Chapter III: Environmental Impacts from Mining Activities and Nuclear Plants.

Can you remember a day when you opened your morning newspaper without finding a disturbing story about some environmental crisis that is either here already or lurks around the corner? On one day the story may be about global warming; on the next it may be about overpopulation or air pollution or resource depletion or species extinction or sea-level rise or nuclear wastes or toxic substances in our food and water.

The uncontrolled exploitation of natural resources for the last two centuries have played havoc on our earth. The phenomenal advance of science and technology, and the frightening increase in population, have placed enormous pressure on the earth's resources. Depletion, desertification and deforestation, climatic changes, droughts and floods and other natural problems threaten life on earth. And with pollution on a hazardous scale these problems are being compounded to even more alarming proportions.

Human civilization has been developed with mineral and energy resources. Mineral and energy resources such as metal, petroleum and coal are the most important materials for the industrial development of a country. It is true that the stable and continuous supply of resources is the major factor for economic growth of a country. However, environmental damages such as acid mine drainage (AMD), mine tailing sweeping, ground subsidence, and forest ruin are inevitable in the development of a mine.

These mining hazards are considered as causes of natural damages such as ground collapse, contaminated water outflow, heavy metal contamination of soil, dust scattering, noise and vibration. These damages are caused by the process of mine development such as exploration, excavation, grinding, transportation and concentration. The mining hazards are characterized as contamination, continuation, accumulation and diffusion, so they may happen long after the mine development has finished, and result in environmental problems, safety concerns and a civil appeal. The crisis from mining activities has resulted in dire consequences for everyone.

With such grave concerns, we are challenged by the urgent task of coming to grips with root issues. Dealing with superficial symptoms will not be sufficient. Neither can we look only at local situations, as environmental concerns are interlinked and have assumed global dimensions, penetrating total human life. And therefore, whether philosophically, theologically, economically, socially, politically or in any other way possible, we will need to collectively handle these mounting problems with determination and dedication.

Getting to root issues will turn out to be an absorbing theological discussion. Restoring, even reinterpreting biblical doctrines will help the Church to face the challenge as God's people need to be doing.

3.1. Environmental Impact from Mining Activities.

It is now well understood that mining activities such as exploration, development, production, processing, refining and transportation have surely generated environmental pollutions by altering land-forms and ecosystems, disrupting the hydrological cycle and discharging waste into air and water.

Mining has left a lasting mark on people and landscapes around the world. Each year mining activities take more materials out of the earth than the world's rivers move. A single mine in Papua New Guinea, the Ok Tedi, generates an astounding 200,000 tons of waste a day on average which is more than the waste of all the cities in Japan, Australia, and Canada combined.

Mines have uprooted tens of thousands of people from their homelands and have exposed many more to toxic chemicals and pollution. And mining is the world's most deadly occupation. 40 mine workers are killed on the job each day on average, and many more are injured (Sampat 2003:111-129).

If an accountant were to weigh the costs and benefits of extracting minerals from the earth and then processing and refining them, the balance sheet would reveal that the mining industry consumes close to 10% of the world energy, spews almost half of all toxic emissions from all the industries in some countries, and threatens nearly 40% of the world's undeveloped tracts of forest.

The environmental impact from mining ore is affected by its percentage of metal content, or grade. The more accessible and higher grade ores are usually exploited first. As they are depleted, it takes more money, energy, water, and other materials to exploit lower grade ores. This in turn increases land disruption, mining waste, and pollution.

Although underground mining generally has less dramatic environmental impact than small-scale and open-pit mining, it carries the potential for a collapse of the underground shaft. In addition, the movement of large amounts of waste rock and vegetation can lead to the same pollution problems as an industrial mine, such as acid mine drainage which is discussed further in this section.

Table 3.1: Environmental Impact from Mining Activities.

Activity	Environmental Impacts
Water Discharge	· Acid mine drainage. · Heavy metals overloading.
Dewatering	· Ecological impacts. · Sediment runoff. · Effluent contamination. · Impacts upon water resources.
Smelting	· Air pollution. · Acidic deposition. · Heavy metals contamination.
Transportation	· Noise pollution. · Dust and sediment. · Gaseous emissions. · Oil and fuel spills. · Soil contamination.
Mineral Extraction	· Erosion. · Landform changes. · Alteration of water tables. · Dust. · Vegetation and habitat destruction. · Aesthetics.

Source: Krivtsov, A. I., Geoenvironmental Problems of Mineral Resources Development in Geology and Ecosystems, Springer Inc., Ridgeway, UK, 2006, P. 74.

However, there have been relatively few studies which attempt to identify and quantify the environmental impact from mining activities. So, it is difficult to determine the scale and cost of environmental problems associated with the mining industry at the present.

Currently, most of the harmful environmental costs of mining and processing energy and minerals are not included in the price of the resulting consumer products. Instead, these costs are passed on to society and future generations, which gives mining companies and manufacturers little incentive to reduce waste and pollution. We should call for phasing these external costs into the prices of goods made from energy and mineral resources through full-cost pricing. This makes it an effective preventer to curb mining-related pollution and fulfill an intra-industrial equity and inter-generation equity.

3.1.1. Pollution from Extracting Mineral Resources.

3.1.1.1. Air Pollution.

The environmental impact of mines extends beyond the threats to habitat. The mining industry is one of the planet's leading polluters. Smelting metals contributes some 19 million tons of acid-rain-causing sulfur dioxide to the atmosphere annually, that is about 13% of global emissions. In the USA, processing minerals contributes almost half of all reported toxic emissions from industry, sending 1.5 million tons of pollutants into the air and water each year.

3.1.1.2. Water Pollution.

The amount of waste generated by mines is staggering every year. Canadian mines generate more than a billion tons which are 60 times larger than the amount of trash Canadian cities discard. To transport this waste, some mines now use a kind of giant dump truck that can move 360 tons of material of which each behemoth tire weighs 4.5 tons and stands almost 5 meters high.

In 2000, mines around the world extracted some 900 million tons of metal, and left behind some 6 billion tons of waste ore. This figure does not include the overburden earth moved to access the ores. Much of this waste came from the production of just iron ore, copper, and gold.

For every usable ton of copper, 110 tons of waste rock and ore are discarded, and another 200 tons of overburden earth is moved. For gold, the ratio is more staggering: about 300,000 tons of waste is generated for every ton of market gold, which translates into roughly 3 tons of waste per gold wedding ring. Much of this waste is contaminated with cyanide and other chemicals used to separate the metal from ore.

The amount of waste generated by mines has increased as ore grades have declined for a number of metals. As the more easily accessible and rich veins of metal have been dug out, miners have turned to less abundant sources through using more energy and chemicals to extract the same amount of metal while generating more waste. In 1906, copper ores in the USA yielded on average 2.5 grams of metal for every 100 grams of ore. In 2000, U.S. miners extracted copper from ore with an average grade of 0.44 grams of metal per 100 grams of ore, meaning that five times more waste is now generated per gram of marketable metal.

3.1.1.3. Landscape Transformation.

In the last century, lower energy costs and the development of new mining technologies have made it possible to transform landscapes completely. Earth-moving equipment is used to literally move mountains in order to get to a mineral deposit. These technological advancements have led to two trends: the extraction of minerals from lower-grade ores and the development of open-pit mines instead of underground ones.

Today, about two thirds of metals are extracted from open-pit mines. These open-pit mines use more diesel fuel and generate a lot more waste than the subterranean kind. On average, open-pit mines produce 8-10 times more waste than underground mines do.

3.1.1.4. Deforestation.

By one estimate, mining projects threaten nearly 40% of the world's large, untouched forests. These include a titanium mine being developed in a Madagascar forest that is inhabited by rare lemurs, birds, and indigenous plant species; gold exploration in Peru's Andean cloud forests; and columbite-tantalite mining in the Okapi Reserve in the Democratic Republic of Congo (DRC), home to the endangered lowland gorilla. Also in the works is a nickel and cobalt mine on Gag Island, off the coast of Papua New Guinea. The reefs off the island are inhabited by an astounding variety of coral, fish, and mollusks.

3.1.1.5. Biological Threat.

The Lorentz National Park in the Indonesian province of West Papua, which is the western half of the island of New Guinea, is one of the world's most biologically diverse and least explored places. It is the largest protected area of 2.5 million hectares in Southeast Asia. In the span of about 125 kilometers, the park covers a dramatic range of ecosystems. It is a naturalist's dream come true.

But the area has more than just biological wealth. Lorentz lies next to what is considered the world's richest rode of copper and gold ore, valued at about $50 billion. The U.S. mining company, Freeport McMoRan first dug open the deposit in 1973, and has expanded its foothold ever since. The company now dumps 70 million tons of waste each year into the nearby Ajkwa River, and by the time it closes in 30 years, it will have excavated a 230 ㎢ hole in the forest that is visible from outer space. The region's population has increased from 6,000 to 70,000 in the last 30 years and the area now boasts an 18 hole golf course for mining executives.

Much new mining development is taking place in or near ecologically fragile regions around the world, which are including world heritage sites such as the Bystrinski National Reserve in Russia and the Sierra Imataca Reserve in Venezuela.

3.1.1.6. Remains of Toxic Chemicals.

Chemical innovations have also contributed to the dual trends in low grading and surface mines. In the late 1800s, chemists in the USA patented cyanide heap-leaching as a method of separating gold from ore. Today, gold mines everywhere from South Africa to South Korea use this technique. Cyanide is mixed with water and is then poured or sprayed over heaps of crushed ore in order to dissolve bits of gold. Once the usable gold is removed, the stacks of crushed ore known as tailings are treated to reduce cyanide concentrations, although the chemical is never entirely diluted.

When gold prices shot up in the early 1980s, this method gained new popularity as miners rushed to extract gold from deposits containing even tiny amounts of the metal. Between 1983 and 1999, USA's consumption of crystalline sodium cyanide reached more than tripled to reach 130 million kilograms, about 90 % of which was used in gold mining. A teaspoon containing a 2 percent cyanide solution can kill an adult.

Where do these chemical-laced wastes end up? They are piled into heaps, walled into constructed holding areas called dams, and in some parts of the world simply dumped into rivers, streams, or oceans. Tailing dams are typically built by stacking piles of waste above ground or in freshwater ponds. Today three mines in the world - all of them on the Pacific island of New Guinea - officially uses rivers to dump tailings. Mine waste elsewhere have spilled out of waste sites and poisoned drinking water supplies and aquatic habitat. In the US West, mining has contaminated an estimated 26,000 kilometers of streams and rivers.

3.1.1.7. Emission of Carbon Dioxide (CO_2).

A sizable share of the energy used in extracting and refining minerals comes from fossil fuels such as oil and coal, whose burning emits carbon dioxide which is implicated in global climate change. In the United States, about 50% of the electricity used to smelt aluminium comes from coal-burning power plants, for instance. But mining's role in global climate change does not end with its fossil fuel use. Producing cement from limestone releases an additional 5% of annual carbon emission to the atmosphere each year. The aluminum smelting process releases about 2 tons of carbon in order to produce a ton of primary aluminium.

3.1.1.8 Emission of Perfluoro-carbons (PFCs).

The aluminium smelting process releases about 3 tons of perfluoro-carbons for each ton of primary aluminium produced, which are very rare gases not emitted through any other industrial activity. PFCs are extremely potent greenhouse gases: a ton of PFCs is equivalent to the greenhouse potential of 6,500-9,200 tons of carbon.

In 1997, PFC emissions from aluminium smelters in Australia, Canada, France, Germany, England, and USA were equivalent to about 19 million tons of carbon, although at least this is 50% less than their emissions in 1990, thanks to improvements in smelter efficiency.

3.1.1.9. Energy Consumption.

Extracting, processing, and refining minerals is extremely energy -extensive. Between 7 to 10% of all oil, gas, coal, and hydro-power energy produced globally each year is used to extract and process minerals. Mining and processing of just the three minerals of aluminium, copper and steel consumes an astounding 7.2% of world energy. This is more than the entire Latin American region uses each year. This makes it a major contributor of greenhouse gases such as carbon dioxide (CO_2).

3.1.1.10. Environmental Incidents.

There is no reliable way to dispose of billions of tons of materials discreetly. Catastrophic spills of mine wastes in recent years have resulted in enormous fish kills, soil and water pollution, and damage to human health.

In 2000, for instance, a tailing dam spilt open at the Baia Mare mine in Rumania. This accident sent some 100,000 tons of wastewater and 20,000 tons of sludge contaminated with cyanide, copper, and heavy metals into the Tisza River, and eventually into the Danube - destroying 1,240 tons of fish and polluting the drinking water supplies of 2.5 million people.

That same year major accidents took place at mines in Gallivare in Sweden, Guangxi in China, Cajamarca in Peru, Tolukuma in Papua New Guinea, Sichuan in China, and Borsa in Rumania. The accident at a copper mine in Guangxi killed 29 people and destroyed more than 100 homes.

Of the hundreds of mining-related environmental incidents since 1975, about 75% have involved tailing dam ruptures. According to the United Nations Environment Programme (UNEP), there are 3,500 tailing storage facilities in active use around the world and several thousand others that are now closed, all of which pose potential risks.

3.1.1.11. Life Alteration of Local People.

Mines have not only transformed landscapes, but have also dramatically altered the lives of the local people who live near mineral deposits. Hundreds of thousands of people have been uprooted in order to make way for mine projects. Many others have had to forsake traditional occupations and endure the effects of living beside a mine that poisons their water supplies or near a smelter that pollutes the air they breathe.

