzy theory

Zadeh (1965) first introduced fuzzy set theory, which was oriented to the rationality of uncertainty due to imprecision or vagueness. A major contribution of fuzzy set theory is its capability in representing vague data.

For further details regarding fuzzy theory and its operations, please refer to the summary by Kahramana (2004).

To make the most use of fuzzy theory and to improve upon the limitations of classical AHP, fuzzy AHP is used to extend AHP functionality. Fuzzy AHP has been considered as one of the best multicriteria approaches for dealing with the vagueness of human thought to determine priorities in system elements.

3.3.3 Fuzzy AHP

Based on Chang (1996), fuzzy AHP includes four basic steps.
Let A= $(a_{ij})_{nxm}$ be a fuzzy pairwise comparison judgment matrix. Let $M_{ij}= (l_{ij}, m_{ij}, u_{ij})$ be a triangular fuzzy number. The steps used for the fuzzy AHP are as follows:

Step 1: Pairwise comparison judgments of attributes are made using fuzzy numbers situated on the same level of the hierarchy structure.

Step 2: The value of the fuzzy synthetic extent with respect to the i^{th} object is defined as equation (1):

$$S_i = \sum_{j=1}^{m} M_{ij} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{ij} \right]^{-1} . (1)$$

s.t.

$$\sum_{j=1}^{m} M_{ij} = (\sum_{j=1}^{m} l_{ij}, \sum_{j=1}^{m} m_{ij}, \sum_{j=1}^{m} u_{ij})$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{ij} = (\sum_{i=1}^{n} l_{ij}, \sum_{i=1}^{n} m_{ij}, \sum_{i=1}^{n} u_{ij})$$

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{ij} \right]^{-1} = (\frac{1}{\sum_{i=1}^{n} u_{ij}}, \frac{1}{\sum_{i=1}^{n} m_{ij}}, \frac{1}{\sum_{i=1}^{n} l_{ij}})$$

In this way, the triangular fuzzy number $S_i = (l_i, m_i, u_i)$ is calculated.

Step 3: The values of Si are compared and the degree of possibility of $S_j = (l_j, m_j, u_j) \geq S_i = (l_i, m_i, u_i)$ is defined as follows:

$$V(S_j \geq S_i) = height\left(S_i \cap S_j\right) = \mu_{S_j}(d)$$

$$= \begin{cases} 1, & if\ m_j \geq m_i \\ 0, & if\ l_i \geq u_j \\ \dfrac{l_i - u_j}{(m_j - u_j) - (m_i - l_i)}, & otherwise, \end{cases} \quad (2)$$

where d is the ordinate of the highest intersection point between $\mu_{S_i}\ and\ \mu_{S_j}$. Note that we need both $V(S_j \geq S_i)$ and $V(S_i \geq S_j)$ to compare S_j and S_i.

Step 4: The minimum degree possibility d(i) of $V(S_j \geq S_i)$ for i,j = 1,2,…,k is calculated.

$$V(S \geq S_1, S_2, \ldots, S_k) = V[(S \geq S_1) \text{ and } (S \geq S_2) \ldots \text{and } (S \geq S_k)] = \min V(S \geq S_i),$$
$$\text{for } i = 1,2, \ldots, k \qquad (3)$$

Here, let us assume that:

$$d'(A_i) = \min V(S \geq S_i) \text{ for } i = 1,2, \ldots, k \qquad (4)$$

Then, the weight vector is given by equation (5):

$$W' = \left(d'(A_1), d'(A_2), \ldots, d'(A_n)\right)^T \quad (5)$$

where A_i (i= 1,2, …, n) are n elements.

Step 5: Via normalization, the weight vectors become

$$W = (W_{ij}) = \left(d(A_1), d(A_2), \ldots, d(A_n)\right)^T \quad (6)$$

where W is a non-fuzzy number.

In this sustainable development evaluation model, the fuzzy AHP method can be utilized to determine the weights of criteria and indicators in a sustainable mining system.

3.4 Constructing of mining sustainability system based on AHP concept

Employing AHP and inferring the series of sustainability indicators for mining sector from previous related research (Azapagic, 2003; Azapagic, 2004; Glavic *et al.*, 2005; Singh *et al.*, 2007; Boggia and Cortina, 2010; and Haipu *et al.*, 2010), we construct a sustainability hierarchy that has the first level of sustainable development for the mining sector as the final goal. Then, we expand this goal into more specific criteria (attributes) including economic, environmental, and social performances based on three pillars of the sustainable development concept. From these main criteria, we further expand them into behavior indicators in the third level. Finally, the series of core indicators are categorized in terms of each main criterion, and the priority of each component in this hierarchy represents its contribution to the overall goal.

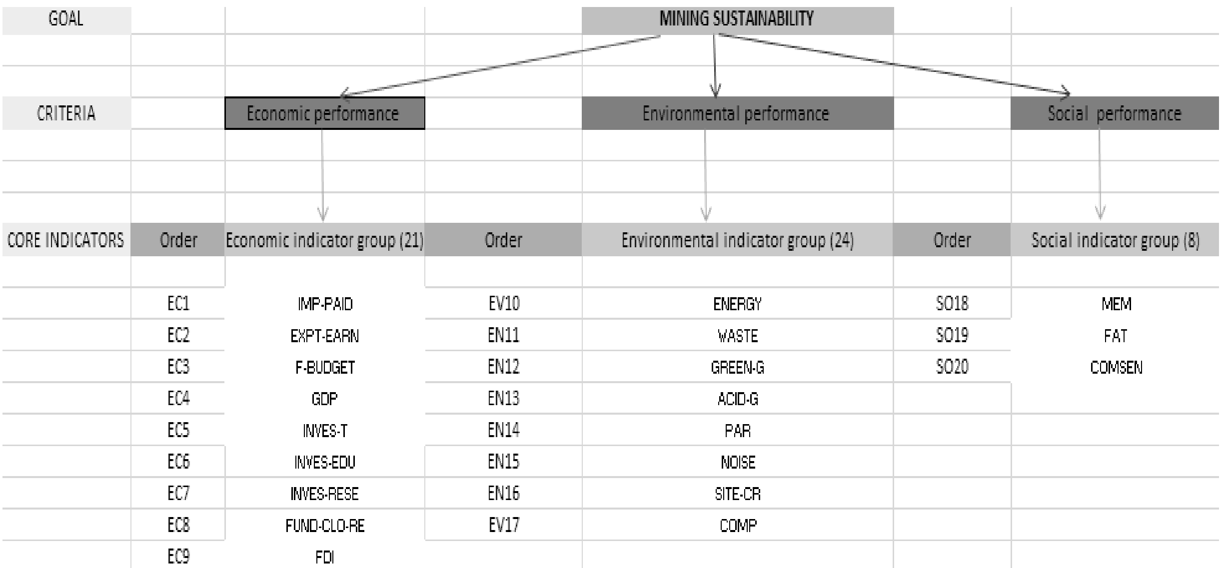


Figure 3.1 Mining sustainability system (MSS)

The indicators in Figure 3.1 are further explained in Table 3.2:

Table 3.2 List of core indicators

Core Indicator		Explanation
List of indicators in the economical performance criterion (ECO)		
EC1	IMP-PAID	Total payment for importing mining products per year
EC2	EXPT-EARN	Total earnings from exporting mining products per year
EC 3	F-BUDGET	Allocation of Fiscal Year Budget to mining sector
EC 4	GDP	Contribution of mining industry to GDP per year (at constant price)
EC 5	INVES-T	Total investment per year for mining industry
EC 6	INVES-EDU	Amount of training investment per year for mining workers
EC 7	INVES-RESE	Investments per year for resettlement of communities
EC 8	FUND-CLO-RE	Total fund for mine closure and mine rehabilitation
EC 9	FDI	Total foreign direct investment per year for mining sector
List of indicators in the environmental performance criterion (ENVI)		
EN 10	ENERGY	Total amount of energy consumption for mining sector per year
EN 11	WASTE	Total waste disposal per year
EN 12	GREEN-G	Amount of greenhouse gas emission from mining operations per year
EN 13	ACID-G	Amount of acid gas emissions (NO_x, SO_x, etc.) from mining operations per year
EN 14	PAR	Emissions of particles from mining operations per year
EN 15	NOISE	% exceeding national standard of noise pollution from mining activities
EN 16	SITE-CR	Total number of mining sites closed and/or rehabilitated per year
EN 17	COMP	Total number of complaints related to living conditions form residents per year
List of indicators in the social performance criterion (SOCI)		
SO 18	MEM	Number of mining employees per year
SO 19	FAT	Number of fatalities at work in the mining industry per year
SO 20	COMSEN	Number of compensated occupational problems caused by mining activities per year

3.5 Application of fuzzy AHP in evaluation of criteria indicator weights in mining sustainability system

Each indicator and attribute has a different contribution to the sustainable development evaluation of mining sector. In order to evaluate individual contributions, we make judgments on pairs of elements with respect to a controlling element based expert opinions. The survey used was conducted within the project "*Balancing competing demands of mining, community and environment to achieve sustainable development in the mining sector*" September, 2010 in Seoul, Korea. Next, fuzzy AHP was used to derive weights for the criteria and indicators in the sustainable system. These weights represent the theoretical importance of each component in the overall goal of attaining sustainable development in the mining sector (SDM), which includes the economy, environment, and society aspects.

3.6 Sustainable development evaluation model for mining sector

The following figure summarizes the calculation process to obtain a sustainable development index for each member of APEC group.

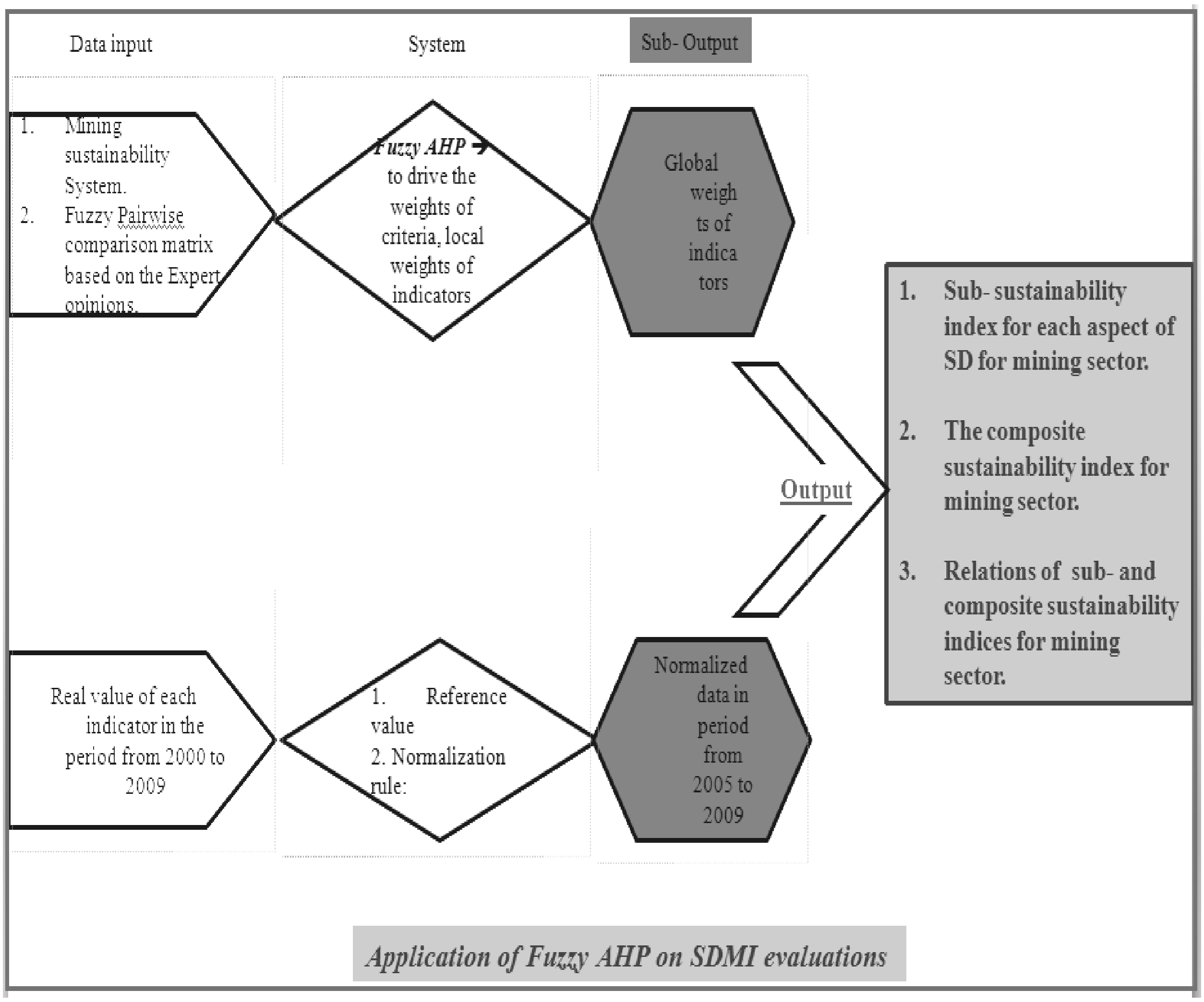


Figure 3.2 Application of fuzzy AHP on the model of sustainable development evaluation for the mining sector (SDMI model)

3.6.1 Theoretical evaluations

Input data includes the series of components in the mining sustainability system and the expert opinions related to the pairwise comparison judgments collected from the above-mentioned survey. The results from this survey are four fuzzy comparison matrixes (criteria, economy, environment and society) represented by linguistic variables such as equal, weak, fairly strong, very strong, and absolute strong preferences.

To handle the uncertainty of pairwise comparison judgments of expert opinions, we use an innovative fuzziness transformation scale to transform linguistic variables into fuzzy sets, as presented in Table 3.3. This transformation scale is recommended because the limit boundary between two preference levels cannot be clearly represented by one real number.

Finally, the four fuzzy comparison matrixes are computed via fuzzy AHP to derive the local and global weights for all components in the mining sustainability system.

Table 3.3 Transformation scale

Fuzzy scale for fuzzy pairwise comparison		
Fuzzy linguistic variables	**Fuzzy transformation scales**	**The relative importance of the pair of elements at the same level**
Equal	(1, 1, 1)	Equally important
Weak	(2/3, 2/2, 3/2)	Slightly important with one over another
Fairly strong	(2/2, 3/2, 4/2)	Strongly important with one over another
Very strong	(3/2, 4/2, 5/2)	Very strongly important with one over another
Absolutely strong	(4/2, 5/2, 6/2)	Extremely important with one over another

3.4.2. Practical evaluations

The real input data in this evaluation are the series of values for the indicators from 2000–2009. We collected this data from the government websites of specific countries and the World Bank website. The normalization process follows equation (7):

$$Nor_{ijt} = \left(\frac{\mathrm{Re}_{ijt}}{AR_{ij0}} \right)^{k} \qquad (7)$$

where Nor_{ijt} is the normalization value of quantitative data ij at year t, (t= 2005, 2006, 2007, 2008, 2009), Re_{ijt} is the quantitative data ij at year t, AR_{ij0} is the algebraic mean of quantitative data ij in the 5 previous years (2000–2004), and k is the impact index. If the indicator has a positive impact on sustainable development of mining sector, the value of k will be 1; otherwise, if the indicator has a negative impact k will be -1.

3.6.3 Output of the model of sustainable development evaluation for the mining sector (SDMI model)

Sub-sustainability indices evaluated by equation (8) include the economic, environmental, and social sustainability indices, denoted as ECO, ENVI, and SOCI, respectively.

$$Sub-index(it) = \sum_{j=1}^{n} Nor_{ijt} * W_{ij}. \quad (8)$$

where Sub-index(it) is the sustainability index for the criterion i and the year t (i represents economic, environmental, or social attributes; t is the year from 2005–2009), and W_{ij} is the weight of indicator j for criterion i.

Finally, the composite sustainability index for mining sector is calculated by equation (9).

$$Comp-index(t) = \sum_{i=eco}^{soci} \sum_{j=1}^{n} Nor_{ijt} * CW_i * W_{ij}. \quad (9)$$

where $Comp-index(t)$ is the composite sustainability index in the year t, Nor_{ijt} and W_{ij} are defined as in equation (8), and CW_i are the weights of the three main criteria.

After obtaining the sub-indices and the integrated indices for the years from 2005–2009, we graphically present the sustainability variation of the mining sector in Section 4.9. After curve-fitting, the linear model clarifies whether the development trend of the mining sector is forward or backward sustainable. If the coefficient of linear model is positive, the development trend is considered sustainable; the more positive the coefficient, the more likely the development trend will be sustainable. Otherwise, if the coefficient of linear model is negative, the development trend is backward sustainable. Moreover, the results from SDMI model provide a significant amount of useful information pertaining to important indicator contributions for decision makers, thus helping them to appropriately manage and adjust their activities and policy implementations.

3.7 Action plan

The action plan of the project is summarized in the flow diagram of the work plan (Figure 3.3). Data collection was performed by distributing the developed questionnaire to representatives of APEC economies via email. The recall was done after approximately two months. Then, the obtained data was analyzed via the proposed method (Section 4.1.2). A preliminary report containing the survey and analyzed results was then made. The discussion, comments, and recommendations for the results were performed in the workshop with the participants. After the workshop, the draft final report was revised according to the comments and recommendations of the participants. The final report with the recommendations for practical applications of sustainable development initiatives related to mining and mine closure was subsequently forwarded for MTF endorsement and submitted to UNSCD; the workshop materials will also be uploaded to the APEC website.

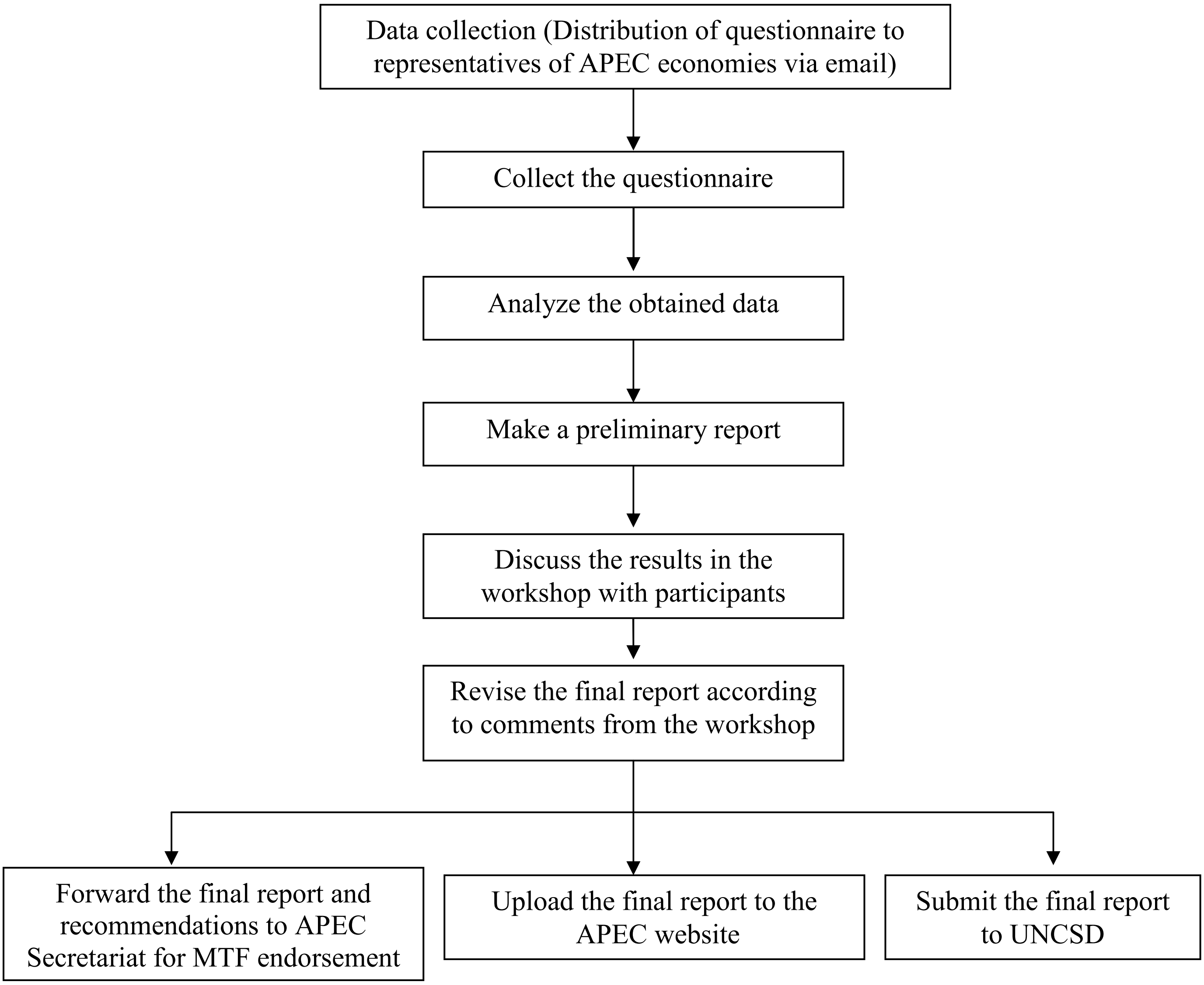


Figure 3.3 Flow diagram of action plan.

3.8 Organization of workshop

A workshop was organized to bring mining officials, experts and industry representatives into direct contact thereby enabled them to establish an effective APEC mining-related expert network for following-up the project outcomes. A brief overview of the workshop is explained as follows.

Topic of workshop: **Balancing between mining, community, and environment for sustainable development in the mining sector**

Brief description: During the APEC Ministers Responsible for Mining (MRM) meetings (2004, 2005 & 2007) and the 3rd APEC Mining Task Force (MTF) meeting (2009), a careful consideration of environment with development was emphasized pertaining to sustainable development in the mining sector. Specifically, the following contents were suggested: **There is a need for strengthening environmental protections and stimulating regional economies. In addition, environmental monitoring in the area of mining and provision of an equitable regulatory system for all APEC economies and smooth exchange of information related to mining for sustainable development in mining sector is also required.**

Issues to be discussed:

1) Interchange and share case studies of social, economic, and environmental impacts from legacy mines and inappropriate mine closures.
2) Cooperate on mine reclamation technologies and leading sustainable development practices relating to the mining industry through the networking of experts in APEC economies.
3) Consider recommendations from the survey on practical applications of sustainable development initiatives relating to mining and mine closures in developing economies to stimulate the adoption of regulations for appropriate mine closures and to invigorate local economies.

Expected outcomes:

- Build an effective APEC mining-related expert network consisting of mining officials, experts, and industry representatives.
- Deepen the consideration of developed recommendations on practical applications of sustainable development initiatives in developing APEC economies from experts related to mine rehabilitation and reclamation technologies for sustainable development in the mining sector.

Date: 31 August –2 September 2010 (3 days)
Venue: MIRECO Building at Seoul and field sites at Kangwon-do, Korea
Major participant: Government officials & industry representatives related to mine reclamation in developing APEC economies and as well as other APEC economies
Sponsor: Mine Reclamation Corporation (MIRECO)
APEC Mining Task Force (MTF) Workshop Committee
Organizer: Korea Mine Reclamation Corporation (MIRECO),
30 Chungjin Street (Susong-dong), Jongno-gu, Seoul 110-727, Korea
Tel) +82-2-3702-6744
Fax) +82-2-3702-6749

3.9 Database development

The data obtained from questionnaires was compiled into a database, including the information on policies, regulations, standards, and technical guidelines related to mine rehabilitation, reclamation, and closure in APEC economies. This database can be used as a reference to improve mine management and to make policies related to the mining sector in APEC economies.

3.10 Beneficiary stakeholders

Stakeholders who were the intended beneficiaries of this project include:

1) Local communities with people living near mining areas will benefit from enhanced health and quality of life as a result of implementing sustainable development initiatives;
2) APEC-wide mining industry, government officers, and experts will acquire a greater knowledge of sustainable development practices in mine reclamation and will be responsible for planning and implementation of mine closures;
3) Policymakers are encouraged to enact domestic policies related to mining industry with a deeper consideration of environmental and social issues in order to pursue sustainable development in the mining sector;
4) Enterprises in the mining industry will adopt sustainable development considerations of effects of closure in their mining operation plans. Mining companies will reap benefits through more streamlined operations, reduced environmental and social risks, and enhanced reputations;
5) APEC members, representatives of each country that provided answers in the questionnaire were involved as experts. Thus, it is expected that they will be involved in the planning, implementation, and evaluation of the project.

3.11 Recommendations on sustainable mining

The project overseers had consulted widely to identify partners and developed a detailed workshop program to ensure that the final recommendations could be used as comprehensive and practical tools. Relevant APEC forum, government agencies, and local experts were given this opportunity to contribute at each stage of the project's development, including the design, implementation, participation, and evaluation phases. The first draft of the report and recommendations were submitted to participants, who were encouraged to read the report before attending the workshop in order to prepare for the discussions and to be able to make inputs for the drafting of recommendations. Participants were then asked to evaluate the workshop after it was completed.

The organizers will follow-up with the participants after endorsement of the workshop results by the Mining Task Force (MTF) to ascertain whether the competencies and knowledge developed during the workshop have led to a revision of processes, and to assess whether the recommendations were or would be employed. In addition, network experts in APEC economies with a view to facilitating sustainable development initiatives within the APEC mining sector will exchange a wide range of information such as environmental regulations related to mining, case studies of impacts from legacy mines and inappropriate mine closure, as well as mine reclamation technologies and lead sustainable development practices relating to mining and mine closure.

4. RESULTS

4.1 Production and market trends of mineral resources: Globally and APEC region

The APEC region accounts for an extensive share of the world's mineral resources, including metallic, nonmetallic, and energy minerals. Major producers in APEC include Australia, Canada, Chile, China, Indonesia, the Russian Federation, and the United States. The high value global trend mineral commodities relevant to the APEC region include bauxite, alumina, aluminum, coal, copper, gold, iron ore, lead, nickel, tin, uranium, and zinc (ABARE, 2007).

4.1.1 Bauxite and Alumina

Bauxite is a naturally occurring, heterogeneous material composed primarily of one or more aluminum hydroxide minerals, plus various mixtures of silica, iron oxide, titanium, aluminosilicate, and other impurities in minor or trace amounts. The principal aluminum hydroxide minerals found in varying proportions with bauxites are gibbsite and the polymorphs bohemite and diaspore. Bauxites are typically classified according to their intended commercial application: abrasive, cement, chemical, metallurgical, refractory, etc., with the bulk of world bauxite production (approximately 85%) being used as feed for the manufacture of alumina via a wet chemical caustic leach method commonly known as the Bayer process (USGS, 2010).

Table 4.1 World bauxite mine production and reserves (in 1000 metric dry tons) (USGS, 2010).

World Bauxite Mine Production and Reserves:

	Mine production		Reserves[9]
	2008	2009[e]	
United States	NA	NA	20,000
Australia	61,400	63,000	6,200,000
Brazil	22,000	28,000	1,900,000
China	35,000	37,000	750,000
Greece	2,220	2,200	600,000
Guinea	18,500	16,800	7,400,000
Guyana	2,100	1,200	700,000
India	21,200	22,300	770,000
Jamaica	14,000	8,000	2,000,000
Kazakhstan	4,900	4,900	360,000
Russia	6,300	3,300	200,000
Suriname	5,200	4,000	580,000
Venezuela	5,500	4,800	320,000
Vietnam	30	30	2,100,000
Other countries	6,550	5,410	3,200,000
World total (rounded)	205,000	201,000	27,000,000

In 2009, world production of bauxite decreased compared to 2008 (Table 4.1). Based on the production data from the International Aluminum Institute, world alumina production during the first two quarters of 2009 decreased by 12% compared with that of the same period in 2008. The reduced output from bauxite mines in Guinea, Guyana, Jamaica, Russia, and Suriname was partially offset by increases in production from new and expanded mines in Australia, Brazil, China, and India, and accounted for most of the slight decrease in the worldwide production of bauxite in 2009 (USGS, 2010).

The main reserves of bauxite are estimated to be 55 to 75 billion tons, which are located in Africa (32%), Oceania (23%), South America and the Caribbean (21%), Asia (18%), and other countries (6%).

4.1.2 Aluminum

Aluminum is the second-most abundant metallic element in the Earth's crust after silicon. It is a comparatively new industrial metal that has been produced in commercial quantities for just over 100 years. It weighs about one-third as much as steel or copper, is malleable, ductile, easily machined, and cast, in addition to having excellent corrosion resistance and durability. Aluminum is important in virtually all segments of the world economy. Some of the many uses for aluminum are in transportation (automobiles, airplanes, trucks, railcars, marine vessels, etc.), packaging (cans, foil, etc), construction (windows, doors, siding, etc.), consumer durables (appliances, cooking utensils, etc.), electrical transmission lines, and machinery.

Recycling of aluminum from scrap has become an important component of the aluminum industry. Sources for recycled aluminum include automobiles, windows and doors, appliances, and other products. However, the recycling of aluminum cans seems to have the highest profile (USGS, 2010).

APEC economies account for more than 60 percent of the global aluminum production. China is the world's largest producer of the aluminum, with an estimated production of 13,000 million tons in 2009, accounting for 35.2% of the global aluminum production market. However, the world primary aluminum production declined sharply in the first quarter of the year in response to price declines in the wake of the financial crises during late 2008 to early 2009. The International Aluminum Institute reported the decrease of the world inventories from 3.0 million tons in 2008 to 2.3 million tons in 2009, though worldwide inventories of primary aluminum metal held by the London Metal Exchange (LME) increased during the year to 4.6 million tons at the end of September from 2.3 million tons at yearend 2008 (Table 4.2).

Table 4.2 World aluminum mine production and reserves.

	Production		Yearend capacity	
	2008	2009[e]	2008	2009[e]
United States	2,658	1,710	3,620	3,500
Australia	1,970	1,970	1,970	1,970
Bahrain	865	870	880	880
Brazil	1,660	1,550	1,700	1,700
Canada	3,120	3,000	3,120	3,090
China	13,200	13,000	15,000	19,000
Germany	550	520	620	620
Iceland	787	790	790	790
India	1,310	1,600	1,800	2,000
Mozambique	536	500	570	570
Norway	1,360	1,200	1,360	1,230
Russia	3,800	3,300	4,400	5,150
South Africa	811	800	900	900
United Arab Emirates, Dubai	910	950	950	950
Venezuela	610	550	625	625
Other countries	4,850	4,600	6,260	6,920
World total (rounded)	39,000	36,900	44,600	49,900

4.1.3 Coal

Coal is currently an important energy source with its 26.5% share of the world primary energy market (International Energy Agency, 2009). Global coal reserves are very unevenly distributed, with a small number of countries controlling the vast majority of the world's coal reserves. The USA, the former Soviet Union (Russian Federation, Ukraine and Kazakhstan), China, India, Australia, and South Africa together control over 93% of the world's hard coal reserves. The USA has almost 30% of the world's total coal reserves, followed by Russia

(20%), China (14%), Australia (9%), India (7%), and South Africa (4%) (British Petroleum, 2009).

Similar to oil, coal extraction will be more expensive and complicated to produce as high grade coal deposits become depleted, finally entering a depletion-driven decline (Milici, 1997). Better extraction technologies have been found to be obscured due to decreasing reserve levels, resulting in a situation in which coal is thus becoming increasingly complicated to mine. Its difficulty in mining means that depletion has been able to offset many of the gains obtained by using new technology (Rodriguez and Arias, 2008).

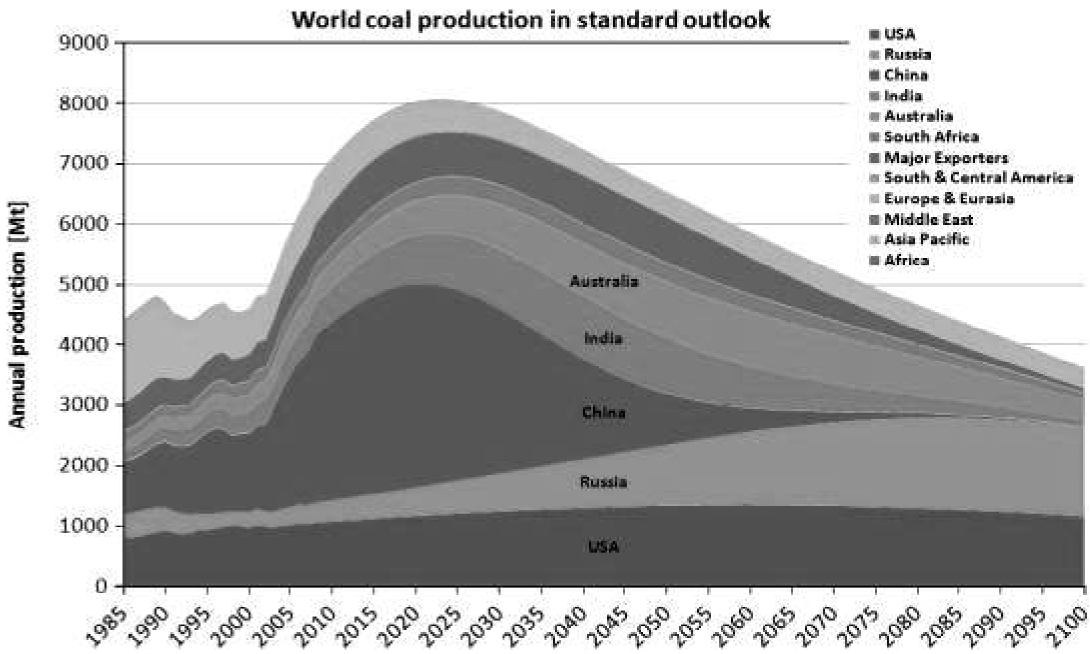


Figure 4.1 Long-term prediction for future global coal production (Höök *et al.*, 2010)

Figure 4.1 presents a long-term prediction for the future of global coal production (Höök *et al.*, 2010), showing that production will likely increase by about 20% over the next couple of decades, mainly driven by China, India, and Australia. A plateau will then be reached around 2025, and global production will go into decline after 2030. Russia will end up as the last important coal producer, due to the vast but remote reserves located in Siberia. Many studies have stated a similar prediction, in which it is thought that China may suffer a fast decline after a peak production around 2025 (Zaipu and Mingyu, 2007; Lin and Liu, 2010). The USA will flatten out at nearly 1000 million tons, and will be able to maintain a quite constant production volume during the remainder of the century (Höök and Aleklett, 2010a; Höök and Aleklett, 2010b).

4.1.4 Copper

Copper is usually found in nature in association with sulfur. Pure copper metal is generally produced from a multistage process. Copper is one of the oldest metals ever used and indeed has been one of the most important materials in the development of civilization. It is third-ranked after iron and aluminum in terms of quantities consumed. Electrical uses of copper include power transmission and generation, building wiring, telecommunications, and electrical and electronic products, which account for about 75% of the total copper used. Building construction is the single largest market, followed by electronics and electronic products.

Copper byproducts from manufacturing and obsolete copper products are readily recycled and contribute significantly to the accessible copper supply.

In 2009, APEC economies shared more than 75% of the refined copper production market. The three main producers of refined copper are Chile (33.7%), followed by Peru (8.0%), and the USA (7.5%) (Table 4.3). Recent assessments of copper resources found 550 million tons of copper remaining in identified and undiscovered resources in the USA (USGS National Mineral Resource Assessment Team, 2000), and 1.3 billion tons of copper in discovered, mined, and undiscovered resources in the Andes Mountains of South America (Cunningham *et al.*, 2008). The world copper production slightly increased by 2.6 % from 15,400 million tons in 2008 to 15,800 million tons in 2009. However, the global production of refined copper was essentially unchanged, as a result of cutbacks in response to the global economic crisis and operational constraints that reduced output in Australia, Chile, and Indonesia, and also because lower scrap availability led to a decline in the availability of secondary refined copper. Refined copper consumption also declined slightly, as double-digit declines in the European Union, Japan, and the USA were offset by growth in China's apparent consumption of more than 25%; China's import of refined copper rose by 1.1 million tons during the first 6 months of 2009. The International Copper Study Group forecast a small refined copper production surplus to develop by end of the year 2009 and a slightly larger surplus in 2010 (International Study Group, 2009).

Table 4.3 World copper production and reserves (USGS, 2010)

	Mine production		Reserves[7]
	2008	2009[e]	
United States	1,310	1,190	35,000
Australia	886	900	24,000
Canada	607	520	8,000
Chile	5,330	5,320	160,000
China	950	960	30,000
Indonesia	651	950	31,000
Kazakhstan	420	410	18,000
Mexico	247	250	38,000
Peru	1,270	1,260	63,000
Poland	430	440	26,000
Russia	750	750	20,000
Zambia	546	655	19,000
Other countries	2,030	2,180	70,000
World total (rounded)	15,400	15,800	540,000

4.1.5 Gold

The price and production behavior of gold are different from most other mineral commodities. During the financial crisis in 2008, the price of gold increased by 6% while many key mineral prices fell and other equities dropped by up to 40% (World Gold Council, 2009). The aggregate supply of and demand for gold from 2002–2007 are shown in Tables 4.4 and 4.5, respectively. The total supply of world gold is around 35,000 tons per year, with the largest source of approximately 2,500 tons being from mining production. Table 4.5 demonstrates the demand trends for gold. An average of 2,500 tons is ascribed to jewelry and 1,000 tons has been ascribed to retail investors, Exchange Trade Funds (ETFs) and industrial production during the last 10 years (World Gold Council, 2008).

Table 4.4 Estimated world gold supply from 2002–2007 (tons) (WGC, 2009)

Year	Mine production	Net producer hedging	Total mine supply	Official sector sales	Old gold scrap	Total supply
2002	2591	−412	2179	545	835	3559
2003	2593	−279	2314	617	944	3875
2004	2463	−427	2036	471	834	3341
2005	2548	−92	2456	663	898	4017
2006	2485	−410	2075	370	1129	3574
2007	2475	−447	2028	501	967	3496

Table 4.5 Estimated world gold demand from 1998–2007 (tons) (WGC, 2008)

Year	Jewellery	Net retail investment	ETFs and similar	Industrial and dental	Total
1998	3164	263	–	393	3820
1999	3132	359	–	412	3903
2000	3196	166	–	451	3813
2001	3001	357	–	363	3721
2002	2653	340	3	357	3353
2003	2477	293	39	381	3190
2004	2613	340	133	414	3500
2005	2708	385	208	432	3733
2006	2284	401	260	459	3404
2007	2400	403	253	461	3517

The world gold demand decreased from 1998 to 2007. One of the peculiarities of gold demand from jewelry is that it can be converted to the supply side. This means gold is considered a renewable resource, and with no degradation in quality it could conceivably be recycled and contribute to a decrease in the global demand for newly mined gold.