At the same time, mines have brought jobs, roads, and electricity to poor regions. Men and women with little other choice for work and communities living in extreme poverty have had to make the Faustian tradeoff—typically not out of their own choice: incur increased risks of lung disease and other health problems in exchange for jobs and income.

Each year 14,000 mine workers are killed at accidents on the job, and many more are exposed to chemicals or particulates that increase their risks of respiratory disorders and certain kinds of cancers. There have been significant improvements in mine safety in the last few decades, but mining is still the world's most hazardous occupation. According to the International Labour Organization (ILO), the sector employs less than 1% of all workers but is responsible for 5% of all worker deaths on the job.

Prostitution and drug use are serious problems at mining camps where migrant workers live, which has led to a high incidence of sexually transmitted diseases, including HIV/AIDS. In South Africa, about 30% of workers at gold mines are HIV positive.

3.1.2. Pollution from Extracting Fossil Fuels.

3.1.2.1. Pollution from Coal.

3.1.2.1.1. Damage from Mining Accidents.

Though safety standards have greatly improved, coal mining has been one of the most dangerous and environmentally damaging of all the major industries. Many thousands of miners have been killed or injured in mining accidents in countries such as Turkey, China and India, and large numbers have had their health impaired by breathing coal dust and working in dark, wet and cramped conditions.

3.1.2.1.2. Emission of Carbon and Sulphur Dioxides and Nitrous Oxides.

Coal's main disadvantage is the pollution it causes in its mining, transportation and use. Sulphur and ash content are especially high in soft coals, but all coals give off the fossil fuel problem emissions such as sulphur dioxide (the cause of acid rain), nitrous oxides (greenhouse gases which contribute to ozone smog), particulates (a cause of respiratory diseases) and carbon dioxide (the cause of global warming).

3.1.2.1.3. Acid Mine Drainage.

Acid mine drainage refers to water with high concentrations of sulfuric acid draining out of surface or subsurface coal mines. The sulfur-laden water originates from rainwater percolating through numerous fractures in crushed sulfur-rich coal in the mines. Prior to the 1950s, coal mining was conducted with little regard for its environmental impact. Today, the greatest problem with acid mine drainage generally stems from abandoned deep mines. Effluent from abandoned mine sites continues to be the leading water quality problem. However, China, India and other developing countries have still based their energy future on coal, while seeking to make use of affordable new technologies for reducing the environmental impact.

3.1.2.1.4. Damage from Metal Exposures.

The increased use of coal in the future will also increase metal exposures because coal ash contains many toxic metals and can be breathed deeply into the lungs. For countries such as China and India, which continue to rely on high-ash coal as a primary energy source, the health implications are ominous. Coal can be washed to reduce its ash content but this itself consumes energy and creates a waste water problem (Silver and Rothman 1995:7).

Coal contains a small amount of radioactive uranium, barium and thorium, around or slightly more than the average concentration of those elements in the Earth's crust. They become more concentrated in the fly ash because they do not burn well (Ojovan and Lee 2005:315).

However, the radioactivity of fly ash is still very low. It is about the same as black shale and is less than phosphate rocks, but is more of a concern because a small amount of the fly ash ends up in the atmosphere where it can be inhaled (USGS 1997:57-69).

3.1.2.2. Pollution from Oil.

Oil is a natural product which quickly breaks down in sea water. Chemical dispersants may do more harm than the oil itself, though heavy spillages close to shorelines can be disastrous for local sea birds and other forms of marine life. Of even greater concern is the build-up of atmospheric carbon dioxide caused by burning oil and other fossil fuels, and the pollution caused by sulphur dioxide, nitrous oxides and volatile organic compounds (VOCs).

Residues from the oil and gas industry often contain radium and its daughters. The sulphate scale from an oil well can be very radium rich, while the water, oil and gas from a well often contains radon. The radon decays to form solid radioisotopes which form coatings on the inside of pipe-work. In an oil processing plant the area of the plant where propane is processed is often one of the more contaminated areas of the plant as radon has a similar boiling point as propane.

3.1.2.3. Pollution from Natural Gas.

Though natural gas produces less pollution and carbon dioxide than oil and coal, it also gives off the fossil fuel problem emissions such as sulphur dioxide, nitrous oxides and carbon dioxide. Methane is 21 times more powerful than carbon dioxide as a greenhouse gas, so pipeline leaks have to be carefully monitored.

3.1.2.4. Oil Leakage.

Oil spills, from crude to used forms, not only in infamous cases like the Exxon Valdez in Prince William Sound, Alaska in 1989 and acts of war in the Persian Gulf in 2001, but also in the little collision between an oil tanker and a barge in the West Sea in South Korea in 2007, can be disastrous for marine life and ecological system.

For example, a total of 38,000 tonnes of crude oil spewed out into the pristine subarctic waters of the estuary with devastating results by the accident of the supertanker Exxon Valdez running around on reefs in Prince William Sound, Alaska in March 1989. The oil slick lost from the Exxon Vldez had spread 750 km down the Alaskan coastline from Prince William Sound into the Gulf of Alaska through Montague Strait. which was the worst incident in the United States waters.

3.1.2.5. Acid Rain.

Acid rain originates from sulfur dioxides and nitrous oxides emitted by motor vehicles, smelters, and especially electrical utility plants using high sulfur coal. Acid rain kills aquatic life in lakes, streams, and bays. It also destroys forests and other vegetation and thereby deprives wild animals of their habitats. It damages crops and corrodes buildings and historical monuments.

3.1.2.6. Discharge of Radioactive Wastes.

Radioactive wastes are waste types containing radioactive-chemical elements that do not have a practical purpose. They are sometimes the products of nuclear processes such as nuclear fission. However, other industries not directly connected to the nuclear industry can produce large quantities of radioactive waste. For instance, over the past 20 years it is estimated that just the oil-producing endeavors of the US have accumulated 8 million tons of radioactive waste (Silver and Rothman 1995:7-8).

3.1.3. Damage from Extracting Heavy Metals.

Since the Industrial Revolution, the production of heavy metals such as lead, copper, and zinc has increased exponentially. Between 1850 and 1990, production of these three metals increased nearly 10 times, with emissions rising in tandem (Nriagu 1996:223).

Heavy metals have been used in a variety of ways for at least 2 millennia. For example, lead has been used in plumbing, and lead arsenate has been used to control insects in apple orchards. The Romans added lead to wine to improve its taste, and mercury was used as a salve to alleviate teething pain in infants. Lead is still widely used as an additive in gasoline (Eaton and Robertson 1994:116-117).

3.1.3.1. Toxicity of Heavy Metals.

The toxicity of heavy metals has been documented throughout history: Greek and Roman physicians diagnosed symptoms of acute lead poisoning long before toxicology became a science. Today, much more is known about the health effects of heavy metals. Exposure to heavy metals has been linked with developmental retardation, various cancers, kidney damage, and even death in some instances because of exposure to very high concentrations.

Exposure to high levels of mercury, gold and lead has also been associated with the development of autoimmunity, in which the immune system starts to attack its own cells, mistaking them for foreign invaders (Glover-Kerkvliet 1995:236-237).

Autoimmunity can lead to the development of diseases of the joints and kidneys, such as rheumatoid arthritis, or diseases of the circulatory or central nervous systems (Glover-Kerkvliet 1995:237). Despite abundant evidence of these deleterious health effects, exposure to heavy metals continues and may increase in the absence of concerted policy actions.

3.1.3.2. Toxic Emissions from Heavy Metals

Once emitted, metals can reside in the environment for hundreds of years or more. Evidence of human exploitation of heavy metals has been found in the ice cores in Greenland and sea water in the Antarctic. The lead content of ice layers deposited annually in Greenland show a steady rise that parallels the mining renaissance in Europe, reaching values 100 times the natural background level in the mid-1990s (Nriagu 1996:223).

Mining of heavy metals is itself a major route of exposure. Despite some noted improvements in worker safety and cleaner production, mining remains one of the most hazardous and environmentally damaging industries. In Bolivia, toxic sludge from a zinc mine in the Andes had killed aquatic life along a 300-kilometer stretch of river system in 1996.

It also threatened the livelihood and health of 50,000 of the region's subsistence farmers (Edwards 1996:4). Uncontrolled smelters have produced some of the world's only environmental "dead zones," where little or no vegetation survives. For instance, toxic emissions from the Sudbury, Ontario, nickel smelter have devastated 10,400 hectares of forest downwind of the smelter (Young 1992:21).

3.1.4. Environmental Impact from Small-scale Mining.

3.1.4.1. Damages from Mercury Use

Mercury is still extensively used in gold mining in many parts of Latin America. The use of mercury in small-scale mining techniques has health and environmental consequences. Mercury is discharged into the environment when miners fail to recover mercury tailings, either by dumping waste directly into rivers or by releasing mercury vapors into the atmosphere when the mercury-gold compound is burned.

Small-scale miners use inorganic mercury, which is often converted through natural processes into toxic organic and inorganic compounds. Of greatest concern is the highly toxic organic compound, methyl mercury, which forms in rivers and lakes when micro-organisms metabolize metallic mercury. This toxic form of mercury then accumulates in fish and when ingested causes mercury poisoning in humans.

Metallic or inorganic mercury can also be hazardous if it is transformed into gas from its liquid state; in a recent case, teenagers in the United States who handled liquid mercury were hospitalized for mercury poisoning after samples of the silvery substance formed a hazardous vapor. Although symptoms differ for poisoning by inorganic and organic mercury, both kinds may result in nervous system disorders, birth defects, or death. Estimates for the amount of mercury released into the environment as a result of small-scale mining vary from 1-4 kilograms per kilogram of gold extracted (Hutcheson 1998:12).

In the Amazon Basin alone, between 90-120 tons of mercury is discharged annually into local rivers (Malm et al. 1990:11-15). In Venezuela, the amount of mercury lost in the environment is estimated to exceed 10 tons per year (Nriagu et al. 1992:389). While the impact of mercury pollution may be severe at a site of mining activity, it is by no means restricted to that area and can affect communities many kilometers away (Stallard 1995:73).

In Venezuela, substantial metallic mercury deposits have been found to exist in the bottom of a river where mining is occurring, and as of 1989, fish were beginning to show evidence of mercury contamination (Malm et al. 1990:11-15). Nonetheless, without baseline data on the water quality and composition of the river bottom materials before mining began, it is difficult to determine with any certainty how much mercury has been deposited in local riverbeds as a result of small-scale mining operations (Litos 1989:7).

3.1.4.2. Soil and Water Damage

Most small-scale mining, mostly operated in under-developed countries, increase sedimentation in rivers through the use of hydraulic pumps and suction dredges. By blasting hillsides with water under high pressure, hydraulic pumps leave scars on the landscape, which may take years to develop even the lightest covering of vegetation.

Since most small-scale miners do not preserve the topsoil removed before excavation begins, this topsoil is often washed away into surface water, carrying with it ecologically valuable seed banks that are necessary for the regeneration of vegetation. Additionally, few small-scale miners engage in reclamation or post-mining recovery practices.

3.1.5. Damage from Closed Mines.

3.1.5.1. Acid Mine Drainage.

Mining's effects frequently persist long after an operation is closed. Acid drainage is an especially long-lived problem. This happens when a mining operation excavates rock that contains sulfide minerals. When these materials are exposed to oxygen and water, they react to form sulfuric acid. This acid will continue to form, and to drain out of the rock, as long as the rock is exposed to air and water and the sulfides have not been depleted - a process that can take hundreds or thousands of years.

Once a mine reaches the end of its operational lifetime, ground-water is contaminated by acid water drainage and eventually flowed into rivers and dams, and adjacent soils are polluted with heavy metals such as cadmium, lead and so forth which come out of abandoned mine sites.

The Iron Mountain mine in northern California, for instance, has been closed since 1963 but continues to drain sulfuric acid, along with heavy metals such as cadmium and zinc, into the Sacramento River. The river's bright orange water is completely devoid of life. Experts report that the mine may continue to leach acid for another 3,000 years.

3.1.5.2. Pollution of Groundwater.

Ground-water pollution from mining is exacerbated by abandoned and derelict mines, which threaten to decant acid mine drainage into the country's water courses. Under normal circumstances, operational mines pump water out of the underground workings to facilitate underground operations and to prevent the water from becoming polluted by the operations as well as to secure access to mineral reserves (Tyrer

2006:8-9).

However, once a mine reaches the end of its operational lifetime and pumping activities cease, clean ground-water can reach mined-out areas where it becomes exposed to iron sulphides, which causes the water to become contaminated with heavy metals and salts. The contaminated water, which is known as acid mine drainage, rises to the surface through shaft entrances, decanting into adjacent mines and eventually reaches rivers and dams.

Beside acid mine drainage, mining operations can affect water quality through heavy metal contamination and leaching of slime dams, processing chemical pollution, erosion and sedimentation and tailings pollution.

3.2. Climate Change from Greenhouse Gases (GHGs) Emissions.

Rapid environmental change is all around us. The most obvious example is climate change alarmed by the Creator today. If we do not act to recover it, the true cost of our failure will be borne by succeeding generations, starting with ours. That would be an unconscionable legacy; one which we must all join hands to avert. So, the climate change is not only a political and geological problem, but also an ethical and peace problem for all creatures (Choi 2008:1).

Mr. Utah Phillips, an American singer, said that "the earth is not dying. It is being killed, and the people killing it have names and addresses." It is necessary for us to make it clear that while the earth is being killed, we are indulging ourselves in human civilization so much.

A population of 6.5 billion used the equivalent of 9.3 billion tons of oil, which released 7.6 billion tons of carbon emissions in 2005. Much of this oil, coal and natural gas supported consumer lifestyle—literally fueling nearly 900 million vehicles on the roads and 3.7 trillion kilometers that passengers flew in planes in 2006, as well as keeping houses warm, lights on, and factories running. Our activities raised the atmospheric levels of carbon dioxide by 2.2 parts per million (ppm) in 2006, bringing the total to 382 ppm, which is 100 ppm higher than pre-industrial level, that resulted in 2006 being the fifth hottest year since 1880.

Weather-related disasters are already having dramatic impacts on all the animals and natures as well as human beings. The climate change is just one indicator of the threats we face as a rigorous alarm from the Creator, God of grace. At least 60% of ecosystem services are being degraded or used unsustainably, according to the Millenium Ecosystem Assessment (Worldwatch Institute 2007:9-10).

The people causing this destruction have name and addresses. They include you and me and all the other consumers in the world. They include politicians who make empty promises or no promises at all. They include corporate executives who continue to ignore the realities of doing business on a finite and fragile planet and instead put profit over long-term concerns by encouraging consumers to crave various kinds of goods that are bad for them and the planet.

3.2.1. Causes of Climate Change.

Since the beginning of the industrial revolution around 1750, human beings have emitted significant amounts of greenhouse gases (GHG) into the troposphere by three activities. One has been the sharp rise in the use of fossil fuels, releasing large amounts of carbon dioxide (CO_2) and CH_4. Another is deforestation and clearing and burning of grasslands to raise crops, releasing CO_2 and N_2O. The third is cultivation of rice in paddies and use of inorganic fertilizers, releasing N_2O in the troposphere (Miller 2004:280-304).

There is no doubt that CO_2 among such greenhouse gases is leading to significant changes in the climate. In 2007, the Intergovernmental Panel on Climate Change (IPCC) released its strongest statement yet linking rising CO_2 emissions and increasing global temperatures. Some 2,500 experts concluded with at least 90% certainty that the observed warming over the last 50 years has been caused by human activities and that discernible human influences are now apparent in changed precipitation and storm intensity and in other instances of extreme weather worldwide (Jung, 2007:8).

The two largest contributors to CO_2 emissions are the world's thousands of coal-burning power and industrial plants and millions of gasoline-burning vehicles. Nor is there doubt that these changes will impose huge costs. The question is no longer whether we can afford to do something, but rather how to control emissions in an equitable and effective way.

The United States is the largest polluter in the world. But she refused to sign the Kyoto Protocol. China is in a race to be the world's worst polluter with the United States. And there are no requirements put on developing countries to control the GHGs emissions in the Protocol, even though they will contribute half or more of emissions. Additionally, nothing was done about deforestation in the Protocol, which is contributing to global warming as well. Indonesia might be the third polluter owing to its rapid deforestation.

3.2.2. Emissions of Carbon Dioxide (CO_2).

Carbon emissions continue rise unrelentingly. In 2006, atmosphere carbon dioxide (CO_2) concentrations reached 381.84 parts per million by volume (7.60 billion tons). Average CO_2 concentrations have risen 20.8% since measurements began in 1959 and are now more than 100 parts per million higher than in pre-industrial times.

Fossil fuel burning represents about 80% of this increase. In 2006, the carbon emissions of 7.60 billion tons means to emit more than one ton for every person on earth. Annual emissions from fossil fuels have risen 17% just since 2000 as shown in the table 2.

The average global temperature increased from 13.85 degree Celsius in 1950 to 14.54 in 2006. The climate is warming most rapidly at the poles. Over the past century, Arctic temperature rose at almost twice the global average rate. One model projects that Arctic summers could be ice-free by 2040. In late 2006, the U.S. Interior Department proposed adding polar bears to the list of threatened species as accelerating ice loss threatens their habitat.

Table 3.2: Global Average Temperature and Carbon Emission from Fossil Fuel Burning and Atmospheric Concentration of Carbon Dioxide.

Year	1950	1960	1970	1980	1985	1990	1995	2000	2005	2006
Atmospheric Concentrations of CO_2	-	316.91	325.68	338.68	345.90	354.19	360.88	369.48	379.66	381.84
Carbon Emissions	1.61	2.53	4.00	5.21	5.30	5.99	6.21	6.45	7.56	7.60
Temperature.	13.85	13.99	14.03	14.18	14.06	14.38	14.38	14.33	14.63	14.54

Sources: GISS, BP, IEA, CDIAC, DOE, and Scripps Inst. of Oceanography. Worldwatch Institute, Vital Signs 2007-2008, New York, 2007, p.43.

The United States remains the world's top emitter, accounting for over 21% of carbon emission from fossil fuel burning in 2005. But the largest increases occurred in Asia. China's emission rose 9.1% in 2005. Experts predict that China will emit more carbon from fossil fuel consumption than the United States does before 2010.

Table 3.3: CO_2 Emission Situation of Major Countries in 2004.

Country	Annual Emission (million tons)	Per Capita Emission (ton)	Increasing Rate from 1990 to 2000 (%)
USA	7,074	19.73	15.2
China	4,938	3.65	32.3
Russia	1,952	10.63	-36.4
India	1,884	1.02	41.5
Japan	1,355	9.52	9.6
Germany	1,015	10.29	-16.7
Brazil	851	1.76	24.8
Canada	758	17.24	20.9
England	659	8.98	-10.1
Italy	583	7.95	7.1
South Korea	521	9.61	79.1

Source: Korean National Statistical Office, International Statistics Yearbook 2007/BP/IEA/Hankyuhrae Shinmoon, June 1, 2007.

3.2.3. Impact of Climate Change.

Floods, droughts, melting ice caps, disappearing coastlines, deadly heat waves and bizarre weather are all the signs of climatic upheaval from global warming caused by the continued build-up of carbon dioxide and greenhouse gases. The heatwaves, floods, and droughts could cause hunger for millions of people and water shortages for billions, with the world's poor hit the hardest.

Weather-related disasters are often perceived as natural events, but many actions have a hand in their creation. For example, climate change is warming sea temperatures, which can lead to stronger hurricanes. Sea levels rising threatens low-lying areas, especially during storms. Damage to mangrove forests and coral reefs weakens natural storm defenses. And with more people forced to live in undesirable, riskier areas, the potential for disaster is ever higher.

However, most developing countries may not feel responsible for the vast majority of the carbon dioxide hanging around in the atmosphere. Because most of it has been emitted by Western advanced countries during their own development over the past 200 years.

Ironically, experts predict climate change will disproportionately affect poorer countries and communities, and insist on the need for solidarity in the fight against global warming. Climate change accompanied by the aforementioned disasters is more unfavourable to the socio-economically weak, who are usually less responsible for the advent of climate change and have less ability to cope with the impact of climate change. Namely, the least responsible are the most vulnerable to climate change.

It has turned out that Africa is the continent most suffering from the impact of climate change. Most of Africa will be hit the hardest if climate change continues in its current course. So, it is necessary to set up an international supporting system for the poor and Africa.

3.2.4. The Kyoto Protocol.

Under the Kyoto Protocol established in 1997 by the U.N. Convention on Climate Change adopted in 1992, developed country members are legally required to cut their greenhouse gas emissions. They agreed to cut greenhouse gas emissions collectively by an average of 5% of 1990 levels over the first commitment period from 2008 to 2012. Each member country has its own specified target listed in an annex.

Developing countries are not required to commit to their emission reductions because of their lower development level and little contribution to the historical buildup of carbon dioxide in the atmosphere. They might commit to collect data on greenhouse gases at the national level and formulate national measures for developed countries to provide them with finances and technologies concerned with global warming.

However, some countries are no longer satisfied with developing countries' exemption from binding emission cuts and suggesting for the second period to place new conditions targeting big countries like China and India and more industrialized countries such as South Korea and Brazil. They are also calling for comprehensive negotiations for a new post-2012 treaty to pull developing countries into making their commitments with different levels for different developing countries. Another problem is the refusal of the United States to join the Kyoto Protocol and follow its emission targets. She has complained about letting big countries off the hook, and used it as a reason for pulling out of the Protocol.

So, the year of 2012 is very important because the first commitment period ends and the second period starts in 2013 to carry out the new agreed binding targets for further reducing their emissions. Global warming is too important to be held hostage in another attempt at squeezing the poor. It is obviously our urgent duty to heal the climate change caused by human beings and alarmed the Creator God. So, we should talk an effective, comprehensive and equitable post-2012 international climate change arrangement based on the will of God as the post-Kyoto Protocol to control GHG emissions perfectly.

U.N. Secretary-General Ban Ki-moon urged at the United Nations Climate Change Conference held at Bali, Indonesia December 3-14, 2007 that the world must reach an agreement by 2009 for a new treaty to meet "the moral challenge of our generation." Succeeding generations depend on us, we need to set a road-map to a more secure climate future. We can not rob our children of their future (Cho 2007:3).

3.3. Environmental Impact from Nuclear Power Plants.

3.3.1. Concern from Nuclear Power Plants.

Concern for the effects on the future of nuclear power plants has focused on high cost, reactor accident risks, radioactive waste management, and potential links in the spread of nuclear weapons.

3.3.1.1. Handling of Radioactive Waste.

When trying to establish a long term nuclear energy production plan, the issue of disposal methods for nuclear waste has been one of the most pressing current problems, which stems from uncertainties, complications and setbacks in handling the issue properly.

3.3.1.2. Risking Future Generations.

Although managing issues for radioactive waste have been raised concerning possible consequences for future generations in the past three decades, many risk decisions may impose risks on future generations that require a different kind of consideration from risks to people living today. The long-term existence of radioactive waste results in referring to the issue of inter-generational equity.

3.3.1.3. Proliferation Concerns for Nuclear Weapons.

Even though being dismantled by the major nations, nuclear weapons are growing in number due to the production of these mass destruction weapons through using the materials generated from nuclear plants. This is another unfortunate legacy for future generations.

When dealing with uranium and plutonium, the possibility that they may be used to build nuclear weapons is often a concern. Active nuclear reactors and nuclear weapon stockpiles are very carefully safeguarded and controlled.

However, high-level waste from nuclear reactors may contain plutonium. Ordinarily, this plutonium is reactor-grade plutonium, containing a mixture of plutonium-239 (highly suitable for building nuclear weapons), plutonium-240 (an undesirable contaminant and highly radioactive), plutonium-241, and plutonium-238; these isotopes are difficult to separate.

Moreover, high-level waste is full of highly radioactive fission products. However, most fission products are relatively short-lived. This is a concern since if the waste is stored, perhaps in deep geological storage, over many years the fission products decay, decreasing the radioactivity of the waste and making the plutonium easier to access. Moreover, the undesirable contaminant Pu-240 decays faster than the Pu-239, and thus the quality of the bomb material increases with time (although its quantity decreases).

Thus, some have argued, as time passes, these deep storage areas have the potential to become "plutonium mines", from which material for nuclear weapons can be acquired with relatively little difficulty. Critics of the latter idea point out that the half-life of Pu-240 is 6,560 years and of Pu-239 24,110 years, and thus the relative enrichment of one isotope to the other with time occurs with a half-life of 9,000 years.

The weapon grade plutonium mines would be a problem for the very far future (9,000 years from now), so that there remains a great deal of time for technology to advance and solve this problem, before it becomes acute.
Pu-239 decays to U-235 which is suitable for weapons and which has a very long half life (roughly 109 years). Thus plutonium may decay and leave uranium-235. However, modern reactors are only moderately enriched with U-235 relative to U-238, so the U-238 continues to serve as

denaturation agent for any U-235 produced by plutonium decay.

One solution to this problem is to recycle the plutonium and use it as a fuel e.g. in fast reactors. But in the minds of some, the very existence of the nuclear fuel reprocessing plant needed to separate the plutonium from the other elements represents proliferation concern. In pyrometallurgical fast reactors, the waste generated is an actinide compound that cannot be used for nuclear weapons.

3.3.1.4. Promoting Energy Consumption.

In order to construct and demolish nuclear power plants and manage nuclear waste safely, we must do an enormous amount of investment into nuclear fields. Nuclear power plants also produce large amounts of electricity. Whereas other types of electrical generation can be limited in scale, no engineer has come up with an effective design for a truly small nuclear plant so far.

This is a problem because it requires the consumption of large amounts of electricity to make up for the high construction, demolition and management costs. For highly developed countries, the results in high consumption need not be an economic problem, but it eventually results in a serious environmental and social impact. Additionally, the energy demand is not that high in much of the developing world yet, and the infrastructure for transmitting electricity throughout sparsely populated areas does not exist.

3.3.1.5. Technical Stigma.

Other problems associated with nuclear reactors deal with safety, the fear of radiation, and the presence of an unwanted facility. There is a stigma attached to nuclear power. Technical stigma is a fact of nuclear power. So, trying to site a future nuclear plant, hazardous waste site, low-level waste site, or any industrial facility does produce substantial public opposition.

In the United States, nuclear power plants and nuclear waste sites have generated substantial public opposition. Controversy over nuclear energy, both bombs and reactors, has been exceptionally durable and violent, exciting more emotion and public protest than any other technology.

3.3.1.6. Apprehensive Substitute Energy.

A fundamental foundation of ecology is that we live on a finite and self-contained planet. Although the limits of non-renewal resources can be sometimes significantly extended by means of human science and technology, there are no inexhaustible energy and mineral resources. So, ecological prudence for resource exhaustion is adaptation to the forces and restraints of nature that cannot be changed, no matter how sophisticated our science and technology develops in the future.

Therefore, the resource issue dominated the early days of nuclear power. Arguments were made that the world has only a finite amount of oil and gas, so that uranium must be used for energy generation. Then it was argued that uranium was in short supply, so it would be necessary to recycle used fuel and to build breeder reactors that could transmute the large quantities of non-fissile uranium 238 into fissionable material.