Australia, South Africa, China, and the USA are the major producers, producing about 40% of the global gold in 2009 (USGS, 2010). The World Gold Council (WGC, 2009) has estimated that the total amount of gold mined in history until 2008 is approximately 160,000 tons. Around 30,000 tons have been used in industrial and dental applications, 30,000 tons is held in the central bank reserves, and about 100,000 tons are in jewelry. Roughly 15 g of gold per head of the world population has been distributed. Based on the 2008 average gold price of $896 per once, the total value of gold used in jewelry, central bank reserves, and industrial applications is $2.9, $0.9 and $0.9 trillion, respectively.

Figure 4.2 illustrates the historical trend of nominal gold prices from 1833 to 2008. Gold was traded in the market from 1967 and the price has increased with rapid fluctuations since then (Mills, 2004). Two significant gold price jumps are shown in the historical trend. The first was in January 1980, when gold prices reached $300 in just three weeks and then decreased significantly in March of the same year. The second jump began in 2008 and is currently in progress. This time, the increase is substantially more firmly based and less volatile than the first jump in 1980. In the current jump, the gold price has increased almost $700 over 6 years, and is continuously increasing. There are two main short-term reasons for these jumps in prices. The first was a period in which the global financial markets crashed and the global economy was in recession. In the second, the devaluation of US dollar versus other currencies, and international inflation with high oil prices are the reasons why big companies are hedging gold against fluctuations in the US dollar and inflation.

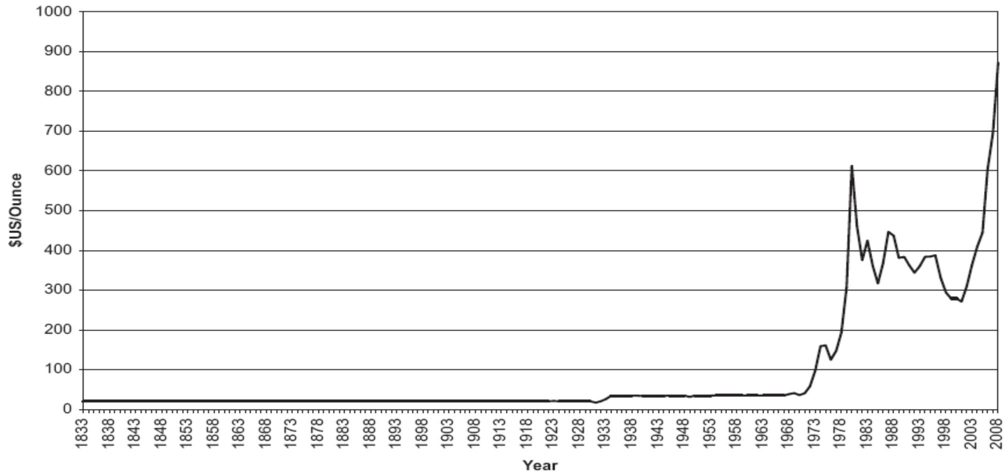


Figure 4.2 Historical trend of nominal gold prices from 1833–2008 (Shafiee and Topal, 2010)

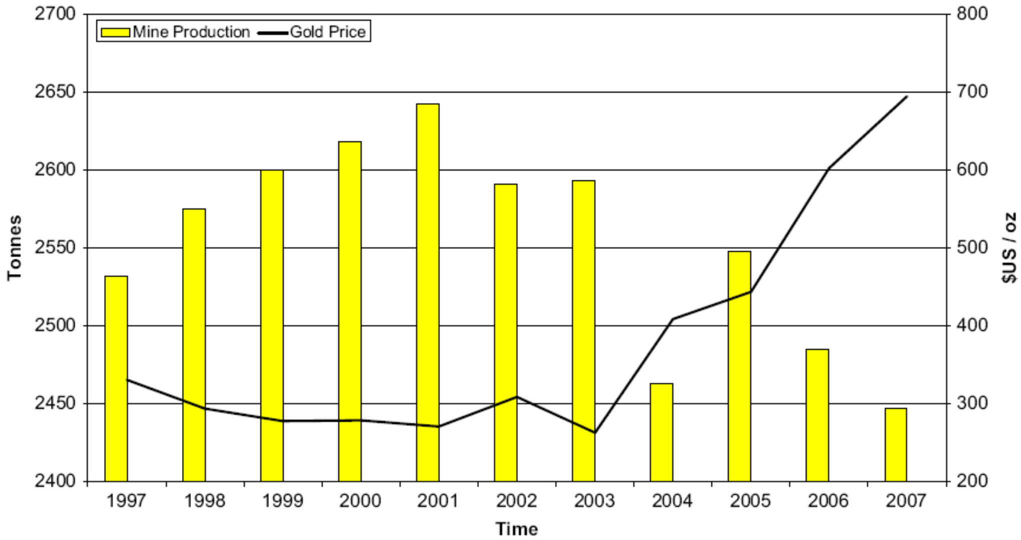


Figure 4.3 Yearly global gold mine production and nominal price from 1997–2007 (Shafiee and Topal, 2010)

For the long-term, there are three reasons for the increase in gold prices. First, mine production has gradually decreased in recent years (Figure 4.3). Increasing mine costs, decreased exploration, and difficulties in finding new deposits are some other factors that may have also contributed to this reduction in mine production. Second, institutional and retail investments have rational expectations when markets are uncertain. Therefore, they keep gold in their investment portfolios as it is more marketable in unstable financial markets. And third, investing in gold is becoming easier via gold Exchange Trade Funds (ETFs).

However, the forecast for the price of gold over the next 10 years from 2007 (Shafiee and Topal, 2010) has indicated that the price will likely stay abnormally high to the end of 2014. After that, the price would revert back to the long-term trend by 2018.

4.1.6 Iron Ore

Iron is the fourth-most abundant element in the earth's crust. Because iron is present in many areas, it is of relatively low value and thus a deposit must have a high percentage of metal to be considered ore grade. Typically, a deposit must contain at least 25% iron to be considered economically recoverable; the percentage can be lower, but the ore must exist in a large deposit so that it can be concentrated and transported inexpensively (Yellishetty et al, 2010). Over 300 minerals contain iron, but the five primary sources of iron ore minerals include magnetite (Fe_3O_4), hematite (Fe_2O_3), goethite ($Fe_2O_3H_2O$), siderite ($FeCO_3$), and pyrite (FeS_2). Among these, the first three are of major importance because of their occurrence in large economically minable quantities (US EPA, 1994).

The United States Geological Survey (USGS) estimates the known global reserves of iron ore—that are economically recoverable with existing technology—to be more than 800 billion tons of crude ore, containing more than 230 billion tons of iron (USGS, 2010). The largest reserves are in Australia, Brazil, China, Russia, and Ukraine (Table 4.6).

Table 4.6 World iron ore mine production and reserves (in 1000 metric dry tons) (USGS, 2010)

	Mine production		Reserves[8]	
	2008	2009[e]	Crude ore	Iron content
United States	54	26	6,900	2,100
Australia	342	370	20,000	13,000
Brazil	355	380	16,000	8,900
Canada	31	27	1,700	1,100
China	824	900	22,000	7,200
India	220	260	7,000	4,500
Iran	32	33	2,500	1,400
Kazakhstan	23	21	8,300	3,300
Mauritania	11	11	700	400
Mexico	12	12	700	400
Russia	100	85	25,000	14,000
South Africa	49	53	1,000	650
Sweden	24	18	3,500	2,200
Ukraine	73	56	30,000	9,000
Venezuela	21	16	4,000	2,400
Other countries	47	47	11,000	6,200
World total (rounded)	2,220	2,300	160,000	77,000

Major iron-ore-mining companies continue to reinvest profits in mine development, but an increase in capacity may soon outstrip expected consumption as the growth in production dominated by China slows. In 2008, it was estimated that China increased the production of most lower grade ores by 17% from 2007, which is significantly lower than its 40% increase between 2005 and 2006. Estimates of Chinese imports of higher grade ore in 2008, mostly from Australia and Brazil, showed an increase of about 16% compared with those of 2007 (USGS, 2010). However, it is estimated that the iron ore production required to the year 2030 will be about 2,883 million tons (Yellishetty *et al.*, 2010).

4.1.7 Lead

Over the past 15 years, the center of the international lead market has shifted to China. China has become the largest producer and consumer of raw and refined lead (Chen *et al.*, 2009). The global mine production of lead concentrate slightly increased in 2009, with production increases in China, which accounts for 40% of the global lead mine production, offset declines in other regions. Lead is frequently recovered as a byproduct of zinc production, so lead production has been affected by the downturn in the zinc market. Also adding to the decline in production is that a mine in Montana was depleted of ore in late 2008, and ceased production after all stockpiled resources were processed in early 2009. Production rates also were slowed at lead mine in Missouri owing to the decrease in lead prices. Following this trend, production in Canada and Peru was expected to decline by more than 10% in 2009, compared to 2008. In contrast, increases in mine production took place in Bolivia, where a recently opened mine began operating at full production levels in 2009. In addition, a significant new mine in Mexico was entering the final phases of development and was expected to begin in producing lead concentrates in 2010. Lead mine in Australia, shuttered since 2007, was scheduled to restart production in early 2010. Production increased in China, but in most other regions refined lead production declined in response to the global financial crisis (USGS, 2010).

Lead consumption was expected to increase by 3% worldwide in 2009 owing to a nearly 25% increase in Chinese lead consumption, which was driven by growth in their automobile and electric markets. The Chinese balance changed in 2009, as China became a net importer of refined lead. In most other regions, lead consumption was expected to remain flat or decline. According to Batter Council International statistics, North American shipments of replacement starting-lighting-ignition (SLI) batteries through August 2009 (Table 4.7), slightly decreased, and shipments of original equipment batteries declined by 30% from August 2008. The Battery Council forecast a 3% decline in shipments of SLI lead acid batteries in 2009 and a 19% decline in shipments of industrial-type lead-acid batteries compared to 2008.

In response to a petition from a dozen environmental and public health organizations, the US Environmental Protection Agency (EPA) reversed its decision and began the rulemaking process to ban lead wheel weights.

Table 4.7 World lead mine production and reserves (in 1000 metric tons) (USGS, 2010).

	Mine production		Reserves[6]
	2008	2009[e]	
United States	410	400	7,700
Australia	645	516	23,000
Bolivia	82	100	1,400
Canada	99	95	700
China	1,500	1,690	12,000
India	87	88	2,600
Ireland	54	50	500
Mexico	101	155	4,700
Peru	345	305	6,000
Poland	62	40	3,500
Russia	60	78	900
South Africa	46	50	300
Sweden	60	70	1,300
Other countries	289	268	14,000
World total (rounded)	3,840	3,900	79,000

Currently, significant resources of lead have been found in association with zinc and/or silver or copper deposits in Australia, China, Ireland, Mexico, Peru, Portugal, and the USA (Alaska). The world total identified lead resources is more than 1.5 billion tons.

4.1.8 Nickel

Nickel (Ni) is a transition element that exhibits a mixture of ferrous and nonferrous metal properties. It is both a siderophile (i.e., associates with iron) and a chalcophile (i.e., associates with sulfur). The bulk of the nickel being mined comes from two types of ore deposits:

- laterites, in which the principal ore minerals are nickeliferous limonite [(Fe,Ni)O(OH)] and garnierite (a hydrous nickel silicate), or
- magnetic sulfide deposits, in which the principal ore mineral is pentlandite [$(Ni,Fe)_9S_8$].

Nickel sulfide deposits are generally associated with iron- and magnesium-rich rocks called ultramafics that can be found in both volcanic and plutonic settings. Many sulfide deposits occur at great depth. Laterites are formed by the weathering of ultramafic rocks and are a near-surface phenomenon. Most of the nickel on Earth is believed to be concentrated in the planet's core.

Nickel is primarily sold for first use as a refined metal (cathodes, powders, briquets, etc.) or as ferronickel. About 65% of the nickel consumed in the western world is used to make austenitic stainless steel. Another 12% goes into superalloys (e.g., Inconel 600) or nonferrous alloys (e.g., cupronickel). Both families of alloys are widely used because of their corrosion resistance. The aerospace industry is a leading consumer of nickel-base superalloys; turbine blades, discs, and other critical parts of jet engines are fabricated from superalloys. Nickel-base superalloys are also used in land-based combustion turbines, such those found at electric power generation stations. The remaining 23% of consumption is divided between alloy steels, rechargeable batteries, catalysts and other chemicals, coinage, foundry products, and plating. The principal commercial chemicals are carbonate ($NiCO_3$), chloride ($NiCl_2$), divalent oxide (NiO) and sulfate ($NiSO_4$). In aqueous solution, the divalent nickel ion has an emerald-green color.

The estimated cumulative world production of nickel up to 2009 was around 49.1 million tons (Mudd, 2010). Identified land-based resources averaging 1% nickel or greater contain at least 130 million tons of nickel. About 60% is in laterites and 40% is in sulfide deposits. In addition, extensive deep sea resources of nickel in the manganese crust and nodules cover large areas of the ocean floor, particularly in the Pacific Ocean. In 2009, world major producers of nickel include Russia (18.6%), Indonesia (13.2%), Canada (12.7%), Australia (11.7%), and New Celedonia (7.5%) (Table 4.8). Global nickel production by country from 1980–2008 is shown in Figure 4.4.

Table 4.8 World nickel mine production and reserves (in metric tons) (USGS, 2010).

	Mine production		Reserves[5]
	2008	2009[e]	
United States	—	—	—
Australia	200,000	167,000	26,000,000
Botswana	38,000	36,000	490,000
Brazil	58,500	56,700	4,500,000
Canada	260,000	181,000	4,100,000
China	68,400	84,300	1,100,000
Colombia	76,400	93,000	1,700,000
Cuba	67,300	65,000	5,500,000
Dominican Republic	31,300	—	840,000
Greece	18,600	14,000	490,000
Indonesia	193,000	189,000	3,200,000
New Caledonia[6]	103,000	107,000	7,100,000
Philippines	83,900	85,000	940,000
Russia	277,000	266,000	6,600,000
South Africa	31,700	34,000	3,700,000
Spain	8,140	7,800	57,000
Venezuela	13,000	12,000	490,000
Other countries	46,000	28,600	3,800,000
World total (rounded)	1,570,000	1,430,000	71,000,000

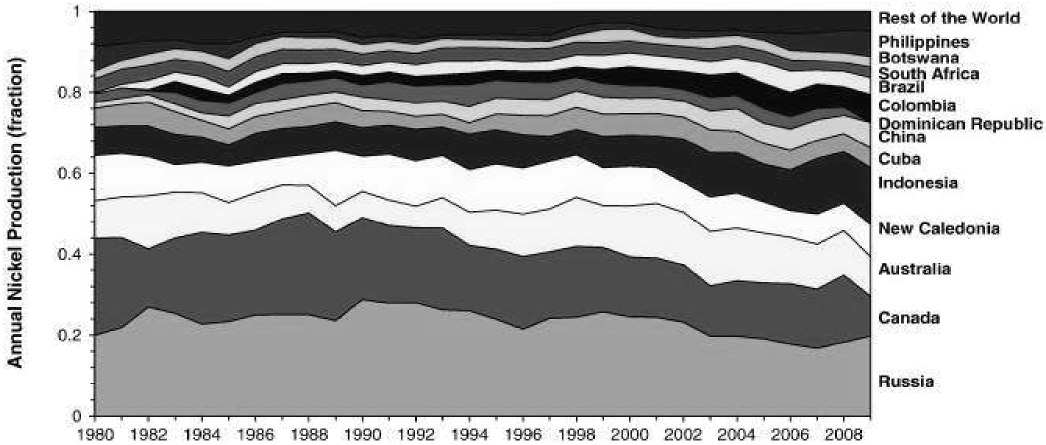


Figure 4.4 Global nickel productions by country (Mudd, 2010).

Nickel market and price

In March 2009, the London Metal Exchange (LME) cash mean for 99.8%-pure nickel averaged $9,693 per metric ton ($4.40 per pound), compared with $27,680 per metric ton ($12.56 per pound) in January 2008. In the third quarter of 2009, the global economy stopped contracting and slowly began to turn upward—in part owing to stimulus programs funded by at least 23 national governments. In October 2009, the LME cash mean averaged $18,520 per metric ton ($8.40 per pound), up 91% from the mean for March 2009. At yearend 2009, high unemployment and tight credit continued to hobble several of the more developed economies, weakening the demand for nickel. As such, a leading nickel producer halted production at its new Ravensthorpe Mine in Western Australia after nickel prices dropped sharply, and has put the $2.2 billion operation up for sale. In addition, several competitors suspended or slowed work on Greenfield nickel mining projects in Canada, Guatemala, Viet Nam, and Zambia. Mine development and construction of downstream facilities, however, continued at laterite projects in Brazil, Madagascar, and Turkey. Nickel prices remained subdued throughout the summer of 2009, despite a labor strike at a key nickel smelting and refining complex in Canada.

During this time, several North American automobile manufacturers were in financial trouble and began switching production to smaller, more fuel-efficient vehicles to boost sales. Some dealers had to put buyers on waiting lists for the more popular hybrid motor vehicles. Nickel-metal hydride batteries continue to be widely used in the latest hybrids, despite inroads made by lithium-ion batteries. Financially strapped airlines cut back, postponed, or canceled orders for new aircraft, further reducing demand for nickel-based superalloys. And environmental concerns and increasing prices for natural gas have triggered a renaissance in the nuclear power industry. The US Nuclear Regulatory Commission was actively reviewing 13 applications from utilities wanting to construct 22 new nuclear reactors—facilities that would require sizeable amounts of austenitic stainless steel and other nickel-bearing alloys.

4.1.9 Tin

Tin is one of the earliest metals to be known and used. Because of its hardening effect on copper, tin was used in bronze implements as early as 3500 BC, although the pure metal was not used until about 600 BC. About 35 countries mine tin throughout the world, and nearly every continent has an important tin-mining country. Tin is a relatively scarce element, with an abundance in the earth's crust of only about two parts per million (ppm)—compared to 94 ppm for zinc, 63 ppm for copper, and 12 ppm for lead. Most of the world's tin is produced from placer deposits; at least 50% comes from Southeast Asia. The only mineral of commercial importance as a source of tin is cassiterite (SnO_2), although small quantities of tin are recovered from complex sulfides such as stanite, cylindrite, frankeite, canfieldite, and teallite.

Most tin is used as a protective coating or as an alloy with metals such as lead or zinc. Tin is used in coatings for steel containers, in solders for joining pipes or electrical/electronic circuits, in bearing alloys, in glass making, and in a wide range of chemical applications. Secondary, or scrap, tin is an important source of the tin supply (USGS, 2010).

In 2009, APEC contributed to 85.6% of the global tin production (USGS, 2010). Major tin producers are China (37.5%), Indonesia (32.6%), and Peru (12.4%) (Table 4.9). China continued as the world's leading tin producer from both mine and smelter sources, but experiences sporadic difficulty in obtaining feedstock for its smelters. Indonesia, the world's second leading tin producer, also continued to experience production difficulties, some related to a government shutdown of possibly illegal production sites.

Table 4.9 World tin production and reserves (in metric tons) (USGS, 2010).

	Mine production		Reserves[3]
	2008	2009[e]	
United States	—	—	—
Australia	1,800	2,000	150,000
Bolivia	17,000	16,000	450,000
Brazil	12,000	12,000	540,000
China	110,000	115,000	1,700,000
Congo (Kinshasa)	12,000	12,000	NA
Indonesia	96,000	100,000	800,000
Malaysia	2,200	2,000	500,000
Peru	39,000	38,000	710,000
Portugal	100	100	70,000
Russia	1,500	2,000	300,000
Thailand	100	100	170,000
Vietnam	3,500	3,500	NA
Other countries	4,000	4,000	180,000
World total (rounded)	299,000	307,000	5,600,000

Prices of tin in 2009 were substantially lower than in 2008, attributable to a decreased worldwide demand due to the global economic slowdown. However, despite the 2009 decline in prices, tin producers continued to respond to higher tin prices of recent years with tin mine and tin smelter openings and expansions, including in Australia, Bolivia, Canada, and Thailand. Tin exploration activity also increased, especially in Australia and Canada. In countries such as Bolivia, old tin tailings were being evaluated for tin reclamation.

4.1.10 Uranium

The only significant commercial use for uranium is as a fuel for nuclear power plants. As of August 2006, there were 442 nuclear power plants worldwide. The worldwide production in 2009 amounted to 50,572 tons, of which 27% was mined in Kazakhstan. Kazakhstan, Canada, and Australia are the top three producers and together account for 63% of the world's uranium production. Other important uranium producing countries (i.e., those producing in excess of 1000 tons per year) include Namibia, Russia, Niger, Uzbekistan, and the USA. The production forecast for 2010 is about 55,000 tons of uranium, as production ramps up in Kazakhstan and Namibia (WNA, 2010).

Table 4.10 World uranium production by country (in metric tons) (WNA, 2010)

Country	2003	2004	2005	2006	2007	2008	2009
Kazakhstan	3300	3719	4357	5279	6637	8521	14 020
Canada	10457	11597	11628	9862	9476	9000	10173
Australia	7572	8982	9516	7593	8611	8430	7982
Namibia	2036	3038	3147	3067	2879	4366	4626
Russia	3150	3200	3431	3262	3413	3521	3564
Niger	3143	3282	3093	3434	3153	3032	3243
Uzbekistan	1598	2016	2300	2260	2320	2338	2429
USA	779	878	1039	1672	1654	1430	1453
Ukraine (est)	800	800	800	800	846	800	840
China (est)	750	750	750	750	712	769	750
South Africa	758	755	674	534	539	655	563
Brazil	310	300	110	190	299	330	345
India (est)	230	230	230	177	270	271	290
Czech Repub.	452	412	408	359	306	263	258
Malawi							104
Romania (est)	90	90	90	90	77	77	75
Pakistan (est)	45	45	45	45	45	45	50
France	0	7	7	5	4	5	8
Germany	104	77	94	65	41	0	0
total world	**35 574**	**40 178**	**41 719**	**39 444**	**41 282**	**43 853**	**50 772**
tonnes U_3O_8	41 944	47 382	49 199	46 516	48 683	51 716	59 875
percentage of world demand			65%	63%	64%	68%	76%

Since the recovery of uranium prices in 2003, many countries have been preparing to open new mines. The World Nuclear Association (WNA) predicted that world uranium demand to be about 77,000 tU in 2015, and most of this will need to come directly from mines (in 2009, 24% came from secondary sources).

Since the early 1990s the uranium production industry has been consolidated by takeovers, mergers and closures. In 2009, only 10 companies marketed 89% of the world's uranium mine production.

Table 4.11 Ten largest uranium mine production companies (WNA, 2010)

Company	tonnes U	%
Areva	8623	17
Cameco	8000	16
Rio Tinto	7963	16
KazAtomProm	7467	15
ARMZ	4624	9
BHP Billiton	2955	6
Navoi	2429	5
Uranium One	1368	3
Paladin	1210	2
GA/Heathgate	583	1
Other	5550	11
Total	**50,772**	**100%**

4.1.11 Zinc

Zinc is the 23rd most abundant element in the earth's crust. Sphalerite, zinc sulfide, is and has been the principal ore mineral in the world. Zinc is necessary for modern living, and, in tonnage produced, stands fourth among all metals in world production—being exceeded only by iron, aluminum, and copper. Zinc uses range from metal products to rubber and medicines. About 75% of zinc used is consumed as metal, mainly as a coating to protect iron and steel from corrosion (galvanized metal), as an alloying metal to make bronze and brass, as a zinc-based die casting alloy, and as rolled zinc. The remaining 25% is consumed as zinc compounds; mainly by the rubber, chemical, paint, and agricultural industries. Zinc is also a necessary element for the growth and development of humans, animals, and plants, and is the second most common trace metal, after iron, naturally found in the human body (USGS, 2010).

Based on a U.S. Geological Survey, the global zinc resources are about 1.9 billion metric tons (USGS, 2010). Production from APEC economies was about 67.7% of the world's production in 2009, which slightly decreased from 70.8% in 2008. China, Australia, and Peru are the major zinc producers. According to the International Lead and Zinc Study Group's October 2009 report, global zinc mine production fell 5.4% to 11.1 million metric tons because of mine closures and cutbacks during late 2008 and early 2009. In addition, refined metal production fell 4.7% to 11.1 million metric tons, while the world consumption fell 5.6% to 10.8 million metric tons, resulting in a surplus of 380,000 tons of metal on the market; another surplus is anticipated in 2010.

Table 4.12 World zinc production and reserves (in 1000 metric tons) (USGS, 2010).

	Mine production[9]		Reserves[10]
	2008	2009[e]	
United States	778	690	14,000
Australia	1,480	1,300	21,000
Canada	750	730	8,000
China	3,200	2,800	33,000
India	610	650	10,000
Ireland	400	380	2,000
Kazakhstan	460	490	17,000
Mexico	400	520	14,000
Peru	1,600	1,470	19,000
Other countries	1,920	2,090	62,000
World total (rounded)	11,600	11,100	200,000

Global economic activity continued to contract during the first half of 2009, with the notable exceptions of China and India. As the global economy began recovering during the third quarter of 2009, the global demand for zinc also began to increase. By the end of 2009, only China and India posted year-on-year zinc consumption increases. Consumption in China has been supported by a fiscal stimulus package to increase the investment into infrastructure.

4.2 Environmental regulations of mining sector in APEC economy

Australia

The Australian Government may become involved in the decision making process if a mining activity is likely to impact matters pertaining to national environmental significance under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage places defined in the Act as matters of national environmental significance.

See: http://www.environment.gov.au/epbc/publications/pubs/epbc-act-fact-sheet.pdf for more information.

States' Environmental Legislation:

For the relevant department for each state and territory, the links below contain further information regarding jurisdictional legislation:

- Queensland: Department of Environment and Resource Management (DERM), http://www.derm.qld.gov.au/
- South Australia: Department of Primary Industries and Resources, http://www.pir.sa.gov.au/home
- Western Australia: Department of Mines and Petroleum, http://www.dmp.wa.gov.au/
- Northern Territory: Northern Territory Treasury, Revenue Office, http://www.nt.gov.au/ntt/revenue/royalties.shtml
- Victoria: Department of Primary Industries, http://new.dpi.vic.gov.au/home
- New South Wales: Department of Primary Industries, http://www.dpi.nsw.gov.au/minerals
- Tasmania: Department of Infrastructure, Energy and Resources, http://www.dier.tas.gov.au/

Minerals Council of Australia

The Minerals Council of Australia (MCA) represents Australia's exploration, mining, and minerals processing industry, nationally and internationally, in its contribution to promoting sustainable development and society. MCA member companies produce more than 85% of Australia's annual mineral output.

The MCA recognizes that the future of the Australian minerals industry is inseparable from the global pursuit of sustainable development. Through the integration of economic progress, responsible social development, and effective environmental management, the industry is committed to contributing to the sustained growth and prosperity of current and future generations.

The MCA provides the Australian Minerals Industry with a framework for sustainable development. This framework aims to ensure that the Australian minerals industry achieves continual improvement in environmental, social, and economic performance and accountability through the implementation of the Principles and Elements of Enduring Value. These Principles are:

1. Implement and maintain ethical business practices and sound systems of corporate governance.
2. Integrate sustainable development considerations within the corporate decision-making process.
3. Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities.
4. Implement risk management strategies based on valid data and sound science.
5. Seek continual improvement of our health and safety performance.
6. Seek continual improvement of our environmental performance.

7. Contribute to the conservation of biodiversity and finding integrated approaches to land-use planning.
8. Facilitate and encourage responsible product design, use, re-use, recycling, and disposal of our products.
9. Contribute to the social, economic, and institutional development of the communities in which we operate.
10. Implement effective and transparent engagement, communication, and independently verified reporting arrangements with our stakeholders.

The Enduring Value Summary Booklet can be found at: http://www.minerals.org.au/__data/assets/pdf_file/0006/19833/EV_SummaryBooklet_June2005.pdf.

The MCA has also established an Environmental and Social Policy Committee to better serve its member companies who are actively engaged in the effective integration of the environmental, social and wealth creation elements of minerals resource development, and recognize this as the key to operate sustainable development. More information is available at: http://www.minerals.org.au/environment/index.html.

Canada

In Canada, surface rights and mineral rights came with the purchase of land until sometimes in the early 1900s, depending on the jurisdiction. Since then, mineral rights have been government-owned and cannot be purchased, but only leased, by individuals or companies. As a result, the mineral rights on more than 90% of Canada's land are currently owned by the government.

Where mineral rights are privately owned, they can be sold independently of surface rights, so that surface and mineral rights on the same property can be held by different owners.

As per the Canadian Constitution, the regulation of mining activities on publicly owned mineral leases falls under provincial/territorial government jurisdictions. Thus, there is separate mining rights legislation for each of the thirteen Canadian jurisdictions, except Nunavut (the northern and eastern portions of the former Northwest Territories that became a separate territory on April 1, 1999).

For the time being, Nunavut mining and exploration activities will continue to be regulated by the Department of Indian Affairs and Northern Development's office based in the Northwest Territories. However, in a land claims settlement, the mineral rights for about 10% of Nunavut have been turned over to the Inuit community. These lands comprise large blocks that are scattered throughout Nunavut. The Inuit community set the rules and regulations in those blocks that are not under federal jurisdiction.

In the Northwest Territories, British Columbia, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia, individuals and companies must obtain a prospector's license before engaging in exploration for minerals. In the Yukon, Alberta, Saskatchewan, PEI, and Newfoundland and Labrador, one can conduct prospecting or exploration activities without a license, but must have a license to actually acquire mineral rights (or "stake claims") so as to protect what one has discovered. In some jurisdictions, a special permit is required to obtain the right to fly an airborne geophysical survey over an area not covered by a mineral claim.

Mining claim units are normally 16 to 25 square hectares, with a maximum individual claim dimension normally varying from 256 to 500 hectares. But in some provinces, or in some areas of certain provinces, maximum claim dimensions can be much larger, especially where claims are registered by way of "map staking." Mining companies can circumvent maximum claim size limits for individuals by having more than one person stake claims for it; individual prospectors then transfer ownership of the claims to the company.

Map staking is being developed and is gaining usage in provinces or regions of provinces in which the area is currently being surveyed. Claims can then be recorded on a map directly at the mining recorders' office without the prospector ever having visited the location on the ground. Elsewhere, claims must actually be marked out on the ground, using marked wooden corner posts and boundaries cut through the forest.

Except for oil and gas, which are subject to different laws and regulations, there is no competitive bidding for mineral exploration rights in Canada. Land locations are selected by companies or individuals according to their wants, provided the claim area is not held by somebody else or reserved for another purpose.

In cases of disputed land claims, the first person to mark a claim out on the ground by staking obtains the claim, based on the time and date of staking marked on the # 1 claim post (in most cases, the northeast corner post). There is a specified period of time within which the claim must be recorded at the mining recorder's office for the precedence of the claim title to hold.

Prospecting license fees and recording fees are imposed at variable rates across jurisdictions. In addition, a certain amount of assessment work must be done each year to keep claims in good standing. For example, all jurisdictions require that claim holders carry out geological mapping of their mineral holdings, a specified amount of diamond drilling, or a specified value of other work. Copies of geological maps, reports, drill logs, and the like must be submitted to the mining recorder. They are kept for future access by any interested party, after the end of a confidentiality period that varies by province or territory.

Holders of claims in good standing must obtain a mining lease in order to proceed with the development of a property into a mine. Mining leases require that claim boundaries be surveyed by a Registered Land Surveyor. They are valid in most provinces/territories for 20 or 21 years and can be renewed. Some provinces impose certain conditions upon the renewal of mining leases (for example, the property must be the site of an active mine).

Mining laws and regulations of Canada are different from province to province; a list of relevant mining laws and regulations is as follows.

Alberta
(http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/trl-lrf/trl-alb-eng.htm#h_reg)

Taxation Regime for Mining in Alberta

1. Mines and Minerals Act
   Regulations
   : Coal Royalty Regulation
   : Enhanced Recovery of Oil Royalty Reduction Regulation
   : Experimental Oil Sands Royalty Regulation

: Experimental Project Petroleum Royalty Regulation
: Horizontal Re-Entry Well Royalty Reduction Regulation
: Low Productivity Well Royalty Reduction Regulation
: Mineral Rights Compensation Regulation
: Natural Gas Royalty Regulation, 1994 Regulation
: Natural Gas Royalty Regulation, 2002
: Oil Sands Royalty Regulation, 1984
: Oil Sands Royalty Regulation, 1997
: Petroleum Royalty Regulation
: Petroleum Royalty Regulation Amendment
: Reactivated Well Royalty Exemption Regulation
: Suncor Oil Sands Royalty Regulation
: Third Tier Exploratory Well Royalty Exemption Regulation

Regulatory Regime for Mining

1. Mines and Minerals Act
   Regulations
   : Ammonite Shell Regulation
   : Crown Minerals Registration Regulation
   : Exploration Regulation
   : Gas Processing Efficiency Assistance Regulation
   : Metallic and Industrial Minerals Exploration Regulation
   : Metallic and Industrial Minerals Regulation
   : Metallic and Industrial Minerals Royalty Regulation
   : Mines and Minerals Administration Regulation
   : Oil Sands Tenure Regulation
   : Petroleum and Natural Gas Tenure Regulation
2. Mines and Minerals Amendments Act (unproclaimed)

Environmental Laws and Regulations

1. Bighorn Agreement Validating Act
2. Boundary Surveys Act
3. Brazeau River Development Act
4. Drainage Districts Act
   Regulations
   : Compensation Regulation
   : Drainage Districts Regulation
5. Environmental Protection and Enhancement Act (EPEA)
   Regulations
   : Activities Designation Regulation
   : Administrative Penalty Regulation
   : Approvals and Registrations Procedure Regulation
   : Beverage Container Recycling Regulation
   : Conservation and Reclamation Regulation
   : Conservation Easement Registration Regulation
   : Disclosure of Information Regulation
   : Environmental Appeal Board Regulation
   : Environmental Assessment (Mandatory and Exempted Activities) Regulation
   : Environmental Assessment Regulation
   : Environmental Protection and Enhancement (Miscellaneous) Regulation

- : Forest Resources Improvement Regulation
- : Lubricating Oil Material Environmental Handling Charge Bylaw
- : Lubricating Oil Material Recycling and Management Bylaw
- : Lubricating Oil Material Recycling and Management Regulation
- : Ozone-Depleting Substances and Halocarbons Regulation
- : Pesticide (Ministerial) Regulation
- : Pesticide Sales, Handling, Use and Application Regulation
- : Potable Water Regulation
- : Release Reporting Regulation
- : Substance Release Regulation
- : Tire Recycling and Management Regulation
- : Waste Control Regulation
- : Wastewater and Storm Drainage (Ministerial) Regulation
- : Wastewater and Storm Drainage Regulation

6. Fisheries (Alberta) Act
   Regulations
   - : Fisheries (Ministerial) Regulation
   - : General Fisheries (Alberta) Regulation
7. Forest Development Research Trust Fund Act
8. Forest and Prairie Protection Act
   Regulations
   - : Fire Control Zone Regulation
   - : Forest and Prairie Protection Reg Part 1
   - : Forest and Prairie Protection Regulations Part II
   - : Forest Protection (Payment for Services, Vehicles and Equipment) Regulation
   - : Forest Protection Area Regulation
   - : Non-Permit Areas Regulation
   - : Drainage Districts Regulation
9. Forest Reserves Act
   Regulations
   - : Forest Reserves Regulations
10. Forests Act
    Regulations
    - : Castle Special Management Area Forest Land Use Zone Regulation
    - : Exploration Regulation
    - : Forest Land Use and Management Regulations
    - : Forest Recreation Regulation
    - : Forest Recreation Regulation Amendment
    - : Forest Resources Improvement Regulation
    - : Forest Technology School Rates Regulation
    - : Metallic and Industrial Minerals Exploration Regulation
    - : Scaling Regulation
    - : Timber Management Regulation
    - : Timber Regulation
    - : Timber Regulation Amendment
11. Government Organization Act
    Regulations
    - : Aboriginal Affairs and Northern Development Grant Regulation
    - : Advanced Education and Career Development Grants Regulation (Learning)
    - : Agriculture, Food and Rural Development Grant Regulation

: Authorized Accredited Agencies Regulation
: Boilers Delegated Administration Regulation
: Calgary Restricted Development Area Regulations
: Children's Services Grants Regulation
: Community Development Grants Regulation
: Corporate Registry Document Handling Procedures Regulation
: Crown Property Regulation
: Department of Labour Grant Regulations (Human Resources and Employment)
: Designation and Transfer of Responsibility Regulation
: Direct Purchase Regulation
: Economic Development Grant Regulation
: Edmonton Restricted Development Area Regulations
: Edmonton-Devon Restricted Development Area Regulations
: Elevating Devices Administration Regulation
: Energy Grant Regulation
: Environment Grant Regulation
: Fees Regulation (Government Organization Act)
: Grants, Donations and Loans Regulation
: Guarantee Regulation
: Health and Wellness Grants Regulation
: Innovation and Science Grant Regulation
: International and Intergovernmental Relations Grant Regulation
: Justice Grants Regulation
: Motor Vehicle Propane Conversions Administration Regulation
: Motor Vehicle Registry Service Charges Regulation
: Municipal Affairs Grants Regulation
: Public Works, Supply and Services Grants Regulation (Infrastructure)
: Radiation Health Administration Regulation (electronic version only)
: Radiation Health Administration Regulation (print version only)
: Radiation Health Administration Regulation Amendment (print version only)
: Radiation Health Administration Regulation Amendment (print version only)
: Radiation Health Administration Regulation Amendment (print version only)
: Records Management Regulation
: Registry Services (Non-Payment of Fees) Regulation
: Reorganization Administrative Transfer Order
: Rural Emergency Home Program Loan Regulations
: School Grants Regulation
: Sherwood Park West Restricted Development Area Regulations
: Solicitor General Grants Regulation
: Storage Tank System Management Regulation
: Transportation and Utilities Grants Regulation