However, there are still some serious problems which we should solve with regard to the use of nuclear energy as the substitute energy for fossil fuels as mentioned above. We should keep in mind that nuclear energy has a much higher environmental impact than fossil fuel energy.

3.3.2. Management of Nuclear Waste.

When trying to establish a long term nuclear energy production plan, the issue of disposal methods for nuclear waste has been one of the most pressing current problems (www.uic.com.au/nip78.htm).

3.3.2.1. Sources of Radioactive Waste.

Radioactive waste comes from a number of sources. The majority originate from the nuclear fuel cycle and nuclear weapon reprocessing. However, other sources include medical and industrial waste as well as naturally occurring radioactive materials (NORM) that can be concentrated as a result of the processing or consumption of coal, oil, gas and some minerals.

Although not significantly radioactive, uranium mill tailings are waste. They are byproduct material from the rough processing of uranium-bearing ore. Uranium mill tailings also contain chemically-hazardous heavy metals such as lead and arsenic.

3.3.2.2. Categorization of Radioactive Waste.

In the United State, radioactive waste is categorized as low level waste (LLW), transuranic waste (TRU), and high level waste (HLW). HLW includes the spent fuel from commercial and other reactors and government waste from the production of nuclear weapons. Currently, HLW is generally being stored at the reactor sites in the country and at several government facilities.

The majority of radioactive waste is low-level waste, meaning it has low levels of radioactivity per mass or volume. This type of waste often consists of used protective clothing, which is only slightly contaminated but still dangerous in case of radioactive contamination of a human body through ingestion, inhalation, absorption or injection.

3.3.2.3. Significance of Radioactive Waste.

Radioactive waste typically comprises a number of radioisotopes: unstable configurations of elements that decay, emitting ionizing radiation which can be harmful to human health and to the environment. Those isotopes emit different types and levels of radiation, which last for different periods of time.

The radioactivity of all nuclear waste diminishes with time. All radioisotopes contained in the waste have a half-life time it takes for any radio-nuclide to lose half of its radioactivity, and eventually all radioactive waste decays into non-radioactive elements.

Certain radioactive elements (such as plutonium-239) in spent fuel will remain hazardous to humans and other living beings for hundreds of thousands of years. Other radioisotopes will remain hazardous for millions of years. Thus, this waste must be shielded for centuries and isolated from the living environment for hundreds of millennia (www.marathonresources.com.au /nuclearwaste.asp).

Some elements, such as Iodine-131, have a short half-life around 8 days and thus they will cease to be a problem much more quickly than other, longer-lived, decay products but their activity is much greater initially.

The faster a radioisotope decays, the more radioactive it will be. The energy and the type of the ionizing radiation emitted by a pure radioactive substance are important factors in deciding how dangerous it will be. The chemical properties of the radioactive element will determine how mobile the substance is and how likely it is to spread into the environment and contaminate human bodies. This is further complicated by the fact that many radioisotopes do not decay immediately to a stable state but rather to a radioactive decay product leading to a decay chain.

3.3.2.4. Difficulty of Repository Location.

Establishing a site has not been easy. For example, the Waste Isolation Pilot Plant (WIPP) site for transuranic waste (TRU) had been under study for 25 years before opening in 1999. In May of that year, the U.S. Environmental Protection Agency (EPA) stated that there is a reasonable expectation that WIPP can be counted on to contain the TRU waste for the next 10,000 years. That points out one of the great difficulties of finding a repository location. The time period required for safety calculations exceeds recorded human history (Ojovan and Lee 2005:315).

3.3.2.5. Disposal Target of Radioactive Waste.

The main objective in managing and disposal of radioactive waste is to protect people and the environment. This means isolating or diluting the waste so that the rate or concentration of any radio-nuclides returned to the biosphere is harmless.

To achieve this, the preferred technology to date has been deep and secure burial for the more dangerous waste. Transmutation, long-term retrievable storage, and removal to space have also been suggested. So in principle the waste needs to be isolated for a particular period of time until its components have decayed such that they no longer pose a threat. In practice this can mean periods of hundreds of thousands of years, depending on the nature of the waste involved to avoid causing harm to remote future generations.

3.3.2.6. Disposal of Low Level Waste (LLW).

Low level waste (LLW) is generated from hospitals and industry, as well as the nuclear fuel cycle. It comprises of paper, rags, tools, clothing, filters, etc., which contains small amounts of mostly short-lived radioactivity. Commonly, LLW is designated as such as a precautionary measure if it originated from any region of an active area, which frequently includes offices with only a remote possibility of being contaminated with radioactive materials.

Such LLW typically exhibits no higher radioactivity than one would expect from the same material disposed of in a non-active area, such as a normal office block. Some high activity LLW requires shielding during handling and transport but most LLW is suitable for shallow land burial. To reduce its volume, it is often compacted or incinerated before disposal.

Low level waste is divided into four classes, class A, B, C and GTCC, which means greater than class C. Intermediate level waste (ILW) contains higher amounts of radioactivity and in some cases requires shielding. ILW includes resins, chemical sludge and metal reactor fuel cladding, as well as contaminated materials from reactor decommissioning. It may be solidified in concrete or bitumen for disposal.

3.3.2.7. Disposal of High Level Waste (HLW).

High level waste (HLW) is produced by nuclear reactors. It contains fission products and transuranic elements generated in the reactor core. It is highly radioactive and often thermally hot. HLW accounts for over 95% of the total radioactivity produced in the process of nuclear electricity generation. The amount of HLW worldwide is currently increasing by about 12,000 metric tons every year, which is the equivalent of about 100 double-decker buses or a two-story structure built on top of a basketball court (Babu and Karthik 2005:93-102).

3.3.3. Issue of Inter-Generational Equity.

The predominant inter-generational issue associated with nuclear waste is that of radioactive waste, primarily the HLW from spent fuel. International bodies have taken the position that in disposal methods, future generations should not be asked to bear a burden any greater than that borne by present generations.

The International Atomic Energy Agency (IAEA) has stressed that it is responsible today to deal with the future: "The objective of radioactive waste management is to deal with radioactive waste in a manner that protects human health and the environment now and in the future without imposing undue burdens on future generations" (par. 314). The IAEA has also stated that "radioactive waste shall be managed in a way that predicted impacts on the health of future generations do not exceed relevant levels that are acceptable today" (par. 314).

What are "undue burdens," and who decides what is acceptable? Kristen Shrader-Frechette has written:

> All alleged risk reductions are actually risk tradeoffs, and one cannot diminish one risk without increasing another......Indeed, throughout life, we exchange risks rather than remove them, and we increase our risks to gain something more valuable.

If a geologic repository is built, the waste would be stored in containers that should not fail for at least 1,000 years, and probably longer. Thus, for the present generation, there would be no risk because the waste cannot get to the surface and cause radiation exposure. But at some unknown future time, a container will fail, and eventually a radionuclide will enter the biosphere. Since some radionuclides will be around for several hundred thousand years, there will be a burden on any people living then that would be greater than the burden on the present generation.

The current focus is to try to design waste packaging and a repository that will be able to last at least 10,000 years. Can we imagine to hold up over such a long time frame? But a National Academy of Sciences study indicated that there is no technical basis to stop at 10,000 years, because the estimated dose that could be received external to the site would continue to rise until perhaps a million years.

A major difficulty in concluding that a HLW repository should be constructed now relates to the uncertainty in estimates of long-term releases. Those opposed to a repository do not believe that a convincing case has been made that the current repositories will be safe for such long periods of time. The opponents ask, "For how long should we be concerned that the nuclear waste is safely stored?" and "How do we protect the future environment and people?" This is called the issue of inter-generational equity.

It is clear that we should not punish our children and grandchildren today, in order to fend off wholly imaginary demons in the unforeseeable future. On the other hand we cannot leave problems for future generations that cannot be resolved today. But it is also of serious concern that doing nothing today may lead to far greater hazards in the future. Nonetheless, we have a responsibility to handle them wisely, not only for the present but also for the future. This is not a technical mandate but an ethical and theological one of long-standing significance (Ahearne 2000:763-770).

Chapter IV: Environmental Impact from Mining Activities and Nuclear Plants in Korea.

South Korea[1] has accomplished a very compressed form of economic growth over the last 50 years. But the rapid economic growth has been accompanied by rapid ecological dilapidation and environmental pollution. The environment was sacrificed by pursuing more economic growth through industrialization. However, the Korean people's recognition of the value of the environment was revitalized with the experience of several environmental disasters including the phenol accident in the Nakdong river in 1991, the acid drainages from closed mines in 2006, and the oil spill in the West Sea in 2007 etc.

Economic growth has made people pay more attention to aspects of quality of life which is mostly dependent upon the quality of the surrounding environment. Since democratization from the long lasting military government in 1987, environmental movements have also grown as rapidly as environmental destruction and have actively engaged in environmental recovery and protection.

However, most of Korean churches used to distance themselves from environmental movements except voluntarily participating in the oil-removing activities in the west seacoast polluted by the oil spill disaster in December 2007. They have not particularly concerned themselves with an ecological mission for mining activities and nuclear power plants in South Korea. They are of the opinion that environmental issues are only for the government and specialized non-government agencies, not for the churches.

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1) Korea is located between 124 11'E and 135 53'E and between 33 06N and 43 01N. Its area is 221.467 km , of which length and width are about 1,000 km and 216 km respectively at its shortest point. It is surrounded by the East Sea, West Sea and South Sea. Korea is divided by the Republic of Korea (South Korea) and the Democratic People's Republic of Korea (North Korea). The governing area of South Korea is 99,117 km (about 45% of total area). Due to the rising of the eastern part of Korea, about 67% of Korean territory is geomorphologically characterized by abundant hills and mountains. The population of South Korea is 48.45 million people in 2007.

4.1. Korean Political and Economic Context.

4.1.1. Economic Growth Trends.

The Koreans are one ethnic family speaking one language and they have a strong cultural identity. A number of wars led to reconstruction efforts which were highly successful in promoting national prosperity and stability. Thus, modern day Korea is a nation that has rebuilt itself from the devastation of wars and has achieved an economic miracle in just 50 years.

Some of the factors that are generally cited to explain the "economic miracle" include the strong government support, the export-oriented economic strategy, the emphasis on high technology in industrial policy and the abundance of highly skilled and educated labourers.

An outward-oriented economic development strategy contributed greatly to the radical economic transformation of South Korea. As a result of such a strategy, Korean exports have rapidly increased from US$ 55 million in 1962 to US$ 371,489 million in 2007 as shown in table 1. Korea's major industries include electronics, automobiles, semi- conductors, steel products, shipbuilding, textiles and so on.

Since the financial crisis in 1997, Korea has achieved the most rapid economic growth among countries belonging to the Organization for Economic Cooperation and Development (OECD) with an annual growth of 6%. As a result of the rapid economic growth, Korea's gross domestic product (GDP) increased from US$ 2.3 billion in 1962 to US$ 7,821 billion in 2007, with its per capita GDP soaring from US$ 87 in 1962 to US$ 20,045 in 2007. The number of cars has also sharply increased from 10.4 million vehicles in 1997 to 16.4 million in 2007. With a history as one of the fastest growing economies in the world, Korea is now working to become the financial and business hub of Northeast Asia in the 21st century (KEEI 2008:253-265).

Nevertheless, it has accomplished little progress on the environmental fields of air, water and waste management as pointed out in the OECD environmental report in 2007. The major environmental problems South Korea is now facing is the increasing emission of CO_2, nuclear waste treatment and pollutions from the closed mines spread all over the country.

Therefore, it has become unrgent to consider seriously the environmental impact of the continuing supply of energy and mineral resources to meet such a rapid economic growth.

Table 4.1: Export and Import Trends of Korea. Unit: US$ Million.

Year	1962	1970	1980	1995	2000	2005	2006	2007
Exports	55	835	17,505	65,016	172,268	284,419	325,465	371,489
Imports	422	1,984	22,292	69,844	160,481	261,238	309,383	356,846

Source: Korea Energy Economics Institute (KEEI), Yearbook of Energy Statistics, 2008, p. 256.

4.1.2. Demand for Energy and Mineral Resources.

Korea has needed a great deal of energy and mineral resources to meet the increasing demand for her rapid economic growth. In order to meet the requirements for mineral resources, she promoted domestic mining activities, but was faced with serious difficulties as a result of the deepening and narrowing of mines, except in the case of some minerals such as anthracite coal, limestone, pyrophyllite, kaolin, sulphur etc. Consequently, she has made an effort to develop overseas energy and mineral resources.

After going through the serious energy shortage from the oil shock in 1973 and 1979 by OPEC, she has developed nuclear power plants from the 1970s. However, most western countries have suspended and/or decreased the development of plants as a result of the serious impact of accidents at three-mile-away Island in America and Chernobyl in Russia, treatment of nuclear waste and technical stigma as mentioned in 3.2.1.

In her energy and minerals development drive to meet the rapid increasing requirements, she confronts some serious environmental and ethical problems at the moment in the light of the demand for sustainable development.

4.1.3. Hot Political Issue.

Korea is the only country in the world that is divided into two states as the result of the superpower hegemony of the U.S.A. and the Soviet Union during the Cold War. In the late 1980s and early 1990s, epochal changes in Eastern Europe and the Soviet Union brought an end to the Cold War, while South Korea moved swiftly to exploit the situation by actively promoting a "Northern Diplomacy." South Korea's energetic pursuit of the Northern

Diplomacy contributed to the enhancing of its ties with North Korea and former socialist countries, which had languished due to ideological and structural differences.

As a result of these efforts in bringing about a peaceful coexistence between South and North Korea, the Agreement on Reunification, Nonaggression and Exchanges and Cooperation (the Basic South-North Agreement) and the Joint Declaration of the Denuclearization of the Korean Peninsula were concluded in 1991. The people of South Korea have surely recognized that these historic documents represent a step towards their common political target of the peaceful reunification of a divided nation.

In spite of the Joint Declaration of the Denuclearization of the Korean Peninsula in 1991, North Korea finally announced at the end of 2004 that it had already developed some nuclear weapons in the vindication of protecting its territorial right. Nevertheless, South Korea is pursuing its diplomacy through dialogue in dealing with the nuclear issue posed by North Korea in coordination with U.S.A., Japan, China, Russia, the European Union, and other countries (KOIS 2008:49-60).

4.2. Mining Situation of South Korea.

Korea is a small state and has poor natural resources. But Korea has rapidly consumed its energy and mineral resources to meet the rapidly increasing demand for mineral resources as a result of her rapid economic growth and welfare promotion.

4.2.1. Historical Summary of Mining Industry.

With Korean mining activities starting from the neolithic and bronze era, the Silla (B.C. 57 - A,D. 935) and Baekje dynasty (B.C. 18 - A.D. 660) transferred their high steel-manufacturing techniques to Japan. But the Choseon dynasty with a self-sufficient economy based on agriculture down-played mining and manufacturing activities due to practicing the principle of confucianism.

The Mines Act was promulgated in 1906 by the Japanese colonial government for the first time in Korea. The Japanese government continually used the Mines Decree to exploit mineral resources in full swing in Korea to supply strategic war materials such as tungsten, iron and coal etc., and the Gold Mining Decree to monopolize the gold mines by the Japanese and to build war funds. During the colonial period of Japan, Korea was the second largest gold-producing country in the world. The reckless mining activities under Japanese colonial rule caused serious environmental damages in Korea (KORES 2003:5-9).

After independence from Japan in 1945, the Korean government encouraged the mining industry to build the foundation funds for a Korea totally destroyed by World War II. The mining law was firstly enacted in December 1951 during the Korean War between South and North Korea (1951-1953). The mining industry had played a pivotal role in the Korean economy so that mineral products accounted for 78% of the total export earnings in 1953.

Korea established the Korea Resources Corporation to promote the mining industry to meet the increasing need for mineral resources as a result of her rapid economic growth, and set up the Korea Petroleum Development Corporation to prevent the serious energy shortage after the oil crises by OPEC.

In spite of trying to promote the domestic mining industry, most of the metallic mining and smelting works were ceased in the 1980s as a result of scanty reserves and the deepening of mines. Most of the metal mines were also shut down due to poor development conditions, except a number of iron and titanium mines currently in normal operation.

Anthracite coal as fuel material has lost its international competitiveness since the late 1980s as a result of environmental problems. The anthracite coal industry in South Korea has been rationalized due to its poor development conditions and environment impact.

Thus, Korea has resorted to import about 99% of her energy and metal consumption. However, the non-metal mines are still viable. Their non-metal products account for 72.78% of her requirements in 2007 (KIGAM 2008:5-7; KEEI 2008:12-13).

4.2.2. Register Trends of Mining Areas.

There are 330 kinds of minerals identified in Korea so far. 66 kinds among them were registered as legal minerals (36 for metallic and 20 for non-metallic minerals). The 20 kinds were under operation in 2007, of which 6 were metallic and 14 non-metallic (KORES 2007:13-17).

However, the registered numbers of mining areas have sharply decreased from 12,036 in 1990 to 5,284 in 2006 due to the closure of mines with low profits as a result of their scanty reserves, the deepening of mines, and increasing environmental impacts as shown in the table 2. The numbers of operating mines have decreased to 506 in 2007 from 830 in 1985, diminishing the mining workers from 13,719 in 1985 to 3,739 in 2007 as shown in table 2.

So, the Korean government has been pursuing a development of overseas mineral resources instead of her domestic ones to meet the rapid increasing demand of mineral resources and avoiding environmental problems.

Table 4.2: Register Trends of Mining Areas in South Korea.

Minerals		1990	1995	2000	2004	2005	2006
Metallic	gold/ silver/ copper/ lead/ zinc	2,581	1,473	691	567	592	561
	iron/ manganese	194	129	55	56	60	57
	others	168	120	94	87	70	73
	Sub Total	**2,943**	**1,722**	**840**	**710**	**722**	**691**
Non-Metallic	limestone	1,879	1,979	1,464	1,451	1,369	1,445
	kaolin/ pyrophylite	2,398	2,450	1,302	1,416	1,384	1,384
	feldspar/ silica stone	1,883	1,973	922	787	854	878
	pagodite	194	155	110	151	129	127
	talc	166	120	166	72	63	65
	mica	182	202	184	185	187	177
	others	1093	713	485	456	453	418
	Sube Total	**7,795**	**7,592**	**4,565**	**4,518**	**4,444**	**4,494**
Energy	coal	1,298	476	178	127	99	99
	Total	**12,036**	**9,790**	**5,583**	**5,355**	**5,265**	**5,284**

Source: Ministry of Knowledge Economy (MIKE), 2008.

4.2.3. Operation Situation of Mines.

Korea has developed 2,006 mines since 1930 and 1,276 mines among them had been abandoned as shown in the table 3. 730 mines were still operating in 2007, of which 669 mines are non-metallic mines. 395 mines out of these non-metallic mines are limestone and kaolinite ones.

533 mines out of the 730 are ones currently under operation (coal 9,

metal 24, and non-metal 500), and 197 mines are planning to start operation on small scale mines operating irregularly according to mineral economic situations. 415 mines out of the 2006 ones are located in Kwangwon, 349 in Kyeongbuk, 308 in Chungnam, 284 in Chungbuk, and 191 in Keongnam province respectively (MIRECO 2007:4-5).

However, the abandoned mines have impacted lots of residents in the mining regions as a result of various environmental impacts such as acid mine drainage, soil contamination, health damage and sudden ground collapse etc. Additionally, the 1,276 abandoned mines are just the confirmed ones which the Korean government has gotten hold of based on the register records in accordance with the Mining Act. But there remains a lot of unconfirmed closed mines imprudently developed during the colonial period of Japan and left without aftermath management.

Table 4.3: The Present Mining Situation in South Korea.

Category	Coal Mines	Metallic Mines	Non-metallic Mines	Total
Operating Mines	9	52	669	730
Abandoned Mines	340	936	0	1,276
Total	349	988	669	2,006

Source: MIRECO, 2007 International Symposium Report on Mine Reclamation, 2007.

4.3. Energy Minerals.

4.3.1. Demand and Supply

4.3.1.1. Energy Consumption

The primary energy consumption of South Korea rapidly grew from 34,214 thousand TOE in 1977 to 236,454 thousand TOE in 2007, with the annual rate of more than 10% on average during the last three decades, due to expanding the industrial sectors, improving the living standards and sharply increasing numbers of vehicles (KEEI 2008:12-13).

The per capita energy consumption also increased from 0.94 TOE in 1977 to 4.86 TOE in 2007. The energy consuming growth will surely be continued due to social and economic development, even though the population is expected to grow at a rate of less than 1% per annum and to be frozen after 2020.

Table 4.4: Primary Energy Consumption Trends of South Korea.
Unit: 1,000 TOE/ TOE.

Year	1977	1987	1992	1997	2002	2006	2007
Consumption	34,214	67,878	116,010	180,638	208,636	233,372	236,454
Per Capita Energy	0.94	1.63	2.65	3.93	4.38	4.83	4.86

Source: Korea Energy Economics Institute (KEEI), Yearbook of Energy Statistics, 2008.

4.3.1.1.1. Consumption Policy Shift.

As a result of industrialization concentrating on the energy intensive industries such as petrochemicals, cement and steel industries in the first stage of her economic policy, the increasing rate of energy consumption had outpaced the economic growth rate. The energy/GDP ratio had risen from 0.314 in 1989 to 0.385 in 1999.

So, Korea had to change the industrial policy to promote less energy intensive industries such as semi-conductors, machinery, electronics and equipment industries owing to the volatile oil price, insecurity of oil supply, concern about the 10th largest emission of CO_2 in 2004. Due to the structural shift of the manufacturing industry together with energy conservation efforts, the energy/GDP ratio has steadily decreased at the peak of 0.385 in 1999 to 0.335 in 2007 (MIKE 2008: 8-9; Yun 2007:3-4).

4.3.1.1.2. Sectoral Energy Consumption.

The sectoral energy consumption in Korea is characterized by a rapid increase in the industry and transportation sectors, and relatively slow growth in the residual, commercial and public sectors. The energy consumption in the industrial sector has increased up to 104,327 thousand TOE in 2007, increasing 6.1% compared with 97,235 thousand TOE.

The most rapidly increasing sector during the last three decades was the transportation sector. A sharp increase took place from 571 thousand vehicles in 1981 to 16,428 thousand in 2007. The consumption came to 36,938 thousand TOE in 2007, increasing 1.1% from 36,527,000 TOE in

2006.

The energy consumption in the residual and commercial sectors grew moderately compared with other sectors, this resulted in shrinking sectoral shares of the final energy consumption. The characteristic consuming trends was fuel substitution from low-quality energy to high-quality. The consumption in 2007 reached 36,212 thousand TOE, increasing 0.6 percent compared with 35,986 thousand TOE in 2006 (KEEI 2008:28-29).

The sectoral shares of energy consumption consisted in 2007 as follows: industrial sector 57.5% of the total energy consumption, transportation 20.4%, residual and commercial sectors 19.8%, and pubic and others 2.7%.

4.3.1.1.2. Energy Consumption Structure.

The increasing requirements of higher quality energy has made petroleum, gas and electricity almost replace firewood and anthracite coal for heating and cooking. In particular, the demand for anthracite coal has sharply decreased in reverse proportion to the increasing income level. The structure of energy consumption in 2007 was composed of petroleum 44.6%, coal 25.2%, LNG 14.7%, nuclear power 13.0%, hydro-power 0.5% and renewable and others 2.0% (KEEI 2008:26-27).

4.3.1.2. Energy Supply.

Korea has a poor endowment for energy resources so that her indigenous energy resources are limited to anthracite coal, firewood and hydro-power. The total primary energy supply reached 236,454 thousand TOE in 2007 as shown in the table 5. But the domestic production was only 38,338 thousand TOE, accounting for 14.5% for the total energy supply, while the imports recorded 246,773 thousand TOE, accounting for 85.5% for the total supply.

In order to diversify energy sources and to substitute the increasing oil consumption, Korea set up a nuclear power plant for the first time in 1978 at Gori, Keongnam province, and liquefied natural gas (LNG) was introduced in 1986. LNG imports had sharply increased from 2,184 thousand TOE in 1987 to 33,239 thousand TOE in 2007, accounting for 14.7% of the total supply (KEEI 2008:18-19).

The nuclear power generation enlarged from 18 thousand TOE in 1997 to 30,731 thousand TOE in 2007, producing 80.2% of the total domestic production. The domestic energy production structure in 2007 was composed of nuclear 80.2% of the total production, anthracite 3.5% hydro 2.8% and renewals and others 13.5% in 2007.

Table 4.5: Primary Energy Supply Trends of South Korea.

Unit: 1,000 TOE.

Year		1977	1987	1992	1997	2002	2006	2007
Production	Anthracite	9,073	11,166	5,387	2,030	1,493	1,271	1,342
	Hydro	348	1,336	1,216	1,351	1,327	1,305	1,084
	Nuclear	18	9,827	14,133	19,272	29,776	37,187	30,731
	Other	3,117	1,319	723	1,344	2,925	4,358	4,828
	Sub-total	**12,556**	**23,649**	**21,459**	**23,997**	**35,521**	**44,582**	**38,338**
Import	Petroleum	21,745	36,508	90,732	151,040	147,133	156,060	159,298
	Coal	1,417	13,865	19,816	32,850	44,990	49,854	54,237
	LNG	n/a	2,184	4,4,53	15,118	22,711	32,788	33,239
	Sub-total	**23,162**	**52,557**	**115,001**	**199,007**	**214,833**	**238,702**	**246,773**
Total		**34,214**	**67,878**	**116,010**	**180,638**	**208,636**	**233,372**	**236,454**

Source: KEEI, Yearbook of Energy Statistics, 2008.

4.3.1.3. Energy Imports.

Energy imports had dramatically increased from 23,162 thousand TOE in 1977 to 246,773 thousand TOE in 2007. The import value had remarkably enlarged from 7,765 million US$ in 1981 to 94,978 million US$ in 2007, accounting for 26.6% of the total imports of 356,846 million US$. So, energy imports has become a huge burden for Korea's international balance of payments. The overseas dependence rate of energy had also increased from 65.8% in 1977 to 96.6% in 2007 (KEEI 2008:20-21).

4.3.2. Major Energy Minerals.

4.3.2.1. Petroleum.

4.3.2.1.1. Demand.

Korea's petroleum consumption showed a dramatic growth during the last three decades, thanks to brisk economic activities more than 10% annually. The petroleum consumption reached 794,946 thousand barrels (2,178 thousand barrels per day (b/d) in 2007, accounting for 44.6% of the total energy consumption, increasing 10.4% compared with 765,520 thousand barrels (2,097 thousand b/d) in 2006, and placing South Korea in the rank of the 6th largest oil consumer in the world (KEEI 2008:72-73).

4.3.2.1.2. Imports.

Korea imports her whole requirement of crude oil from abroad to meet her domestic demands. She imported the crude oil of 872,541 thousand barrels (2,390.1 thousand b/d) in 2007, emerging as the 4th largest crude oil importer in the world, and decreasing 1.7% compared with 888,794 thousand barrels in 2006 (KEEI 2008:78-79).