12. Land Agents Licensing Act
    Regulations
    : Land Agents Licensing Regulation
13. Natural Resources Conservation Board Act
    Regulations
    : Funding for Eligible Interveners Regulation
    : Rules of Practice of the Natural Resources Conservation Board
14. Provincial Parks Act
    Regulations

: Dispositions Regulation (Provincial Parks Act)
: Fees Regulation (Provincial Parks Act)
: General Regulation (Provincial Parks Act)
: Section 7 Declaration Regulations

15. Public Lands Act
    Regulations
    : Disposition and Fees Regulation (electronic version only)
    : Disposition and Fees Regulation (print version only)
    : Exploration Regulation
    : Metallic and Industrial Minerals Exploration Regulation
16. Surveys Act
    Regulations
    : Cadastral Mapping Fee Order
17. Water Act
    Regulations
    : South Saskatchewan Basin Water Allocation Regulation
    : Water (Ministerial) Regulation (electronic version only)
    : Water (Ministerial) Regulation (print version only)
    : Water (Ministerial) Regulation Amendment (print version only)
    : Water (Offences and Penalties) Regulation
18. Wilderness Areas, Ecological Reserves and Natural Areas Act
    Regulations
    : Transfer of Powers Regulation
19. Wildlife Act
    Regulations
    : Wildlife Regulation
20. Willmore Wilderness Park Act
    Regulations
    : Forest Travel Permit Area Regulation

British Columbia
(http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/trl-lrf/trl-bca-eng.htm#h_reg)

Taxation Regime for Mining

1. Mining Tax Act [RSBC 1996], Chapter 295
   Regulations
   : Interest Rate Under Various Statutes Regulation
   : Processing Allowance Formula Regulation
   : Taxable Income Regulation
2. Mineral Tax Act Revised Statutes of British Columbia (1996), Chap. 291 (Consolidated April 21, 1997)
   Regulations
   Supplement
   : Exploration Account Return Form Regulation
   : Mineral Tax Costs and Expenditures Regulation
   : Mineral Tax Disposition of a Mine Regulation
   : Mineral Tax General Regulation
   : Mineral Tax Reclamation Regulation
   : Mineral Tax Return Form Regulation
   : Mineral Tax Transitional Regulation

: Partnership Election Form Regulation
: Quarry Operator Election Form Regulation

3. Mineral Land Tax Act [RSBC 1996], Chapter 290
   Regulations
   : Agricultural Mineral Land Regulation
   : Certificate of Forfeiture Form Regulation
   : Mineral Land Tax Adjustment Regulation
   : Mineral Land Tax Interest Rate Regulation
   : Surrender of Interests in Mineral Land Regulation

Regulatory Regime for Mining

1. Mines Act [RSBC 1996], Chapter 293
   Regulations
   : Mine Reclamation Fund Regulation
   : Mines Regulation
   : Notice of Debt Form Regulation
   : Workplace Hazardous Materials Information System Regulation (Mines)
2. Mineral Tenure Act [RSBC 1996], Chapter 292
   Regulations
   Supplement
   : General Survey Instruction Regulation
   : Mineral Act Regulations
   : Mineral Tenure Act Regulation
   : Mining Rights Compensation Regulation
   : Recreation Area Regulation
3. Mining Right of Way Act [RSBC 1996], Chapter 294

Environmental Laws and Regulations

1. Ministry of Environment Act
2. Ministry of Lands, Parks and Housing Act
   Regulations
   : Affordable Housing Purposes Regulation
   : British Columbia Housing Management Commission Regulation
   : Certificate Regulation
3. Boundary Act
4. Commercial River Rafting Safety Act
   Regulations
   : Commercial River Rafting Safety Regulation
5. Creston Valley Wildlife Act
   Regulations
   : Discharge of Firearms Regulation
   : Fees for General Uses
   : Permit Regulations
   : Summit Creek Campground and Recreation Area Regulations
6. Drainage, Ditch and Dike Act
7. Dike Maintenance Act
8. Diking Authority Act
9. Ecological Reserve Act
   Regulations
   : Application of Park Legislation to Ecological Reserves Regulation

: Ecological Reserve Regulations

10. Environment and Land Use Act
11. Environment Management Act
    Regulations
    : Supplement
    : Environmental Appeal Board Procedure Regulation
    : Environmental Data Quality Assurance Regulation
    : Environmental Impact Assessment Regulation
12. Environmental Assessment Act
    Regulations
    : Concurrent Approval Regulation
    : Prescribed Time Limits Regulation
    : Public Consultation Policy Regulation
    : Reviewable Projects Regulation
    : Transition Regulation
13. Financial Administration Act
    Regulations
    : BCAL Services Regulation
    : Collection and Loan Management Branch Regulation
    : Commission on Collections Regulation
    : Commodity Derivatives by Government Bodies Regulation
    : Designated Institutions Regulation
    : Designation Regulation
    : Financial Administration Act General Regulation
    : Financial Agreements Regulation
    : Fiscal Agent for Universities Regulation
    : Forest Recreation Commission Regulation
    : Forgiveness of Debts and Obligations Regulation
    : Forgiveness of Student Loans Regulation
    : Gaming Control Regulation
    : Guarantees and Indemnities Regulation
    : Health Emergency Act Remission Regulation
    : Insurance and Risk Management Account Regulation
    : I.C.B.C. Tax Collection Fee Regulation
    : Interest on Overdue Accounts Payable Regulation
    : Interest on Overdue Accounts Receivable Regulation
    : Mediation Officers Allowance Regulation
14. Motor Vehicle Act and Commercial Transport Act Retention of Fees Regulation
    Official Duties Expense
    Regulation
    : Permitted Cost of Administering Road Tests Regulation
    : Permitted Cost of Services Regulation
    : Propane Motor Vehicle Fuel Tax Remission Regulation
    : Regional Health Authorities Retention of Fees Regulation
    : Remission Regulation No. 3 (Commonwealth of Learning Agency)
    : Remission Regulation No. 4 (Vancouver Indy)
    : Retention of Commission Regulation (Horse Racing Tax Collection)
    : Retention of Commission by Self-Regulatory Organizations Regulation
    : Retention of Fee by British Columbia Assets and Land Corporation Regulation

: Retention of Fee by British Columbia Assets and Land Corporation Regulation No. 2
: Retention of Fee by British Columbia Assets and Land Corporation Regulation No. 3
: Retention of Fee by Publisher of the British Columbia Accommodation Guide Regulation
: Retention of Fees or Commissions for the Collection of Delinquent Accounts for the Ministry of Forests Regulation
: Retention of Fees Regulation (Acrofax Inc.)
: Retention of Fees Regulation (W.L.C. Developments Ltd.)
: Transportation and Highways Collections Commission Regulation

15. Fish Protection Act
Regulations
: Sensitive Streams Designation and Licensing Regulation
: Streamside Protection Regulation
16. Fisheries Act
17. Greenbelt Act
18. Industrial Development Act
19. Industrial Operation Compensation Act
20. Land Act
Regulations
: General Survey Instruction Regulation
: Land Act Fees Regulation
: Land Act Interest Rate Regulation
: Land Act Regulation
: Land Act Shellfish Aquaculture Fee Regulation
: Prohibition Regulation No. 1 to No. 8
: Subscription Fee Regulation
21. Land Survey Act
Regulations
: General Survey Instruction Regulation
: Subdivision Plan Regulation
22. Land Surveyors Act
Regulations
: General Survey Instruction Regulation
: Subdivision Plan Regulation
23. Land Title Act
Regulations
Supplement
: Application for Subdivision Approval Regulation
: General Survey Instruction Regulation
: Incompatibility Regulation
: Land Tax Deferment Regulation
: Land Title Act Regulation
: Land Title (Transfer Forms) Regulation
: Sechelt Indian Band Designation Regulation
: Torrens System Application Regulation
24. Libby Dam Reservoir Act
25. Litter Act
26. Motor Vehicle (All Terrain) Act

Regulations
Supplement
: Prohibition Regulation No. 1 to No.8
: Snowmobile Regulation

27. Park Act
Regulations
: Application of Park Legislation to Ecological Reserves Regulation 364/97 in Ecological Reserve Act
: Class "C" Parks Regulations
: Park and Recreation Area Regulation

28. Integrated Pest Management Act
Regulations
: Pesticide Control Act Regulation

29. Railway Act
Regulations
Supplement
: Boiler Code
: B.C. Electric Railway Company Vision Testing Equipment Regulation
: (Part II) General Operating Regulations
: (Part III) Locomotive Regulations
: (Part IV) Railway Safety Appliance Standards Regulation
: (Part V) Power Cars and Rail Cars Regulations
: (Part VI) Visual Acuity, Colour Perception and Hearing of Railway Employees Regulations
: (Part VII) Interurban Tramways Regulations
: (Part VIII) City Streetcar Equipment and Operation Regulations
: (Part IX) Locomotive Cranes Regulations
: (Part X) Buildings, Shops and Terminals Employing Workmen Regulations
: (Part XI) Location, Construction, Operation and Use of Aerial Tramways
: (Part XII) Storage, Handling and Transportation of Dangerous Goods by Railway
: (Part XIII) Notification and Reporting of Railway Accidents Regulation
: (Part XIV) Occupational Safety and Health Regulation
: (Part XV) Notification and Reporting of Rail Transit Accidents Regulation
: Railway Fees Regulation
: Testing of Air Reservoirs Regulations
: Workplace Hazardous Materials Information System Regulation (Railways)

30. Skagit Environmental Enhancement Act
31. Sustainable Environment Fund Act
32. University Endowment Land Act
33. Waste Management Act
Regulations
: Agricultural Waste Control Regulation
: Antisapstain Chemical Waste Control Regulation
: Asphalt Plant Regulation
: Beverage Container Stewardship Program Regulation
: Cleaner Gasoline Regulation
: Conditional Exemption Regulation
: Contaminated Sites Regulation
: Finfish Aquaculture Waste Control Regulation

: Gasoline Vapour Control Regulation
: Land-Based Fin Fish Waste Control Regulation
: Motor Vehicle Emissions Control Warranty Regulation
: Motor Vehicle Emissions Reduction Regulation
: Mushroom Composting Pollution Prevention Regulation
: Oil and Gas Waste Regulation
: Ootsa Lake Beehive Burner Regulation
: Open Burning Smoke Control Regulation
: Organic Matter Recycling Regulation
: Ozone Depleting Substances and Other Halocarbons Regulation
: Petroleum Storage and Distribution Facilities Storm Water Regulation
: Placer Mining Waste Control Regulation
: Post-Consumer Paint Stewardship Program Regulation
: Post-Consumer Residual Stewardship Program Regulation
: Public Notification Regulation
: Pulp Mill and Pulp and Paper Mill Liquid Effluent Control Regulation
: Rebate of Waste Management Fees Regulation
: Return of Used Lubricating Oil Regulation
: Solid Fuel Burning Domestic Appliance Regulation
: Special Waste Regulation
: Spill Cost Recovery Regulation
: Spill Reporting Regulation
: Storage of Recyclable Material Regulation
: Sulphur Content of Fuel Regulation
: Waste Management Act Municipal Sewage Regulation
: Waste Management Permit Fees Regulation
: Wood Residue Burner and Incinerator Regulation

34. Water Act
    Regulations
    : British Columbia Dam Safety Regulation
    : Sensitive Streams Designation and Licensing Regulation
    : Water Regulation
35. Water Protection Act
36. Water Utility Act
37. Wildlife Act
    Regulations
    : Angling and Scientific Collection Regulation
    : Closed Areas Regulation
    : Designation and Exemption Regulation
    : Designation of Officers Regulation
    : Elk Valley Roads Closure Regulation
    : Firearm and Hunting Licensing Regulation
    : Freshwater Fish Regulation
    : Hunter Safety Training Regulation
    : Hunting Regulation
    : Kootenay Land District Roads Closure Regulation
    : Limited Entry Hunting Regulation
    : Management Unit Regulation
    : Motor Vehicle Prohibition Regulation
    : Muskwa-Kechika Access Management Area Regulation

: Officer Designation Regulation
: Permit Regulation
: Rose and Kirkland Islands Access Prohibition Regulation
: Stum Lake Seasonal Closure Regulation
: Tofino Mudflats Wildlife Management Area Regulation
: Wildlife Act Commercial Activities Regulation
: Wildlife Act General Regulation
: Wildlife Management Areas Regulation [Pitt-Addington & Chilanko Marshes, Dewdrop-Rosseau Creek & Tranquille]
: Wildlife Management Areas Regulation No. 2 to No.16

More information about the laws and regulations relating to mining in each province/territory can be found at:

: Manitoba
(http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/trl-lrf/trl-man-eng.htm#h_reg)
: New Brunswick
(http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/trl-lrf/trl-nbw-eng.htm#h_reg)
: Newfoundland and Labrador
(http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/trl-lrf/trl-nfl-eng.htm#h_reg)
: Northwest Territories
(http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/trl-lrf/trl-nwt-eng.htm#h_reg)
: Nova Scotia
(http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/trl-lrf/trl-nsc-eng.htm#h_reg)
: Nunavut
(http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/trl-lrf/trl-nun-eng.htm#h_reg)
: Ontario
(http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/trl-lrf/trl-ont-eng.htm#h_reg)
: Prince Edward Island
(http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/trl-lrf/trl-pei-eng.htm#h_reg)
: Quebec
(http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/trl-lrf/trl-qbc-eng.htm#h_reg)
: Saskatchewan
(http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/trl-lrf/trl-skn-eng.htm#h_reg)
: Yukon
(http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/trl-lrf/trl-ykn-eng.htm#h_reg)

Chile

The 1980 Political Constitution of Chile consecrates in Article 19 Nbr. 8 the right to live in an environment free of pollution. By the same token, it stipulates the duty of the State to ensure that such a right is not affected, and to observe the preservation of nature. Such a formula, whereby environmental provisions are restricted to nature and pollution has been later supplemented by a broader interpretation of what environment is, as the Law of Environmental Basis enacted in 1993 brings a human dimension and the concept of sustainable development, to the traditional environmentalist approach adopted by the Constitution. This same norm provides for mechanisms for participation. It also authorizes the establishment of specific restrictions on the application of certain rights in order to protect the environment, which is in a broad interpretation of the term, comprises both the aim of ensuring the right of all people to live in an environment free from contamination, and also to preserve natural resources. Section

19 Nbr. 24 2nd paragraph, authorizes the government to set limitations and obligations derived from the social function of property, which comprises what is required for the conservation of the environmental heritage.

The submission of an environmental impact study (EIS) will be determined by the characteristics of the project to be assessed, and its ability to provoke harmful effects on the environment, population health, and local communities. Minor projects will require an environmental impact declaration (EID), which is a simpler instrument done in the form of a sworn statement and whose contents can allow the relevant authority to assess if the environmental impact complies with applicable environmental legislation. It could also contain voluntary requirements, in which case the project operator would be bound to them.

Environmental management tools of Chile include a mitigation measures plan that is aimed to avoid or reduce harmful effects of the project (Section 59, Regulation). In addition, if a reparation and/or restoration plan aimed at repairing one or more environmental elements to an analogous quality than the one held before the harm was caused, or to reestablish basic properties in case the first is not possible, a compensation measures plan is aimed at producing or generating an alternative positive effect, equivalent to the identified negative effect (Section 61, Regulation). A monitoring plan is then used to follow up any environmental aspects, which are the grounds for elaborating the EIA.

In Chile, although prospecting has been included within the activities that require a prior EIA, as the term has not been defined, it is still unclear what sort of prospecting is subject to an EIA. By one interpretation of the law, EIAs would be applicable just to exploration work that can be harmful to the environment, which usually occurs in advanced stages of exploration, once a specific target has been identified. A great deal of concern here has been the interface between environmental assessment and exploration permits, for which the duration is two years, and extendible for two more years, and the chances of delaying the commencement of exploration within that tight schedule while awaiting the environmental assessment approval. Moreover, although there are a few and general references to the closure phase throughout the law and its regulations, as well as in the Mine Safety Regulations, no formal closure plans have been established.

China

Mine closure was mentioned in the Mineral Resources Law, Article 21: “If a mine is to be closed down, a report must be prepared with information about the mining operations, hidden dangers, land reclamation and utilization, and environmental protection, and an application for examination and approval must be filed in accordance with relevant State regulations.”

In terms of environmental concern, it was mentioned in Article 32 of the Mineral Resources Law that a mining enterprise or individual must observe the legal provisions on environmental protection in order to prevent pollution of the environment. In the case that mining activity is conducted on cultivated land, grassland, or forested land, the mining enterprise concerned shall take measures to utilize the land affected, such as by reclamation, tree and grass planting, as appropriate to the local conditions. Article 15 states that: *“Anyone who wishes to establish a mining enterprise must meet the qualifications prescribed by the State, and the department in charge of examination and approval shall, in accordance with law and relevant State regulations examine the enterprise's mining area, its mining design or mining plan, production* *and technological conditions and safety and environmental protection measures."* Only those that pass the examination shall be granted approval.

The responsibility of a mining enterprise or individual to the community mentioned in Article 32 states that: *"Anyone who, in mining mineral resources, causes losses to the production and well-being of other persons shall be liable for compensation and shall adopt necessary remedial measures."* China's requirement in its three simultaneous regulation principles (TSRP) first appeared as an administrative provision for environmental management in 1973. It has now become a major mechanism—equivalent to an EIA—for licensing and pollutant charging in the Environmental Protection Law of the PRC. It applies to all construction projects with the potential to damage and pollute the environment (Cao, 2007).

China's mine land reclamation first started in the 1950s and 1960s with a sporadic, regional, and voluntary nature (Zhang and Peng, 1999). The promulgation of the Regulations on Land Reclamation (RLR) in 1988 marks the commencement of legalization and standardization of mine land reclamation programs in China. It is the first regulatory document specifically designed for the reclamation of damaged land including mined land. It defines land reclamation as *"the activities in which the land destroyed by extraction, subsidence, and re-occupation, etc. during the process of production and construction is to be restored to a reusable state through certain measures"* (Art. 2, RLR). The RLR also specifies the responsibilities and obligations of industrial authorities, mining companies, and individuals to restore the disturbed land, and the funding sources concerned (Cao, 2007).

Moreover, a general emphasis on the reclamation and restoration of mined land is also found in a number of laws and regulations such as the Land Administration Law (LAL), the Mineral Resources Law (MRL), the Environment Protection Law, the Coal Law, the Water Resources Law, the Soil Conservation Law, the Forestry Law, and the Grassland Law. These laws, along with the Technical Criteria for Land Reclamation (for trial implementation, 1995) are expected to assist the RLR in regulating land reclamation activities.

Indonesia

Environmental concern in Indonesia seemed to begin when the Act of the Republic of Indonesia No.4 of 1982 pertaining to the Basic Provisions of Environmental Management was promulgated. Before 1982, however, several technical sectors had already issued regulations related the protection of the environment. For example, in 1974 some regulations were issued in the field of offshore oil and gas activities in conjunction with the emerging oil and gas industry.

The agriculture sector also had issued regulations on the control of pesticides and fertilizers as early as the 1960s.The forestry sector had also established regulations on Selective Cutting and Compulsory Reforestation in the early 1970s (Coutrier, 2002).

Act no 4 of 1982, however, was used as an umbrella for all the previous environmental regulations and those still to come, like Act no 5 /1994 on the Biodiversity Convention, Act no 6/1994 on the Climate Change Convention, etc. As a result, the basic law (Act no 4/1982) above has a quite far-reaching outlook in terms of environmental management and puts forward some principles towards their grand strategy. In this law, basic principles on environmental management were introduced, such as strict liability, the polluter pays principle, environmental impact analysis (AMDAL), and sustainable development. In October 1997, Act no 23/1997 was established replacing Act no 4/1982. The new Act is titled the Law on Environmental Management. It is more operational in nature, and is very strict with heavy criminal penalties—like 10 years in jail and Rp. 500 million for pollution violations (previously only 1 year and Rp. 10 million). When the pollution incident causes a fatality, the jail term will increase by an additional 3 to 5 years. AMDAL has become compulsory and should involve public participation (Coutrier, 2002).

Another feature of the new act is in the acknowledgement of voluntary arrangements, such as environmental auditing; however, strict liability and polluter pays principles have not been further deliberated although it was understood that these two principles should remain. In the future this lack of deliberation may cause a difference of legal interpretation. Based on the concept of strict liability, it is no longer the duty of the victim of pollution to prove that pollution occurs, but rather the accused polluter must prove that there is no pollution. This is a good message to ensure that all developers, including the mining industry, should consistently monitor all their effluent and emissions so as to prevent pollution from happening. If and when pollution occurs, they then know exactly what went wrong and how to quantify the potential impact.

The polluter pays principle means that the polluter is liable to pay for all damage incurred by pollution. As such, all developers should have an effective monitoring system to enable proper quantification of the damage value.

AMDAL is a study of the large and significant impacts of a planned business and/or activity, and is a requirement in the decision-making process for business and/or activity implementation. It tries to describe the potential impacts a development is predicted to create from its activities and what should be done to develop a positive impact and prevent or mitigate the negative impacts of the development. The AMDAL study should cover not only the physical, biological, chemical, and geological impacts but also the socioeconomic impact of the development. AMDAL is compulsory according to Act no 23/1997 Article 18 and PP 27/1999. In view of the euphoria of democracy and basic reforms, a set of Ministerial Decrees were issued as implementation guidelines to support AMDAL, including:

- Ministerial Decree 08/2000 on Compulsory participation of the public in AMDAL study
- Ministerial Decree 02/2000 on Guidelines for evaluation of AMDAL studies
- Ministerial Decree 03/2000 on Type of activities that require AMDAL
- Ministerial Decree 04/2000 on The Guidelines to draft an AMDAL study for Human Settlement
- Ministerial Decree 05/2000 on AMDAL for wetland areas
- Ministerial Decree 09/2000 on Guidelines to form AMDAL studies

These decrees reflect the concern of the social impacts of developments. However, the guidelines are easy to read, but very difficult to implement—like all social studies. This will mean that the AMDAL studies for mining activities will be time-consuming because public hearings are not common in Indonesia (Coutrier, 2002).

Indonesia has a regulation for managing mine closures. The relevant regulation is the Mining and Energy Minister's decision numbers 1211.K/008/M.PE/1995 pertaining to the prevention and mitigation of environmental destruction and pollution in general mining operations in Chapter IV (http://www.iips-online.com/KEP_MPE_1211_1995_IND.pdf).

Korea

Currently, legislation governing the mining industry is the Mining Industry Act, which has the following subordinate laws: the Enforcement Decree of the Mining Industry Act, the Mining Industry Registration Decree, and the Enforcement Rule of the Mining Industry Registration. Other relevant laws are the Submarine Mineral Resources Development Act, the Mining Safety Act, and the Act on the Prevention and Recovery of Mine Damage.

The objective of the Mining Industry Act is to develop mineral resources rationally in order to promote the growth of national industry and to provide a basic system for the mining industry; this Act was first legislated in December 1951.

The objective of the Mine Safety Act is to prevent damages to mine laborers and to mines, in order to promote the rational development of underground resources. For sustainable development under this mining-related legislation system, the Act on the Prevention and Recovery of Mine Damage was introduced and enacted**.**

The environmental impact assessment system exists as a system that requires the consent of residents for mining activities. According to the Environmental Impact Assessment Act, if the area of forest damage due to the rock/mineral collection business is greater than 100,000 m^2, an environmental impact assessment is mandatory; if the area is less, a prior environmental review is required. Assessment items include factors of the natural environment such as weather, soil quality, animals/plants, and factors of the living environment such as use of land, air quality, water quality, waste, noise/vibration, and view, and factors of the socioeconomic environment such as transportation and historical assets (http://www.un.org/esa/dsd).

During the period Japan colonized the Korean Peninsula, Korea was the second largest gold-producing country in the world. This was due to the mineral exploitation policy the Japanese government had towards Korea. However, in December 1951, in the midst of the Korean War, the Korean National Assembly passed and implemented mining laws for the first time. Since then, Korea's mining industry has played an important role in the development and shaping of Korea's economy.

Korea's first national environmental law was the Pollution Prevention Act (PPA), enacted in 1963, which was replaced by the Environmental Preservation Act in 1977. Thereafter, in 1979, the Environmental Administration (EA) was established to "*orchestrate environmental duties that were then spread out among a host of ministries and agencies*." In 1980, the Constitution of Korea was amended to provide all Korean people with the right to live in a healthy and clean environment (Cho, 1999).

Since the early 1990s, the Korea government has raised their environmental focus by promulgating many new environmental laws; the general public has tried in vain to pursue its own environmental goals through litigation based upon this provision. The EA was subsequently upgraded to full ministry level as the Ministry of the Environment (MOE).

Basic Environmental Policy Act (BEPA)

The Basic Environmental Policy (BEPA) is the more recent backbone of Korean environmental law. BEPA sets forth general principles, fundamental policies, and an administrative framework for environmental preservation and remediation. It leaves the more detailed regulations and emission limits to separate environmental statutes targeting air, water, and solid waste and to national and local regulations, to the extent that they are consistent with BEPA. The polluter pays principle, the strict liability standard for repairing environmental damages, and the environmental impact assessment are among its distinctive features. BEPA also authorizes the central and local governments to establish environmental quality standards to preserve the environment and to protect human health against environmental degradation (Cho, 1999).

Below BEPA are a number of statutes, each focusing on a specific medium, which further the general principles of BEPA.

: Air Environment Preservation Act (AEPA)
: Water Environment Preservation Act (WEPA)
: Noise and Vibration Control Act (NVCA)
: Waste Management Act (WMA)
: Toxic Chemicals Control Act (TCCA)
: Enforcement Decree of the Toxic Chemicals Control Act (1990)
: Environmental Impact Assessment Act (EIAA)
: Enforcement Decree of the Environmental Impact Assessment Act (1999)
: Soil Environment Preservation Act (SEPA)
: Framework Act on Low Carbon, Green Growth (enacted 2010)
: Framework Act on Environmental Policy (enacted 1990)
: Enforcement Decree of the Framework Act on Environmental Policy (1990)
: Natural Environment Conservation Act (1991)
: Act on Special Measures for the Control of Environmental Offenses (1991)
: Environmental Dispute Adjustment Act (1990)
: Environment Improvement Expenses Liability Act (1991)
: Development of & Support for Environmental Technology Act (1994)
: Enforcement Decree of the Development of and Support for Environmental Technology Act (1994)
: Water Quality and Ecosystem Conservation Act (1990)
: Enforcement Decree of the Water Quality and Ecosystem Conservation Act (1990)
: Sewerage Act (1968)
: Water Supply & Waterworks Installation Act (1961)
: Management of Drinking Water Act (1995)
: Soil Environment Conservation Act (1995)
: Enforcement Decree of the Soil Environment Conservation Act (1995)
: Enforcement Decree of the Water Supply and Waterworks Installation Act (1961)
: Enforcement Decree of the Management of Drinking Water Act (1995)
: Clean Air Conservation Act (1990)
: Enforcement Decree of the Clean Air Conservation Act (1990)
: Indoor Air Quality Control in Public Use Facilities, etc. Act (1996)
: Wastes Control Act (1986)
: Enforcement Decree of the Wastes Control Act (1986)
: Act on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal (1992)
: Act on the Promotion of Saving and Recycling of Resources (1992)
: Enforcement Decree of the Act on Promotion of Saving and Recycling of Resources (1992)

: Promotion of Installation of Waste Disposal Facilities and Assistance, etc. to Adjacent Areas Act (1995)

Malaysia

Mineral Development Act 525 (1994)
http://www.jmg.gov.my/
Section 20: Mine Abandonment

1) Before any mining operation is abandoned or discontinued, a written notice shall be given to the Assistant Director and to the Director General of the Geological Survey no later than three months before such intended abandonment or discontinuance by the holder of the proprietary mining license or mining lease or manager.
2) Where any mine is to be abandoned, the holder of the proprietary mining license or mining lease or manager shall make an accurate plan, to the satisfaction of the Director, showing the workings of such mine up to the time of abandonment, and copies of such plan shall be submitted to the Director and the Director General of the Geological Survey within one month after the abandonment.
3) Where a mine or part of a mine is to be abandoned, the holder of the proprietary mining license or mining lease or manager shall securely fence or cover every mine shaft or audit and the holder of such license or lease and the manager shall continue to be personally responsible for the due compliance of this provision until the Director has confirmed in writing that the work has been properly executed, notwithstanding that the mine or part of the mine has been abandoned.
4) Abandoned mines and waste retention areas shall be made safe in such a manner as may be prescribed.

However, there is no specific requirement about mine closure or mine reclamation in this law. In terms of environmental concern in the mining sector, refer to the Environmental Quality Act 1974.

Environmental Quality Act 1974
http://www.doe.gov.my/v2/files/legislation/a0127.pdf

A list of regulations, rules, and orders related to this law can be seen at:
http://www.doe.gov.my/en/content/environmental-quality-act-1974

Section 34A of this Act: Report on impact on environment resulting from prescribed activities

- According to the Environmental Quality Order 1987 (Prescribed Activities) (Environmental Impact Assessment)
(http://www.doe.gov.my/v2/files/legislation/pua0362y1987.pdf)
Mining activities are in the list of prescribed activities that have to submit a report of impact on the environment before any approval for the carrying out of such activity is granted by the relevant approving authority.

Peru

The 1993 Political Constitution of Peru recognizes human protection and respect for human dignity as the supreme goals of society and the State. Section 2.22 mentions that "*every person has the right to enjoy a balanced environment suitable for the development of life*." Section 67 stipulates that the State will establish a national environmental policy, and that it will promote the sustainable use of natural resources. Sections 2, 4, and 5, acknowledge the right to information, while the Code of the Environmental and Natural Resource, in Section 6, Preliminary Title, the right of any person to participate in the definition of policies and adoption of actions related to the environment and natural resources, at a national, regional, and local level. The Organic Law of Sustainable Use of Resources Nbr 26821 also states that citizens have the right to be informed and to participate in the definition and adoption of policies related to the conservation and sustainable use of natural resources.

Monitoring plans are also available in Peru. A special emphasis has been placed on the adjustment and management of ongoing operations. The tool adopted is the Environmental Adjustment and Management Programme (PAMA), applicable to ongoing operations in the production and operational stage, which lays out actions and investments for incorporating technologies and/or alternative measures to reduce or eliminate emissions in order to comply with applicable standards. PAMA is the basis for a stabilization agreement between the operator and the Ministry of Energy and Mines not to set out further requirements to the operator as long as the approved programme is complied with. Prior to elaborating the PAMA, there is an obligation to prepare a Preliminary Environmental Assessment (Evaluación Ambiental Preliminar, EVAP) in order to identify the environmental problems generated by mining.

Since the enactment of general environmental regulations for mining activities between 1993 and 1998, there have been no environmental requirements for exploration. As mining concessions in Peru comprise both of exploration and exploitation activities (a “single concession system”), the Ministry of Energy and Mines just established regulations to file an Environmental Impact Study (EIS) for the exploitation stage. Since 1998, it is necessary to file an Environmental Assessment (EA), applicable to exploration activities that are to incur a significant disturbance. It requires the description of the project, activities to be conducted, effects, control and mitigation measures, and closure or temporal shutdown plans. As compared to the EIS, the EA requires shorter periods of approval, and there is no requirement for public hearings. During the closure stage, closure plans must be part of an EIA or PAMA. There is a specific non-binding document on the Guidelines for Mine Closure and Abandonment, while the Environmental Guideline for PAMAs also includes a chapter on Closure Plan. There are no requirements to incorporate pollution prevention measures as a condition for the plan to be approved, though there is a draft law that would establish the obligation to file a closure plan prior to starting with operations, as a specific and differentiated document from the PAMA or EIA, and includes a system of financial surety.

Some notable developments are taking place in Peru, in which enforced regulations recommend the operator to use a Community Relations Guide prepared by the Ministry of Energy and Mines (Division of Environmental Affairs). The Guide provides a set of guidelines for preparing a Social Impact Assessment and Community Relations Plan, in addition to other measures aimed at an appropriate method to manage the relationship between companies and communities. Although such guidelines are not binding, they certainly provide some insights on the direction of further developments towards the increasing use of social management tools.

The Philippines

The Department of Environment and Natural Resources (DENR) is the primary government agency responsible for the conservation, management, development, and proper use of the country’s natural resources, including its minerals (USGS, 2002).

The DENR requires an Environmental Clearance Certificate (ECC) for any mining activity at more advanced stages than mineral exploration. The ECC is issued by the DENR based on an Environmental Impact Statement prepared by the company in accordance with the procedures under the Environmental Impact Assessment System. A completed ecological profile of the proposed mining area is required as a part of these procedures (http://www.mbendi.com).

The ECC is the basis for the Environmental Protection and Enhancement Program (EPEP), which every party to an MPSA must undertake within the subject area of the MPSA. In order to approve the EPEP, an Annual Environmental Protection and Enhancement Program must be submitted 30 days prior to the beginning of every calendar year. To ensure compliance with the APEP, mine site inspections and quarterly monitoring are conducted by the DENR, in which the monitoring team consists of a local government representative, any affected indigenous cultural communities, non-governmental organizations, the DENR, and a company representative (http://www.mbendi.com).

The Philippines DENR, in coordination with other relevant government agencies and the mining industry, is currently attempting to finalize a Mineral Action Plan (MAP) to harmonize the laws of local governments with forestry and land legislation, and the indigenous people's rights. The responsibilities for the environment will then be separated from the DENR. In January 2004, the Philippine Supreme Court nullified some provisions in the 1995 Philippine Mining Act that allow 100% foreign equity in large mining projects (requiring an investment of more than $50 million) through Financial and Technical Assistance Agreements (FTAAs). The Supreme Court also declared as null and void provisions in the Mining Act relating to Exploration Permits and Mineral Processing Permits. A recent law gives the power of veto to indigenous people for cases in which a new mine is planned on ancestral lands (http://www.mbendi.com).

Environmental laws and regulations relating to mining activity include:

: Philippine Mining Act of 1995 (R.A.7942)
: The Indigenous Peoples Rights Act of 1997 (R.A. 8371)
: National Integrated Protected Areas System Act of 1992 (R.A.7586)
: People's Small-Scale Mining Act of 1991 (R.A. 7076)
: Ecological Solid Waste Management Act of 2000 (R.A. 9003)
: Wildlife Resources Conservation and Protection Act of 2001 (R.A. 9147)
: Philippine Clean Air Act of 1999 (R.A. 8749)
: National Water & Air Pollution Control Act (R.A. 3931)
: Small-Scale Mining Law (President Decree No.1899)
: Environmental Impact Statement System (President Decree No.1586)
: Philippine Environment Code (President Decree No.1152)
: Philippine Environmental Policy (President Decree No.1151)
: Environmental Impact Statement System-Areas/Types of Projects (Proclamation No.2146)

Recent Administrative Orders have weakened participation rights, including the right to information, participation in decision making, and access to justice. In addition, EIA processing timeframes have been reduced, with automatic approval if they are exceeded; requirements to provide public information have been relaxed, as has the need to provide notice of public hearings. These changes have been accompanied by a relaxing of the controls in the Mining

Act. Taken together, they seriously undermine the protection afforded by EIAs in the Philippines (Doyle et al, 2006).

Thailand

The Thai government is concerned about major environmental problems related to water and air pollution. In the case of environmental aspects in mining sector, any person who wants to conduct mining business in Thailand must follow the related environmental regulations:

- Mineral Act No. 5 B.E. 2545 (2002); Section 67 pertains to prohibition of discharge of slime or tailings outside the mining area; Sections 88/6 and 88/7 pertain to Environmental Impact Assessment (EIA) report submission as a condition of obtaining permission to conduct mining activities; Section 88/9 and 88/10 pertain to rights of stakeholders to participate, in which the owner should establish a supporting fund for the research project for stakeholders of the underground mining project.
- The Enhancement and Conservation of Natural Environmental Quality Act B.E.2535 (NEQA 1992) and its related ministerial regulations; the Ministry of Science, Technology and Environment (MoSTE) has the authority to set the regulatory floor of effluent standards. According to this Act, mining has been identified as one of the fifteen point sources in which the EIA report is required in order to obtain approval for starting a mining business.
- A mine reclamation plan is recently required in EIA reports for mining projects. The government has provided technical guidelines pertaining to mine closure in terms of environmental, engineering, and architectural aspects. Thailand has about 900 active mines and almost 400 closed mines. There are available case reports of rehabilitated mines for less than 10% of the closed mines (DPI&M, 2009); this could indicate an insufficient enforcement of the environmental laws.

USA

The U.S. Environmental Protection Agency (US EPA) has provided the follow information related to environmental regulations for the mining sector:

- Summary of Federal Statutes and Regulations "*Profile of the Metal Mining Industry*" (Publication number EPA/310-R-95-008 SIC Code:10) http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/metminsnpt3.pdf
- Summary of Federal Statutes and Regulations "*Profile of the Non-Fuel and Non-Metal Mining Industry*" (Publication number EPA/310-R-95-011 SIC Code: 14) http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/nomtmisnpt2.pdf
- Summary of Federal Statutes and Regulations "*Profile of Stone, Clay, Glass, and Concrete Industry*" EPA/310-R-95-017 SIC Code: 32 http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/stclglsnp2.pdf
- Mining and Mineral Processing Compliance Assistance Resources for the Gold and Copper Industries http://www.epa.gov/compliance/resources/publications/assistance/sectors/miningcompendium.pdf

- Summary of Applicable Federal Statutes and Regulations "*Profile of the Iron and Steel Industry*" EPA/310-R-95-005 SIC Code**:** 331 http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/ironstlpt2.pdf

Viet Nam

A list of environmental laws and regulations of Viet Nam are presented as follows:

1. Primary Legislation on the Environment
    : Environmental Protection Law 1994
    : Decree on Guiding Implementation for Environmental Protection Law (Gov. Decree No. 175-CP, 1994)
    : Decree on Sanction for Administrative Violations for Environmental Protection Law (Gov. Decree No.26-CP, 1996)
    : Decree No. 22/CP on Responsibilities, Authority and Organization of the Ministry of Science, Technology and Environment (22 May, 1993)
    : Instructions on Strengthening Environmental Protection in the period of Industrialization and Modernization (No. 36-CT/TW, 1998, Viet Nam Communist Party)

2. Specific Legislation on the Environment

2.1 Pollution control
    : Air Quality, Ambient Standards (TCVN 5937, 1995)
    : Air Quality, Hazardous Substance Standards (TCVN 5938, 1995)
    : Air Quality, Industrial Standards for Inorganic Substances (TCVN 5939, 1995)
    : Air Quality, Industrial Standards for Organic Substances (TCVN 5940, 1995)
    : Standards for Noise in Public and Residential Areas (TCVN5945, 1995)
    : Standards for Noise on Road Motor Vehicle (TCVN5948, 1995)
    : Soil Quality Standards on Pesticide Residue Limits (TCVN5941, 1995)
    : Industrial Waste Water Discharge Standards (TCVN5945, 1995)
    : Water Quality Standards; Coastal Water (TCVN5943, 1995)
    : Water Quality Standards; Groundwater (TCVN5944, 1995)
    : Water Quality Standards; Surface Water (TCVN5942, 1995)

2.2 Nature conservation
    : Law on Forest Protection and Development (12 August 1991)
    : Regulations on management regulations for production forests, protection forests and Special-use Forests: attached to Decision No. 1171/QD (November 1986)
    : Decree on endangered species and management and conservation mechanisms (No. 18/HDBT, 17 January 1992)
    : Decision on use of open land, bare hills, forest, coastal alluviums, and water bodies (No. 327/CT, 15 September 1992)
    : Directive on protection and management of endangered plant and animal species (No. 130/TTg, 27 March 1993)
    : Directive on urgent measures to protect and develop wild animal species (No. 359/TTg, 29 May 1996)
    : Official Letter on strengthening wildlife protection and development (No. 2472/NN-KL-CV, 24 July 1996)

: Decree on allocation and lease of forest land to organizations, households and individuals for long-term forestry purposes (163/ND-CP, 16 November 1999)
: Decision on the management of Special-Use Forest, protection forest and production forest (No. 08/QDTTg, 11 January 2001)

2.3 Environmental impact assessment (EIA)
: EIA and Licensing, Decision on Regulations and Appraisal Council (MOSTE decision No. 1806/QDMTg, 1994)
: EIA and Licensing, Regulations and Appraisal Council (MOSTE Decision No. 1807/QD-MTg, 1994)
: EIA Instruction for Guiding Operating Units (MOSTE Instr. No.1420/QD-MTg, 1994)
: EIA Instruction for Report to the Direct Foreign Investment Project (MOSTE Instr. No. 715/QD-MTg, 1995)
: Temporary Guidance for Environmental Impact Assessment of Technical-Economic Project, No.1485/MTg, 1993
: Circulation No. 490/1998/TT-BKHCNMT, MOSTE, Guiding the Preparation and Evaluation of AEI (EIA) Reports for Investment Projects

2.4 Others
: Law on Water Resources (January 1999)
: Law on Minerals (20 March 1996)
: Law on Fishery (draft)
: Law on Land, 1993
: Decree No. 22/1998/ND-CP (Compensation for lost property due to State expropriation)
: Circulation No. 145/1998/TT-BTC, Guidelines on the Implementation of the Decree 22/1998/ND-CP, Ministry of Finance (Extracts)
: Master Guidelines and Policies to Utilize Unoccupied Land, Barren, Hilly Areas, Forests, Denuded, Beaches and Waterfront (COM Decree No. 327, 1992)

4.3 International standards and guidelines on prevention of mine hazard

Sustainable development as related to a natural resource that is in essential depletion when it is mined, has been seen as an oxymoron. The traditional manner in which mining has been carried out for centuries has tended to emphasize short-term gains, with no consideration for the negative impacts on the environment and communities where the project takes place; not only in terms of operations, but also beyond mine closures. Increasing awareness for sustainability concerns, coupled with technological developments, has shifted the center of the debate to how mining can be sustainable. From this perspective, sustainability in mining involves the following dimensions (UNEP, 2000):

- The environmental dimension emphasizes the sustainability for the natural environment and the stock of natural resources.
- The social dimension underscores the social and cultural sustainability, related to both the distribution of benefits and the cost of mining, of the process, and refers to how decisions are made and how all stakeholders are involved in decision-making.
- The economic dimension highlights the economic sustainability of human living standards. An important issue is substitution, and in this sense, depletion of resources

that could be compatible to sustainability if interest from the revenues generated from mining are reinvested in building human and social capital, or into other sustainable activities.

4.3.1 Berlin Guidelines

Even though Agenda 21 emphasized the need for guidelines for natural resource development, there is no specific chapter dealing with the minerals sector. The Berlin Guidelines provide the most useful guidance for mining sector governance in the context of sustainable development (MMSD, 2002). The Guidelines were drafted in 1991 as the outcome of the Round Table Conference organized by the United Nations and the German Foundation for International Development; they then served as a basis for the first edition of the 1994 Environmental Guidelines for Mining Operations prepared by the UN Department of Economic and Social Development and its Commission for Sustainable Development, and the United Nations Environment Programme (UNEP) at the request of a number of countries looking for environmental guidance. The final draft of a second edition of the Guidelines reflecting these changes focused on the mining sector being adopted, and on sustainable development—particularly in the evolution of legal, fiscal, and regulatory policies, in addition to the growing awareness for developing tools for managing the social impacts of mining. The Guidelines provide a model, rather than a blueprint, for the sound and sustainable management of mineral development, and should be amended and improved according to the specific needs of each country.

The Berlin Guidelines provide some criteria relevant for the analysis conducted in this paper, as they acknowledge the need to:

- recognize environmental management as a high priority, notably during the licensing process and through the development and implementation of environmental management systems. These should include early and comprehensive environmental impact assessments, pollution control and other preventive and mitigative measures (among other measures and procedures);
- recognize the importance of socio-economic impact assessments and social planning in mining operations from the earliest stages of project development;
- ensure participation of and dialogue with the affected community and other directly interested parties on the environmental and social aspects of all phases of mining activities; and
- encourage long-term mining investment by having clear environmental standards with stable and predictable environmental criteria and procedures.

Consistently, the Guidelines state that "*if sustainable development is defined as the integration of social, economic, and environmental considerations, then a mining project that is developed, operated and closed in an environmentally and socially acceptable manner could be seen as contributing to sustainable development.*" We will see what governments are doing to provide the framework and the legal tools for sustainable minerals development, in the sense delimited by this paper. Prior to that, some developments on the matter in regional initiatives will be revised.

4.3.2 Roles of Intergovernmental Organizations (IGOs) on guidelines and standards for the mining sector

The number of Intergovernmental Organizations (IGOs) is estimated to range from between 270 to more than 1000. They cover multiple issues and involve governments from every region of the world, including offices in the U.S. Among the oldest IGOs are the United Nations, which replaced the League of Nations, the Universal Postal Union, and the North Atlantic Treaty Organization (NATO). The Universal Postal Union, founded in 1874, is currently a specialized agency of the UN. Other well-known IGOs are the European Union (EU), the Organization of Petroleum Exporting Countries (OPEC), the African Development Bank (ADB), and the World Trade Organization (WTO).

Since the creation of the UN and NATO, IGOs have become essential actors in the international community. Additionally, as many IGOs such as the UN and the EU have the ability to make rules and exercise power within their member countries, their global impact continues to increase (http://www.law.harvard.edu).

Intergovernmental organizations (IGOs) have played a central role in the origin and refinement of the concept of sustainable development. They have in effect brought the concept to the center stage and provided the impetus for governments to consider how the concept applies to their country and how resulting policies can be implemented. In some instances, international laws resulting from IGO activities (in the form of various treaties and protocols) have, or may in the future have, an impact on the mining industry. For instance, the Basel Convention has impacted the trade in metal scrap, which is a key element in sustainable development from the perspective of recycling. Indeed, the main impact of efforts by IGOs has not been to develop effective sustainable development regulatory systems, but rather to shape the agendas of national lawmakers and company officers with regard to issues and policies. Thus, concepts that are developed as usually unenforceable international “soft” laws are adopted into enforceable “hard” national laws or into internal company policy and practice. The range of IGO-originated international laws affecting mining has been extensively dealt with by others and will not be dealt with in detail here. However, it is illustrative to consider the broad range of matters taken up by IGOs and related institutions. A list of the principle treaties and protocols identified by Pring, Otto and Naito (1998) as having the potential to impact mineral sector sustainable development policy is given in Table 4.13. It is ironic that even as the role of IGOs increased in the 1990s in regard to sustainable development policy stage setting, their role in actual national regulatory development assistance has decreased (UNEP, 2000).

UN agencies that could potentially play a role in legislative advisory support, such as the Commission on Sustainable Development (UNCSD), Environment Program (UNEP), United Nations Conference on Trade and Development (UNCTAD), Industrial Development Organization (UNIDO), Educational, Scientific and Cultural Organization (UNESCO), International Labour Organization (ILO), Revolving Fund for Natural Resources Exploration (UNRFNRE), and regional economic and social commissions (UNESCAP, UNECLA, UNECE, UNECA) lack either the mandate (the mining sector is usually accorded a very low priority), budget, or legal staff to effectively fill the void left by the dissolution of UNDTCD and the refocusing of UNCTC. After 1995, IGO support with regard to mineral regulatory matters has been largely restricted to efforts by the World Bank and, to a lesser extent, the Commonwealth Secretariat and East-West Center.

The World Bank and its sister organizations (IDA, IMF, MIGA) have played an increasingly larger role in regulatory development assistance during the 1990s. Through its country assistance projects, it has provided advisory services to assist a number of countries in drafting laws affecting the mineral sector. In addition, on a project- and country-lending basis like other development banks and private lenders, it has been able to pressure governments to implement a broad range of green conditions as part of its lending practice.

Table 4.13 International laws and their potential applicability to the stages of mining (UNEP, 2000).

Item	Land Access	Production	Product
World Heritage Treaty	X	X	
Ramsar Convention	X	X	
Regional Nature Treaties	X	X	
Biodiversity Treaty	X	X	
Law of the Sea Treaty	X	X	
Antarctic Treaty Regime	X	X	
EIA Conventions	X	X	
Regional Seas Treaties		X	
Water Quality Treaties		X	
Convention on Long-Range Transboundary Air Pollution (LRTAP)		X	
LRTAP Heavy Metals Protocol		X	X
Air Quality Treaties		X	
Stratospheric Ozone/Montreal Protocol		?	
Climate Change Convention		X	
General Agreement on Tariffs and Trade (GATT)			X
Regional Free-Trade Treaties			X
Basel Hazardous Waste Convention		X	X
Regional Hazwaste Treaties		X	X
Multilateral Development Bank Guidelines	X	X	
Development Assistance Agency Guidelines	X	X	
Stockholm/Rio Principles	X	X	X
Agenda 21	X	X	X
Regional IGO Programmes	X	X	
ISO 14,000 Standards	X	X	X
Indigenous Peoples/Local Communities Legal Developments	X	X	

The Commonwealth Secretariat maintains an economic and legal advisory group that provides assistance to governments that are part of the Commonwealth of Nations. Recently, these services have primarily been to backstop governments in mining agreement negotiations. Most agreements in the 1990s contain some provisions related to sustainable development concepts. For example, the East-West Center provides advisory services similar to those offered by the Commonwealth Secretariat, but with a greater emphasis on capacity building and educational programs, to nations in the Asia Pacific region. Budget cutbacks during the 1990s have limited the scope of its activities but it remains a valued asset to the region. On a regional basis, the European Union has collectively begun to consider the adoption of various regulatory measures designed to provide a more uniform mineral sector regulatory system for its member nations. A framework document was issued in 1992 that identified the potential issues to be recommended for EU common regulation or for countries within the EU to individually consider in order to achieving greater harmonization.

While work by the World Bank, Commonwealth Secretariat, East-West Center, European Commission and similar organizations aiding governments in the development of mineral sector regulatory schemes has had an appreciable effect in a few countries, the vast majority of governments rely on their own expertise to evolve regulatory systems.

4.4 Adaptation of standards and guidelines to increase the level of sustainable development in the mining sector

Australia

There is no national registry for closed mines, abandoned mines, or rehabilitated mines in Australia.

The Australian Government and the Minerals Council of Australia are currently producing an Abandoned Mines Framework to encourage a strategic approach to abandoned mines management, which promotes efficiency, sustainability, innovation, and consideration of the unique assets and community values for each mine. Currently, each State has developed its own approach to managing these sites. The Strategic Framework will promote convergence of these approaches across jurisdictions, and provide high-level guidance on issues to be addressed when managing abandoned mines.

Geoscience Australia has developed the Australian Mine Atlas, which maps Australia's mineral resources, mines, and processing centers (http://www.australianminesatlas.gov.au/).

The Australian Government supports appropriate mine rehabilitation and has developed, under the Australian Pacific Partnership, a best practice handbook on mine rehabilitation through the *Leading Practice Sustainable Development Program* (LPSD) for the Mining Industry. The handbook is located at: http://www.ret.gov.au/resources/Documents/LPSDP/LPSDP-MineRehabilitationHandbook.pdf

The Minerals Council of Australia has also developed *A Handbook for Mine Rehabilitation*: http://www.minerals.org.au/__data/assets/pdf_file/0016/33019/Mine_Rehabilitation_Handbook.pdf

In Australia, on-shore mining operations, including mine rehabilitation, are primarily regulated under state government legislations. The Australian Government supports state government regulations that require mining enterprises to have future plans in place for managing mine rehabilitation.

The Commonwealth supports proposals that lead to the sustainability and improved rehabilitation of environmental credentials in the mining sector, along with improved reporting while reducing undue compliance burdens on the operators. The Commonwealth seeks to promote a nationally consistent approach to inform mining operators on responsibilities over the life of a mine, encouraging progressive rehabilitation as a national practice.

The Commonwealth will only engage in mining rehabilitation issues under a broader cross-jurisdictional legislation such as the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). More information can be found in http://www.environment.gov.au/epbc/publications/pubs/epbc-act-fact-sheet.pdf.

As part of state government regulations, mining companies are required to have mining securities whereby a trust is established to reduce the governments' financial risk for the rehabilitation of mining sites. For this purpose, jurisdictions develop their own bond policies, which include assessments of liability risk, optimal financial products and tools, and design processes to ensure compliance is enforceable if required. Mining securities are a key to underpinning the best practice principles in the life-of-mine considerations.

Chile

Chile's mining regulations include closure requirements and provide general guidelines for closure. This legislation is the Reglamento de Seguridad Minera (December 2002). Chile does not currently have detailed legislation that provides closure guidelines, though the law established a deadline of February 2009 for all current mining operations to submit a closure plan to authorities. New projects should present a closure plan in the Environmental Impact Study for the project permit. There is a closure law that was proposed several years ago, but is still pending approval; the closure law includes requirements for technical workplans, public disclosure, and a provision of financial assurance (Garcia, 2008).

Korea

History of Mine Damage Prevention System in Korea

On 12 December 1951, the Chosun Mining Order in Clause 8 stated that the "*Chosun Japanese Government General will delegate all authority regarding mining*" (Chosun Mining Order Article 8) be redacted. The Chosun Mining Rule was enforced in January 1938; after independence, the new Mining Security Law was enacted and enforced on 12 December 1951 as Clause 234 Law. Since then, mining security has been emphasized, and with its importance was enacted and practiced from 5 March 1964 after a 1-year preparation period.

In the 9th Amendment of the Mining Security Law, the administration's practical importance was recognized as the government tried to support the prevention of mine damage in 1980s.

On 8 January 1986, the government constructed a fund for mining after enacting Article 26 of the Coal Industry Law, which included Support to Prevent Mine Damage" (Article 27, Section 1, Clause 1).

The new establishment of Article 33 of the Constitutional Law indicated that all citizens have a right to live in a clear environment, and the economy and its citizens must put efforts towards environmental conservation (9th Clause of Constitutional Law on 27 October 1980), which made an initial expansion of environmental conservation to the whole economy. Article 35 of the amended Constitutional Law, and the Environmental Rights Act were enacted on 29 October 1987.

The government started the First Stage Mine Region Comprehensive Development Plan (1982–1986) and the Second Stage Mine Region Comprehensive Development Plan (1987–1991) as the GDP increased and influenced the economy's industrial environment. In the case of coal mines, the Coal Industry Law was enacted as Clause 4030 on 16 December 1988, which included the Coal Industry Rationalization Plan, so that the government now had a legal base to support "expenses of mine damage from abandoning mines" such as forest recovery, prevention of outflow from mines, and prevention of mine damage. On 19 January 2002, the Mining Law was amended as Clause 6612 and enacted (Clause 76 of Section 3), to include a legal base to support prevention of mine damage or recovering business. As a result, an efficient and unified legal system has been in place for the comprehensive prevention of mine damage since August 2005.

Improvement of mine damage prevention system in Korea

1) Responsibility of contributors is enforced in order to prevent mine damage and the government is given all responsibility for mine damage.
2) According to the contributor responsibility principle, the person who has the mining right or concession must manage mine damage and has primary responsibility after abandoning mines, and the government is responsible to control additionally generated mine damages.
3) The mine damage prevention system must be consistent and systematic. A professional institution to manage mining activities must be operated by law, with the law system to be unified so that the legal system of mine damage prevention is applied in a consistent and systematic manner.
4) Fundamental plans of mine damage prevention are promoted based on cooperation between various departments.
5) Comprehensive plans and research about the relationships between elements of mine damage prevention must be built for mine damage control. Therefore, the economy's fundamental plans and operating system are constructed with consideration of the relationship between the departments in charge of water and land pollution.
6) The post-mining damage prevention system has been replaced by a beforehand system.
7) Efficiency of the mine damage prevention system has been increased through unification of the legal system. Funding of mines' shares by each law should be unified, so that not only the post-mining mine damage prevention system but also the total development plan are improved and operated efficiently.

In addition, prevention of mine drainage is mentioned in Chapter 10 of the Mine Security Law Enforcement Rules (see Appendix B).

Peru

Details about mine closure are outlined in the law of Peru (Ley No.28090, Ley que regula el cierre de minas, published October 14, 2003). The deadline for Closure Plan submittal was 2006. The law requires that closure plans include the reclamation methods, closure cost estimate, methods of control and verification, closure and post-closure plans, and financial assurance. The Peruvian Ministry of Energy and Mines published a guide for preparing mine closure plans in 2006 (*Perú, Ministerio de Energía y Minas, Guía para la elaboración de planes de cierre de minas*, April 2006). The Ministry publishes the most recent version of the regulations and other pending laws on their website (http://www.minem.gob.pe).

USA

The United States programs related to the environment, and specifically the mining sector, include the following:

Federal Mining Dialogue
The Federal Mining Dialogue (FMD) is a cooperative initiative among federal environmental and land management agencies for remediating contamination, improving safety, and minimizing releases from operating, abandoned, and inactive hard rock mining and mineral processing sites. Member agencies encourage efficient management of the nation's public land and mineral resources in an environmentally sound manner. FMD member agencies include

USACE, USDA, USFS, BLM, OSM, USGS, NPS, Department of Justice, MSHA, and EPA. One goal of the FMD is to focus on future uses of abandoned mine lands (AMLs), and to identify the economic, environmental, and social benefits that accrue from their reuse. Reuse may serve as a catalyst for expediting environmental risk reduction.

https://www.abandonedmines.gov

Department of the Interior, Office of Surface Mining

The Surface Mining Control and Reclamation Act of 1977 (SMCRA), calls on the Office of Surface Mining (OSM) to balance the environmentally adverse effects of surface coal mining with the nation's need for coal as an essential energy source. OSM ensures that coal mining is conducted in an environmentally responsible manner and that the land is adequately reclaimed during and following the mining process. OSM requires plans that assure that mining sites will be restored to their original contours and to mitigate acid mine drainage before a permit is granted for mining operations. The primary responsibility for regulating surface coal mining now rests with the coal-mining states, with OSM performing an oversight role. OSM works with colleges and universities and other state and federal agencies to further the science of reclaiming mined lands and protecting the environment. These initiatives include promoting the planting of trees and establishing much-needed wildlife habitats.

http://www.osmre.gov/index.shtm

Appalachian Regional Reforestation Initiative

The Appalachian Regional Reforestation Initiative (ARRI) is a coalition of citizens, the coal industry, and government that is dedicated to restoring forests on coal-mined lands in the Eastern United States. The goals of the initiative are to

- plant more high-value hardwood trees on reclaimed coal mined lands in Appalachia;
- increase the survival rates and growth rates of planted trees; and
- expedite the establishment of forest habitat through natural succession.

ARRI advocates using a technique known as the Forestry Reclamation Approach to plant trees on reclaimed coal mined lands. Highly productive forestland can thus be created on reclaimed mine lands under existing laws and regulations by using the Forestry Reclamation Approach.

http://www.arri.osmre.gov/

Department of the Interior, Bureau of Land Management

The Bureau of Land Management (BLM) manages public lands under its domain using the principles of multiple use and sustained yield. BLM’s statutory mandate under the Federal Land Policy and Management Act of 1976 (FLPMA) is to prevent unnecessary or undue degradation. Exploration and mining activities on mining claims on BLM administered lands are subject to the regulations in 43 CFR 3809 and for Wilderness Study Areas, 43 CFR 3802. For activities other than casual use, they require the operator to submit either a notice or a plan of operations and a reclamation plan. A plan of operations must describe in detail the site and the proposed operation, including measures that will be taken to prevent undue and unnecessary degradation and to reclaim the site to regulatory standards. Reclamation must include salvaging topsoil for later use, erosion and runoff control, toxic materials isolation and control, reshaping the area, reapplication of topsoil, and revegetation (where reasonably practical).

General Info: http://www.blm.gov/wo/st/en.html
Coal Mining: http://www.blm.gov/wo/st/en/prog/energy/coal_and_non-energy.html

The Bureau of Land Management's Abandoned Mine Lands Program
The Bureau of Land Management (BLM) Abandoned Mine Lands Program (AMLP) works in partnerships with the EPA, state agencies, tribes, private parties, and other groups to accelerate the rate of cleanup of watersheds affected by abandoned hard rock mines.

http://www.blm.gov/wo/st/en/prog/more/Abandoned_Mine_Lands.html

Department of the Interior, National Park Service
The National Park Service (NPS) has the responsibility for managing the National Park System to conserve scenery, natural and historic objects, and wildlife, and to provide for the public enjoyment of those resources that will leave lands unimpaired for the enjoyment of future generations. The NPS ensures that mineral activities prevent or minimize damage to the environment and that the pristine beauty is preserved for the benefit of present and future generations.

http://www.nature.nps.gov/geology/mining/

National Park Service Abandoned Mineral Land Restoration Program
The Abandoned Mineral Land Restoration Program encourages the full restoration of lands affected by mining activities, addresses environmental concerns (metals contamination, acid mine drainage), safety hazards (vertical mine openings, unstable slopes), and the sustainability of bat species, which may rely on mineshafts for habitat.

http://www.nature.nps.gov/geology/aml/index.cfm

Department of the Interior, U.S. Geological Survey
Under the Geological Survey Organic Act of 1879 and the Economy Act of 1932, the United States Geological Survey (USGS) provides statistics and information on the worldwide supply of, demand for, and flow of minerals and materials essential to the U.S. economy, national security, and protection of the environment. The USGS publishes the annual Mineral Commodity Summaries and Minerals Yearbook, which also provides mining information for most countries of the world.

http://minerals.usgs.gov/minerals/pubs/mcs/
http://minerals.usgs.gov/minerals/pubs/myb.html

The USGS also provides scientific expertise to help land managers minimize or eliminate the adverse environmental effects of AMLs. The U.S. Geological Survey Mine Waste Characterization Project has taken a multidisciplinary approach to assemble, develop, and refine methods and tools for characterizing and screening weathered solid-mine wastes. Researchers from a variety of disciplines, including geophysics, geochemistry analytical chemistry, geology, mineralogy, remote sensing, and spatial modeling have worked together at metal mining waste sites in Colorado and New Mexico to develop an integrated toolkit for the rapid screening and characterization of historical mine-waste piles. Detailed studies have been conducted at eight main mine-dump sites (six are located in Colorado), representing both igneous-hosted and carbonate-hosted polymetallic deposits, to examine the influence of carbonate materials. Two other sites, including arid analog mine-waste piles in southwestern

New Mexico, have been chosen to study the influence of climate. Tools developed from this work can then be used in ranking and prioritizing historical mine-waste piles.

http://mine-drainage.usgs.gov/

Department of the Interior, Minerals Management Service

The Minerals Management Service (MMS) is the Federal Agency that manages the nation's natural gas, oil, and other mineral resources on the outer continental shelf (OCS). The agency also collects, accounts for, and disburses more than $8 billion per year in revenues from federal offshore mineral leases and from onshore mineral leases on federal and Indian lands. The MMS's mission is to manage the ocean energy and on/off-shore mineral resources and revenues to enhance public and trust benefits, promote responsible use, and realize fair value.

http://www.mms.gov/

Department of Agriculture, U.S. Forest Service

The United States Forest Service (USFS) regulates the use of public lands in accordance with various authorities and program specific statutes. Exploration and mining activities on lands administered by the USFS are subject to the regulations in 36 CFR 228(A). Any proposed operation that could likely cause significant disturbance of surface resources must gain the approval of the USFS. The USFS ensures that the mines and oil, gas, and geothermal energy operations on federal lands comply with pollution control laws, standards, or implementation plans or land management requirements.

http://www.fs.fed.us/

An important part of the USFS Minerals and Geology Management Program's mission is the restoration of land disturbed by historic mining activities. In 1995, the USDA Forest Service, using data compiled by the US Bureau of Mines, estimated the number of abandoned mines inside national forest boundaries to be 38,991 total abandoned mine sites and that 13,597 (34%) of the total were mines with records of mineral production. And many involved minerals such as arsenic, cadmium, copper, lead, mercury, and zinc which can cause human health and environmental impacts.

http://www.fs.fed.us/geology/aml-index.htm

Environmental Protection Agency, Superfund Program

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as the Superfund, the EPA has remediated over 500 mining and mineral processing sites, focusing on sites in which no other regulatory tools have achieved protection goals. The EPA's Superfund program established the Beneficial Use of Mining Waste workgroup to identify, resolve, and/or clarify key issues with respect to the beneficial use of mining and mineral processing wastes for non-residential use purposes. The EPA's AML Program is coordinated through the National Mining Team (NMT) and the Abandoned Mine Lands Team (AMLT).

http://www.epa.gov/superfund/
http://www.epa.gov/superfund/programs/aml/

EPA Brownfield's Program

It is estimated that there are more than 450,000 brownfields in the US. The EPA's Brownfield's Program provides grants and technical assistance to communities, states, tribes, and other stakeholders to prevent, assess, safely clean up, and sustainably reuse brownfields. The Mine-Scarred Lands initiative provides technical assistance to communities to reclaim and reuse mine-scarred lands.

http://epa.gov/brownfields/index.html
http://epa.gov/brownfields/policy/initiatives_sb.htm#msl

EPA Office of Federal Activities
The National Environmental Policy Act (NEPA) requires federal agencies to consider potential environmental impacts before taking major actions, such as issuing mining permits or making decisions that affect federal lands. This environmental assessment (EA) is then used to assess the adequacy of proposed mitigation measures and reclamation procedures in order to prevent unnecessary and/or undue degradation. If significant impacts are likely from mining activities, the agency must prepare an environmental impact statement (EIS). The EPA reviews EISs on proposed federal agency actions and prepares written comments and complies with NEPA by writing EAs or EISs for certain EPA actions.

http://www.epa.gov/Compliance/nepa/

EPA Re-Powering America's Land Initiative
The EPA encourages renewable energy development on current and formerly contaminated land and mining sites. For example, eight wind turbines were installed on an old slag pile at the Bethlehem Steel site in Lackawanna, NY, which now produce enough electricity to power 7,000 homes.

http://www.epa.gov/renewableenergyland/

EPA Office of Water
The Clean Water Act (CWA) is one of the most widely used regulatory tools for ensuring environmental sustainability at mining sites, by providing limitations on impacts to the nation's waterways. Under Section 402 of the CWA, all point source discharges from mining must be authorized under a National Pollutant Discharge Elimination System (NPDES) permit. Under the stormwater program, runoff from mining operations requires a permit if it comes into contact with overburden, raw material, intermediate products, finished product, byproduct, or waste products located on the site of such operations.

http://cfpub.epa.gov/npdes/indpermitting/mining.cfm

Although most Section 402 mining permits are issued by states, the Office of Water (OW) may review permits to ensure that the permits contain appropriate technology- and water quality-based effluent limitations. Section 404 of the CWA provides authority for regulating the discharge of dredged or fill material. Section 404 permits are generally issued by the Corps of Engineers.

http://www.epa.gov/ow/

EPA Resource Conservation and Recovery Act Program

Regulations affecting mineral processing wastes were developed through a long process covering the period 1980–1991. The EPA has jurisdiction to regulate solid wastes from mining activities in the United States under the Resource Conservation and Recovery Act (RCRA). However, the current program focuses primarily on hard rock mining (i.e., mining of metallic ores and phosphate rock).

http://www.epa.gov/osw/nonhaz/industrial/special/mining/

U.S. Army Corps of Engineers
The Restoration of Abandoned Mines (RAMS) Program utilizes the United States Army Corps of Engineers (USACE) environmental authorities to provide technical, planning, and design assistance to federal and non-federal interests in carrying out projects to address water quality problems caused by drainage and related activities from abandoned and inactive non-coal mines.

https://www.nwo.usace.army.mil/html/rams/rams.html

In the case of mine closures, the USA has multiple federal environmental laws, including state and local registrations, related to mine closures. Most states with mining activities have state-specific laws as well as regulations with technical requirements and guidance documents for closure. Arizona, for example, has two regulatory agencies that oversee closure plans and closure activities: the Arizona Department of Environmental Quality (ADEQ) and the State Mine Inspector’s Office. ADEQ is responsible for the oversight of impacts to the environment (soil, water, air), whereas the State Mine Inspector’s Office is responsible for the physical safety of the site (such as stability of closed tailings impoundments and underground shafts). Detailed assessments of conditions during operations and the predicted post-closure conditions are required for a closure permit. Closure plans are required as part of the approval to operate and include estimates of closure costs as well as a financial assurance. Closure approval will be based on conditions after closure and the plans for long-term monitoring (Garcia, 2008).

However, the level of foreign investment in mining is influencing the way closures are being approached. Demands on sustainable development issues have led mining companies to apply stricter closure policies from their home countries to operations in developing countries, despite a lack of local policy in some countries. Even though the mine closure regulations in each country are different, the trend of adaptation by governmental and lending agencies in this matter for sustainable development appears to be increasing.

4.5 Mine reclamation technologies in APEC economies

In general, reclamation has thus involved the replacement and grading of the overburden (topsoil and other near-surface materials) using large earthmovers, followed by seeding with grasses and other herbaceous vegetation. The end result is the transformation of native forests and their associated soils into predominantly herbaceous-covered mine lands with reduced soil infiltration capacity due principally to surface compaction (Townsend *et al.*, 2009).

The process of reclamation includes maintaining water and air quality, minimizing flooding, erosion and damage to wildlife and aquatic habitats caused by surface mining. The final step in this process is often topsoil replacement and revegetation with suitable plant species.

Canada

In Canada, there is an absence of national provincial or municipal building codes that would require identification of the presence of active or abandoned mines as well as the assessment of geo-mechanical risk potential before initiating projects pertaining to new or updated infrastructure. Site closure remediation to prevent access is normally required from property owners. Provincial site projects focus on remediating sites are known to have an important failure consequence potential. The option for remediation is often to place a fence around the danger zones when further access to the site is not critical; placing a concrete cap when the site use is an issue. Other options such as backfilling, digging/blasting, structural bridging, are rarely used for abandoned mines as a result of their high costs, unless there are special surface considerations. Broad consultations with populations impacted by inactive mine problems are carried out routinely. This can take the form of advisories, information availability, and meeting with citizens and municipal representatives. Specific abandoned mine site use is reviewed by municipalities and requires professional advice. A manual for disused metal mines management has been made in order to define a common methodology for understanding the site condition, record the necessary data, and supply site solutions for pursuing long-term site stability and evaluate risks and related site uses (Bétournay, 2004).

Mine reclamation technologies in Canada can be seen from the following examples of successfully reclaimed sites.

Coal Creek North Pit 7 Mine NB Coal Limited Minto, New Brunswick

Coal Creek North Pit 7 was operated as a surface coal mining operation between 1989 and 1991. The goal of reclamation for the site was to return it to a wildlife habitat. During mining, a stream had to be diverted around the operations. During reclamation in 2000, a stream channel was excavated back across the site through an area that was being used as an unauthorized construction waste dumpsite. The banks of the channel were graded and stabilized for erosion control using hay. Because of the remote location, limited access to the site, and the late summer application time, the weediest hay was procured for this task. Seeds from cattails and reeds in adjacent wetlands were cast just above the waterline of the wider stream sections in order to speed up the establishment of shoreline vegetation (Figure 4.5).

Figure 4.5 Coal Creek North Pit 7 before (left) and after (right) reclamation

Westville surface coal-mining site, Nova Scotia

The pre-reclamation image in Figure 4.6 (left) was taken in 1996. The figure on the right, following reclamation of the site, was taken in 1999. Clearly, the surface has been restored and revegetated with an initial grass mix. Footpaths to a small park can be seen in the foreground (of the reclaimed area), which was provided by the mine operator for the Town as part of the reclamation plan. A future land use plan was developed by the mine operator in cooperation with the town of Westville. Once the area has settled and compacted, this site will be available for new development including residential, commercial, and industrial areas.

Figure 4.6 Westville surface coal mining site, Nova Scotia before (left) and after (right) reclamation

Don Valley Brick Works Quarry, **Toronto, Ontario**

The quarry was originally opened in 1882, and for over 100 years high-quality clay bricks were produced on the site, located within the Don Rover Valley and floodplain near the city of Toronto. Figure 4.7 (left) of the Don Valley Brick Works was taken in August 1982 just before it ceased operations. It shows the different lifts of extraction in the clay quarry.

In 1984, a development company purchased the site for residential use, and they started to fill the property. A public outcry stopped the development of the site, and the property was put into public ownership (Toronto Regional Conservation Authority). The photo on the right was taken in 2000 when the Aggregate Producers' Association of Ontario was presented a bronze plaque for the outstanding rehabilitation of the site. The site has been transformed to a natural environment and cultural heritage park. The quarry face in the background is considered an internationally significant geological site, and it has been preserved for study purposes. The rehabilitation includes gardens, wetlands, a boardwalk, and a wildflower meadow; the brick-making buildings and kiln chimney have been restored.


Figure 4.7 Don Valley Brick Works Quarry, Toronto, Ontario before (left) and after (right) reclamation

Denison Mine/Mill, Elliot Lake, Ontario

Denison Mines Limited operated in Elliot Lake from 1957 to March 1992, producing about 70 million tonnes of uranium waste at the Stanrock Can-Met and Denison mines. Figure 4.8 shows the before and after images of the Denison Mine/Mill in Elliot Lake, with the mine/mill complex in the foreground and tailings that the top and middle right. Quirk Lake is in background at the top left. Uranium tailings were reclaimed via a water cover to control acid mine drainage and the release of radionuclides. The tailings impoundments now support a variety of aquatic life.


Figure 4.8 Denison Mines Limited operation at Elliot Lake

More information about mine reclamation technologies applied for mining sites in Canada is available at http://www.clra.ca/reclamation%20stories.html.

Nowadays, Canada has developed remote sensing systems such as Light Detection and Ranging (LiDAR) which have been applied to effectively decommission and remediate mine sites. Following mine closure, detailed vegetation mapping can be carried out with a combination of LiDAR and hyperspectral data, which yield detailed physical and chemical characteristics of vegetation allowing for accurate monitoring of mine reclamation programs.

Japan

In Japan, due to the fact that the risk of collapse above shallow mines exploited by room and abandoned pillar technique (e.g. lignite, limestone) is increased by the occurrence of serious earthquakes, the backfilling technique is now frequently used to deal with the problem in urbanized areas (Sakamoto *et al.*, 2005). Figure 4.9 shows an example of the principle and the actual application of this technique in the Tokai region (ISRM, 2008).


Figure 4.9 Illustration and application of backfilling technique in Japan (ISRM, 2008)

The Japan Oil, Gas and Metals National Corporation (JOGMEC) was established in February, 2004 pursuant to the Law Concerning the Japan Oil, Gas and Metals National Corporation, which was promulgated on July 26, 2002. JOGMEC integrates the functions of the former Japan National Oil Corporation, which was in charge of securing a stable supply of oil and natural gas, and the former Metal Mining Agency of Japan, which was in charge of ensuring a stable supply of nonferrous metal and mineral resources and implementing mine pollution control measures. JOGMEG also provide financial assistance, technology development, and technical support, stockpiling, and gathering/providing information, in addition to mine pollution control and overseas field surveys.

Development of mine reclamation technology in Japan by JOGMEG pertains to mine pollution control for measures at dumping sites and mine drainage control. Several examples are presented below (http://www.jogmec.go.jp).

Development of mine drainage source control technology (polymer-based mine drainage outflow control technology)

A method of using a superabsorbent polymer for restraining or for cutting off the inflow of groundwater into the underground pits or the outflow of contaminated mine drainage has been developed (Figure 4.10). According to this use, the national effluent standards for mine drainage and smelter wastewater in Japan have been revised in recent years. For example, new effluent standards have been established or existing effluent standards have been made stricter with respect to permissible fluorine, boron, and selenium levels, and the national government is discussing the transfer of nickel, antimony, and molybdenum to environmental quality standards. JOGMEC is promoting research on the performance of polymer materials, the examination of polymer-filled construction techniques at mine tunnels and dumping sites, and demonstrations at a model mine (http://www.jogmec.go.jp).