The import value of crude oil reached 60,324 million dollars, accounting for 64.4% of the total energy imports in 2007. Even though the crude import sources were remarkably diversified to 26 countries, the dependency on the Middle East region was still high at over 70% of the total imports.

4.3.2.1.3. Refining Facilities.

The first oil refinery plant with a capacity of 35 thousand b/d was built in 1963. The crude distillation capacity had remarkably grown up to 2,812 thousand b/d in 2007 in a comparatively short span of time, ranking the 6th in the world (KEEI 2008:90-91).

4.3.2.1.4. Oil Stockpile.

According to the recommendation of International Energy Agency (IEA) in the light of meeting her huge demand, she has maintained an oil stockpile of a 90-day consumption, preparing for a national state of energy emergency, and comparing with advanced countries such as Japan with a stockpile of 75 days and USA with 35 days (Kim 2007:1-2).

4.3.2.2. Coal.

The coal demand was up to 94,128 thousand tons increasing 10.7% toward 87,827 thousand tons in 2006, which will be increased in the future owing to the increasing requirement of bituminous coal for industrial sectors. The coal imports reached 88,898 thousand tons in 2007, increasing 11.0% compared with 80,067 thousand tons in 2006. The import value amounted to 6,445 million US$, accounting for 6.8% of the total energy imports in 2007 (KEEI 2008:108-109).

4.3.2.2.1. Anthracite Coal.

Anthracite coal is a major indigenous energy source mainly consumed in the residential and commercial sectors, which contributed so much to overcome the two oil crises that occurred in 1973 and 1978. The anthracite reserve reached 331.1 million tons in 2006, but the bituminous reserve was not yet identified in South Korea (KORES 2007:26-29).

The production had peaked at 24,295 thousand tons in 1988, and then decreased to 2,886 thousand tons in 2007 due to increasing production costs with the deepening and narrowing of the coal mines. The imports increased to 5,444 thousand tons in 2007 (448 million US$) from 5,113 tons in 2006 (407 US$).

The consumption also dropped to 4,254 thousand tons from 26,843 thousand tons in 1987 due to the favoring of higher quality energy as a result of the increase in income level and concern about the environmental impact. So, the Korean government restructured the anthracite mining industry, while she promoted the consumption of anthracite coal through establishing two anthracite power plants. However, the demand will not be increased in the future.

4.3.2.2.2. Bituminous Coal.

South Korea has totally imported bituminous coal for power generation, cement plant, and steel industry. She imported 83,454 thousand tons (5,997 million US$) in 2007 from Australia, Canada, Indonesia, Russia and South Africa, an increase of 11.3% compared with 74,954 thousand tons (4,911 million US$) in 2006.

4.3.2.3. Natural Gas (LNG).

In order to reduce the oil dependence rate of her economy, Korea has tried to promote a diversity of energy sources. She signed a long-term contract with Indonesia to import 2 million tons of liquefied natural gas (LNG) annually for 20 years in 1983. Since then, the LNG consumption has exploded to 34,663 thousand TOE in 2007, with a share of 14.7% of the total energy consumption (KEEI 2008:94-103).

The consumption will continually be increased for town gas and power generation in the future, with the completing of the supply infrastructure such as receiving terminals and nationwide pipeline networks, and the encouragement of its consumption to mitigate the environmental concern from CO_2 emission.

4.3.2.4. Uranium.

Even though the grade is low (the average grade of U_3O_8 0.039%), Korea identified a uranium reserve of 115.6 thousand tons in Chungcheong province. It is not economical yet to do commercial production with the current mining technology. So, Korea has been importing all the uranium required to operate 20 nuclear power plants at the moment (KORES 2003:49-50).

4.3.3. Electricity.

The supply and demand for electricity has ever-increased along with the rapid economic growth and improvement of living standards. The electricity consumption rapidly grew to 368,605 GWh in 2007 from 35,424 GWh in 1981. The major consuming entity was the industrial sector, using 50.5% (186,252 GWh) of the total consumption in 2007.

The capacity of electric power generation showed a remarkable growth from 9,835 milliwatts (MW) in 1981 to 67,196 MW in 2007, while electric generation increased from 40,207 GWh in 1981 to 403,208 GWh in 2007. The generation structure of electricity utilities is composed of hydro (5,056 GWh), steamed thermal (177,511 GWh), internal combustion (77,706 GWh), and nuclear power (142,934 GWh) in 2007 (KEEI 2008:128-133).

4.4. Metallic and Non-metallic Minerals.

4.4.1. Demand.

The total demand for metallic and non-metallic minerals were 14,678.9 billion Won (₩) in 2007, an increase of 10.3% compared with 13,303.1 billion Won in 2006 as shown in table 6. The metallic mineral requirements has rapidly increased due to the expansion of copper, lead and zinc refinery plants, steel manufacturing, vehicle and the electronic industry. The non-metallic mineral demand has steadily increased due to the expansion of steel, cement, and paper and steel manufacturing (KIGAM 2008:6-7).

Table 4.6: Demand Trends of Mineral Resources in South Korea.

unit: billion Won(₩)

Year	1995	1998	2000	2002	2004	2005	2006	2007
Total Demand	5,187	13,832	7,130	8,191	11,621	9,678	13,303	14,679
Domestic Consumption	3,062	4,037	4,372	6,230	7,553	8,755	11,542	12,473
Exports	1,942	9,617	1,877	1,382	3.862	655	1,309	1,340
Stocks	182	179	882	579	205	267	452	867

Source: Korea Institute of Geology and Mineral Resources (KIGAM), The Demand and Supply Situations of Mineral Resources in Korea, 2008.

4.4.2. Production.

The domestic production was 2,759 billion Won in 2007, an increase of 13.4% from 2,434 billion Won in 2006 as shown in table 7. The domestic production of metallic minerals such as gold, silver, zinc, iron and titanium has decreased due to scanty reserves, deepening of mines and closure of existing mines, while imports has sharply increased to meet the rapidly increasing requirements (KIGAM 2008: 11-12).

The domestic production of non-metallic minerals has increased with abundant reserves of limestone, kaolin, pyrophyllite, feldspar and silica, while the imports of premium refined product has also increased along with high quality needs.

The minerals with a self-supply rate of more than 50% of the domestic demands are 11 kinds such as limestone, pyrophyllite, silica stone, kaolin, feldspar and titanium, while the rest of the minerals are imported from foreign countries such as Australia, Chile, Peru, South Africa, Brazil and Indonesia etc. The domestic production of metallic and non-metallic minerals accounted for 0.31% of GDP and 0.4% of total export earnings respectively in 2007.

Table 4.7: Supply Trends of Mineral Resources in South Korea.
unit: billion Won(₩)

year	1995	1998	2000	2002	2004	2005	2006	2007
Total Supply	5,185	10,650	7,131	8,191	11,239	9,431	12,956	15,049
Domestic Production	1,059	1,204	1,203	1,557	1,937	2,069	2,434	2,759
Imports	3,970	9,224	5,756	5,633	9,097	7,094	10,070	11,423
Transfer	156	222	172	1,001	205	268	452	867

Source: KIGAM, 2008./ Note: transfer is amounts transferred from previous year.

4.4.3. Reserves.

Korea has relatively rich reserves of non-metallic resources such as limestone, pyrophyllite, feldspar, kaolin and silica as shown in the table 8, while the reserves of metallic resources are very poor and most of the mines are in poor condition (KORES 2007:13-19).

The average self-supply rate of all the minerals was 10.39% in 2007, of which metallic was 1.06% and the non-metallic 72,78%. Completely self-supply minerals are silica, pyrophyllite, feldspar, alunite, serpentine, green gemstone, partly self-supply ones are gold, silver, zinc, iron, limestone, talc etc. Completely imported minerals are copper, phosphate, magnesite, sulphur and so on.

Table 4.8: Major Metallic Reserves in South Korea. unit: 1,000 tons.

Metallic	Gold	Silver	Copper	Lead/ Zinc	Iron	Tungsten	Rare Earth
Reserve	4.7	6,452	1,642	14,589	23,725	12,958	20,181
Non-Metallic	Talc	Kaolin	Fedspar	Limestone	Graphite	Pyrophyllite	Silica Stone
Reserve	6,102	75,904	67,110	7,533,765	6,102	54,489	939,177

Source: KORES, 2007.

4.4.4. Imports and Exports.

The imports of metallic and non-metallic minerals amounted to 12,292.8 million US$ in 2007, accounting for 3.4% of the total imports and increasing with 16.6% compared with 10,539.2 US$ in 2006 due to an increase in the mineral prices, while the exports amounted to 1441.6 million US$, accounting for 0.4% of the total exports and increasing with 5.2% compared with 1,370.1 million US$ in 2006 as shown in the table 9.

The minerals of which more than 1 million US$ in value that were imported in 2007 are gold, silver, platinum, molybdenum, lead, and sulphur, titanium, kaolin, diamond and pyrophyllite etc., while the minerals of which more than 1 million US$ were exported are gold, silver, platinum, molybdenum, lead, sulphur, magnesite, kaolin, diamond and pyrophyllite etc. The major countries to which these minerals were exported are England, Holland, Germany, Japan and the USA.

Table 4.9: Import and Export Trends of Mineral Resources in Korea.

Unit: million US$

Year	1985	1990	1995	2000	2005	2006	2007
Exports	41.0 (0.14)	239.0 (0.37)	2.516.7 (2.01)	1,660.3 (0.96)	641.1 (0.23)	1,370.1 (0.42)	1441.6 (0.40)
Imports	783.2 (2.52)	1,752.9 (2.51)	4,958.0 (3.67)	7,247.3 (4.52)	9,282.8 (4.70)	10,539.2 (5.10)	12,292.8 (5.2)

Source: KIGAM, 2008./ Note: The numbers in the parenthesis is the export and import ratio to their total amounts.

4.4.5. Major Metallic Minerals.

4.4.5.1. Ferrous Metallic Minerals.

A great tungsten mine at Sangdong, Kangwon province, which old Koreans were proud of as a major exporting locomotive in the 1960s and 1970s, was closed in 1987 due to loss of commercial profit as a result of the deeping of the mine and a drop in the international price as a result of a great supply of Chinese low-priced tungsten from the beginning of 1980s. Presently, several mines of iron and titanium are maintaining the domestic production of ferrous metallic minerals in South Korea.

4.4.5.1.1. Iron.

4.4.5.1.1.1. Production.

South Korea produced 290.8 thousand tons in 2007, an increase of 27.9%

compared with 227.4 thousand tons in 2006, which were supplied by cement plants such as Asia Co. and Dongyang Co. and iron foundries such as Pohang Steel Corporation (POSCO) and Kwangyang Steel Corporation.

However, the domestic production was only 0.6% of the total requirement of 47,777.0 thousand tons in 2007. So, Korea imported 46,176.3 thousand tons from Australia, Brazil, South Africa and India, an increase of 10.5% compared with 43,895.4 million tons in 2006. The iron ore reserve amounted to 23,725 thousand tons with the average grade of Fe 38.3% in 2006, mainly located in Keongki, Kwanwon and Chungbuk provinces (KIGAM 2008:21).

4.4.5.1.1.2. Steelmaking Capacity.

The steel industry has played a leading role in the rapid economic growth in Korea. The steel-making capacity has dramatically increased up to 48,883 thousand tons in 2007 from 150 thousand tons in 1962. It has grown by 12% annually and expanded 326 times more since 1962. The expansion trend of the steelmaking capacity will be continued to meet the increasing domestic requirements. The steel production has almost completely been to meet the domestic demand and only 9.9 thousand tons were exported to China and Japan.

4.4.5.1.2. Titanium.

The demand of titanium reached 225.5 thousand tons in 2007, decreasing 19.5% compared with 280.2 thousand tons in 2006 due to a slump in the vehicle and aircraft industry. However, the domestic production increased with 7.8% from 179.9 thousand tons in 2006 to 193.9 thousand tons in 2007. Imports decreased from 188.3 thousands tons in 2006 to 116.4 thousand tons in 2007, while exports increased to 98.8 thousands tons in 2007 from 78.9 thousand tons in 2006. The titanium ore reserve amounted to 857.6 thousand tons with the average grade of TiO_2 19.2% in 2006, located in the iron mines of Keongki and Kwangwon provinces (KORES 2007:164-165).

4.4.5.2. Major Non-ferrous Metallic Minerals.

4.4.5.2.1. Smelting and Refinery Capacity.

Kumho mine used to be the only zinc one in Korea and produced 10,000 to 20,000 tons of zinc concentrate ores every year, but it was closed in 2001. So, there is not a base metal mine in South Korea at the moment, but there are two big smelters operating with the concentrate ores imported from Indonesia, Chile, Peru, Papua New Guinea, Australia and Guinea etc.

One is the copper smelter with a smelting capacity of 420,000 tons and refinery capacity of 510,000 tons per year. The smelting and refinery plants are located at Onsan and Janghang and operated by LC-Nikko Co. The other is the zinc smelter with capacity of 400,000 tons for zinc and 200,000 tons for lead per year, managed by Korea Zinc Co. Adding to the smelters, Young-Poong Co. has also operated the zinc smelter at Sukpo with the capacity of 110,000 tons per year (KORES 2003:52-56).