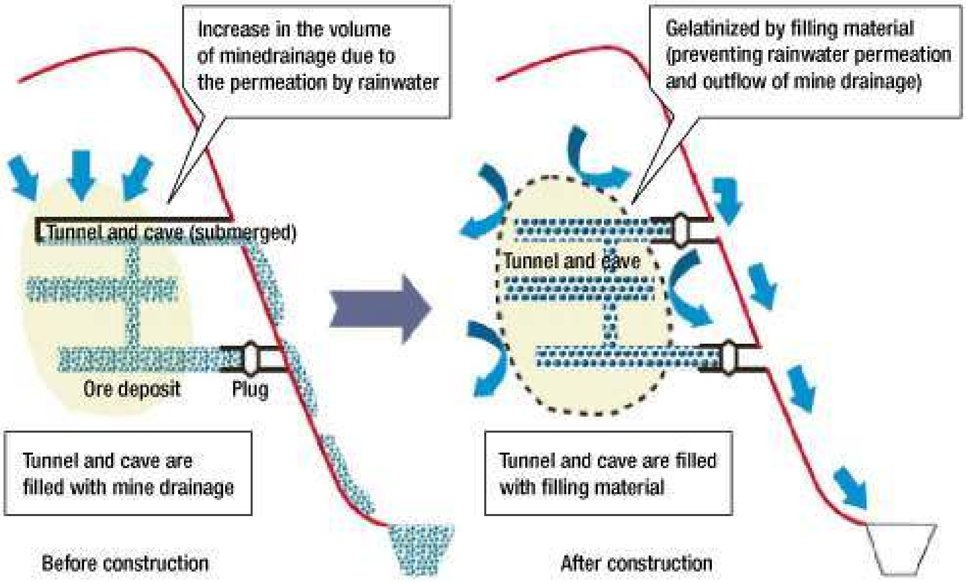


Figure 4.10 Conceptual diagram of polymer-based mine drainage discharge control

Sludge reduction technology

Sludge reduction technology is another technology that Japan has developed. Neutralization sludge, which generally occurs in mine drainage treatment, accumulates at a dumping site, with a sludge storage dam for final disposition. Therefore, a mine's pollution prevention bodies are bound to acquire and construct a new site to dispose of the neutralization sludge in the future, which will place additional heavy burdens on the mine pollution prevention bodies. Since 2005, JOGMEC has began the development of a technology that aims to reduce neutralization sludge by stabilizing the two-stage neutralization process, which can then be applied to lower the processing cost and significantly reduce the amount of neutralization sludge by utilizing iron-oxidizing bacteria.

Figure 4.11 Test of sludge reduction at Horobetsu Sulfur Mine (Hokkaido Prefecture)

Neutralization system and treatment facility at the abandoned Matsuo Mine

The abandoned Matsuo Mine is the largest sulfur mine in the Far East, which now dumps large volumes of strongly acidic water into the nearby Red River. A large-scale neutralization and treatment facility was constructed by Iwate Prefecture, with assistance from the former

Ministry of International Trade and Industry (MITI), and operation was delegated to the Metal Mining Agency of Japan (MMAJ), a precursor of JOGMEC. Full-scale operation began in April 1982 with a treatment capacity of around 18 tons per minute (Figure 4.12). The acidic wastewater has pH of 2 and contains large quantities of iron and arsenic. After sediments have been separated, only supernatant water is released into the Red River. In parallel with this undertaking, to reduce the amount of water inside the mine and the amount permeating from it, construction work on water generation sources was carried out up to fiscal year (FY) 2002 by the Iwate Prefectural Government, and JOGMEC also provided support for this endeavor.

Figure 4.12 Confluence of the polluted Matsu River (Red River downstream) and the Kitakami River at closure of the Matsuo Mine (left) and the neutralization and treatment facility at the abandoned Matsuo Mine (right)

Korea

Mine reclamation in Korea was originated when the government announced the mine reclamation policy in conjunction with the environmental rights in the 1980s. Abandoned coal mines were first reclaimed by the government during the 1990s. According to the Mine Pollution Prevention and Reclamation Law enacted in 2005, Korea has a 5-year-plan for mine reclamation. Reclamation activities include:

- improvement of water quality,
- restoration and prevention of ground subsidence,
- removal of waste facilities and treatment,
- soil amendment,
- survey of mine hazards,
- research and development, and
- education

However, it is obvious that the Korean government will be taking the most responsibility for mine reclamation. To this end, the Mine Reclamation Corporation (MIRECO) was established in 2006 according to Article 31 of the Mine Reclamation and Pollution Prevention Law, tasked with the mine reclamation of all operating and abandoned mine sites in Korea. Recently, the government has provided 100% of the financial support needed to reclaim abandoned mines, with operating mines to receive 70% support.

Based on the data in 2008, Korea has 61,400 abandoned mine sites, of which 62% are coal-mining sites and 38% are metal mines. The increased concern pertaining to the environment and sustainable development has led to the rapid improvement of mine reclamation technologies. According to the MIRECO reclamation plan, reclamation research and technologies have been primarily focused on soil remediation (21%), tailing treatment (17%), and water treatment (16%). Soil remediation technologies include solidification/stabilization, soil washing, phytoremediation, and electrokinetics. Mine water has been treated by passive, active and electrodialysis treatment systems. And in terms of technological advances, a graphic information system (GIS) is now being utilized as comprehensive management tool of mine hazards, such as accidents in the mining area and environmental pollution.

The following presents examples of successful mine reclamation projects in Korea.

- Abandoned coal mine in Sukgong-Dogye was reclaimed and a mine water treatment system installed.
- The former tailings dam of Il-kwang mine was landscaped to form a wild flower park (Figure 4.13).
- Coal mines in Kangwon province have been landscaped and transformed into a large tourist complex, which has contributed to sustainable land use based on environment conservation and promotion of the local economy (Figure 4.14).
- An abandoned metallic mine in Dalchun has been reclaimed via the application of a soil washing technique and an onsite contaminated groundwater treatment system.

Figure 4.13 Tailing dam of Il-kwang mine that has been reclaimed to form a wild flower park

Figure 4.14 Kangwon land tourist complex after reclamation of Dongwon Samsung coal mine

Figure 4.15 An active treatment facility of the abandoned coalmine in Hamtae (left) and electrodialysis treatment system in Najun coal mine

Figure 4.16 Samchuck coal mine – reforestation.

flat ground (79,026 ㎡) built on the dam of waste rock 1 level : 10,904 ㎡, 2 level : 45,870 ㎡, 3 level : 22,252 ㎡

Figure 4.17 Restoration of abandoned facilities (Tae-young coal mine)

Figure 4.18 Seeding land of Kangwon land Jungdong (Daeduck) coal mine

The process of mine reclamation in Korea is presented as the followings;

Mine reclamation business

1) Prevention of subsidence

- Survey for sites that can cause serious damages to life or public facilities
- Conduct mine safety assessment of professional organization for the underground mines and construct reinforcement for the underground structure
- Measure and manage the ground changes in the reinforced and risk concerned areas regularly for 5 year
- Remove the cause of subsidence through conducting the recharging projects for mine tunnels prior to closure
- Construct a database for the concerned area of subsidence

2) Acid mine drainage treatment

- The treatment is conducted for mines that have high contamination load which are located nearby residential or agricultural area.
- Decide for water treatment method among passive or active treatment by considering flow rate, pollutant types and concentration and site condition.
- Construct database and make a contamination map for the release of AMD

3) Soil remediation

- The remediation is performed soil for the highly contaminated fields that have been found by the crop safety survey in 2006.
- Enforce for the contaminated fields the measure of fallow (compensation) and remediation project after preventing the release of sources

- Switch the simple methods such as landfill or covering soils to eco-friendly treatment methods.

4) Reforestation

- Firstly conduct the project requested by miner having mining rights for the case of operating and paused mines.
- The reforestation is conducted for areas nearby city, load, and public facilities.
- Restoration of damage sites adopts an environmentally friendly method such as vegetation method. The land which has highly valued for other use rather than mountainous area can be restored by switching to high-value of land-use.

5) Removal of abandoned facilities

- Firstly, remove the abandoned facilities that are giving a large damage to landscapes nearby city.
- According to the request of local governments, mainly conducted for the facilities, of which the owner agreed to demolish without any compensation.
- Project avoids the individual business and takes the bulk demolition method
- Maintenance needed prior to closure of mine following the mining safety law

6) Prevention of waste rock and tailings losses

- Firstly perform the project for the area adjacent by dwellings, river, roads and agricultural land
- Conduct the project using the lasting and eco-friendly natural process
- The project includes not only seal and encase methods but also recycling, solidification and stabilization
- Seek measures to minimize the waste rocks from the early stages of mine development.

7) Prevention of noise, vibration, and dust

- The project is performed for the mine adjacent to residential area and the extent of the damage is large.
- Apply a method as environmentally friendly as possible, setup the mechanical facilities if it is difficult to apply.
- Mine risk monitoring will be conducted for the facilities that generate noise, vibration and dust, following the Mine Security Law.
- Propulsion of installation standards for the noise, vibration and dust prevention facilities (until 2011).

Case study of water treatment at Honam mining

1) Survey of flow rates and pollution level

2) Construction

3) Construction of SAPS

4) Facilities management

Purification efficiencies

pH : 5.98 → 6.81
Fe : 42.3 mg/L → 0.5 mg/L (99%)
Al : 1.36 mg/L → 0.38 mg/L (74%)

Malaysia

There are several research projects that have been conducted for rehabilitation of mining sites in Malaysia. The following is an example of the ongoing project.

Rehabilitation of Limestone Hill Quarry

The objectives of the project are to:

1. Identify suitable tolerant plant species for rehabilitation of limestone hill quarry.
2. Develop appropriate rehabilitation technique for the chosen plant species.
3. Establish guidelines for rehabilitation of limestone quarry.

Rehabilitation of limestone hill quarry area that is in operation and that is to be abandoned is part of the operation management program of a quarry. Results from this research project are to assist limestone quarry operators to rehabilitate their quarries with suitable tolerant plant species. Benefits from rehabilitation of a limestone hill quarry are:

1. Reduce dust, noise, accident due to fly rocks, and increase the esthetic value of the quarry area,
2. Provide conducive working environment,
3. Accelerate plant colonization at the limestone hill quarry,
4. Restore quarry area to its original state,
5. Establish plant-soil system that could self maintain soil fertility to reduce planting management cost and
6. Establishment of ecological environment that stimulate colonization of wild life for natural plant propagation. At the same time this will increase the biodiversity of the system.

Figure 4.19 Planting of Ficus benjamina at the slope of an abandoned limestone hill quarry (left) and Monitoring of growth, weeding, and fertilization of Ficus microcarpa "Golden" on a bench of an abandoned limestone hill quarry (right).

Peru

In 2006, through Decree No. 058-2006-EM, the government established Acitivos Mineros SAC as a state corporation to be in charge of implementing the remediation of environmental liabilities that Centromin had not finished. Since 2007, Activos Mineros SAC is the company responsible for the remediation of all environmental liabilities of the state.

Mine reclamation technologies have been used in Peru to secure the physical, chemical, and hydrological stability of the mined area in addition to reducing the environmental impact and protecting human health and safety.

The following are examples of successful reclamations and techniques in Peru.

- The tailings deposit of Tablachaca in the Central Andes of Peru was reclaimed by slope stabilization, cover (back fill), and revegetation techniques. The reclamation was completed in 2004 with an overall investment of $3,157 million. Since then, the site has been continuously monitored and maintained (Figure 4.20).
- Abandoned rock stock piles of an old coal mine, Goyllarisquizga Mine, located in the Central Andres Mountings of Peru, were operated between 1903 and 1993. Reclamation by physical stabilization was performed by cut and fill, with a beam and retaining gabions system applied to handle surface water and runoff. Cover, revegetation, and diversion of the stream were also utilized at this site.
- A high-diversity sludge neutralization system for the treatment of the acidic mine drainage of the Kingsmill Tunnel has been tested since it was completed in July 2010. The system is expected to commence operations in September 2010 (Figure 4.21).

Figure 4.20 Reclamation of tailings deposit of Tablachaca, Peru, before (left) and after (right)

Figure 4.21 High-diversity sludge neutralization system for the treatment of the acidic mine drainage of the Kingsmill Tunnel

Chinese Taipei

In Chinese Taipei, advanced technologies have been utilized to minimize the environmental impact. An obvious technique for mine reclamation is reforestation. In this case, the slope design is very important to ensure the stability of the reclaimed site, especially since the country has experienced many earthquakes.

Figure 4.22 Before (left) and after (right) mine reclamation in Shou Shan Limestone Mine, Chinese Taipei

Thailand

Techniques that have been applied for mine drainage treatment in Thailand include;

1. Active treatment
Neutralization is the technique that has been used for active treatment by application of calcium carbonate, lime, sodium hydroxide, ammonia, etc.

2. Passive treatment
Constructed wetland, open limestone channel/anoxic limestone drainage and diversion well are used (http://www.dpim.go.th).

In Thailand, a notable reclamation project is the work done at the Mae Moh Lignite Mine. Restoration and reforestation was applied to the mined land. Since the reclamation, the area has been landscaped to form a golf course, resort, and recreation area (Figure 4.20).

Mine Reclamation and Rehabilitation of Mae Moh Mine

A case study about mine reclamation in Thailand can be clearly seen in the large scale mining site. This report will present about mine reclamation of a coal mine in Thailand named "Mae Moh Mine". The mine belongs to the Electricity Generating Authority of Thailand (EGAT) which is a Thailand's state owned enterprise under the Ministry of Energy. Mae Moh Mine is the largest lignite mine in Southeast Asia with the total mining area of 9,200 acres and the external dumping area 10,240 acres. Presently, waste removed by EGAT is hauled to contractor's crusher, from there to dumping areas; waste removed by contractors is also transported by the belt conveyor systems. Almost all waste to be excavated will be transported by contractor's conveyor and dumped by spreaders at the outside dumping areas. Later part of the waste, however, is backfilled on pit dumps whenever dumping space is available. The shovel truck system with the combination of crusher and conveyor devices has been implemented for the mining operation. Then the produced coal of about 16 Mt/annum is transferred forward to the 10 units of the Mae Moh Power Plants with the provided total power generation of 2,400 MW. The Mae Moh Mine contains coal reserve geologically at the total amount of 1,140 Mt. with the economic coal reserve of 895 Metric tons, stripping ratio 6.09 BCM/t and the heating value of 2,810 Kcal/kg.

When coal has been extracted from the mine for fuel utilization of power stations on-site, the total area to be reclaimed would be approximately 24,250 acres. Mine reclamation is the important prevention and remedial method to prevent environmental deterioration. The Mae Moh basin is bounded by steep rugged mountains. Most forest stands in original plains have been subjected to some forms of exploitation. Most soil of dumping area in these plains is developed from shale of which it showed the infertility of the area. Moreover, the climate at Mae Moh in the northern part of Thailand is warm and dry. EGAT sees its responsibility to return the post mining surfaces and the outside dumps to economically and socially profitable use by the community of the region. EGAT therefore, has undertaken pilot test for soil quality improvement, selected suitable trees, and covering crop species for the area plantation, including agricultural program and controlled spontaneous combustion area. Benefit results gained from the pilot study included the land-use principles and environmental problem mitigation required in establishing a reclamation Master Plan.

Reclamation activities at Mae Moh Mine started in 1981 and have been being carried out continuously to the present time. The goal of Mae Moh Mine reclamation is to return the post mining surfaces and the outside dumps to economically and socially profitable use by the community of the region. Also, some Mae Moh reclaimed area will be gradually developed for tourist and education of geology and mine history. To achieve these, an environment must be created on the reclaimed surfaces, which can be harmonized with the ecology of the Mae Moh Basin. The Master Plan for Mine Reclamation had been prepared so as to emphasize EGAT' strong intention in the process of the Mine Reclamation activities. At present, reclamation of

Mae Moh Mine is known as reclamation study center in Thailand and nearby countries. The accomplished reclamation has come from various factors as follows;

At present, Mae Moh Mine has been certified of international standard for ISO9001, ISO14001 and OH&SMS 18001. Also, the Master Plan has been defined in compliance with the government Acts and Regulations standard such as;

- Mine Act in 1967 deals with mining
- Forests Act in1941 deals with protection and reservation forest, and clearing forest or rock explosion for mining
- National reserved forests Act in 1964 deals with protection and reservation forest, and permission to earn a living or dwell in reserved area.
- Environmental Impact Assessment (EIA.) and etc.

After the organization's vision and policies concerning with the environment has been issued by the top manager, the concrete targets of those would be committed. Reclamation Master Plan is the best concrete commitment, it is the significant planning preparation for the mine reclamation. The Reclamation Master Plan of Mae Moh Mine has been implemented for every 5-year period of revision or when the major changes in the mining plan occurred. Mine reclamation activities will be carried out following mining operation as set out in the five year stage plan, from 2002 to 2028. The mine reclamation master plan will end by the year 2032. The reclamation areas and reclamation activities are given in;

Reclamation areas	Reclamation activities
1. Side slopes and benches	
1.1 Intermediate slopes	- Covering crop planting and drainage Management
1.2 Permanent slopes	- Tree and covering crop planting
1.3 Dump slopes and benches	- Tree and covering crop planting
2. Top of overburden dumps	
2.1 Intermediate dump	- Re-vegetation
2.2 Permanent dump	- Covering crop and tree planting, Infrastructure, settlement, agriculture, water well and water route providing
3. Surrounding dumping areas	- Settling ponds and wetland treatment - Green belts

The final land-use concepts of the project are using basic principles for implementing established by the Royal Forestry Department such as reforestation action and developing soil quality to maintain the ecology system and environment. Mae Moh Reclamation Master Plan has been classified by those concepts as follows;

- Reforestation 62% (of reclaimed area)
- Reservoir 19%
- Living& Land used 11%
- Recreation 8%

The final land – use concepts of the project are:

- Reclaiming the mined areas according to the original purpose and land use, using basic principles for settlement as established by the Royal Forestry Department.
- Reforestation

• Developing soil quality to maintain the ecology system and environment.
Details about the study of final land uses are described in:

Mine Reclamation Plan According to Environmental Impacts

Environmental Impact		**Reforestation**	**Revegetation**	Agriculture	Water Storage	Settlement	Recreation
1.	Water quality	●	●				
2.	Air quality	●	●				
3.	Socio -	●	●	●	●	●	●
	economics and resettlement						
4.	Land resource	●	●	●	●	●	●

At present, Mae Moh Mine Reclamation has been being implemented by Mae Moh Reclamation Section which consists of 6 tasks as follows;

- Reclamation Planning
- Land Preparation
- Seedling Preparation
- Planting and Maintenance Trees and Cover Crop
- Recreation Area Maintenance

Mine Reclamation Cost

Information and assumption of the mine reclamation are based on the study of the mine investment cost. According to the study, it indicated that the average selling cost of coal to support the mine reclamation fund. This cost, however, will be revised for every 5 years. The Mine Reclamation Fund was established in 1982. The fund was transferred to "Account of Provision Liabilities for Mine Reclamation". For the time being, EGAT allocated 0.164 US$/ton of sold coal for the expense of the mine reclamation. The total cost of mine reclamation is 124 million US$. Recently, the expenditure of 16.71 million US$ has been spent.

Mae Moh mine reclamation Performance

Reclamation activities at Mae Moh Mine have been started since 1981 and have been being carried out continuously to the present period.

Ground Preparation

Ground preparation concerns the improvement of dumping areas to be suitable for reforestation. The activities cover ground leveling, access road construction, fire protection belt, drainage system and ripping of compacted areas. Until now ground preparation of 8,000 acres has been completed and 21 units of 35-60 meter drop structures for drainage have been constructed.

Seedling

Seedling concerns the production of forest tree species to be used in reforestation program and the production of decoration and maintenance of recreation areas. Two nurseries were constructed for these purposes. Each consists, for example, a nursery, a stock and equipment house, a yard for seedling arranging, a house for advanced plant, water thank, etc. At least 50,000 seedlings are produced annually which are adequate for the reforestation program, and construction and maintenance of recreation areas. Until now, approximately 2,000,000 nursery seedlings have been produced.

Planting

Selected tree species having been planted are northern indigenous species, fast growing species, high value species and natural food species etc. Until now, approximately 3,860 acres has been achieved in planting more than 1,458,180 trees of more than 60 species.

Maintenance

Plantation Maintenance: the work includes watering, weeds control, soil loosening and fertilization and trimming and pruning off. The maintenance will continue three years after planting. Until now 3,860 acres has been achieved under the program with the tree survival rate of 75-85%.

Access Road and Fire-protection Belt Maintenance: the work includes weeding, ground grading to make the access roads possible not only for area observation and plantation maintenance, but also for being regarded as the fire-protection belts for the area. The access roads have been built every year in the reforestation areas and ground cover planting area.

Drainage System Maintenance: the work included digging out drains, sediment ponds and sediment traps in dumping areas, and drop structure maintenance. The program has been carried out continuously in the reforestation and ground cover planting areas. Until now 21 units of drop structures has been implemented.

Electric Fences: The first three years of reclaimed areas, trees are quite small and not strong enough to survive by themselves, moreover, they are often damaged by cattle of near by community. For the reason of having good relationship with the near by community, cattle has been allowed for grassing in reclaimed areas but can not move into areas surrounded by electric fences which constructed by Reclamation Section. This method can save trees damaged by cattle at least 60%.

Recreation Area Maintenance: the work includes maintaining recreation areas to be clean and attractive all the time. The construction of recreation areas is one of the land end-use objectives to provide recreation areas for public as well as mine visitors. The maintenance has been carried out continuously.

Figure 4.23 Mine operation of the Mae Moh Mine

Figure 4.24 The reclaimed area of the Mae Moh Mine, Thailand

USA

In the USA, the Appalachian Regional Reforestation Initiative (ARRI) is a coalition of citizens, the coal industry, and the government, and is dedicated to restoring forests on coal-mined lands in the Eastern United States. The goals of the initiative are to

- plant more high-value hardwood trees on reclaimed coal mined lands in Appalachia,
- increase the survival rates and growth rates of planted trees, and
- expedite the establishment of forest habitat through natural succession.

ARRI advocates technique known as the "Forestry Reclamation Approach" to plant trees on reclaimed coal-mined lands. Highly productive forestland can be created on reclaimed mine lands under existing laws and regulations via this approach (http://www.arri.osmre.gov/).

4.6 Current status of each APEC economy on the application of standards and guidelines for responsible mine closure

All economies in APEC have put in place policies and legislation pertaining to mine closure and reclamation; either directly in national Mining Laws or indirectly in national Environment Laws. However, only the province of Ontario in Canada and the State of Nevada in USA have enacted and implemented actual mine closure laws. In most countries, mine closure requirements occur either within the mining law and/or its associated implementing rules and regulations (IRRs) for the mining laws, or within specific environmental legislation that is applicable to the mining sector.

In the USA, the national government legislated the National Environmental Policy Act (1969), the Clean Air Act (1970), the Clean Water Act (1972), and the Resource Conservation and Recovery Act (1976), all of which generally apply to issues related to mine closures (Clark and Clark, 2005).

The Requirement of Environmental Impact Assessment Report, in consideration of the social impacts of the mine as well as those on the environment, is another common feature of policy and legislation relating to mine closure. Existing policy and legislation and/or executive decrees require that social impacts must be considered during mining, closure, and post-mining periods. In all cases, policy and legislation requires that local and indigenous people should be included in all developmental planning activities, in the approval processes, and throughout the life of the mine (Clark and Clark, 2005).

In developing countries, the level of provisions for mine closure within the mining laws and regulations are mainly dependent on three factors:

1) the age of the country's mining law and regulations,
2) the activities of past mining enterprises, and
3) related policy and legislation; in particular, environmental policy and legislation.

The countries whose mining policies and laws have not been rewritten or revised since 1985 have few if any specific provisions pertaining to the environment (generally) or for mine closure (specifically). For example, the 1983 Mining Law of Chile, one of the world's largest mineral producing countries, does not contain provisions for reclamation, rehabilitation, or mine closure. Chile has recently moved to deal with these issues under its environmental policy and legislation, with the Environmental Unit of the Ministry of Mines taking a leading role in carrying out studies to develop the new Chilean legislation for mine closure.

Korea Mining Law also does not contain specific provisions for mine closure. In Korea, the owner of a mine is only responsible for the treatment of the mine area for 5 years after closure. The Mine Safety Code prescribes that the government is thereafter endowed with the responsibility for maintaining closed or abandoned mines. The authorities that finance the expense for the programs of mine hazard prevention are the Ministry of Commerce, Industry, and Energy (MOCIE), Ministry of the Environment (ME) and provincial governments (ISRM, 2008). However, the Korean government has increased the focus on mine reclamation by enacting the Mine Pollution Prevention and Reclamation Law in 2005. The effective enforcement of this law has led to an increase of mine reclamation funds and the establishment of a specific organization (the Mine Reclamation Corporation) in 2006, which is tasked with being completely in charge of the management of mine closures and reclamation activities.

In Japan, the relevant mining law is the Mining Act of 1950. The Act is mainly concerned with mining rights, though several sections in this law could refer to a concern about the environment and local community.

Compensation for mining pollution in Chapter VI of this Japanese law mentions the obligation of compensation by the holder of the mining rights for damage incurred by mining activity. The compensation can be money or an order from the court for restoration instead of monetary compensation. The Director of the Regional Bureau of Economy, Trade, and Industry is in charge of formulating fair and appropriate general standards concerning the scope and methods of compensation for damage, upon consultation with the Local Mining Council. The court can also specify the responsibility and scope of compensation if there is any cause to attribute liability to an aggrieved party. A security deposit is required from holders of mining rights for coal or lignite. In this case, a certain amount of money must be deposited every year in proportion to the quantity of coal or lignite mined in the previous year. The amount of the deposit will be specified by the Director of the Regional Bureau of Economy, Trade, and Industry, though it is not to exceed more than 20 yen per ton of coal or lignite mined in the previous year. An aggrieved party shall have a higher priority of right to seek compensation for damage and to receive the payment of money deposited to ensure the compensation for damage caused in the mining area (http://www.japaneselawtranslation.go.jp).

Mining rights will not be provided in areas in which the Environmental Dispute Coordination Commission finds that it is not appropriate to mine minerals due to conflicts with public interests, agriculture, forestry and other industries, and where the creation of mining rights of specified minerals is prohibited.

Indonesia issued Law No 4 of 2009 on Minerals and Coal Mining (the 'new mining law') to replace Law No 11 of 1967 (the 'old mining law'). A significant change was made in the arrangement whereby the government provides permits/licenses to mining minerals and coal; activities the writings/articles from the media/news reports as being the concept of a Contract of Work (COW) made by the government and mining companies as the basis of contractual relations. In addition, the Kuasa Pertambangan (KP) mechanism, which was practiced for the last 40 years, was changed and replaced by the Permit/License of Mining Minerals and Coal (http://www.allvoices.com). Another subject relating to mine closure is about guarantees in the form of a time deposit, bank guarantee, insurance policy, and/or accounting reserve, which are required in relation to reclamation and post mining activities plans. Where, after such plans are carried out, the guarantees are found not to have been sufficient to cover the actual expenses of such activities, the shortfall must be met by the relevant IUP/IUPK holder. The IUP/IUPK holder may also, indirectly, suffer from expenses incurred by the mining services providers they engage (e.g., compliance with quarterly and monthly reporting obligations to the relevant government authority, community development obligations, etc). An IUP/IUPK holder is required to manage its finances in accordance with the Indonesian accounting system. This would require an additional set of accounting reports for a foreign investor who may use a different accounting system in its business. However, the Environmental Impact Assessment and mitigation plans—including issues of reclamation, rehabilitation, and mine closure—are still required for mining licenses.

Common features of APEC economies pertaining to mine closure policies are as follows.

C Economies such as Chile, Peru, Russia, Indonesia, and China that still have large state-run mining operations are characterized by:

1) having general policies and legislation for mine closure;
2) mine closure issues are normally negotiated and incorporated into individual mining agreements;
3) the retention of a high degree of state responsibility for the closure of past and present and state mining operations;
4) few bonding procedures to ensure comprehensive mine closure; and
5) limited contingent liability for foreign investors with respect to mine closure issues arising from past operations (Clark and Clark, 2005).

Mexico, Papua New Guinea and Thailand, which have a long mining history of private sector mineral development, are characterized by

1) having general policies and legislation for mine closure;
2) providing for mine closure on a negotiated mine-by-mine basis;
3) a high degree of state responsibility for both abandoned and some operational mines; and
4) few bonding procedures to ensure comprehensive mine closure (Clark and Clark, 2005).

Within the developing economies in APEC, Peru, the Philippines, and Viet Nam can be said to have policies and legislation that provides for comprehensive mine closure and for post-mining sustainable development (Clark and Clark, 2005).

Requiring bonds is a key element in achieving comprehensive mine closure in order to ensure that there will be adequate financial resources available to the mine, or the government to ensure that the closure can be carried out successfully. Bonding is especially important for developing countries in which other forms of ensuring compliance may be weak or non-existent. Among the studied APEC developing economies, Indonesia, the Philippines, and Viet Nam have provisions for bonding. Australia, Canada (except Quebec and Saskatchewan), Japan, and the U.S. (Alaska, Montana, and Nevada) are developed economies that have implemented bonding procedures.

In any case, Clark and Clark (2005) recommend that the basic components of a comprehensive mine closure policy and associated legislation should:
1) provide specific provisions for reclamation and rehabilitation,
2) require both environmental and social impact assessments and associated work plans,
3) have a comprehensive bonding and financial security program,
4) contain specific provisions for abandonment and post-closure activities, and
5) have specific monitoring and enforcement procedures to ensure compliance.

4.7 Case studies of impacts from legacy mines and inappropriate mine closures

Potential hazards and harmful effects during the post-mining period may persist over the long term, after mine closure. Abandoned mine sites may affect people and goods under the influence of mining works and disturb the occupation or economic development on the surface within the vicinity of the mine.

There are several types of impacts induced by abandoned mines, though they appear to be quite similar from one country to another. The impacts can result in potentially harmful surface or underground water flow modifications as well as affecting surface instability developments capable of being sometimes dangerous to people or infrastructure. Mine closures can also cause potentially dangerous or toxic gas emissions or produce discharge, and are therefore the largest single waste stream in the world (Wolkersdorfer, 2006).

4.7.1 Flooding or disturbance of river flows

The dewatering system designed for mineral extraction usually stops after mine closure. This induces flooding in abandoned mine workings and raises the water table level. Abandoned workings, even when they have been backfilled, generally constitute a much more permeable medium than the surrounding rock mass. They thus form a local hydraulic perturbation inducing, in the surrounding abandoned mine, a water table that never completely reaches its initial position (before extraction).

4.7.2 Surface instabilities

For open pit mines, the main instabilities vary from localized rockfalls to major landslides that can affect huge volumes of rock. In terms of underground mining works, the mining method used mainly depends on the geological context and technologies available at the period of extraction. After abandonment, surface instabilities that may affect mines that have been exploited by total extraction methods are generally restricted, which causes a low level of smooth subsidence. For exploitations allow the persistence of important residual voids, the surface may also, depending on the context, be affected by discontinuous features such as sinkholes and massive collapses. Other kinds of surface instabilities may also affect waste dumps that have not been properly designed (ISRM, 2008).

4.7.3 Mine gas emissions on the surface

Large quantities of rocks that were extracted in gas-rich rock masses contribute to form an underground mining tank filled with mine gas. This gas consists of a mixture of several components under various mechanisms (water table rising, pressure differential); mine gas may flow out through natural openings like faults or cracks. Dangerous gas mixtures can then affect the safety on the surface when mined gas is trapped in non-volatile voids (e.g., cellars). The major hazards can be an ignition or explosion (if it is methane), intoxication (e.g., CO, CO_2, H_2S), a lack of oxygen, or irradiation.

4.7.4 Ground & water pollution and emission of ionizing radiation

Mining activities may result, in a more or less significant way, deterioration of parameters governing the environmental quality within the mine surroundings. This degradation mainly affects underground or surface water and soil. It can also affect the atmosphere in the case of ionizing radiation or toxic particle emissions.

4.7.5 Geomechanical hazards

4.7.5.1 Ground movements above underground mines

Continuous movements can be subsidence or heave. Subsidence is characterized by a usually slow, smooth, and flexible readjustment of the surface. This well-known phenomenon induces topographical depressions without major failure, leading to a dish-shaped feature on the surface. In most cases, the maximum amplitudes observed in the center of the depression, during or after operations, are on decimetric to metric scale (Peng, 1996). In most cases, subsidence results from the collapse of underground cavities due to the extraction or disappearance (dissolution, combustion) of deposits. Deformations and slopes are then proportional to the maximum subsidence in the center of the subsidence, though it is proportional to the volume of residual voids underground and inversely proportional to the depth of the mining works. If a single thickness is exploited, the deeper the operation, the lower magnitude of the effect (ISRM, 2008).

A burning structure is a kind of subsidence that is based on the accidental or spontaneous heating of organic material remaining in old underground workings. It can indicate combustion in solid fuel mines (e.g., coal, lignite, bituminous, and shale), which can cause a disappearance of material and therefore the possible development of surface subsidence (Figure 4.25). This phenomenon may also be observed on the surface of burning stockpiles or slag heaps in areas of old mine workings subject to spontaneous combustion. Apart from ground movement, there are other types of harmful effects to people and property in the surrounding areas (e.g., fires, accumulation of toxic gases) and can be the source of secondary accidents (e.g., proximity of gas feeders, presence of old ammunitions).

Figure 4.25 Subsidence above an underground fire in Pennsylvania (USA), (ISRM, 2008)

4.7.2 Discontinuous movements (Sinkholes)

A sinkhole is characterized by a sudden appearance of a crater at the surface (Piggott and Eynon, 1978). The horizontal extension of this kind of instability varies in diameter usually from a few meters to several tens of meters. Normally, the depth of the holes is a few meters, though can reach more than 10 meters in some specific cases, such as for a shaft collapse. Depending on the mechanism initiating the damage and the type of substance rock, the walls of the crater may be sub-vertical or inclined, so giving rise to a characteristic funnel shape (Figure 4.26). The dimensions of the sinkhole and a sudden development on its surface make sinkholes potentially dangerous, especially when they develop in or close to urban infrastructures (Figure 4.27).

Figure 4.26 Sinkhole crater (ISRM, 2008)

Figure 4.27 Sinkhole crater in Korea (left) and within an urban area in France (ISRM, 2008)

The mechanisms of sinkholes are as follows. The primary cause of a sinkhole is strata failure affecting the roof of a cavity. Evidence from several mining areas has shown that, within flat sedimentary deposits, old mine cavities can cause a sinkhole if they are less than 40–50 m deep (Taylor and Fowell, 2007), though there are exceptions in the case of major geological or mining specificity (e.g., a thick layer of sand in the overburden, very large cavity underground). Other factors include:

- an isolated pillar failure,
- shaft failure (e.g., remobilization of backfill material),
- plug failure,
- fill run-out, and
- underground combustion.

4.7.3 Induced seismicity

Mining induced seismicity can range from less than 1.0 on the Richter scale to more than 5.0; only a few events with a magnitude higher than 5.0 have taken place. These events usually occur in areas mined out at great depth of more than 100 m below surface. In South Africa, seismicity often occurs in gold mining districts such as Johannesburg, Carletonville, Klerksdorp, and the Free State gold fields. It also occurs in deep coal mining in Europe.

Actually, the mechanism(s) for induced seismicity have not yet been clearly explained. Under certain conditions, however, it is thought that mining may cause an increase of the parallel forces or a decrease of the perpendicular forces or both, resulting in a displacement of one plane relative to the other. This in turn gives rise to seismic shock. The released energy is due to the potential energy of the rock compressed at great depth and the energy disturbance caused by mining. In general, mining is often trigger that may induce a great release of energy leading to a seismic event (ISRM, 2008).

Induced seismicity does not have to disappear after mine closure. Even if deformations of rock mass do not occur at the same rate during mining, some residual compression can still be active at a diminishing rate. The main concern is a potential change in the environment, especially water level rising and, consequently, increases of hydraulic pressure. This may lubricate pre-existing fault planes, reducing the distance to displacement and thereby inducing seismic events.

4.7.4. Slides or slope movement

Slope movements (slides, erosion) are most commonly observed along the sides of waste heaps or slopes of excavations in loose rock masses of shallow or deep open pit mines.

Shallow movements usually only cause a nuisance in the landscape, but rarely generate risk to people and/or property. However, the rubble may affect water flow immediately downstream of the foot of the slope. The risk of causing an accident of falling increases when eroded gullies are up to several meters deep.

4.7.5 Flow slides

Dynamic flow slides can occur as a combination of material transport by water and slope failure. Flow slides are the most dangerous disorders likely to affect people and property in the neighborhood of slopes associated with old waste heaps. They mainly affect lagoons, which consist of retention ponds of fine materials. This kind of phenomenon may have potential catastrophic environmental consequences. Two well-known recent examples are Aznalcóllar in Spain and Baïa Mare in Romania, which occurred during the mine operation phase. In addition, the propagation of very large quantities of semi-fluid materials at high speed over long distances can also represent a high risk to people and property in the area of the flow.

Mechanisms that can cause flow slides are:

- Weakening and failure of retention dams. When the dam breaks, fine wet materials with no cohesion may be released. Dam construction techniques are of major importance in this case.
- Tailings liquefaction when powdered and saturated material is inadequately drained, in the case of severe vibration (e.g., earthquakes, mine explosion, caving-in of part of the slope), there may be an increase in the interstitial pressure within the deposit. When the interstitial pressure exceeds the contact force between grains, the partly consolidated materials may suddenly liquefy and cause a sudden transmission of stress onto the dam flanks (Troncosco and Garcès, 2007).
- Burning clouds, the dynamic flow consists of hot material that may cover a large area of the heap bottom and may combine with potentially fatal burning dust.
- Flow slides affecting pit slopes in open-cast mines that lack effective drainage to cope with the surface flow are the main factor of this event.

Geohazard of mining in APEC economies

Japan

Japan has ten underground coal mines in operation and approximately a thousand mines either inactive or abandoned. All active mines are operating under the sea, forests or waste lands. The reasons for this are not so much due to the shortage of coal reserves but rather for preventing damages in the land. Due to huge mining damages in the past and for prevention of damages in the future, the Japanese government and mining companies have been devoting themselves to fulfilling rehabilitation plans and have spent much effort towards preventing and minimizing future damage. However, remnant damages are estimated at about 590 billion yen (4.9 billion dollars); this may depend on social and political situations to a certain extent. Most of the damages are due to extraction of coal seams, that is usual surface subsidence. Discharging of mine water or used water, accumulation of abandoned stones and mineral tailing, or discharging of mining smoke have also cause damages in some districts. However, changes in mining operations, accompanied by mining under worse conditions or mine closure, have caused new complicated environmental impacts, namely: subsidence due to mining and dewatering in areas of thick alluvium, cave-in due to cavities remaining at shallow depths, and springing out of ground water at abandoned mines. These damages were first brought to public attention at the end of the 1940's, though they had occurred before, and have brought a severe social problem. In addition, some types of damage will continue for a long period. This paper describes the characteristics of subsidence related environmental problems and some preventive measures against them from a geotechnical point of view.

Underground coal mining has been practiced in Japan, particularly in Kyushu, the southernmost of the four main Japanese islands, for approximately 500 years. This condition constituted a potential mining damage. Within Kyushu, the Miike and Chikuho coal fields were discovered in the 15 century, and the Takashima coal field was developed in the 18 century, where coal was produced primarily for domestic use. In the latter part of the 19 century, coal industries had an important role as a major energy supplier for the overall Japanese economy, and production of coal increased at an accelerated rate. Up until the middle of the 19 century, mining damage was neither physically severe nor a socially serious matter, because of primitive method of mining and small scale production. However, after the introduction of mechanized methods of mining for large scale underground production, near the end of the 19 century, tangible damage like as land subsidence began to emerge (Esaki et al., 1989),

Korea

In Korea, ground subsidence occurrences at abandoned underground mines have been a serious problem. Cases of ground subsidence occurrences in residential areas near abandoned mines have been reported. For instance, 154 graves were ruined with the sudden collapse of a graveyard in 1993, due to a failure of mining operations at the Bupyeong abandoned metallic mine in Incheon City (Kim and Kwon 2007). This specific accident instigated the establishment of the Mine Reclamation Corporation (MIRECO), which specializes in mine reclamation, to implement projects for preventing ground subsidence occurrences.

Figure 4.28 Incheun Bupyung mine in 1993-subsidence and loss of cemetery yard (about 2000 m^2) after 6 years of mine closure

The Philippines

The Philippines is identified to be among the top ten countries at climate risk (Germanwatch, 2008). With climate change already upon us, extreme weather events, mine tailing dam failures and other mining disasters are most likely to happen with poor disaster risk reduction planning, and mining monitoring and regulation by government.

A study of Philippine Indigenous Peoples Links (PIPLinks) reported at least eight mine tailing dam failures attributable to heavy rainfall and typhoons in the Philippines (in the period 1982 to 2007). These incidents caused massive fish kills, toxic heavy metals contamination apparent in land and waters, damage to agriculture, displacement and economic disruption of mining affected communities.

Recently, the Department of Environment of Natural Resources (DENR) presented a P60-million geohazard mapping study of the Philippines that identified landslide- and flood-prone areas. Given this information and cognizant of the economy's mountainous topography, Alyansa Tigil Mina (ATM), an advocacy group composed of more than 80 organizations based in mining-affected communities and national civil society organizations, urges government to use geohazard maps to review mining tenements and abandoned mines to prevent mining disasters (http://www.manilatimes.net).

Critical mine structures include tailings dams, waste dumps and small-scale mining areas, while geohazard areas refer to areas that are susceptible to landslides, floods, liquefaction, ground subsidence and other ground instabilities, the DENR press report explained.

The Geohazard assessment for critical mine structures include tailings dams, waste dumps and small-scale mining areas, while geohazard areas refer to areas that are susceptible to landslides, floods, liquefaction, ground subsidence and other ground instabilities, conducted by the DENR has identified the following top ten areas prone to landslides: Benguet, Mt. Province, Kalinga-Apayao and Ifugao in the Cordillera Autonomous Region (CAR); Abra in Region 1; Nueva Viscaya in Region 2; Marinduque in Region 4B; Catanduanes in Region 5; Cebu in Region 7; and Southern Leyte in Region 8.

The DENR press report disclosed the economy's top ten flood-prone areas identified by the DENR also include the following: Pampanga, Nueva Ecija, Tarlac and Bulacan, all of Region 3; Pangasinan and Ilocos Norte of Region 1; Maguindanao in ARMM; Metro Manila; North Cotabato in Region 12; and Mindoro Oriental in Region 4B.

Region 13, along with Region 2, Region 4A, Region 5, Region 8 and Region 11, were among the regions in the economy's eastern seaboard that were given the priority concern under the DENR's geohazard assessment activity (http://www.pia.gov.ph).

Viet Nam

The economy has a wide variety of mineral resources. However, environmental management of mining activities remains relatively poor. Illegal mining activities are common in certain areas. For example, gold mining is causing significant local and regional environmental impacts, due to the mercury contamination of downstream watercourses and groundwater. Groundwater quality is generally suitable for most domestic purposes, although there are hotspots of contamination. Groundwater resources are abundant; however, in the Red River and Mekong River deltas, over-exploitation is leading to falling water tables and subsidence issues (ADB, 2005).

4.8 Capacity among developing APEC economies on the best practice in mine reclamation and rehabilitation

Evaluation of the capacity among developing economies on the best practice in mine reclamation and rehabilitation was obtained from the workshop. The participants from developing economies include Chile, China, Malaysia, Mexico, Philippines, Chinese Taipei, Thailand, and Viet Nam. The titles of presentations were related to the mining situation in each country, and were mainly about plans, policies, laws and regulations, research, technologies, and case studies of successful mine closures. Most APEC economies do not have specific regulations for mine closure, but rather are in the process of developing policies, regulations, and laws on mine reclamation, rehabilitation, and closure in order to comply with the demands of sustainable development. To this end, Chile has issued a Mine Closure Bill, which is now under the approval process. Malaysia has the National Mineral Policy, which focuses on sustainable development and the effective utilization of mineral resources, and is developing Mine Rehabilitation Regulations. The Chinese government has made many plans and invested related to mine rehabilitation, such as the National Mine Rehabilitation Plan 2009–2015. Mexico has established national criteria for determining acceptable contaminant levels for the remediation of contaminated soil. The DENR Administrative Order No. 2005–07 of the Philippines has established a Final Mine Rehabilitation and Decommissioning Fund (FMRDF) in which an annual deposit is required from the mining license holder in order to manage rehabilitation activities. Many advanced technologies for mine reclamation were presented in cases from Chinese Taipei. In addition, the Thai Government recently announced Green Mining Standard and Green Mining Policy in 2009 in order to enforce the reclamation and rehabilitation of mining sites considering on environmental and social aspects. And Viet Nam has been focusing on the development of technologies for mine reclamation and rehabilitation.

4.9 Sustainable development index for mining sector in APEC economies

4.9.1 Result interpretations from the SDMI model

Eight members of the APEC Group have demonstrated applications of the SDMI model, including both developed and developing economies. The representatives of developed economies are Australia, Korea, and Japan, and the representatives of the developing economies are Malaysia, Indonesia, the Philippines, Thailand and Viet Nam.

Nine core economic, eight environmental, and three social indicators are represented to determine the respective performance of the mining sector in each country. The quantitative data for these indicators were mainly found on government websites or obtained from the World Bank website; they were not officially supported by government offices. Thus, the outputs recommended by this report are to demonstrate the Project's proposed SDMI model only. However, based on the scientific comparisons between the results from the model and the real situations in the eight economies of the APEC Group, we strongly believe that this model is an appropriate approach for evaluating sustainable development in the mining sector at a national scale. We strongly believe that if governments apply this proposed model as an evaluation of the sustainability index of their mining industry, they could obtain very useful information for making decisions. From these meaningful results, the governments could appropriately consider their judgments then utilize these results to check and adjust their management enforcement and implementation policies.

4.9.2 Model applications in mining situations of developed economies in APEC

4.9.2.1 Sustainability index for the mining sector in Australia

a. Australia's mining economic performance

Benefitting from an abundance of mineral resources, Australia's mining sector has been a large contributor to the country's economic development. It has been one of the top five producers of most of the world's key minerals commodities. The vital role of this sector is confirmed by being the world's leading producer of bauxite, alumina, rutile, and tantalum; the second largest producer of lead, ilmenite, zircon and lithium; the third largest producer of iron ore, uranium, and zinc; the fourth largest producer of black coal, gold, manganese and nickel; and the fifth largest producer of aluminum, brown coal, diamonds, silver, and copper. Their mineral resource exports contributed about $109 billion, the same as around 67% of the total commodity trade in October 2009 (MCAu, 2010). Thus, the output from the SDMI model again confirms the strong economic development of this mining industry, with a strongly positive development rate of 0.296 (Figure 4.29). The Australian mining-economic performance has been strongly pointed toward sustainable development, with the intent to maintain its position in the future.

b. Australia's mining environmental performance

As a highly developed country, the concept of sustainable development in Australia has been wholly considered in most economic sectors. According to the latest report from the Minerals Council of Australia Mining, the Australian industry has spent more than $200 million annually on the rehabilitation of disturbed lands in 2007–2008, and has accumulated provisions of nearly $3.5 billion for rehabilitation. However, due to the increasing sea of mining production, the negative impacts from mining operations such as the amount of greenhouse gas emissions every year, and the amount of particulate matter (PM10) emission into the air environment have also been dramatically increasing. The output from the SDMI model gives more information about the mining industry's environmental performance, with a rate of -0.016 (Figure 4.29).

The results may not reflect 100% of the real environmental aspect of the Australian mining sector, though a small negative sustainable development rate indicates that the Australian government should pay more attention to regulation implementation and enforcement in mining enterprises.

c. Australia's mining social performance

In terms of social performance, the Australian mining industry has been gradually shifting toward sustainable development, with a development rate of 0.125. In this country, the mining sector has also been a significant contributor in creating jobs for residents. Every year, the number of people employing in the mining industry has been increasing. The major factor for this great variation in social sustainability is the special consideration of the central factors of development. These are people working in the mining sector and local residents living around the mining sites. Australia has put the safety issue for workers as its first priority; they have also increased the amount of compensation for occupational accidents.

d. Sustainability performance of the Australian mining sector

Combining the sustainability performances of the three main contributions of the mining industry, the sustainable development variation of Australian mining sector is relatively good, as presented in Figure 4.29.

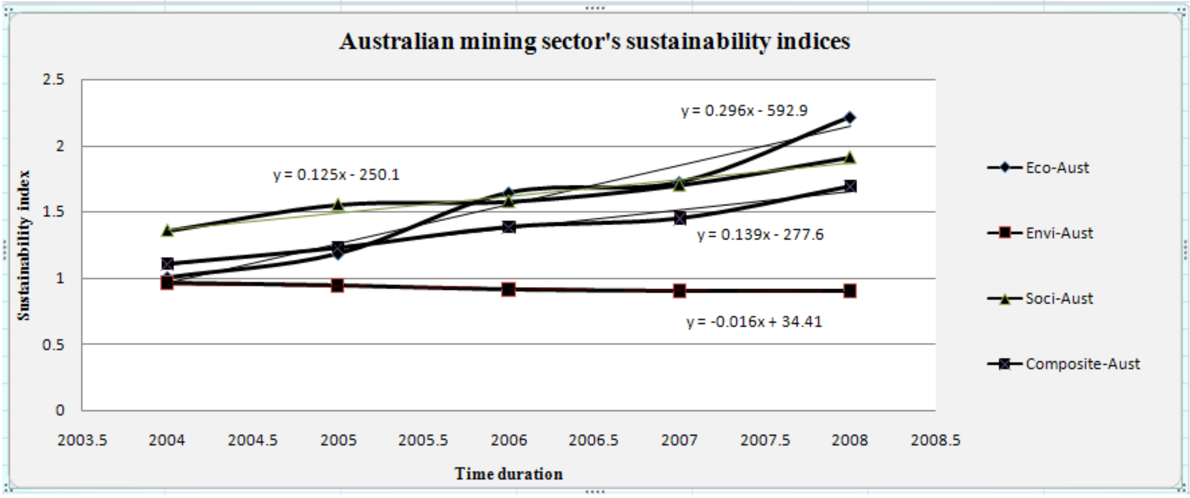


Figure 4.29 Sustainability index for the mining sector in Australia

As a result, the Australian mining industry has been strongly moving toward sustainable development, with a highly positive development rate of 0.139 shown during this period. The outputs from SDMI model confirm that this trend is likely to be maintained into the future.

4.9.2.2 Sustainability index for the mining sector in Japan

Having few natural resources, the Japanese mining industry consists of a small mining sector consisting of coal and non-ferrous metals, a large mining sector of industrial minerals, and a large minerals-processing sector of ferrous and non-ferrous metals and industrial minerals. The mining and mineral-processing businesses here are owned and operated by private companies incorporated in Japan. Thus, it is quite convenient for Japanese government to support, manage, and enforce the mining enterprises and their operations.

a. Japan's mining economic performance

The mineral industry has not been overly important to the Japanese economy, the contribution to the GDP, other than playing a role in supplying primary materials for the construction and manufacturing sectors of other countries. To secure a stable and efficient supply of mineral resources, Japan has promoted the exploration and development of minerals overseas and encouraged domestic metals recycling. However, aspects of the Japanese mining economic have been gradually shifting toward sustainable development, with a medium-positive rate of 0.046 (Figure 4.30).

b. Japan's mining environmental performance

Generally, Japan has been considered one of the most highly industrialized and technologically advanced economies in the world. A lack of natural mineral resources is one advantage for managing the Japanese government. The Japan Oil, Gas and Metals National Corporation (JOGMEC) is the general organization providing financial support for mine pollution control, which covers three categories: restoration of abandoned mine sites, wastewater treatment for mine drainage, and disbursements of the mine pollution control fund.

The output from SDMI model shows that the Japanese mining environment has been moving toward sustainable development, with a positive rate of 0.159 (Figure 4.30). One particular reason for this sustainability is due to its waste disposal management. For example, in FY 2006, the total emissions of industrial wastes across the country was 418.5 MT, about 51% of which was reclaimed, about 43% was reduced by intermediate processing, and only 5% of the total amount was subject to final disposal.

c. Japan's mining social performance

The results benefit society by creating economic opportunities and controlling pollution; the Japanese mining sector has also considered the safety issue for workers and increased the occupational-accident compensation. As such, the Japanese social aspect has been gradually shifting toward sustainable development, with a positive rate of 0.046.

d. Sustainability performance of Japan's mining sector

For the mining industry, Japan's sustainability index shows a highly positive rate of 0.122, implying that this trend toward sustainability will be maintained into the future. Indeed, the mining sector in Japan is one of the best case studies regarding sustainable development in the APEC Group because the benefits from economic development have been powerful incentives for implementing environment protections and social development.

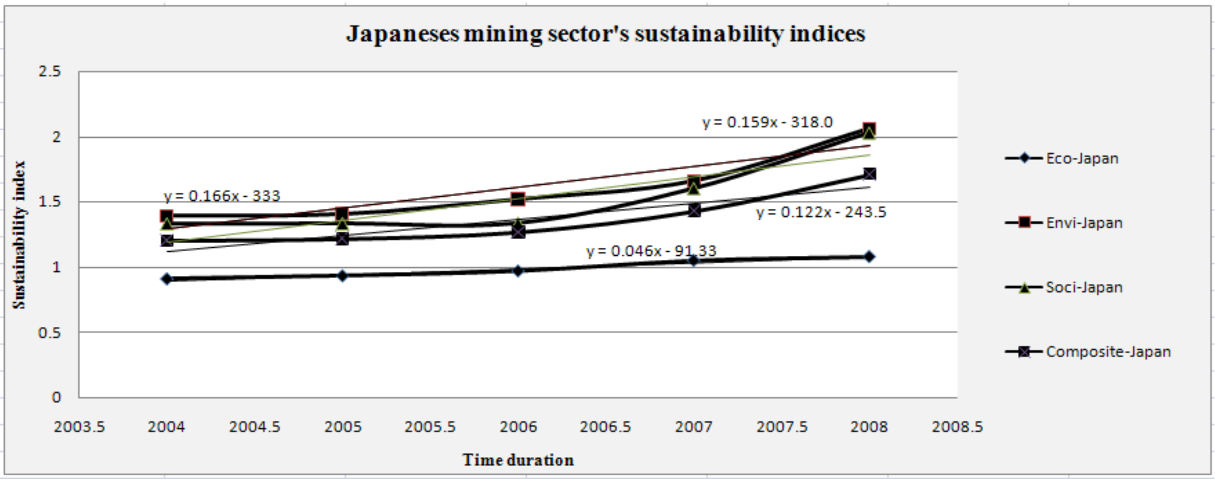


Figure 4.30 Sustainability index for the mining sector in Japan

4.9.2.1.3 Sustainability index for the mining sector in the Republic of Korea

a. Korea's mining economic performance.

Korea is a newly industrialized country in East Asia. The most economical mineral resources in Korea are gold, silver, lead, zinc, copper, tungsten, molybdenum, iron, fluorite, graphite, kaolin, talc, and pyrophyllite. Recently, export earnings from the mining sector and FDI inflows have increased dramatically in Korea; the total investment for the mining sector and education has also been considerably increased. The strong development of the Korean mining sector is demonstrated by its highly positive rate of sustainable development of 0.815 (Figure 4.25). The SDMI model predicts that this developmental trend will continue into the future.

b. Korea's mining environmental performance

As for the results of fast-economic development, the amount of noise pollution and particulate matter from Korean mining industry has increased dramatically in 2007; funding for mine closures and reclamation have also recently increased. Thus, the environmental aspect has been gradually moving toward sustainable development, based on a medium-positive development rate of 0.04 (Figure 4.31).

c. Korea's mining social performance

As in the other developed economies, the Korean social aspect of the mining industry has also been strongly moving toward sustainable development, as noted by its positive rate of 0.068 (Figure 4.31).

d. Sustainability performance of Korea's mining sector

Based on the output of the SDMI model, the Korean mining industry has been strongly moving toward sustainable development, with a highly positive rate of 0.32 (Figure 4.31).

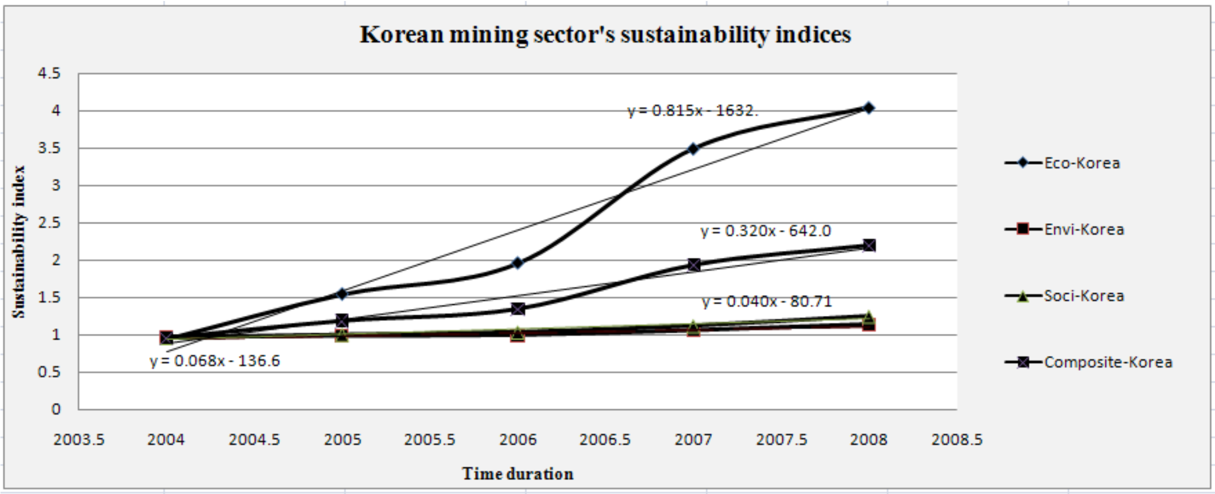


Figure 4.31 Sustainability index for the mining sector of Korea

4.9.3 SDMI model application in the mining situations of developing economies in APEC

In developing economies, the government normally pays close attention to FDI because the investment flowing into and out of their economies can have a significant impact. To this end, economists consider FDI to be a major driving force for economic growth, as it contributes to national economic measures. They also argue that FDI promotes development because this investment can provide a source of new technologies, processes, products, organizational systems, and management skills to the host country. It can also provide new markets and marketing channels, cheaper production facilities, and access to new technology, products, skills, and financing. That is why most economic sectors of developing countries have been developed due to the increase of FDI inflow.

4.9.3.1 Sustainability index for the mining sector of Indonesia

a. Indonesia's mining economic performance

Indonesia is the world's 7th largest bauxite producer, 2nd largest copper producer, 6th largest gold producer, 3rd largest nickel producer, 11th largest silver producer, and 2nd largest tin producer (1st is China).

The SDMI model demonstrated that the economic aspects of the Indonesian mining industry have been strongly moving toward sustainable development, a positive rate of 0.309. The main reason for this development trend is that FDI inflow has been dramatically increased. As a result, the mining products explored have increased, and the allocation of the fiscal year budget to the mining sector has increased annually.

b. Indonesia's mining environmental performance

Even though Indonesia has regulations for managing mine closures and pertaining to the prevention and mitigation of environmental destruction and pollution in general mining operations, a lack of advanced technologies, professional management, and enforcement have allowed the mining industry to pose a serious threat to the environment. Though there were only small differences between the annual emissions of greenhouse gases, emissions of particles from mining activities have increased since 2007. For this reason, the Indonesian mining environmental aspects have not been stable, with backward sustainable development with the rate of -0.278 (Figure 4.32).

c. Indonesia's mining social performance

The Indonesian mining sector has been a great contributor in terms of creating jobs for residents. In addition, safety issues in the mining industry have been a serious consideration since 2007; thus, the number of work fatalities has decreased. This trend has contributed to the Indonesian mining environment aspect moving slightly toward sustainable development, with a small-positive rate of 0.068 (Figure 4.32).

d. Sustainability performance of Indonesia's mining sector

Based on the three sustainability performances, Indonesian mining industry has been slightly moving toward sustainable development, with a rate of 0.02 (Figure 4.32). Using the information in the Report, the government could become more aware of mining development strategies to increase attention to environment protections and social satisfaction.

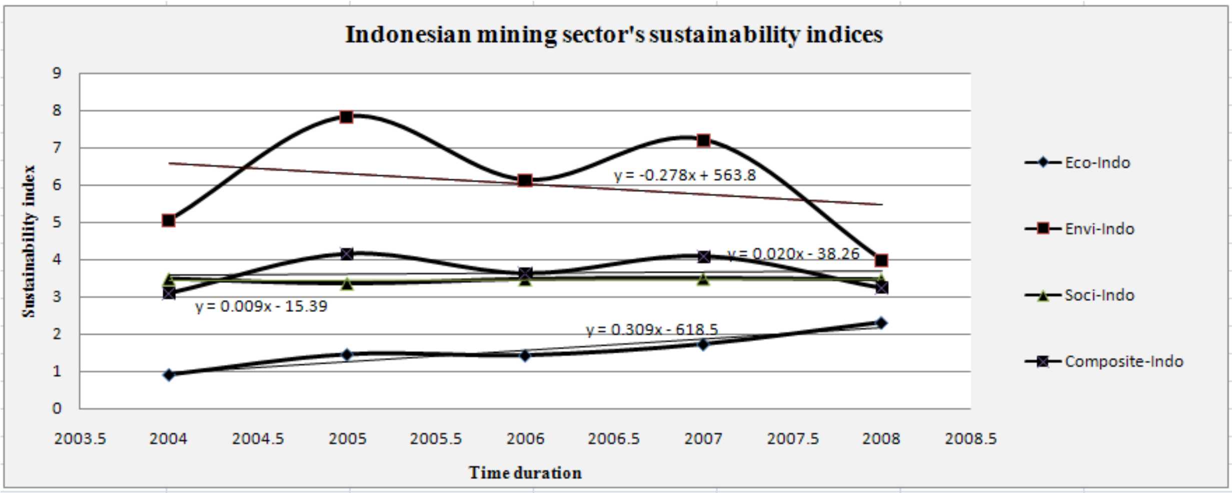


Figure 4.32 Sustainability index for the mining sector in Indonesia

4.9.3.2 Sustainability index for mining sector of Malaysia

a. Malaysia's mining economic performance.

Malaysia is a major tin producing country in the world, and the production of commodities such as mined tin and tin metal increased by more than 10% in 2008. Overall, the Malaysian mining economic performance has been strongly moving toward sustainable development; as presented in Figure 4.33, the development rate was 1.945. The main reason is due to the dramatically increasing amount of FDI. For example, FDI in 2007 and 2008 were double that in the FYs 2004 and 2005.

b. Malaysia's mining environmental performance

Malaysian environmental performance of mining industry has been not stable, with backward sustainable development, with a rate of -0.071 shown in the SDMI model output (Figure 4.33).

c. Malaysia's mining social performance

Malaysia's mining environmental aspect has been slowly moving toward sustainable development, with a positive rate of 0.113.

d. Sustainability performance of Malaysia's mining sector

Based on the overall benefits of economic development, the Malaysian mining industry has been strongly moving toward sustainable development, as evidenced by a highly positive rate of 0.690 (Figure 4.33).

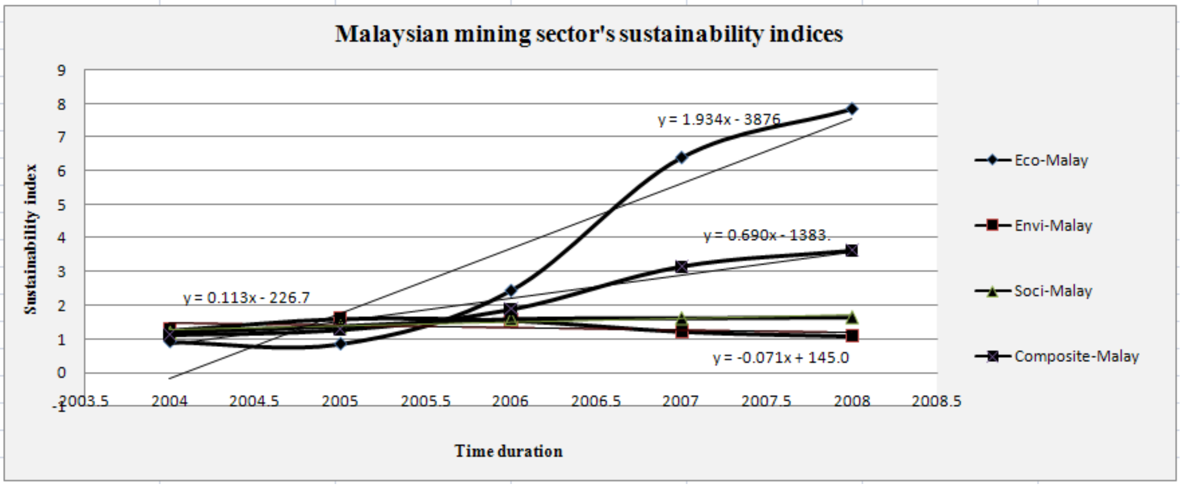


Figure 4.33 Sustainability index for the mining sector in Malaysia

4.9.3.3 Sustainability index for the mining sector of the Philippines

a. The Philippines' mining economic performance

Benefitted by rich mineral deposits, the Philippines is one of the world's most highly mineralized economies, with an untapped mineral wealth estimated at more than $840 billion. The Philippine deposits of copper, gold, and chromate are among the largest in the world. Other important minerals include nickel, silver, coal, gypsum, and sulfur. The Philippines also has significant deposits of clay, limestone, marble, silica, and phosphate.

The Philippines mining economic aspect has been toward sustainable development, with the positive rate of 0.109 (Figure 4.34). The main reason for the move is due to improvement in the Philippines's investment regulations. For example, a Supreme Court decision upheld the constitutionality of the 1995 Mining Act, thereby allowing up to 100% foreign-owned companies to invest in large-scale exploration, development, and utilization of minerals.

b. The Philippines' mining environmental performance

In contrast to the development trend and the increasing amount of funds for mine closures and reclamation, the Philippine's mining activities have incurred significant negative impacts to environment and society. The reasons may also be due to the serious disasters and calamities frequently happening in this country. In any case, the SDMI shows that the environment aspect of the Philippines' mining sector has been unstable, with a backward sustainable development rate of -0.001.

c. The Philippines' mining social performance

The number of fatalities in the mining sector has dramatically and annually increased. Based on these factors, the progress of sustainable development for the social aspect has decreased during 2004–2008, at a rate of -0.0006.

d. Sustainability performance of the Philippines' mining sector

Even though the final sustainability index for the Philippines' mining sector is still toward sustainable development (Figure 4.34), how to reduce the negative impacts on the environment and social benefits is still challenging not only for the Philippines but also for international mining enterprises.

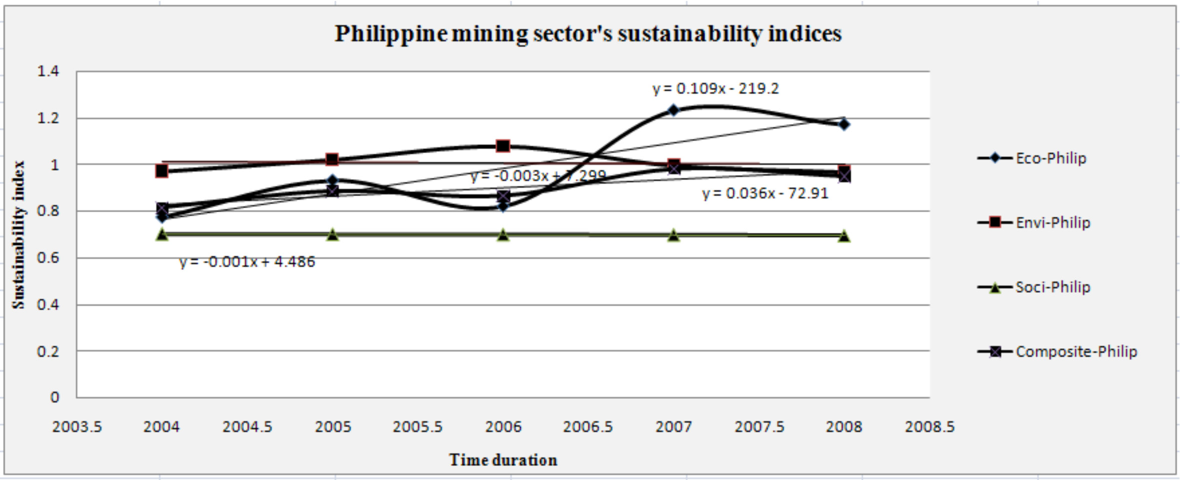


Figure 4.34 Sustainability index for the mining sector of the Philippines

4.9.3.4 Sustainability index for the mining sector in Thailand

a. Thailand's mining economic performance

Because of the slowly increasing FDI inflow and the national budget, Thailand's mining economic aspect has been slowly moving toward sustainable development, with a positive rate of 0.175 shown in the model (Figure 4.35).

b. Thailand's mining environmental performance

The Thailand's mining-environment aspect has been moving step-by-step towards sustainable development, with the slightly positive rate of 0.023.

c. Thailand's mining social performance

The number of fatalities has been slowly decreasing since 2008; thus, Thailand's mining social aspect has been slowly moving toward sustainable development, with a positive rate of 0.185.

d. Sustainability performance of Thailand's mining sector

The development rate of 0.129 for sustainable development, shown by the SDMI model, demonstrates that the Thai mining performance has been moving toward sustainable development. If the country pays more attention to social satisfaction, it is likely that this developmental trend will continue to improve relative to other countries.

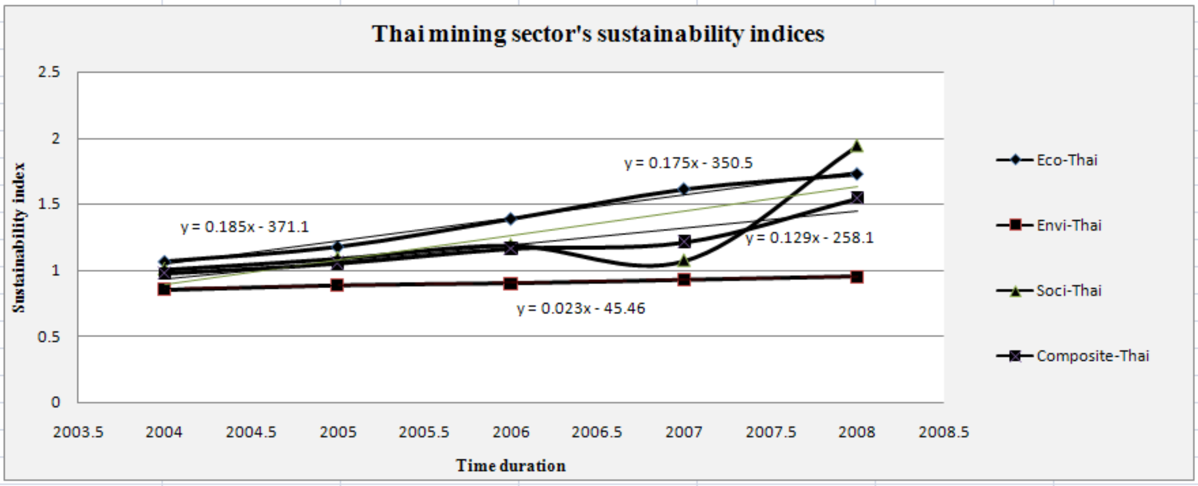


Figure 4.35 Sustainability index for the mining sector in Thailand

4.9.2.2.5 Sustainability index for the mining sector in Viet Nam

a. Viet Nam's mining economic performance

Viet Nam is rich in mineral resources with approximately 5,000 deposits and 60 types of minerals, mainly located in the north; with large reserves of anthracite coal, phosphates, high-grade chromite, tin, antimony, bauxite, gold, iron ore, lead, tungsten, zinc, and lime. The mining industry has contributed more than 10% of the government's annual revenue. Moreover, resulting from an improvement in investment policy, the FDI inflow of Viet Nam has dramatically increased since 2005. Recently, the increasing involvement of foreign companies in the Vietnamese mineral sector has accelerated the development of high-value, export-orientated minerals, especially as some of the neighboring economies (notably Japan and Korea) lack mineral resources. Thus, the Vietnamese mining economic aspect has been strongly moving toward sustainable development, with a highly positive rate of 0.105 (Figure 4.36).

b. Viet Nam's mining environmental performance

As a developing country, the concept of sustainable development has been but recently considered in the mining sector. In general, most mining business activities in Viet Nam are medium and small scale. As such, it is quite difficult for the government to mandate management and implementation policies; hence, it is thought that the available data has not accurately reflected the real environmental situation of the mining sector in Viet Nam. Here, however, the SDMI model shows that Viet Nam's mining environment aspect has been moving toward sustainable development, with a positive rate of 0.077 (Figure 4.36).

c. Viet Nam's mining social performance

Resulting from small-scale operations in addition to a lack of safety awareness and advanced technologies, serious work safety problems have been threatening community health. As such, the progress towards sustainable development in terms of the social aspects of the mining sector has been slowly decreasing, at a rate of -0.04.

d. Sustainability performance of Viet Nam's mining sector

Even though the Vietnamese mining industry has been slowly moving toward sustainable development; how to manage operations and find a balance between economic benefits and the effects on environment and society is still a serious challenge for Viet Nam.

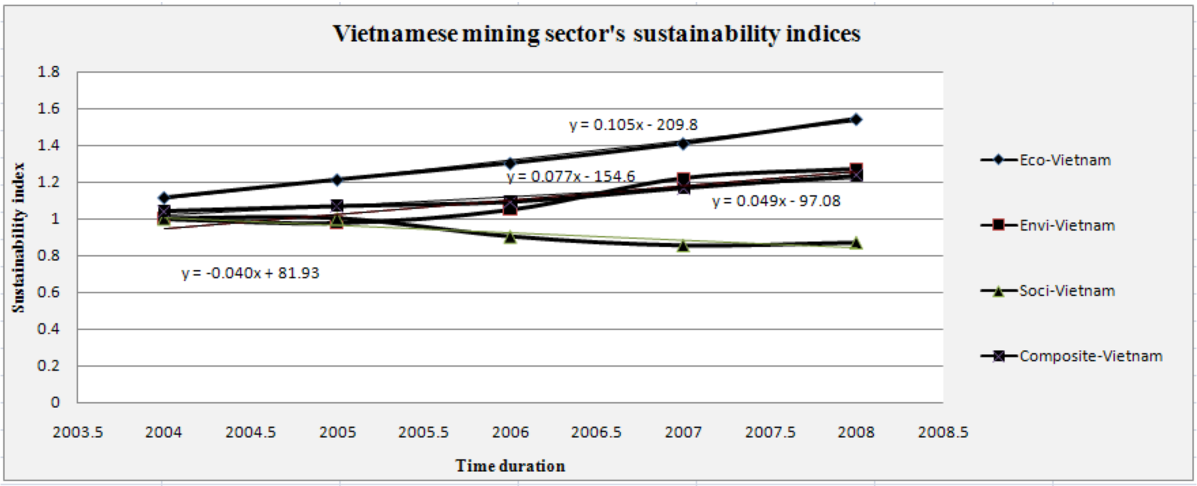


Figure 4.36 Sustainability index for the mining sector in Viet Nam

4.9.4 Summary

a. SDMI model

1) AHP is the most appropriate approach for developing a comprehensive framework of sustainability criteria for the mining sector.
2) Utilizing fuzzy logic and fuzzy AHP is an appropriate and innovative approach for deriving the priorities of components, because they could deal with the primary criticisms of classical AHP—the inability to handle uncertain and imprecise decision-making problems.
3) The greater the number of indicators considered, the more appropriate the index could reflect reality.

b. SDMI applications

1) The SDMI model was developed and applied to the case studies of APEC economies. The model showed reasonable results for each member and the whole of the APEC region's mining sectors. However, to make the outputs more accurate requires the cooperation of governments in allowing the input of believable data.
2) The sustainable development index stands for the overall view of development trend. Thus, to assess the sustainability of one economic sector, we should consider the development trend in a time-based series of inputs.
3) With respect to the comparison of the sustainability indices among a number of given representatives; we cannot compare by index vs. index, so we compare the development trend represented by the angular coefficient of linear fitting of the sustainability index.
4) The mining sector of APEC has been strongly moving toward sustainable development and will keep do so in the near future, but maintaining this movement requires cooperation among all group members to reach sustainable development for the whole APEC region.