4.4.5.2.2. Demand.

Korea was the fifth largest lead consumer following China, USA, Japan and Germany and the fourth largest zinc consumer following USA, China and Germany in 2007. She consumed lead of 179.5 thousand tons and zinc of 1,388.1 thousand tons. The increasing requirements were almost met with imported lead of 256.4 thousand tons and zinc of 1,333.5 thousand tons in 2007. The domestic production of lead and zinc were no more than 24 tons and 4,067 tons respectively in 2007. So, the imports of lead and zinc will be continually increased in the future to meet the increasing demand. The lead and zinc ore reserves with average grade of Pb 2.2% and Zn 3.2% amounted to 14,588.9 tons in 2006 (KIGAM 2008:15-16).

4.4.6. Non-metallic Minerals.

4.4.6.1. Limestone.

4.4.6.1.1. Reserve.

Limestone is one of the abundant minerals in Korea with a reserve of 7,533,765 thousand tons in 2006. It has played a leading role in promoting the building industry and social infrastructure in South Korea, because it is a major material for making cement and iron-manufacturing solvents (KORES 2007:266-269).

4.4.6.1.2.

South Korea produced 86,121.3 thousand tons in 2007, an increase of 8.5 % compared with 79,404.1 thousand tons in 2006, and consumed 87,198.4 thousand tons with an increase of 7.5% in comparison to 81,132.8 thousand tons in 2006. She exported 62.7 thousand tons in 2007 with an increase of 55.6% in comparison to 40.3 thousand tons and imported 1,337.0 thousand tons in 2007, a decrease of 9.8% compared with 1,482.1 thousand tons in 2006 (KIGAM 2008:5-6).

Table 4.10: Major Mineral Situation in South Korea, 2007.

Minerals	Demand	Production	Import	Export
Gold (kg)	44.527	47,078 (3,098)	60,610	36,574
Silver (kg)	1,093,803	1,393,935 (57,369)	1,207,046	1,504,940
Copper (t)	1,428,547	6	1,402,886	n/a
Lead (t)	179,454	24	256,367	134,041
Zinc (t)	1,388,113	4,067	1,333,481	16,923
Iron (t)	47,777,024	290,802	46,176,285	9,930
Chrome (t)	2,536	n/a	2,596	n/a
Titanium (t)	255,463	193,953	116,374	98,756
Aluminium (t)	276,580	n/a	276,622	42
Platinum (kg)	26,093	n/a	28,253	297,856
Limestone (t)	87,198,375	86,121,391	1,336,971	62,696
Talc (t)	122,536	9,557	119,124	10,176
Pyrophyllite (t)	653,290	798,654	4,889	101,193
Feldspar (t)	463,630	398,513	6,929	23,912
Kaolin (t)	2,963,571	2,630,358	391,776	57,887
Silica Stone(t)	3,550,748	3,510,699	48,849	3,850
Sulphur (t)	510,28	670,000	118,525	277,905
Mica (t)	127,716	42,385	78,119	244
Zeolite (t)	161,397	157,408	1,541	109

Source: KIGAM./ Note: The numbers in the parenthesis of gold and silver column is the amount produced at the domestic mines.

4.4.6.2. Kaolin.

Kaolin is used in various fields such as ceramics, chemical industry and radioactive waste water treatment etc. The demand of kaolin was up to 2,963.6 thousand tons in 2007, an increase of 10.2% compared with 2,690.5

thousand tons in 2006 due to a boom of ceramics, fire-resisting industry and treatment of nuclear waste water (KIGAM 2008:7-8).

The domestic production also increased with 9.6% from 2,399.5 thousand tons in 2006 to 2,630.4 thousand tons in 2007 to meet the increasing requirements. Imports increased from 363.7 thousands tons in 2006 to 391.8 thousand tons in 2007, while exports decreased to 57.9 thousands tons in 2007 from 71.8 thousand tons in 2006. The kaolin ore reserve is relatively abundant with 75,904.5 thousand tons in South Korea in 2006.

4.5. Nuclear Power Plants.

South Korea has continually built nuclear power plants to meet her increasing energy demand since she started the operation of the first nuclear plant in 1978. She is planning to set up 10 more plants by 2030 in a small country of 99,117 km .

However, except for a few Asian countries such as Japan, China and India, most of the western countries have suspended and/or decreased the number of nuclear plants to prevent serious environmental impacts until new technology is developed for nuclear waste treatment and operation safety as mentioned in 3.3.2.

4.5.1. Facilities.

Due to her efforts for diversity of energy sources to alleviate the insecurity of oil supply, South Korea started the operation of the first nuclear power reactor with Kori Unit #1 in 1978. She is now operating 20 reactors and 5 reactors are under construction as shown in the table 11, producing 80.1% of the total domestic energy production in 2007.

Additionally, she announced the first national energy basic plan (2008-2030) in August 2008 to build 10 more plants until 2030. And then, nuclear electric power generation will be expanded from 36% of the total generation in 2008 to 59% in 2030 (Kim 2008:3-4).

4.5.2. Uranium Demand.

South Korea consumes uranium at 4,000 tons annually to operate 20 nuclear plants at present. But she doesn't produce it at all and has a lack of conversion and enrichment facilities. So, she has imported all the nuclear fuels in their semi-processed form of UO_2 on long-term contracts with USA, England, Canada, Australia, France and South Africa. Additionally, she signed an agreement with Uzbekistan for the long-term supply of uranium on September 25, 2006 (KHNP 2007:27-31).

Table 4.11: Nuclear Power Plant Situation in South Korea.

Situation	Name	Unit No.	Capacity(MW)	Operation Date	Reactor Type
Operation	Kori	#1	587	Apr. 29, 1978	PWR
		#2	650	Jul. 25, 1983	PWR
		#3	950	Sep. 30, 1985	PWR
		#4	959	Apr. 29, 1986	PWR
	Wolsong	#1	679	Apr. 22, 1983	PHWR
		#2	700	Jul. 01, 1997	PHWR
		#3	700	Jul. 01, 1998	PHWR
		#4	700	Oct. 01, 1999	PHWR
	Yonggwang	#1	950	Aug. 25, 1986	PWR
		#2	950	Jun. 10, 1987	PWR
		#3	1,000	Mar. 31, 1995	PWR
		#4	1,000	Jan. 01, 1996	PWR
		#5	1,000	May 21, 2002	PWR
		#6	1,000	Dec. 24, 2002	PWR
	Ulchin	#1	950	Sep. 10, 1998	PWR
		#2	950	Sep. 30, 1989	PWR
		#3	1,000	Aug. 11, 1998	PWR
		#4	1,000	Dec. 31, 1999	PWR
		#5	1,000	Jul. 29, 2004	PWR
		#6	1,000	Apr. 22, 2005	PWR
Construction	Shin-Wolsong	#1	1,000	2011	PWR
		#2	1,000	2012	PWR
	Shin-Kori	#1	1,000	2010	PWR
		#2	1,000	2011	PWR
		#3	1,400	2013	PWR
		#4	1,400	2014	PWR

Source: KHNP, 2007/ Note: PWR and PHWR are Pressurized Water Reactor and Pressurized Heavy Water Reactor respectively.

4.5.3. Nuclear Waste Treatment.

Nuclear waste from nuclear plants have been stored in temporary storage facilities located at each of its nuclear plant sites in Korea. But such a interim waste treatment has put pressure on her to seek permanent disposal sites and construct permanent disposal facilities. Because she had faced strong opposition in the course of deciding which sites. Much more serious opposition is expected in the process of seeking the disposal sites for high level waste (HLW). Furthermore, that is an urgent matter, because Kori Unit #1 with an age of more than 30 years should be closed down in the near future.

The Korean government designated the Gyeonju region to be the final candidate to build disposal facilities for low to medium level radioactive waste as the result of voting local residents in December 2005 after a long struggle with serious opposition to the site decision. The facilities constructed at Bonggilri in Gyeongju city will accommodate a total of 800,000 drums (KHNP 2007:28-29).

The first facility consists of cylinder-shaped vertical caves with a depth of 80 meters to dispose of 100,000 drums of waste, to be completed at the end of 2009. A temporary storage facility as well as inspection and processing facility will be set up at the ground level. The disposal facility for the remaining 700,000 drums will be designed from reflecting the experiences of the first construction stage and changes in composition and processing technologies of nuclear waste.

4.6. Overseas Energy and Mineral Development Policy.

The uncertainty in the international resource market has increased in recent years owing to a rapid rise in energy and mineral demand in developing countries, in particular China and India. In addition, some oil and mineral-producing countries are showing signs of resource nationalism by taking advantage of their energy and mineral resources to serve their political and diplomatic purposes or by adopting policies that support and foster their national resource companies.

Consequently, energy and mineral-importing countries have been eager to improve their energy and mineral security. The United States and Western Europe have gained firm footholds in resource-owning countries through their long history of resource development. Though China, Japan and India initiated overseas resource development much later than the United States and major European countries, they have increased their investment aggressively and supported their companies by offering overseas developmental assistance (ODA) or by exploiting their diplomatic influence.

Most of the companies of advanced countries have avoided to develop domestic energy and minerals due to strict environmental regulations and pursued to develop overseas resources by taking advantage of the poor environmental legal systems in developing countries, without taking into account their responsibility to be stewards of the earth.

4.6.1. Developing Trends.

In Korea, the overseas resource development refers to corporate activities in which Korean companies are partly or wholly involved in the processes of resource development such as exploration, development, production, and distribution in foreign countries. Since Korea imports nearly all of its energy and minerals, overseas resource development is regarded as one of the effective measures for promoting resource supply security.

Korea's first venture into overseas resource development was in 1977 when she invested in the San Antonio Uranium Mine in Paraguay. She invested in an oil field in the Madura region of Indonesia in 1981, and then expanded continually to invest and participate in overseas resource development projects.

However, due to the financial crisis of 1997 that impaired her two-decade-long efforts, her investment in overseas resource development projects did not pick up until 2005. And her overseas resource development policy underwent a sort of paradigm shift in terms of investment scale, regional diversification, and project numbers.

4.6.2. Performing Result.

Korean companies invested 8.9 billion dollars in oil and gas development and 2.5 billion dollars in developing other mineral resources to carry out 286 ongoing resource development projects in 53 countries as of the end of 2007 (Lee 2009:37-43).

4.6.3. New Development Policy.

The Korean government set energy and mineral security as one of the high priorities of the national policy in 2008, and planned to achieve a goal for the independent resource development rate[2] of 32% in 2012 from 18.24% in 2007 and then 40% by 2030 for strategic resources such as oil, natural gas, uranium, copper, iron, lead and zinc.

In order to improve her energy and mineral security by means of overseas resource development, she made a decision to set up the resource development fund of about 1 billion US$ to support the overseas projects in May 2009. And she has promoted overseas resource development as an item on the national agenda and conducted resource cooperation diplomacy with various countries.

4.7. Environmental Impact from Mining Activities in Korea.

Human civilization has been developed with mineral and energy resources. Mineral and energy resources such as metal, petroleum and coal are the most important materials for the industrial development of a country. It is true that the stable and continuous supply of resources is the major factor for the economic growth of a country. However, environmental damages such as acid mine drainage (AMD), mine tailing sweeping, ground subsidence, and forest ruin are inevitable in developing a mine.

These mining hazards are considered as causes of natural damages such as ground collapse, contaminated water outflow, heavy metal contamination for soil, dust scattering, noise and vibration. But these damages are caused by the process of mine development such as exploration, excavation, grinding, transportation and concentration. The mining hazards are characterized as contamination, continuation, accumulation and diffusion. They may happen long after the mine development has finished, and result in environmental problems, safety concerns and civil appeals.

Until the early 2000s, only simple construction methods such as stone embankments and retaining walls were used as measures to prevent mine

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2) The "independent resource development rate" is a concept used in Korea and Japan to indicate the proportion of resources which a country developed and produced for itself in comparison to the total imports. Independently developed resources from a project are calculated by multiplying the output from the project by the share of the country in the project.

hazards in South Korea. At the moment South Korea is confronted by some serious problems. More comprehensive technologies related to geology, mining chemical, civil, mechanical and environment engineering are necessary to reclaim mine sites.

Therefore, the Korean government launched the Mine Reclamation Corporation (MIRECO) in 2005 in accordance with the Mining Damage Prevention and Mine Reclamation Act of 2005, and set up a mine reclamation plan in June 2006 to carry out long-term and systematic projects. However, most of the Korean churches have not been concerned about an ecological mission regarding mining activities in Korea, even though it involves environmental problems that can't be solved by government and specialized agencies alone.

4.7.1. The Current Situation of Mine Hazards.

Once a mine reaches the end of its operational lifetime and dumping activities cease, ground-water is contaminated by acid water drainage that eventually flows into rivers and dams. Adjacent soils are polluted with heavy metals such as cadmium and lead, which come out of abandoned mine sites.

According to MIRECO, 936 sites of 388 mines out of 515 abandoned non-coal mines and 399 sites of 220 mines out of 340 abandoned coal mines are producing various types of mine hazards and contaminations as shown in table 12. However, the exact number of the abandoned mines in Korea has not established yet. Many of the closed mines recklessly developed under Japanese colonial rule are still spread out all over the country, and has impacted serious environmental damages.

Table 4.12: The Current Mine Hazard Sites from Abandoned Mines.

category	AMD	waste rock	tailings	mine subsidence	waste facilities	abandoned mine head	outflow water	total
abandoned mines (936)	19	90	30	9	20	348	-	516
abandoned coal mines (340)	36	138	-	114	104	-	7	399
total	55	228	30	123	124	348	7	915

Source: MIRECO, 2007 International Symposium Reports on Mine Reclamation held in Korea on September 13-14, 2007.

According to the report on the environmental impacts from mining activities, 44% (418 sites) of 936 abandoned mine sites have seriously contaminated the adjacent soil so that vegetables, rices and corns produced in the areas in 2005 contained lead and cadmium at a much higher level than the international standard approved by International Food Regulatory Commission (Yang 2006:7; Kim$_{(a)}$ 2006:6).