4.10 Recommendations on practical applications of sustainable development initiatives relating to mining and mine closure in developing economies

In the overall picture of mine closure laws, regulations, and guidelines of APEC economies, most economies have put requirements for mine closure in the relevant mining law, and/or its associated implementation rules and regulations (IRRs) for the mining laws, or within specific environmental legislation pertaining to the mining sector. However, awareness of the need for mine closure regulation has increased, and APEC economies are now in the process of developing legislation and policies. Examples of pending guidelines for mine closures are Mexico and Chile. Mexico does not have detailed reclamation legislation, but it has national environmental laws and is currently developing more specific mine closure requirements. For instance, guidance for the construction, operation, and closure of tailings impoundments was provided in a national regulation promulgated in 2003 (NOM-141-SEMARNAT-2003) (Garcia, 2003). And Chile has proposed a mine closure law that is still pending approval. The law includes requirements for technical work plans, public disclosure, and provision for financial assurance.

According to the absence of well-defined closure regulations, developing countries may decide to use mine closure guidance from international resources such as the World Bank and the International Finance Corporation, as well as prominent national, state, or province specific legislations. For the developing economies in APEC, the author would like to recommend the applicable international guidelines for mine closures from the World Bank and the International Finance Corporation, in addition to the United Nations and the International Council of Mining and Metals (ICMM).

4.10.1 World Bank and International Financial Corporation

There are two guidelines from the World Bank and International Financial Corporation (IFC) that are recommended for the management of mine closures in APEC-region developing economies, including the *Environmental Health and Safety Guidelines for Mining* (EHS) and *Guidance Notes for the Implementation of Financial Surety for Mine Closure*.

4.10.1.1 Environmental, Health, and Safety Guidelines for Mining

(http://www.ifc.org/ifcext/sustainability.nsf/Content/EHSGuidelines)

The EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). The guidelines are normally applied as required when one or more members of the World Bank Group are involved in a project. The guidelines for mining are applicable to underground and open-pit mining, alluvial mining, solution mining, and marine dredging. The guidelines are divided into three types of mining: coal mining and production, base metal and iron ore mining, and mining and milling underground.

4.10.1.1.1 Environmental aspect

The guidelines on environmental issues associated with mining activities include the following recommended management strategies and practices:

4.10.1.1.1.1 Water use and quality

Emissions and effluent guidelines for mining

Table 4.14 presents effluent guideline values for process effluents, which are indicative of GIIP as reflected in the relevant standards of countries with recognized regulatory frameworks. Effluent guidelines should applied to site runoff, treated effluent, and surface water for general use. Site-specific discharge levels may be established based on the availability and conditions in the use of publicly operated sewage collection and treatment systems or if discharged directly into surface water.

Table 4.14 Effluent guidelines (IFC, 2007).

Pollutants	Units	Guideline Value
Total Suspended Solids	mg/L	50
pH	S.U.	6 – 9
COD	mg/L	150
BOD_5	mg/L	50
Oil and Grease	mg/L	10
Arsenic	mg/L	0.1
Cadmium	mg/L	0.05
Chromium (VI)	mg/L	0.1
Copper	mg/L	0.3
Cyanide	mg/L	1
Cyanide Free	mg/L	0.1
Cyanide WAD	mg/L	0.5
Iron (total)	mg/L	2.0
Lead	mg/L	0.2
Mercury	mg/L	0.002
Nickel	mg/L	0.5
Phenols	mg/l	0.5
Zinc	mg/L	0.5
Temperature	ºC	<3 degree differential
Note: Metals concentrations represent total metals.		

4.10.1.1.1.2 Wastes and hazardous materials

Tailings management strategies

Tailing management strategies should consider how tailings will be handled and disposed of during operation, in addition to their permanent storage after decommissioning.

- A Guide to the Management of Tailings Facilities (1998), and Developing and Operations, Maintenance and Surveillance Manual for Tailings and Water Management Facilities (2003) by the Mining Association of Canada (http://www.mining.ca) are referred as recommendations on strategies considering site topography, downstream receptors, and the physical nature of tailings (e.g., projected volume, grain size distribution, density, water content).
- International Commission on Large Dams (ICOLD) (http://www.icold-cigb.net) and the Australian National Committee on Large Dams (ANCOLD) (http://www.ancold.

org.au/) are recommended for the design, construction, operation, maintenance, and ongoing monitoring of both the structure and water quality, during both operation and decommissioning.

Waste geochemical characterization

Mining operators should prepare and implement ore and waste characterization methods for proper routing of potential-acid-generating materials and acid rock drainage (ARD). Recommended international methodologies for evaluating ARD potential in all formations should be referred to: Acid Mine Drainage Prevention and Mitigation by the Office of Surface Mining, U.S. Department of Interior (http://www.osmre.gov/amdpvm.htm), and the Policy for Metal Leaching and Acid Rock Drainage at Mine Sites in British Columbia (BC MEM 1998) (www.em.gov.bc.ca/Mining/MinePer/ardpolicy.htm).

Hazardous materials

Detailed guidance for hazardous materials management including spill prevention and control planning for the handling, storage, and transport of materials as fuels and chemicals is provided in the General EHS Guidelines for Hazardous Material Management (http://www.ifc.org/ifcext/sustainability.nsf/Content/EHSGuidelines).

4.10.1.1.1.3 Land use and biodiversity

The protection and conservation of biodiversity is fundamental to attaining sustainable development. Integrating the conservation needs of local communities is often a critical issue for mining projects. The EHS Guidelines provide recommended management strategies for terrestrial, aquatic, and marine habitats, in which the information was obtained from such international organizations as:

- *Integrating Mining and Biodiversity Conservation-Case Studies from around the world* (IUCN and ICMM, 2004) and *Good Practice Guidance for Mining and Biodiversity* (ICMM, 2006) for terrestrial management,
- Assessment and management of marine impacts should be in compliance with applicable host country commitments to international conventions, including the United Nations Convention on the Law of the Sea (1982) (http://ewww.un.org/Depts/los/index).

4.10.1.1.1.4 Air quality

Air emissions and ambient air quality guidelines

Emissions should not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards, based on nationally legislated standards, or in their absence. The World Bank and IFC recommend several applicable guidelines related to air emissions from mining, such as:

- World Health Organization (WHO) Air Quality Guidelines (see Table 4.15),
- United States National Ambient Air Quality Standards (NAAQS) (heep://www.epa.gov/air/criteria.html),

- European Council Directives (Council Directive 1999/30/EC of 22 April 1999, Council Directive 2002/3/EC of February 12, 2002).

Table 4.15 WHO Ambient Air Quality Guidelines (IFC, 2007).

	Averaging Period	Guideline value in µg/m³
Sulfur dioxide (SO_2)	24-hour 10 minute	125 (Interim target-1) 50 (Interim target-2) 20 (guideline) 500 (guideline)
Nitrogen dioxide (NO_2)	1-year 1-hour	40 (guideline) 200 (guideline)
Particulate Matter PM_{10}	1-year 24-hour	70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3) 20 (guideline) 150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 50 (guideline)
Particulate Matter $PM_{2.5}$	1-year 24-hour	35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3) 10 (guideline) 75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 25 (guideline)
Ozone	8-hour daily maximum	160 (Interim target-1) 100 (guideline)

4.10.1.1.1.5 Noise and vibrations

Noise guideline levels

Guideline levels of noise occurring due to mining activities are referred to the WHO Guidelines for Community Noise, 1999. Noise impacts should not exceed the levels presented in Table 4.16, or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

Table 4.16 Noise level guidelines (IFC, 2007).

Receptor	One Hour L_{Aeq} (dBA)	
	Daytime 07:00 - 22:00	Nighttime 22:00 - 07:00
Residential; institutional; educational[55]	55	45
Industrial; commercial	70	70

4.10.1.1.1.6 Energy use

The most significant energy consuming activities in mining are transport, exploration, drilling, excavation, extraction, grinding, crushing, milling, pumping, and ventilation processes. Recommended energy conservation measures include the following:

- use non-invasive technologies such as remote sensing and ground-based technologies to minimize exploratory digging and drilling; and
- use correctly sized motors and pumps in excavation, ore moving, ore crushing, and ore handling processes, as well as use adjustable speed drivers (ASDs) in applications having highly varying load requirements.

4.10.1.1.1.7 Visual impacts

Potential contributors to visual impacts include high walls, erosion, discolored water, haul roads, waste dumps, slurry ponds, abandoned mining equipment and structures, garbage and refuse dumps, open pits, and deforestation.

Mining operations should prevent and/or minimize negative visual impacts through consultation with local communities about potential post-closure land use, and by incorporating visual impact assessments into the mine reclamation process.

Reclaimed land should conform to the visual aspects of the surrounding landscape. The reclamation design and procedures should take into consideration the proximity to public viewpoints and the visual impact within the context of the normal viewing distance.

Mitigation measures may include strategic placement of screening materials, including trees and the use of approximate plant species in the reclamation phase, as well as modification of the placement of ancillary facilities and access roads.

4.10.1.1.2 Occupational health and safety

Mining activities should provide an operation where people are able to work without being injured and where the health of the workforce is promoted.

Facility-specific occupational health and safety hazards should be identified based on a job safety analysis or comprehensive hazard identification study (HAZID), hazard and operability study (HAZOP), or quantitative risk assessment (QRA).

Health and safety management planning should include the adoption of a systematic and structured approach for the prevention and control of physical, chemical, biological, and radiological health and safety hazards described in the General EHS Guidelines (http://www.ifc.org/ifcext/sustainability.nsf/Content/EHSGuidelines).

Information on occupational health and safety issues occur during all phases of the mine cycle has been classified into the following categories:

- General workplace health and safety
- Hazardous substances
- Use of explosives
- Electrical safety and isolation
- Physical hazards
- Ionizing radiation
- Fitness for work

- Travel and remote site health
- Thermal stress
- Noise and vibration
- Specific hazards in underground mining (fires, explosions, confined spaces and oxygen deficient atmospheres)

4.10.1.1.3 Community health and safety

Issues that may be associated with community health and safety in mining are transport safety along access corridors, transport and handling of dangerous goods, impacts on water quality and quantity, inadvertent development of vector breeding sites, and potential for transmission of communicable diseases (e.g., respiratory and sexually transmitted infections resulting from an influx of project labor). Significant household and community level issues can affect the social determinants of health (e.g., drug, alcohol, gender harassment, and other psychosocial effects). However, non-communicable diseases such as hypertension, diabetes, obesity, and cardiovascular disorder can affect large mining communities in which the positive economic impact is high.

Specific concerns to mining activities, with community health and safety implications are described in the following sections.

4.10.1.1.3.1 Tailings dam safety

4.10.1.1.3.2 Water storage dams

Water storage dams may create a breeding site for mosquitoes, snails, and parasitic diseases.

4.10.1.1.3.3 Land subsidence

Recommendations for the management of land subsidence include:

- Development of the mine with consideration of the location/size of the ore body, overlying strata, and required well depths for extraction;
- Monitoring the size and shape of mined caverns using well logging devices and modern operating techniques;
- Filling shafts, raises, stope openings, audits, and drift openings to the surface with reinforced concrete or with other material to prevent subsidence in high risk areas; and
- Subsidence areas should be managed to ensure adequate drainage and re-established to previous land use or another use acceptable to the community. Roads in such areas should be sign-posted adequately.

4.10.1.1.3.4 Emergency preparedness and response

An Emergency Response Plan should be prepared in accordance with the guidance of the UNEP APPEL for Mining: Awareness and Preparedness for Emergencies at the Local Level process (Technical Report No. 41). The report provides a framework for the preparation of an Emergency Response Plan involving the mine, emergency response agencies, local authorities, and communities.

4.10.1.1.3.5 Communicable diseases

Project housing and catering facilities and services should be designed and maintained according to internationally accepted standards such as the Hazard Analysis Critical Control Point (HACCP) standards in order to reduce the potential for transmission of food related illness from the project to the community.

Significant pre-existing burdens of sexual transmitted diseases including HIV/AIDS should be considered when developing a mining project—especially in developing countries. The hallmark of this situation is referred to as the Four M's:

- Men: labor influx;
- Money: surge in disposable cash;
- Movement: development of new transport routs facilitating access to rural communities;
- Mixing: interface between high prevalence rate groups (e.g., police, security, truckers and sex workers) with local low prevalence rate men and women.

Over time, the spread of HIV/AIDS is not only a cause of human misery and suffering, but can also cause negative effects to the company in terms of staff turnover, declining productivity, increasing costs, changing markets, and access to contracts and procurement opportunities. Mining operations should define and understand the potential effect of HIV/AIDS, and design appropriate management responses, including the application of:

- Strategies to manage the impact of the disease through assessment, surveillance, action plans, and monitoring;
- A workplace program to prevent new HIV infections and provide care and support for infected and affected employees; and
- Outreach activities within the community, sector, and/or broader society.

4.10.1.1.3.6 Specific vector control and prevention strategies

Project sponsors, in close collaboration with community health authorities, should implement an integrated control strategy for mosquitoes and other arthropod-borne diseases.

4.10.1.1.4 Mine closure and post-closure

Closure and post-closure activities should be considered as early in the planning and design stages as possible. Mine sponsors should prepare a Mine Reclamation and Closure Plan (MRCP) in draft form prior to the start of production, clearly identifying allocated and sustainable funding sources required for implementing the plan. For short-life mines, a fully detailed Mine Reclamation and Closure Plan (with guaranteed funding) as described below should be prepared prior to the start of operations. A mine closure plan that incorporates both physical rehabilitation and socio-economic considerations should be an integral part of the project life cycle and should be designed so that:

- future public health and safety are not compromised;
- the after-use of the site is beneficial and sustainable to the affected communities in the long term; and
- adverse socio-economic impacts are minimized and socio-economic benefits are maximized.

The MRCP should address beneficial future land use, which should be determined using a multi-stakeholder process, and includes regulatory agencies, local communities, traditional land users, adjacent leaseholders, civil society, and other impacted parties. The plan should have the prior approval of the relevant national authorities, and be the result of consultation and dialogue with local communities and their government representatives.

The closure plan should be regularly updated and refined to reflect changes in mine development and operational planning, as well as reflect the current environmental and social conditions and circumstances. Records of the mine works should also be maintained as part of the post-closure plan.

Closure and post-closure plans should include appropriate aftercare and continued monitoring of the site, pollutant emissions, and related potential impacts. The duration of post-closure monitoring should be defined on a risk basis; however, site conditions typically require a minimum period of five years or longer after closure.

Timing for the finalization of the MRCP is site specific and depends on many factors, such as the potential mine life. However, all sites need to engage in some form of progressive restoration during operations. While plans may be modified, as necessary, during the construction and operational phases, plans should include contingencies for temporary suspension of activities and permanent early closure, and meet the following objectives for financial feasibility and physical/chemical/ecological integrity.

4.10.1.1.5 Financial feasibility

The costs associated with mine closure and post-closure activities, including post-closure care, should be included in business feasibility analyses during the planning and design stages. Minimum considerations should include the availability of all necessary funds, by appropriate financial instruments, to cover the cost of closure at any stage in the mine life, including provision for early or temporary closure. Funding should be by either a cash accrual system or a financial guarantee. The two acceptable cash accrual systems are fully funded escrow accounts (including government-managed arrangements) or sinking funds. An acceptable form of financial guarantee must be provided by a reputable financial institution. Mine closure requirements should be reviewed on an annual basis and the closure funding arrangements adjusted to reflect any changes.

4.10.1.1.6 Performance indicators and monitoring

4.10.1.1.6.1 Environment

Emission and effluent guidelines

As mentioned in Table 4.14, effluent guidelines should be applied for any site runoff and treated effluent that is to be discharged into surface water for general use. Site-specific discharge levels may be established based on the availability and conditions in the use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification as described in the General EHS Guidelines.

Environmental monitoring

Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project. In some mining projects, monitoring should extend for a minimum period of three years after closure or longer if site conditions warrant. The frequency of monitoring should be sufficient to provide representative data for the parameters being monitored.

4.10.1.1.6.2 Occupational health and safety performance

Occupational health and safety guidelines

Applicable internationally published exposure guidelines recommended for use as an evaluation of occupational health and safety performances include:

- *Threshold Limit Value* (TLV®) *Occupational Exposure Guidelines* and *Biological Exposure Indices* (BEIs®) published by the American Conference of Governmental Industrial Hygienists (ACGIH);
- *The Pocket Guide to Chemical Hazards* published by the United States National Institute for Occupational Health and Safety (NIOSH);
- *Permissible Exposure Limits* (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA); and
- *Indicative Occupational Exposure Limit Values* published by the European Union member states, or other similar sources.

Accident and fatality rates

Projects should try to reduce the number of accidents among workers to a rate of zero. Fatality rates may be benchmarked against the performance of facilities in this sector in developed countries, via consultation with published sources (e.g., the U.S. Bureau of Labor Statistics and the UK Health and Safety Exclusive).

Occupational health and safety monitoring

Monitoring should be designed and implemented by accredited professionals that may include Certified Industrial Hygienists, Registered Occupational Hygienists, Certificated Safety Professionals, or their equivalent. Additional guidance on occupational health and safety monitoring programs is provided in the General EHS Guidelines.

4.10.1.2 Guidance notes for the implementation of financial surety for mine closure

The guidelines provided by the World Bank and IFC aim to provide the information necessary to assist governments in making their own informed decisions regarding financial surety for mine closure. The report is based on a review of existing financial surety systems in a number of countries. The author has summarized the important parts of the guidelines related to the financial surety. Detailed information can be found at http://siteresources.worldbank.org/INTOGMC/Resources/financial_surety_mine.pdf.

The latest IFC (World Bank) Environmental, Health, and Safety Guidelines for Mining (2007) state that mine closure and post-closure should be included in the business feasibility at the design stage, with the minimum consideration being the availability of funds to cover the cost of closure. These funds should be established by a cash accrual system or financial guarantee.

4.10.1.2.1 Standards that should be taken into consideration when establishing financial surety

The standards that should be taken into consideration when establishing financial surety procedures are summarized as follows (Da Rosa, 1999):

Closure costs: Financial assurances must cover the operator's cost of reclamation and closure as well as redress any impacts that a mining operation causes to wildlife, soil, and water quality. The bond should also cover the cost of a post-closure monitoring period. To accurately compute the level of financial assurance, reclamation and mitigation activities should be clearly spelled out in the operation plan. In addition, the bond should cover the costs of addressing impacts that stem from the operator's failure to complete reclamation, such as the need for the long-term treatment of surface and ground water, environmental monitoring, and site maintenance. During mining, assurance levels should be subject to periodic reviews, in order to allow regulators to adjust operators' assurance amounts upward or downward as clean-up needs, environmental risks, or economic factors dictate.

Liquidity: All forms of financial assurance should be reasonably liquid. Cash is the most liquid asset, but high-grade securities, surety bonds, and irrevocable letters of credit can serve as acceptable forms of assurance. However, assets that are less liquid, particularly the mine operator's own property or equipment should not be considered adequate assurance, since these items may quickly become valueless in the event of an operator default or bankruptcy.

Accessible: Financial assurances should be readily accessible, dedicated, and only released with the specific assent of the regulatory authority, so that regulators can promptly obtain funding to initiate reclamation and remediation in case of operator default. Forms of financial assurance should be payable to regulators, under their control or in trust for their benefit, and earmarked for reclamation and closure. Furthermore, such financial assurances must be discreet legal instruments or sums of money releasable only with the regulatory authority's specific consent.

For their part, regulators must obtain financial assurance up front before a mine project is approved. While regulators, as determined by their periodic reviews, must have the authority to secure financial assurance during the course of mining, waiting until late in the mining process to obtain substantial assurance is unwise, since reduced cash flows at this stage may make it difficult for operators to secure bonding from a surety, bank, or other guarantor.

Healthy guarantors: To assure that guarantors have the financial capacity to assume an operator's risk of not performing its reclamation obligations, regulators must carefully screen guarantors' financial health before accepting any form of assurance. Any risk-sharing pools should also be operated on an actuarially sound basis. Regulators should require periodic certification of these criteria by independent third parties.

Public involvement: Since the public runs the risk of bearing the environmental costs not covered by an inadequate or prematurely released bond, the public must be accorded an essential role in advising authorities on setting and releasing of bonds. Therefore, regulators must give the public notice and an opportunity to comment both before the setting of a bond amount and before any decision on whether to release a bond.

No substitute: Any financial assurance should not be regarded as a surrogate for a company's legal liability for clean-up, or for the regulators' application of the strictest scrutiny and standards to the proposed mining plans and operations. Rather, a financial assurance is only intended to provide the public with a buffer against having to shoulder the costs for which the operator is liable.

4.10.1.2.2 Financial surety instruments

The most commonly used forms of financial surety are letters of credit, surety bonds, trust funds, and cash. Success of any financial surety instrument depends on the care and effort put into setting it up and managing it. Most will work if they are done properly.

A Letter of Credit (Bank Guarantee) is the most frequently used type of financial surety instrument. These are acceptable to the industry because they are relatively cheap to set up and they are attractive to governments because there are fewer administrative requirements. However, obtaining a Letter of Credit may reduce the borrowing power of a company.

Surety Bonds have many similar attributes to the Letter of Credit and are attractive to smaller companies as they do not involve tying up capital. However, the long-term viability of the insurance company providing the bond should be taken into consideration.

Trust Funds are more visible and often better understood than other forms of financial surety. Any surpluses created in the fund can be returned to the proponent with more ease but, if they are invested, there is the possibility that the value of the fund will fall. It can be difficult to ensure that their value stays in line with the rehabilitation obligations. Trust Funds are more available to smaller mining companies, which often do not have sufficient assets to satisfy the requirements for a Letter of Credit or Surety Bond.

Cash also provides an attractive option for smaller companies (see Trust Fund) and the money can earn interest and thereby keep ahead of inflation. There are no delays in getting access to the money and no need to retrieve the entire fund if only part is required. Cash is also easier to place in a pooled fund. However, a cash fund may be more accessible to misappropriation. There is also the risk that, should the mining company become bankrupt, any cash deposits will be recovered by the receiver.

A Company Guarantee is the financial instrument of choice of mining companies due to the lack of cost and paperwork involved. However, they do tend to fail because the time when the money is most needed is often when the company is not able to deliver. They are also unpopular with the public, which does not hold the mining industry in very high regard and therefore does not trust this form of financial surety. This type of financial surety instrument is only acceptable for large, well-established companies, and can therefore be seen as being a disadvantage to smaller operations.

Insurance Schemes are currently not available to the mining industry outside of the USA.

A Unit Levy & Pledge of Assets are increasingly unlikely to be accepted as financial surety instruments because of the uncertainty of the fund meeting the rehabilitation requirements.

A Fund Pool & Transfer of Liability are not widely available and generally not recommended.

The choice of financial surety instrument will depend on the record of accomplishment and financial strength of the proponent, the level of surety required, and the period of time it is necessary. It is essential that the financial surety can be converted into cash quickly and reliably and that it can only be used for the purpose for which it was designed. It is also essential that the financial surety be quarantined from other company assets, so that it cannot be seized in the event of bankruptcy, or from government abuse. In some instances, a combination of financial surety instruments may prove to provide the best coverage.

Among APEC developing economies, the Philippines, Indonesia, and Vietnam have adopted financial surety requirements to mine closures and reclamation. Chile has put the requirement for financial assurance in their new proposed Mining Law, which is currently in the approval process.

4.10.2 The United Nations Guidelines

4.10.2.1 Mining Closure: Policies and Guidelines for Sustainable Mining Practice and Closure of Mines

UNEP, UNDP, OSCE, and NATO (2005) published a report entitled: *Mining for Closure: Policies and Guidelines for Sustainable Mining Practice and Closure of Mines* for Southeast Europe and within the Tisza River Basin (http://www.grida.no/_res/site/file/publications/envsec/mining-for-closure_src.pdf). The report suggests the following principles be used to guide the management of mining and support work with abandoned mining sites:

In order to prepare a mine for closure, jurisdictions, policies, and work approaches should be:

Consistent: Mine closure requirements and procedures should be consistent with those in place in other territories of the region. This is particularly important where two countries share trans-boundary risks.

Centralized: Governments should strive for an independent mine closure law that establishes a single agency for implementation.

Strict: Legislation should apply the polluter pays principle strictly and should ensure that the owner or operator of a mining operation be held responsible for the execution and completion of successful reclamation.

Financially assured: Legislation should provide that (particularly for new operations and operations with considerable lifespan remaining) financial assurance is provided to ensure successful reclamation.

Long-term financed: Where conditions requiring long-term care exist, the funding of long-term care and management should be included in the assurance. However, government legislation should explicitly provide that at a certain moment the company can be relieved of future liabilities for the site.

Temporary bounded: The operator should be responsible until the relief of liability for the cases in which long-term care is involved. Amenable temporal bounds of such liability should be included in agreements. This requires that care should be long-term financed.

Low hazard and viable: Viable, rather than only self-sustaining ecosystems that are compatible with a healthy environment & human activities and are low hazard should be left post-mining. Measures to address and prevent ongoing pollution from the site should be in place.

Considered and flexible: The target condition of a mining site should be carefully considered in the light of long-term environmental stability, but not in the absence of social and economic uses that can contribute to making it safe. All-encompassing requirements to return a site to its original condition or to a condition permitting a maximum range of land uses may be inappropriate. Jurisdictions should be flexible in devising solutions that match site-specific needs in terms of the types of mining operation, climate, topography, the sensitivity of the surrounding environment, and social requirements, and which deliver outcomes consistent with sustainable development principles and objectives.

Synergistic: Synergies between actors, particularly actors with the capacity to provide rehabilitation services at the lowest cost, should be pursued. This may be achieved by providing incentives for the current industrial actors to provide expertise, equipment, supplies, and/or personnel to support government funding in addressing legacies.

Elastic: Innovative, flexible, and forgiving frameworks for indemnification against potential liabilities should be sought, particularly in situations where this may provide the necessary incentives for multi-stakeholder participation in reclamation/rehabilitation works.

Reasonable: There must be recognition that insistence on protection against extremely unlikely events will impose excessive costs and consequently investment incentives may be significantly reduced. Reasonable approaches must be applied when jurisdictions seek assurance against the possibility of loss or damage to the environment.

Creative: In situations where the mine is only marginally profitable or is approaching the end of its life, a creative approach to the design of the instrument may be called for.

Incentive-based and tax-balanced: Taxation or royalty regimes of the country should recognize that financial assurance imposes some costs on the operator. This should be balanced to ensure that sustainable development objectives are assured.

4.10.3 Guidelines from the International Council on Mining and Metals

4.10.3.1 Planning for Integrating Mine Closure: Toolkit

In 2007–2008, the International Council on Mining and Metals (ICMM) developed a report entitled: *Planning for How to Integrate a Mine Closure: Toolkit* (http://www.icmm.com/page/9568/planning-for-integrated-mine-closure-toolkit), which provides practical guidance for key challenges to closing a mine in a sustainable manner. It covers the entire mine life cycle and brings together existing tools (e.g., the ICMM Community Development Toolkit) and new ones. Thirteen toolkits were designed primarily for people who manage and implement mine closures. These tools provide the practitioner with practical work processes, examples, and contexts to apply to the closure planning discipline. A list of the toolkits with their available web links are presented as follows:

Tool 1: Stakeholder engagement (http://www.e3mining.com/index.cfm)
Tool 2: Community development (http://www.icmm.com/library_pub_detail.php?rcd=183)
Tool 3: Company/Community interactions to support integrated closure planning
Tool 4: Risk/Opportunity assessment and management
(http://www.cqurire.com/htm/paper/risk/Aust_Standards_4360-2004.pdf)
Tool 5: Knowledge platform mapping
Tool 6: Typical headings for contextual information in a conceptual closure plan
Tool 7: Goal setting
Tool 8: Brainstorming support table for social goal setting
Tool 9: Brainstorming support table for environmental goal setting
Tool 10: Cost risk assessment for closure
Tool 11: Change management worksheet
Tool 12: The domain model
Tool 13: Biodiversity management

In addition, the concept of closure planning is shown in Figure 4.37. The life cycle of mining has been characterized as eight phases, including: exploration, prefeasibility, feasibility (including planning and design), construction, operation, decommissioning, closure, and post-closure (which may include relinquishment of tenure and liability). Application of tools during life cycle of mining is summarized in Figure 4.38.

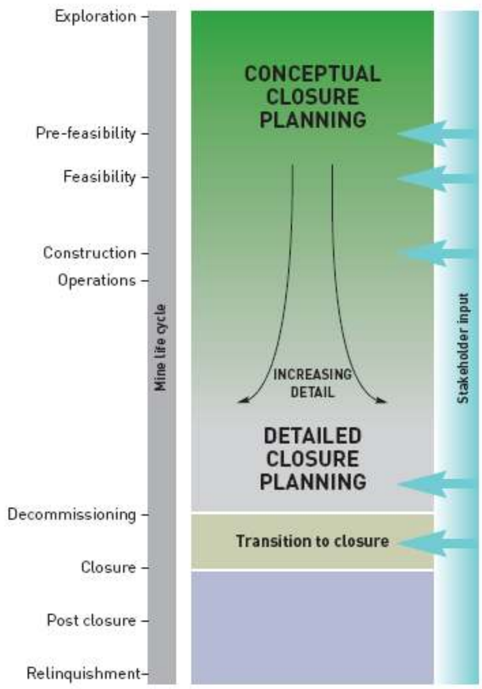


Figure 4.37 Closure planning (ICMM, 2010)

The guidelines have suggested that positive outcomes of effective closure planning should mean that

- engagement with affected and interested parties will be more consistent and transparent,

- communities will participate in planning and implementing actions that underpin successful closure,
- closure decisions will be better supported by stakeholders,
- planning for closure will become easier to manage,
- the accuracy of closure cost estimates will be improved,
- the risk of regulatory non-compliance will be minimized,
- potential problems will be identified in a timely manner,
- there is more likely to be adequate funding for closure,
- potential liabilities will be progressively reduced, and
- opportunities for lasting benefits will be recognized and planned for adequately.

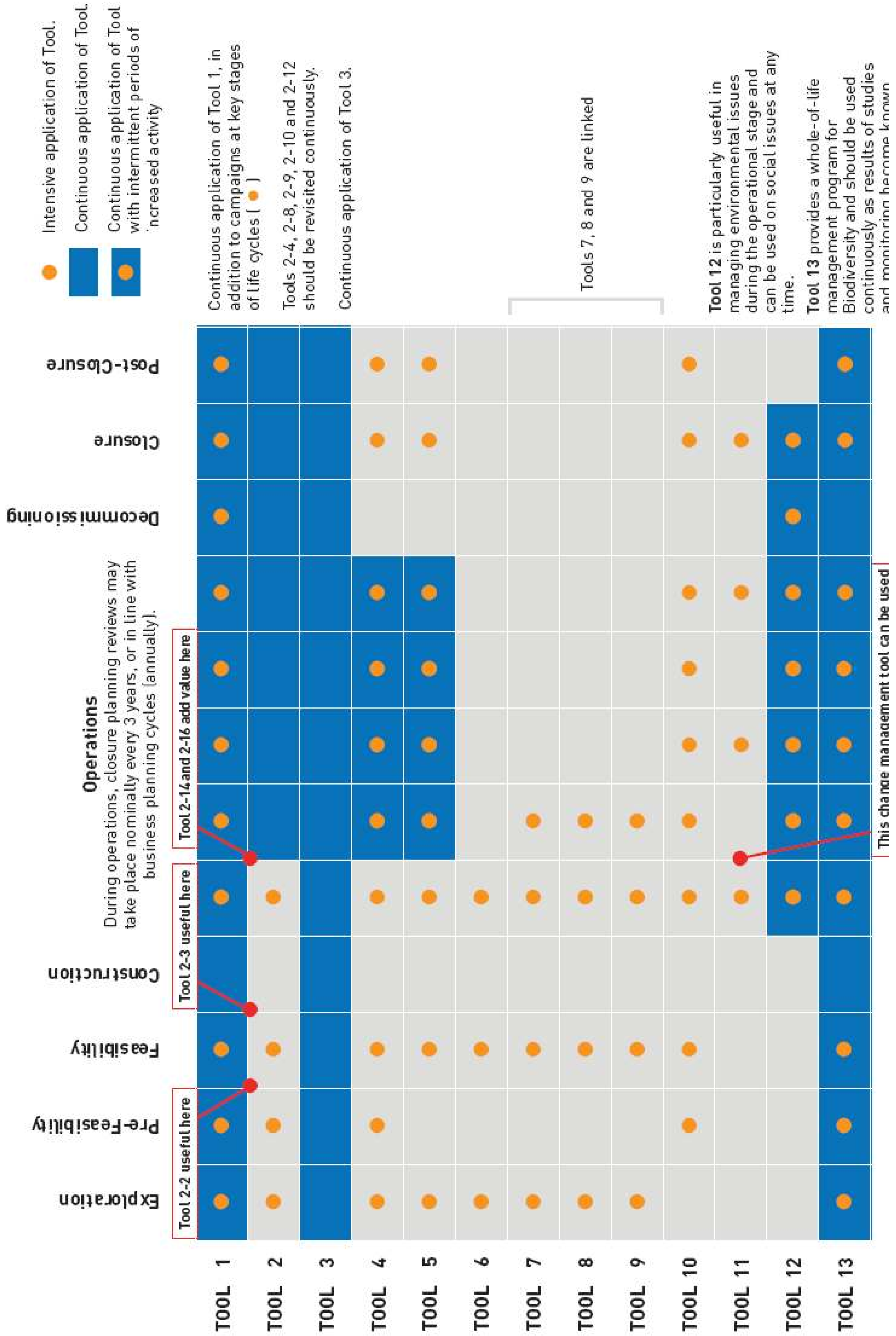


Figure 4.38 Application of tools during the life cycles of mining facilities (ICMM, 2010)

4.10.3.2 Summary

Internationally accepted guidelines from international organizations including the World Bank and IFC, the United Nations (UNEP) and ICMM have been recommended to APEC developing economies in order to attain a level of sustainable development in the mining sector. The World Bank and IFC have applied the Environmental Health and Safety Guidelines for Mining to their supported projects, while the Guidance Note for the Implementation of Financial Surety for Mine Closure has been issued to assist governments' decisions regarding the obtaining of financial surety for mine closure. The United Nations has produced the Policies, Practices and Guidelines for Sustainable Mining and Closure to be used with Southeast Europe and Tisza River Basin, with options and ideas towards application of funding and execution of mine closure and rehabilitation. As the Planning for How to Integrate Mine Closure: Toolkit made by ICMM provides practical guidance for a key challenge to close a mine in a sustainable manner, along with thirteen applicable tools for handling important issues during a life cycle of mining.

Practically, there is no single law or decree that specifically deals with all obligations related to the mine closure process. Rather, there are a number of acts and regulations that control different aspects of mining operations and closure. For some activities, legislation defines objective and provides an operational framework, while in practice, decisions are typically made via a combination of best practice guidelines and previous experience. However, the application of guidelines is still based on site-specific demands. In other words, consideration of diverse factors must be taken into account, including the mineralogy and chemical composition of the ore, mining methods, the nature of the surrounding environment and land-use priorities, the scale of the mining operations, as well as the type of enrichment and processing used.

5. CONCLUSION

5.1 Evaluation of sustainable development level of the studied APEC economies

The study on balancing the competing demands of mining, community and the environment to achieve sustainable development in the mining sector was performed with three main objectives. The first objective is to evaluate competing sustainable development demands within the APEC mining sector through a network of experts in APEC economies. The second is to exchange a wide range of information, including environmental regulations related to mining, case studies of the impacts from legacy mines and inappropriate mine closures, as well as mine reclamation technologies and leading sustainable development practices relating to mine closures. The third is to provide recommendations on practical applications of sustainable development initiatives relating to mining and mine closures in developing economies. The final objective is to develop a reference database on the policies, regulations, standards, and technical guidelines related to mine rehabilitation, reclamation, and mine closure among APEC economies. The results of this project provide a beneficial database of the policies, regulations, and technical guidelines for mining sectors among APEC economies. A sustainable development index was developed and recommendations on best practice applications for sustainable development were conducted via application of the developed SDMI model.

Nine economic, eight environmental, and three social indicators were aggregated into sustainability sub-indices for each economy and finally merged into composite sustainable development indices. The composite sustainable development indices are high if its individual sustainability sub-indices are high relative to other years. The higher is the value of the composite sustainable development index, the greater is the improvement of the economy in moving towards sustainable development. The same principle is also applicable for obtaining sustainability sub-indices; the calculation was based on the available data from the questionnaires and web links obtained from Australia, Indonesia, Japan, Korea, Malaysia, the Philippines, Thailand, and Viet Nam.

The composite sustainable development and sub-indices were calculated to determine the rate of sustainable development (rate of SD) in order to show each economy's direction (positive or negative) facility—moving towards or away from sustainable development—in the period between 2004–2008. The rates of sustainable development for the mining sector were calculated as the slopes of lines through the values of composite and sub-indices in that period. Using this method, progress pertaining to sustainable development in the mining sector could be evaluated.

Progressing towards sustainable development in terms of economic aspects for mining of all studied economies can be seen from the positive rates of sustainable development for economic sub-indices, which ranged from +0.05 to +1.95. Malaysia and Korea showed the highest rates of sustainable development during this period. According to the 9th Malaysia Plan (2006–2010), the government has provided specific incentives to attract investment and improve access to sources of finance. This plan resulted in a 54.1% raise of net foreign investment in the first three months of 2007 (ADB, 2007) and has boosted a rapid increase of foreign direct investment for mining into the economy in 2007 and 2008. In the case of Korea, a dramatic increase in funding for mine closures could be clearly seen since the government enacted the Mine Pollution Prevention and Reclamation Law in 2005.

The rates of sustainable development for the environment were related to a quite small portion of mining sector in the studied economies. A slightly negative progress on environment issues was found in Australia, Indonesia, Malaysia and the Philippines. In the case of Australia, the amount of greenhouse gases and particulate matter (PM10) emissions had dramatically increased. In the cases of Indonesia, Malaysia and the Philippines, the yearly increase of green house gases had led to the negative growth rate of the environmental sustainability. However, the negative values of the rate indicated that environmental sustainability should be taken into account for the studied APEC economies. Therefore, the Governments of these economies should be stricter on their pollution control especially the emission of green house gases. Since the climate change is a very important issue which requires effective, efficient and equitable collective responses from policy makers. The suggestions for the economies with the negative rate of SD include;

- The national strategy in order to control the greenhouse gases emission from the mining sector should be established to achieve both short-term measures designed to lessen the growth of greenhouse gas emissions and long-term strategies that will ultimately manage greenhouse gas emissions to appropriate levels in a scientifically sound, and responsible fashion.
- The government should encourage developing and promoting new technologies that continue to improve efficiencies and environmental performance in mining and processing operations and in the use of our products;

Low rate of SD for the social sustainability indices can be seen in most of the economies except Japan. The negative growths of the social sustainability indices in the Philippines and Viet Nam indicated that both Governments should increase their policies and regulations on the safety of workers in the mining sector as the numbers of fatality at work have been yearly increase. In order to decrease fatality rate, sustainable development of mining should be attempted to stabilize the mining structures within the earth, keeping workers safe. Miners should be equipped with monitors that alert them when there is an oxygen deficiency, or toxic and explosive gases. Through sustainable development with mining, closed circuit breathing machines were developed so that the miners can breathe clean air in a potentially polluted environment. The United Nations Economic Commission for Europe (UNECE) released a *Best Practice Guidance* which offers successful practices and experiences on methane drainage and effective ways of preventing the occurrence of explosive methane concentrations, or diluting it to safe proportions. The details of the guideline can be seen in (http://www.unece.org/se/pdfs/cmm/pub/BestPractGuide_MethDrain_es31.pdf).

It is obvious that the rate of sustainable development in the mining sector in terms of economic aspects is higher than those of environmental and social aspects, except in Japan in which rates of sustainable development for social and environmental aspects were higher than that of economic aspects. According to these findings, Japan has reduced their mining activities and increased the financial support for research and development of technologies for mine pollution control.

The positive rate of composite sustainable development indices of all studied APEC economies indicates that they are progressive towards promoting sustainable development in the mining sector. However, the values of composite sustainable development indices for the mining sector were mainly from the contribution of economic development, except in Japan—in which the major contribution of the composite sustainable development index was from the environmental and social sustainability sub-indices. Therefore, in order to balance the sustainable development in the mining sector of APEC, the economies should consider their development of the environment and society, in conjunction with the active development of economic factors.

5.2 Suggestions for sustainable development of mining sector of APEC economies

1) Based on the results of the sustainable development index, all the studied economies have progressed towards sustainable development in the mining sector in terms of economic area, though are on a slower pace for developing the environment and society. In order to balance the sustainable development in mining sector of APEC, it is recommended that governments should consider an implementation of policies that can improve the performance in both environmental and social areas, together with their economic path.

2) According to that each economy has its own unique social, political, economic and legal circumstances. The regulatory approach in order to achieve sustainable development of the mining sector of developing APEC economies must therefore be exactly tailored to fit these special needs and unique attributes of the economy they are meant to serve. The problem of how to draft and implement the policy and legislation of sustainable development in mining sector that fits the administrative, practical and philosophical needs of developing economies is the most challenging for the APEC mining sector.

3) New policies and legislation being formulated for mine closures in developing APEC economies should contain the following major components:

- specific provisions for mine reclamation and rehabilitation;

- a requirement of both environmental and social impact assessments, and associated work plans;
- financial surety and bonding is recommended as an effective tool to achieve a comprehensive mine closure, in order to make sure that there will be enough financial support available to the mine. The government can be ensured that the mine closure can be performed successfully;
- provision of specific abandonment and post-closure activities; and
- enforceable and specific monitoring procedures to ensure the compliance with the law and regulations.

4) A provision of help in terms of technologies, training, and financial support from developed economies would be beneficial for the development of sustainable development and mine closure management in developing economies.

5) Guidelines of operation of mines and mine closures from international organizations such as the World Bank, United Nations, and International Council of Mining and Metals, etc. are recommended to be applied appropriately to mines in developing economies.

5.3 Suggestions from MTF Korea for attaining sustainable development in the mining sector of developing APEC economies

Korea has successfully applied the principle of sustainable development in the economy's mining sector. The following strategies have been implemented to achieve sustainable development in the mining sector of Korea, which MTF Korea would like to suggest to the developing economies in APEC.

1) The mining security system should be built by employing laborers who have economic or technical skills.

- More than one certified technician (higher than certified mining security engineer) is required for a mining company that has more than $2 million of capital.

2) A global mining foundation should be built through the improvement of government supports.

- In Korea, support for the facility modernization plans was 70% completed in 2007. Then, the government subsidy was replaced by a loan system.

3) The social understanding that mining is a 3D (Dirty, Difficult and Dangerous) occupation should be changed through environmental improvements such as the minimization of disasters and accidents through modern technological security systems.

4) Promoting mining as a great source of taxation for local governments should be encouraged.

5) Cooperation for the management of mines and securing of mineral resources through technical cooperation and interactions with developed countries and countries holding rich mineral resources should be established.

- Recently, Korea has been cooperating with the US, China, Russia, and Finland, all of which have plenty of mineral resources and advanced mining technology.

6) Application of a cost-benefit analysis is recommended for developing APEC economies as they approach promulgating policies related to sustainable development in the mining sector.

- There has been a recent cost-benefit analysis on establishing mine damage prevention systems in Korea.

Development of mine damage prevention systems is a high-value business field. In particular, mine damage prevention systems are the green technology that are likely to increase in demand because of the world's need for CO_2 reduction policies. For this reason, Korea has attempted to evaluate the cost and benefit in developing technology through the economic feasibility of a mine damage prevention strategy.

The evaluated benefit of technological developments from world's markets is $93.4 million at end of 2009, at a cost of $17.9 million; i.e., at a B/C ratio of 5.20. After the first step of the plan (pollution improvement technology, land improvement, recovery and purification skill, land sink prevention technology, prevention technology of loss of mining disposal, forest recovery, noise & vibration prevention, and GIS technology) had been completed, the current value of benefits is $2.8 million, while its cost remains at $17.9 million. Therefore, its B/C ratio is 0.16. In addition, the effective improvement benefit is $41.4 million, and its estimated cost is $1.79 million, for a B/C ratio of 2.02. As a result, the evaluated economic achievement in Korea from the mine damage prevention strategy can be calculated from the sum of the cost reducing and effectiveness improvement benefits, for a domestic B/C ratio of 2.18.

The evaluated results of benefits from mine damage prevention strategy can be used in various ways. Benefits of the mine damage prevention strategy will be used in many ways, such as for an economic evaluation of mine damage, evaluation of the mine damage prevention plan, setting the direction of mine prevention policy, and moving forward based on citizen's intentions.

According to specific circumstances, there is not yet enough information about the achievements of the mine damage prevention plan, such as monitoring and scientific data, and that the economic benefits may not be perfect. However, these numbers still offer useful information about the benefits of each plan. Therefore, this result would be an important basis for building future mine damage prevention plans, decision making, evaluation, marketing, and securing a budget.

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7. APPENDIX

APPENDIX A

QUESTIONNAIRES FOR APEC PROJECT 2010

(Done by April .16.2010) (16pages)

A. INFORMATION OF REPRESENTATIVES:

Representatives (Gender)	Position	Organization and main responsibilities	Phone & email address	Postal Address
1.				
2.				
3.				
4.				
5.				

B. INFORMATION OF PROJECT

We are running a project entitled: "***Balancing between mining, community and environment for sustainable development in mining sector***", in order to:

- Build an effective APEC mining-related experts network which will be consisted of mining officials, experts and industry representatives;
- Deeply consider of developed recommendations on practical applications of sustainable development initiatives in developing APEC economies from the experts related to the mine rehabilitation and reclamation technologies for sustainable development in mining sector.

C. TERMINOLOGIES AND DEFINITIONS

- ❖ **Mine:** Facility that produces exploitable minerals through excavating the earth crust and by extracting the valuable minerals from un-exploitable rock.
- ❖ **Mining**: the sector of economy that includes the extraction of raw materials for ferrous and non-ferrous metallurgy (include metallic and non-metallic resources), the production of steel and non-ferrous base metals (aluminum, copper, lead, tin, zinc, nickel) and supporting processes as well like recycling and scrap collections. Mining does not include energy resources' like oil and gas, or uranium.
- ❖ **Mine closure:** Permanent cessation of mining operations and all subsequent activity related to decommissioning and site rehabilitation or ongoing monitoring.
- ❖ **Rehabilitation, reclamation:** Activities taken to restore the mine site into condition that poses no hazard to human health or environment after the ore is extracted.
- ❖ **Sustainable development***:* The combination of economic, social, ecological approaches on local, national, regional and global levels which provide the preservation the world's natural wealth for future generations.

D. QUESTIONNAIRE

I. GENERAL QUESTIONS

Q1.1. Please provides the list and some information relating to resources of **the main mining productions** (the ones have had a main contribution to your country).

Name of main mineral resources	Explored amount (million tone)	Annual average of Extracted amount (million tone)
1.		
2.		
3.		
4.		
5.		

Please list the name of <u>special grade</u> productions from mining:
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……………………………………………………………………………………………….

Q1.2. What kinds of **mining operations** have been conducted in your country?

Surface mining		Sub-surface mining (underground mining)	
Hydraulic mining		Drift mining	
Open-pit mining		Slope mining	
Quarrying Strip mining		Shaft mining	
Placer mining		Hard rock mining	
Mountaintop removal		Borehole mining	

Q1.3. Normally in your country, the main **objective**(s) of **mine-closure** situations is/are:

- □ protect public health and safety;
- □ eliminate environmental damage;
- □ achieve a productive use of the land, or a return to its original condition or an acceptable alternative;
- □ to the extent achievable, provide for sustainability of social and economic benefits resulting from mine development and operations.
- □ Others (Please list here)
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…………………………………………………….

II. ECONOMIC ASPECT

Q2.1. Please provide the web-links and/or records of **production, import, export, and consumption** of mining products in your country in period of last ten years (2000-2009):

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q2.2: Please provide the web-links and/or records to explain the fiscal year condition of your country during the period of last ten years (2000-2009):

- **Fiscal year condition:**

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

- **The amount of budget of each fiscal year** (in US dollar) during the period of 2000 - 2009:

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

- The **amount of budget of each fiscal year** (in US dollar) **allocated to mining sector** during the period of last ten years (2000 – 2009):

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q2.3. Please provide the web-links and/or reports of **foreign investments** for mining business in the period of last ten years (2000-2009).

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q2.4. Please provide the web-links and/or reports of **GDP** (Gross Domestic Product) of your country and **GDP allocated to mining** in the period of last ten years (2000-2009.

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links (GDP):

web-links (GDP contribution to mining):

Q2.5. Please provide any website or the link containing the **taxation regulation** applied for mining enterprises in your country in period of last ten years (2000- 2009):

a. Taxation regulation applying for *domestic enterprises*:

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

b. Taxation regulation applying for *international enterprises*:
- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q2.6. Please provide the any web-links and/or reports of the **number of mining employee**s and **their average incomes per year** in the period of last ten years (2000-2009).
- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q2.7. Please provide the any web-links and/or reports of **mining labor force** in the period of last ten years (2000-2009)
- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q2.8. Please provides the any web-links and/or attached file about **mining investment policies** of your country.
- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q2.9. Please provides the any web-links and/or reports relating to the **percentage increasing in domestic share from mining business with previous year** in your country in the duration 2000-2009
- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

III. ENVIRONMENTAL ASPECT

Q3.1.1 Please provide the any web-links and/or reports of **national air quality** relating to mining activities in the period of last ten years (2000-2009) (The reports should be related to the amount of **emissions of greenhouse gases** (CO_2, CH_4, N_2O, HFCs, PFCs, or SF_6), Emissions of **acid gases** (NO_x, SO_2…), and % exceeding national standard of **particle emissions** to the air)
- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q 3.1.2. Please provide the any web-links and/or reports of **% exceeding national standard of noise pollutants** relating to mining activities in the period of last ten years (2000-2009)
- By attachment files when emailing Questionnaire to us.

- By web-links

web-links:

Q3.2. Please provide the any web-links and/or **reports of national water quality** relating to mining activities (for *surface* and *groundwater*) in the period of last ten years (2000-2009)

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q3.3. Please provide the any web-links and/or **reports of national soil quality** relating to mining activities in the period of last ten years (2000-2009)

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q3.4. Are there any **regulation** to force mining enterprises to *have future plans* for managing **mine closure**? If yes, please provide those regulations

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q 3.5 Energy, water, and chemical consumption for mining:
Please provide any web-links and/or reports of nation relating to **energy, water, and chemical consumption** for doing **mining activities** in your country in the last ten years (2000-2009)

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q3.6. Closure and rehabilitation
3.6.1. Please provide any web-links and/or reports of nation relating to the total number of **mining sites, total number of active mines, closed mines, abandoned mines, and mining sites rehabilitated** in your country up to now

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

3.6.2. Please provide any web-links and/or reports of nation relating to total area of land rehabilitated and total land area occupied by mining operation in the last ten years

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

3.6.3.: Please provide **policies, regulations, technical guidelines** related to mine rehabilitation, reclamation and mine closure in your country up to now

- By attachment files when emailing Questionnaire to us.

- By web-links

web-links:

Q3.6.4 This is example of general closure objectives for mining activities (Brodie *et al.* 1992, MMSD 2002a, EC 2004, Robertson & Shaw 2004).

Criteria	Closure objectives
Physical stability	• All remaining anthropogenic structures are physically stable, sustainable to erosion and safe, and impose no risks to public health in long-term • Structures are performing the functions for which they were designed
Chemical stability	• All remaining anthropogenic structures are chemically stable and impose no risk to public health or environment throughout all phases of their life-cycle ◦ Closure is appropriate to the site-specific requirements in terms of the quality of surface water, groundwater and soils
Biological stability	• The biological environment a) is restored to a natural, balanced ecosystem typical of the area, or b) is left in such state so as to encourage and enable the natural rehabilitation of a biologically diverse, stable environment
Geographical and climatic influences	• Closure is appropriate to the demand and specifications of the location of the site in terms of climatic (e.g. rainfall, storm events, seasonal extremes) and geographic factors (e.g. proximity to human habitations, topography, accessibility of the mine)
Land use and aesthetics	• Rehabilitation is such that the ultimate land use is optimised • Closure optimises the opportunities for restoring the land and the upgrade of land use is considered whenever appropriate and/or economically feasible • Closure enables the productive and economical post-operational land use following the principles of sustainable development
Natural resources	• Closure aims at securing the amount and quality of the natural resources of the site
Financial consideration	• Adequate and appropriate readily available funds are allocated for the closure
Socio-economical issues	• Negative socio-economical impacts are minimized • Requirements of the local communities are taken into consideration to appropriate extent

Please provide any reports of the **best practices of mine closure** in your country in last ten years (2000-2009)?

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Q3.7. Please provides the **environmental protection regulations** and/or policies relating to mining activities and **any reports of total investment for environmental protection or reclamations** in your country in the last ten years (2000-2009)

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q 3.8. Biodiversity

3.8.1. Please provide any web-links and/or **reports** of nation relating to **number of species under a threat of extinction** affected by **mining operation** and the **activities** for protection and **rehabilitation** of habitats in the last ten years 2000-2009

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

3.8.2. Please provide the policies or regulations (if your country has) required for mining companies to protect and **rehabilitate species** and their **habitats** surrounding mining sites

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q 3.9. Solid waste

Please provide any records and/or web-links relating to the amount of **solid waste** generated in the extraction and production mining activities; and the **disposal methods for hazardous waste** during the last ten years in your country

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- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

IV. SOCIAL ASPECT

Q4.1. License

4.1.1. Please provide the regulation relating to the procedures for enterprises to get **licenses** to do mining?

With *International* enterprises:

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

With *domestic* enterprises:

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

4.1.2. Please provide the any reports (if your country has) relating to the number of mining enterprises has **been lost the licenses** to do mining activities during last ten years (2000-2009).

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

Q4.2. Health impacts

4.2.1. Please provide any web-links and/or reports of nation relating to the **requirement of Health Impact Assessment (HIA)** for mining enterprises (if applicable)

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

4.2.2. Please give any web-links or reports providing any **accidents in mining sectors** during 2000-2009 in your country.

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

4.2.3. Does your country have **regulations** relating to responsibilities to **resettle community** for mining enterprises?

☐ If yes, please email that regulation to us.

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

☐ **No**

4.2.4. Please provide the **regulation** in your country relating to the **rights** to working for mining with **women and man** (If applicable)

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

4.2.5. Please provide the **regulation** in your country relating to any responsibilities of enterprises towards **protecting and ensuring proper health care for woman-mine workers** (If applicable)

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

4.2.6. Mining is considered as a dangerous occupation. Thus, are there any **policies or regulations** provided by Government to insure safety of mining workers in your country?

☐ Yes, Please list those policies and/ or regulations:

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

☐ **No**

4.2.7. Are there any Government regulations concerning the **equal benefits for women and men** who work for mining sectors?

☐ Yes, please attach that regulation file when emailing a questionnaire back to us

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

☐ No

4.2.8. Are there any regulations relating to **social insurances or additional benefits** for mining - employed women?

☐ Yes. Please attach that regulation file when emailing a questionnaire back to us.

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

☐ No

4.2.9. Are there any **reports of health and safety occupational programs** training for mining employees during the period of last ten year?

☐ Yes. Please attach that regulation file when emailing a questionnaire back to us.

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

☐ No

V. TECHNOLOGY

Q5.1. Are there any regulations to force enterprises to **install waste water treatment system** for their mining activities?

☐ If yes, Please attach that regulation file when emailing a questionnaire back to us.

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

☐ No

Q5.2. Are there any **regulations**/ **incentive strategies** provided by the government in order to force /or encourage the mining companies apply any **clean technologies** to their mining activities?

☐ If yes, please provide those regulations/incentive strategies

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

☐ No

Q5.3. Are there any **regulations** provided by the government in order to force/ encourage the mining companies apply any **noise-pollution preventions** during mining operation?

☐ If yes, please provide those regulations

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

☐ No

Q5.4. Products

5.4.1. Are there any **reports** of **complaints** about the **quality of mining products** from costumers in the period of last ten years?

☐ If yes, please attach please provide those reports

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

☐ No

5.4.2. Are there any **reports** of **applying advanced techniques** to do mining in your country in the period of last ten years?

☐ If yes, please attach please provide those reports

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

☐ No

Q5.5. Please provides any **reports** of **% of budget** Government invested for **mining technology development** per year in the duration last ten years (2000-2009)

- By attachment files when emailing Questionnaire to us.
- By web-links

web-links:

VI. REPRESENTATIVE'S EXPECTATIONS

6.1. In term of implementation, do you think that the current policies, regulations and guidelines provided from your Government are **good enough or not**?

☐ Yes, definitely.

☐ Basically, those are good, but I expect some things that should be improved more, such as

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6.2. Please only use the **scores (1, 3, 5, 7, 9)** to **evaluate** the **positively important effect level** of indicators to **sustainable development**. (The **higher value** of indicator is, the **bigger of score** indicator is marked and the **much more positively important effect level** of the indicator to **sustainable development**). Where:

1: not positively important; 3: moderately positively important; 5: strongly positively important; 7: very strongly and positively important; and 9: extremely positively important.

And

Use the **scores (-1, -3, -5, -7, -9)** to **evaluate** the **negatively important effect level** of indicators to **sustainable development**. (The **higher value** of indicator is, the **bigger of absolute score** indicator is marked and the **much more negatively important effect level** of the indicator to **sustainable development**). Where:

-1: not negatively important; -3: moderately negatively important; -5: strongly negatively important; -7: very strongly and negatively important; and -9: extremely negatively important.

LIST OF INDICATORS	Scores
1. ECONOMIC DEVELOPMENT	
The amount of domestic mineral consumption/ year	
Number of type of mining products/ year	
Total amount of mining products /year	
Income from mining/year	
Total earning(without tax and interest) of mining business/year	
Total amount of mining products imported /year	
Total payment for importing products/year	
Total amount of mineral export earning/ year	
The amount of Fiscal Year Budget allocated into mining sector/year	
Number of countries for selling mining products/year	
Mining contribution to GDP/year	
The amount of Investment in employee training and education program/year	
The amount of mining employment costs/year	
Total amount of foreign direct investment (FDI) /year for mining/ year	
Total investment for mining business/year	
Total investments into resettlement communities	
Total taxes and royalties paid	
Fines paid for non-compliance (economic, environmental and social)	
Total investment for environmental protection program/year	
Total fund for mine closure and rehabilitation/year	
2. ENVIRONMENT PROTECTION	
Amounts of primary mineral resources that need to be extracted	
Total waste discharged (non-saleable material) /year	
Total amount of products' yield per year	
Total amount of chemicals used for mining business/ year	
Total amount of water used for mining business/ year	
Total amount of energy consumption during mining operation/year	
Ratio of total number of mines closed and mine abandoned	
Ratio of total number of mining sites rehabilitated and total number of mines closed	
Total area of land rehabilitated/ Total land area occupied by mining operation	
Number of awards for rehabilitation	
Number of sites officially designated for biological recreational or other interest as a result of rehabilitation	
Total number of species under a threat of extinction in areas affected by operation	
Total amount emissions of greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6)	

Total amount emissions of acid gases (NOx, SO2…)	
Percentage amount emissions of particles exceeding national standard/ year	
Total amount toxic emissions (heavy metals, dioxins, crystalline, silica…)/year	
Total volume of water discharged into waterways/ year	
Total volume of tailings/ year	
Total discharges of substances with liquid effluents enables	
The amount of solid waste generated in the extraction and production activities	
Total number of prosecutions for environmental non- compliance	
Total number of sites certified to an EMS (e.g.ISO14001/EMAS…)	
Total number of external complaints related to noise, road	
Percentage amount of noise pollutants exceeding national standard/year	
3. SOCIAL PERFORMANCE	
Number of mining Employees per year	
Labour/management: Number of complaints from employee to employers	
Number of fatalities at work IN MINING	
Number of compensated occupational diseases	
Percentage of women employed in mining companies	
Total number of health and safety complaints from local communities	
Having the regulation to require resettlement of communities	
Number and type of instances of non-compliance with regulations concerning customer health and safety, the fines assessed for these breaches	
4. TECHNOLOGICAL DEVELOPMENT	
Ratio between the amount earning from mining export and total earning from mining business.	
Number of special grades productions from mining	
Market performance (% increase in domestic share with previous year)	
No. of complaints regarding to quality of mining products from customers	
Advanced Equipment availability (%)	
% of budget Government invested for technology development per year	

Thank you very much for your kind cooperation!

E. <u>REVIEW AND APPROVAL</u>

I hereby certify that I have reviewed the information provided in this questionnaire, have determined that all questions have been appropriately answered.

Authorized Representative's

Signatures: --------------------------------**Full name:** --

Date……………………………

Please email your complete questionnaire answered together with addition data/ info required to email address: "Lunchakorn PRATHUMRATANA" lunchakorn@gist.ac.kr

APPENDIX B

Korea Mine Security Enforcement Rule

Chapter 10: Prevention of Mine Damage

Paragraph 1: Prevention of mine damage caused by excavation work

Article 232 Prevention of Ground Subsidence (Modified on 7 November 2007)

1. Measurement of ground subsidence by order of the Head of Office
2. Restriction of mining
3. Filling an excavated place
4. Water drainage in the mine
5. Other security matters

② Person who has a mining right or concession must report a result of measurement that is accordance with clause 1 of Article 1.

Article 234

① Person who has a mining right or concession must have the mine located from 50 to 100 meters horizontally or vertically less than 150 meters far away from any public structures such as roads or railroads or receive an approval from the head of office through land security tests that are performed by professional institutions such as Korea Land Resource Research Center.

② The head of office must give a mining approval within the range of clause 1 after receiving accurate terms such as a mining place, mining way, mining period and recover plan.

Paragraph 2: Prevention of mine damage caused by waste rock and disposal of mining work

Article 238

1. Person who has a mining right or concession must report a result of waste rock and disposal of mining work once a quarter. The report must be done once a month if the rainfall is more than 50 mm/day.

2. When it comes to dangers such as collapse or loss caused by crack or sink on the surface of disposal of tailings or waste rock, the owner of mine must order an evacuation or other expediencies and report to the security manager.

3. Person who has a mining right or concession must build a drainage system to prevent inflow of water to disposal area, neutralization agent to disposals to prevent outflow of harmful heavy metals.

4. When cessation or abandoning mining, tree or walls that are preventing outflow of waste stones must be built to prevent mine damage caused by cessation or abandoning mining.

Paragraph 3: Prevention of mine damage caused by dust (Modified on 23 August 1999)

Article 243:

② A crusher, pulverizer, grinder machine and belt conveyer must be built for preventing dust in places that are generating dust. Necessary machines are as followings.
1. Structures that are preventing dust.
2. Watering machine
3. Dust collector
4. Dust protecting covers
5. Other machines those are effective for prevention of dust.

Paragraph 4: Prevention of mine damage caused by water

Article 248

1. Wastewater or mine water sanitation facilities must be inspected more than once a week.
2. In outflow water, pH, BOD, COD, SS, chrome or other harmful elements that Water Quality Reservation Law indicates must be measured more than once a week.
3. The amount of wastewater or mine water must be measured once a month.
4. In result of measuring based on Clause 2 of Article 3, it must to be reported to security managers or person who has a mining right or concession when mine damage caused by waste water or mine water is likely to be happened.

Paragraph 5: Prevention of mine damage caused by noise

Article 252

1. Noise generating facilities and facilities preventing noise must be inspected periodically and its result must be reported in the security report.

Paragraph 6: Prevention of mine damage caused by vibrations

Article 256

2. Vibration levels of mining site and its surrounding area must be measured periodically according to the recommended method and its results must be reported in the security report.

Paragraph 7: Prevention of mine damage caused by cessation or abandoning mine

Article 259 (Mine Damage Prevention) Person who has a mining right or concession must take following actions when they want to stop or abandon mining.
1. Recovering damaged forest or land
2. Removing unused mining facilities
3. Action to preventing collapse of abandoned mines
4. Treatment of mine water
5. Preventing work for outflow of disposals of mining or waste rock

6. Preventing actions to prevent other mine damages

APPENDIX C

Summary of important data from APEC economies

Table C-1 Per capita GDP output (PPP), USD per capita

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009
Australia	28,390.28	29,619.39	30,859.27	32,305.73	33,877.55	35,307.87	37,397.78	38,245.59	38,663.17
Brunei Darussalam	44,399.23	45,764.90	47,004.12	47,376.67	47,464.68	49,442.68	50,061.71	49,155.48	47,930.20
Canada	29,846.89	30,882.87	31,842.83	33,409.03	35,150.18	36,942.78	38,448.93	39,031.17	37,947.01
Chile	9,934.32	10,189.29	10,712.56	11,454.73	12,237.15	13,064.07	13,919.32	14,607.48	14,315.76
China	2,612.63	2,877.93	3,217.46	3,614.10	4,102.50	4,748.66	5,553.39	6,187.71	6,778.09
Hong Kong, China	26,891.12	27,848.22	29,136.54	32,298.41	35,549.52	38,876.56	42,309.81	43,816.49	42,653.03
Indonesia	2,552.39	2,674.30	2,824.75	3,004.87	3,207.44	3,448.69	3,727.02	3,985.41	4,150.81
Japan	25,892.27	26,325.01	27,221.89	28,702.68	30,315.33	31,942.64	33,656.83	33,996.33	32,554.15
Korea	17,408.11	18,849.40	19,696.82	21,138.10	22,783.23	24,662.13	26,596.62	27,716.29	27,938.22
Malaysia	9,135.44	9,578.92	10,158.55	10,902.08	11,610.47	12,477.74	13,448.75	14,149.13	13,799.53
Mexico	10,651.66	10,769.29	11,044.28	11,829.73	12,488.66	13,414.00	14,144.17	14,545.97	13,608.82
New Zealand	20,446.80	21,415.58	22,353.54	23,763.16	24,882.42	25,640.81	26,850.38	27,139.96	26,669.95
Papua New Guinea	1,682.32	1,702.37	1,772.46	1,841.84	1,770.91	1,827.45	1,968.18	2,095.43	2,166.66
Peru	5,113.45	5,373.58	5,624.03	5,998.05	6,474.70	7,093.36	7,788.78	8,606.12	8,626.20
The Philippines	2,364.67	2,458.28	2,581.56	2,763.76	2,934.98	3,129.63	3,382.70	3,514.88	3,515.94
Russia	8,229.44	8,825.75	9,683.02	10,726.89	11,823.92	13,269.24	14,888.17	16,033.54	14,912.75
Singapore	32,280.66	34,702.48	36,617.96	40,330.02	43,975.70	47,319.22	50,129.89	51,246.71	50,179.60
Chinese Taipei	20,278.21	21,580.21	22,769.01	24,942.06	26,657.33	28,887.62	31,404.71	32,215.31	31,775.85
Thailand	5,140.33	5,455.85	5,920.34	6,350.06	6,837.56	7,404.28	7,942.09	8,242.80	8,050.87
United States	36,064.52	36,949.99	38,324.38	40,450.62	42,680.64	44,822.96	46,577.19	47,155.32	45,934.47
Viet Nam	1,535.00	1,648.47	1,781.40	1,949.43	2,142.72	2,364.70	2,609.18	2,800.84	2,941.68

Source: International Monetary Fund, World Economic Outlook Database, October 2010

Table C-2 Gross Domestic Product (in constant prices), % vs. previous year

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009
Australia	2.564	3.913	3.233	3.629	3.203	2.554	4.811	2.243	1.246
Brunei Darussalam	2.745	3.872	2.903	0.504	0.388	4.398	0.155	-1.939	-0.493
Canada	1.784	2.925	1.881	3.12	3.019	2.823	2.2	0.518	-2.462
Chile	3.527	2.159	3.972	6.041	5.547	4.591	4.573	3.724	-1.529
China	8.292	9.101	10.101	10.091	11.29	12.692	14.191	9.595	9.096
Hong Kong, China	0.497	1.841	3.006	8.467	7.082	7.02	6.382	2.164	-2.761
Indonesia	3.643	4.499	4.78	5.031	5.693	5.501	6.345	6.007	4.546
Japan	0.184	0.262	1.414	2.744	1.934	2.039	2.363	-1.202	-5.217
Korea	3.973	7.15	2.803	4.619	3.957	5.179	5.106	2.298	0.196
Malaysia	0.518	5.391	5.789	6.783	5.332	5.849	6.48	4.708	-1.714
Mexico	-0.157	0.827	1.684	4.048	3.205	4.933	3.341	1.49	-6.538
New Zealand	2.527	4.872	4.15	4.375	3.161	1.01	2.784	-0.146	-1.593

Papua New Guinea	-0.045	2.008	4.388	0.57	3.924	2.294	7.152	6.656	4.535
Peru	0.215	5.012	4.04	4.977	6.827	7.74	8.905	9.804	0.862
The Philippines	1.756	4.449	4.93	6.38	4.952	5.341	7.089	3.692	1.061
Russia	5.091	4.744	7.253	7.151	6.388	8.153	8.535	5.242	-7.9
Singapore	-1.22	4.239	4.599	9.236	7.383	8.641	8.536	1.782	-1.283
Chinese Taipei	-1.651	5.264	3.669	6.19	4.703	5.437	5.983	0.731	-1.909
Thailand	2.167	5.318	7.14	6.344	4.605	5.146	4.931	2.463	-2.248
United States	1.08	1.814	2.49	3.573	3.054	2.673	1.947	0	-2.633
Viet Nam	6.895	7.08	7.341	7.789	8.442	8.229	8.456	6.311	5.323

Source: International Monetary Fund, World Economic Outlook Database, October 2010

Table C-3 Share of APEC economies in the global GDP output (PPP), %

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009
Australia	1.26	1.273	1.27	1.246	1.231	1.203	1.199	1.193	1.219
Brunei Darussalam	0.034	0.034	0.034	0.032	0.031	0.031	0.029	0.028	0.028
Canada	2.1	2.102	2.069	2.03	2.003	1.963	1.916	1.869	1.835
Chile	0.348	0.345	0.347	0.349	0.351	0.35	0.349	0.351	0.349
China	7.581	8.044	8.548	8.949	9.405	9.999	10.756	11.451	12.556
Hong Kong, China	0.411	0.407	0.405	0.418	0.43	0.439	0.444	0.441	0.433
Indonesia	1.206	1.225	1.24	1.239	1.248	1.254	1.27	1.308	1.379
Japan	7.477	7.291	7.143	6.984	6.854	6.662	6.491	6.233	5.958
Korea	1.873	1.952	1.938	1.934	1.941	1.945	1.946	1.934	1.954
Malaysia	0.498	0.511	0.522	0.529	0.533	0.538	0.543	0.553	0.548
Mexico	2.425	2.378	2.336	2.347	2.297	2.296	2.259	2.228	2.1
New Zealand	0.181	0.184	0.186	0.185	0.182	0.175	0.172	0.167	0.165
Papua New Guinea	0.02	0.02	0.02	0.02	0.018	0.018	0.018	0.019	0.02
Peru	0.297	0.304	0.305	0.306	0.312	0.32	0.332	0.354	0.36
The Philippines	0.422	0.429	0.435	0.44	0.443	0.444	0.453	0.457	0.465
Russia	2.742	2.793	2.894	2.95	3.005	3.082	3.17	3.254	3.022
Singapore	0.3	0.304	0.305	0.319	0.331	0.343	0.353	0.348	0.344
Chinese Taipei	1.032	1.057	1.058	1.078	1.074	1.079	1.088	1.065	1.054
Thailand	0.735	0.753	0.779	0.787	0.788	0.789	0.788	0.785	0.773
United States	23.365	23.137	22.907	22.607	22.367	21.876	21.269	20.758	20.422
Viet Nam	0.274	0.286	0.296	0.305	0.315	0.325	0.335	0.346	0.368
Total APEC share	54.581	54.829	55.037	55.054	55.159	55.131	55.18	55.142	55.352

Source: International Monetary Fund, World Economic Outlook Database, October 2010

Table C-4 Carbon dioxide emissions (metric tons per capita)

Country	2000	2001	2002	2003	2004	2005	2006	2007
Australia	17.17	16.60	17.09	17.06	16.91	17.85	17.95	17.74
Brunei Darussalam	19.56	18.16	17.12	16.37	16.74	15.36	14.48	19.75
Canada	17.45	16.95	16.63	17.50	17.30	17.31	16.75	16.89
Chile	3.89	3.46	3.55	3.53	3.97	4.01	4.12	4.31
China	2.69	2.74	2.88	3.37	3.93	4.30	4.66	4.96

Hong Kong, China	6.08	5.65	5.47	5.95	5.66	5.95	5.62	5.77
Indonesia	1.26	1.39	1.44	1.43	1.54	1.55	1.54	1.77
Japan	9.69	9.61	9.70	9.85	9.89	9.72	9.67	9.81
Korea	9.40	9.48	9.96	9.91	10.20	9.61	9.74	10.38
Malaysia	5.44	5.75	5.57	6.48	6.67	7.15	7.10	7.32
Mexico	3.98	4.08	3.99	4.11	4.09	4.27	4.29	4.47
New Zealand	8.47	8.79	8.51	8.39	8.21	8.06	7.97	7.72
Papua New Guinea	0.50	0.58	0.62	0.68	0.75	0.75	0.74	0.52
Peru	1.16	1.03	1.02	0.97	1.16	1.34	1.24	1.51
The Philippines	1.01	0.97	0.94	0.92	0.94	0.94	0.78	0.80
Russian Federation	9.86	9.88	9.85	10.24	10.42	10.58	10.97	10.81
Singapore	12.99	12.69	12.24	11.93	12.21	13.95	12.76	11.80
Thailand	3.23	3.44	3.62	3.80	4.04	4.10	4.19	4.14
United States	20.33	19.73	19.77	19.58	19.77	19.73	19.27	19.34
Viet Nam	0.69	0.76	0.89	0.98	1.24	1.24	1.24	1.31
World	4.10	4.10	4.10	4.20	4.40	4.50	4.60	4.60

Source: World Bank.

Table C-5 Energy use (kg of oil equivalent per capita)

Country	2000	2001	2002	2003	2004	2005	2006	2007
Australia	5,687.15	5,520.94	5,633.29	5,609.84	5,567.24	5,921.75	5,924.47	5,887.67
Brunei Darussalam	7,358.96	6,687.83	6,389.12	7,254.39	7,156.07	6,860.77	7,224.95	7,189.78
Canada	8,162.71	7,981.08	7,930.14	8,258.65	8,381.15	8,407.99	8,245.15	8,168.64
Chile	1,699.95	1,643.78	1,683.95	1,683.27	1,791.86	1,816.91	1,849.73	1,850.79
China	864.97	855.11	918.84	1,039.44	1,202.22	1,296.1	1,407.62	1,484.02
Hong Kong, China	1,965.64	2,053.23	1,955.04	2,001.69	1,919.22	1,924.06	1,948.2	1,984.58
Indonesia	735.22	759.09	764.24	768.06	791.06	799.36	813.71	848.57
Japan	4,080.45	4,007.01	3,993.93	3,952.33	4,076.82	4,061.09	4,056.91	4,019.07
Korea	4,017.44	4,041.87	4,236.78	4,298.00	4,395.89	4,370.33	4,427.62	4,585.54
Malaysia	2,134.78	2,199.7	2,194.52	2,338.29	2,167.09	2,545.74	2,553.85	2,733.47
Mexico	1,504.94	1,508.91	1,538.3	1,567.51	1,600.56	1,699.09	1,680.07	1,750.2
New Zealand	4,360.00	4,366.96	4,337.34	4,090.68	4,090.03	3,966.23	3,973.14	3,966.37
Papua New Guinea	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Peru	468.19	445.14	441.62	426.79	465.05	490.27	469.12	493.85
The Philippines	527.24	496.47	493.01	484.7	472.39	464.09	452.15	450.64
Russian Federation	4,170.19	4,229.71	4,224.15	4,395.48	4432	4,549.57	4,707.03	4,730.04
Singapore	4,799.52	4,864.67	5,138.65	4,814.57	5,452.52	6,490.69	6,160.77	5,830.54
Chinese Taipei	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Thailand	1,158.58	1,201.8	1,268.06	1,353.67	1,445.28	1,474.73	1,501.45	1,552.58
United States	8,091.81	7,855.12	7,884.89	7,799.03	7,886.00	7,855.88	7,712.18	7,758.94
Viet Nam	477.44	496.74	529.28	543.31	608.47	613.59	626.73	655.12
World	1,645.6	1,632.4	1,648.2	1,686.2	1,742.6	1,768.6	1,793.1	1,819.2

Source: World Bank.

APPENDIX D

List of respondents of the questionnaire

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