4.7.2. Acid Mine Drainage.

Once a mine reaches the end of its operational lifetime, ground-water is contaminated by acid water drainage that eventually flows into rivers and dams, and the adjacent soil is polluted with heavy metals which come out of abandoned mine sites. Fish and aquatic plants cannot live in the water, because mine water is acidic and includes a number of heavy metals such as iron, lead, zinc, cadmium, manganese.

It is also difficult to use this water as an agricultural water source. Mine water often contaminates farm lands because of the high content of heavy metals. From a survey of the Ministry of Knowledge and Economy, 60,000 tons of mine water is coming out at 137 abandoned coal mines a day and 3,800 tons from 124 metal mines a day in South Korea (MIRECO 2007:7-8).

4.7.3. Mine Tailings.

Most of the metallic mining and smelting works were ceased in the 1980s and huge amounts of mine tailings were left behind without proper environmental treatment. The unprotected mine tailing piles have been dispersed down slopes by wind and water.

Sweeping of mine tailings in abandoned metallic mines could cause ecosystem contamination and high concentrations of heavy metals in soil that exceeds the current regulation for arable land. The case of Keumjung mine is a serious example. The tailing deposit of the Keumjung mine was swept by typhoon Lusa in 2002. As a result of tailing discharges, water and soil were contaminated by heavy metals (MIRECO 2007:5-6).

Most cases of abandoned mine areas in South Korea are in remote mountains. It is difficult to transport tailings out of the mine areas and procure treatment sites.

4.7.4. Soil Contamination.

Soil contamination in mine areas can be caused by heavy metals in AMD outflow and mine tailings. Heavy metals are accumulated in agricultural soil and crops. Eventually, they may cause a potential health risk to the residents in the vicinity of the mines.

In 2004, there was a report about a possibility of cadmium toxicities for residents near abandoned metal mines in Kosung county in Kyungnam province. As a result of this report, consumption of the crop produced from this province was severely affected. Also in 2006, the Korean government announced that heavy metals exceeded the standard regulation in these crops from metallic mined areas (MIRECO 2007:9).

Korean newspapers disclosed in September 2006 that some of the adjacent soil of the 936 abandoned mine sites are seriously contaminated so that vegetables, rices and corn produced in those areas in 2005 contained lead and cadmium above the international standard level approved by the International Food Regulatory Commission. It has become a big social issue in the country.

The Korean government surveyed heavy metals in those arable lands near the 236 abandoned metal mines until 2008, and will survey other 310 abandoned metal mine areas during 2009. It is also ready to start soil remediation projects to treat the affected arable lands.

4.7.5. Mine Subsidence.

There was a sudden collapse of a graveyard located in Incheon Bupyeong in May 1993. The accident was occurred by the neglect of management of the Bupyeong abandoned metallic mine. As a result, the 154 graves were ruined. This is a typical example of mine subsidence of abandoned metal mines (MIRECO 2007:9-10).

Mine subsidence means that the ground collapses and cracks when the upper part of an underground goaf breaks down with the lapse of time. That is developed into the upper part of the goaf and linked to the ground surface. Therefore, ground safety near an underground goaf is emerging as an important issue. Several projects for the prevention and restoration of ground subsidence were performed in the coal mined areas in South Korea. Most of the projects were performed in the vicinity of national highways and the Yeungdong railroad.

4.7.6. Pollution from Limestone and Coal Mines.

South Korea has abundant reserves of limestone, feldspar, pyrophyllite, talc and anthracite coal, which are the main materials for various cements, iron-manufactured solvents and briquette. However, limestone and coal mines bring about serious air and walter pollution with dust coming out of mining activities.

Most of the roofs at Donghae and Samchuk, the main mining areas for limestone and coal are covered in grey with dust from the mines. The residents complain that they cannot hang up their clothes outside after washing them. They also complain about health problems such as asthma and chest troubles as a result of the environmental impact from limestone mining and cement plants.

In 2007, Korean journalists exposed in 2007 that several heavy metals are contained in cements such as cadmium, lead and arsenic, causing cancer. The reason for this was that many companies made various cements from industrial waste such as waste tyres and iron-smelting dregs etc. It causes serious social concerns about health problems and the environmental impact from cement and cement plants. Some medical doctors warned that if a family moves into a new apartment built with this cement, skin deceases could break out as a result of this toxical cement (Yoon 2007:6-7; Jang 2007:5).

4.7.7. Pollution from Asbestos Mines.

Asbestos is a useful material for cement, tile, plastic, chemical tools etc. produced mainly in Canada, South Africa and Russia. It, however, causes various diseases of respiratory organs such as lung cancer and asthma.

In 2008, it was collectively discovered that the residents living in the vicinity of asbestos mines at Hongsung, Boryung, Suhsan and Yesan in the Chungnam province were suffering from chest diseases (Han 2009:12). They have asked the government to do a comprehensive health check for all the residents and prepare a detailed course of treatment in response to an enactment of a special act concerning health damage as a result of the mines.

4.7.8. Pollution from Oil Refining Plants.

The oil refining industry is facing a lot of environmental problems such as air pollution, water and soil contamination. Other problems are oil spillages seriously polluting the sea coasts in the course of transportation and the shortage of refinery construction sites in the small land of South Korea.

4.7.9. Pollution from Oil Leakage.

The worst-ever oil spill took place in the West Sea, located 90 km southwest of Seoul on December 7, 2007, when a Hongkong-registered giant tanker (Hebei Spirit) collided with a barge owned by Samsung Heavy Industries Company. The oil leak caused about 11,000 tons (81,000 barrels) of crude oil to gush into the waters and it has seriously damaged the region's marine farms and beaches. The vessel was carrying crude oil to the refinery factory of Hyundai Oilbank Company located at Daesan, which is the fourth biggest refinery in South Korea (Jan 2008: 1).

The accident resulted in spilling more than twice the size of the spill of 5,035 tons of crude oil that occurred in 1995, when a tanker struck a reef off the south coast (Yeosu) of Korea, located 455 km south of Seoul. According to data on the International Tanker Owners Pollution Federation, this oil leakage is a third of the 37,000 tons spilled into the Prince William Sound, Alaska by the Exxon Valdez in 1989 (Bang 2008:9).

According to the Ministry of Marine Affairs and Fisheries, the accident hit 350 oyster and abalone marine farms covering 3,571 hectares and 6 beaches covering 221 hectares in Taean Country and about 50 kilometers of the western coastlines of Korea. The giant spill also dealt a blow to the tourism business in the region which is popular for its beautiful beaches and sunsets.

The government declared a state of disaster for Taean County and its five surrounding counties and cities on December 8, 2007. It had also made all-out efforts to stop the oil from spreading to a couple of western bays which are rich in marine resources and farms. A lot of workers including soldiers tried their best to remove as much of the oil as possible, along with some vessels and helicopters.

More than 50,000 citizens voluntarily participated in removing the oil everyday for about 3 months since the accident occurred. It was confirmed by the government that most of them were christians systematically sent by all the Korean churches at their own cost.

4.7.10. Pollution from Copper and Zinc Smelting and Refinery Plants.

Korean citizens living in the vicinity of the copper, zinc and lead smelting and refinery plants have for many years been complaining about health impediments and economic troubles from the serious air and water pollution. As a result, the Korean government does not allow the expansion of zinc and copper refining facilities. Instead, it has met the increasing demand by importing the ingots and semi-ingots (KORES 2003:53-54).

4.7.11. Some Case Studies of Mining Pollution.

4.7.11.1. Soil and Ground-water Contamination from the Residual Mine Tailings at Shihung Mine Area.

The Shihung mine was restored in the early 1990s after abandonment of 20 years since 1973. Although the disposed mine tailings were removed and the site was replaced by an incineration plant, still some residual mine tailings were prone to impose an adverse impact on the soil and ground-water and needed investigation for potential contamination.

Mine tailing samples were collected from the old tailing disposal area and the rice paddy. The pore-water from the mine tailing was extracted and analysed to investigate chemical changes along the reaction path. Batch leaching tests were also carried out in the laboratory to find any supporting evidence found in the field analysis.

Evidence of elemental leaching was confirmed both by the investigation of the mine tailing and the pore-water chemistry. The element concentrations of Cu, Cd, Pb, and Zn in the pore-water exceeded the standard for drinking water in Korea and the U.S.A. In batch leaching tests, it was confirmed that heavy metals were continuously released.

Combining the information with pore-water variation with depths and the geochemical modeling results, most of the elements are controlled by dissolution and/or precipitation processes, with some solubility controlling solid phases (Cu, Pb, Fe, and Zn).

The batch leaching test conducted at a fixed pH4 showed much higher releases at heavy metals up to 400 times (Zn) compared with the legitimate standard level. This area is becoming more vulnerable to soil and ground-water pollution by the shift into an acidic condition through precipitation of pH4 (Jung and Lee 2001:461-470).

4.7.11.2. Environmental Assessment on the Acid Mine Drainage at Youngwol, Jungseon and Pyungchang Areas.

During December 2000 to July 2002, water samples were collected seasonally from acid mine drainage and nearby streams at 13 coal mines to carry out an environmental assessment of the water system in the Youngwol, Jungseon and Pyungchang Areas in Korea. The physical and chemical properties, including pH, Eh, total dissolved solids (TDS), salinity, bicarbonates and dissolved oxygen (DO), were measured in the field. Eighteen cations including Al, Ca, Fe, Mg, Mn and Zn, and 6 anions nitrates were also analyzed respectively.

The acid water from the Jungam coal mine has characteristic of AMD with a very low pH (3-4 mg/l) and high TDS (1,000-5,000 mg/l). But high concentrations of heavy metals, such as Al (380 mg/kg), Fe (80), Mn (44) and Zn (8), were found in the water samples from the Jungam coal mine area. The water samples from the Seojin, Sebang and Sungjin coal mines also contained Al (more than 50 mg/l), Fe (100) and Mn (10). In addition to anions, over 1,000 mg/l of sulfate was found in several water samples.

Seasonally, the concentrations of metals and sulfates varied. During the wet season samples were relatively higher in metals and sulfates than dry season samples. It is necessary to establish the proper remediation and environmental monitoring of the AMD continuously (Jung 2003:111-121).

4.8. Climate Change from Emission of CO_2 in Korea.

The climate change is a warning from the Creator concerning the unsustainability of modern industrial society based on fossil fuels and unsound economic wealth orientation. It is not only a environmental issue but also a survival matter for all the creatures created by God. It is not only a scientific issue but also a ethical matter considering the will of the

Creator. Nobody can avoid responding to this urgent issue.

It asks us to control the current unrestrained and imprudent economic growth. Every nation should voluntarily give up trying to have a bigger share of GHGs emissions to avoid an immediate economic burden. Even though Korea has achieved some progress in environmental performance, more complicated challenges lie ahead to supply energy and mineral resources to meet its rapid economic growth and modern lifestyle.

4.8.1. Environmental Progress.

Several environmental pressures have been decoupled from growth in gross domestic product (GDP). Sulphur oxide (SOx) emissions are remarkably decoupled from economic growth. The emission growth of carbon monoxide, nitrous oxides (NOx), small particles (MP_{10}), lead, and bydrocarbons (VOCs) are all slightly decoupled. Actually, Korean emissions of SOx and NOx per unit of GDP are below the OECD average.

Concerning the management of general waste, she has accomplished massive progress. Although the generation of municipal waste has increased about 6% since the middle of the 1990s, the growth rate is lower than GDP through volume-based waste fees and the 3R strategy of reduce, recycle and reuse. The Korean government has constructed sanitary landfills and achieved energy recovery by landfill gas capture and combustion. The environmental expenditure has increased and exceeded 2% of GDP in 2007.

4.8.2. Environmental Challenges.

Despite the progress in environmental management, more serious challenges lie ahead. The problems require more than technological treatment. What is needed is social restructuring and changes in lifestyle based on self-reflection on the modern industrialization process and the relationship between society and nature.

Korea still has problems in managing PM_{10}, Ozone, NOx, and carbon dioxide (CO_2) emissions. The air quality in Seoul turned out to be the worst among the capitals of member countries of the OECD in 2007. Concentration levels of PM_{10} and nitrogen dioxide, and an increasing frequency of high ozone concentrations are problematic in the Seoul megalopolis. The concentration levels of PM_{10} in the Seoul megalopolis satisfies the Korean environmental standard (70 micrograms per cubic meter), but are much higher than the standard of WHO (40 micrograms per cubic meter). Increasing numbers of cars and high population density have led to a deterioration of air quality despite improving fuel quality and engine technology.

Chemical management is also troublesome. Even though the risk posed by chemicals was forewarned by Rachel Carson in her "Silent Spring" (1962), more than 100,000 kinds of chemicals are globally circulated and more than 2,000 kinds of chemicals are annually developed and commercialized. Chemicals are used everywhere from home detergents to mining fields. In pursuit of a convenient life and profitable industrial production, their safety has not been assured through risk assessment.

Since the consumption of chemicals is rapidly increasing year by year in Korea, the safe management of chemicals has become urgent. Thorough risk assessment and cautious management are necessary, because a lot of chemicals can make a fatal impact on human health and the ecosystem. Korea is facing a very critical moment requiring deeper recognition of the interlocking relationship between human beings and the ecosystem, because the chemical management is just beginning in Korea.

4.8.3. Emission Control of CO_2.

The most serious environmental problem Korea is facing now is increasing CO_2 emissions. CO_2, mainly produced from fossil fuel combustion, is the most effective greenhouse gas (GHG), which causes climate change resulting from global warming.

CO_2 takes the largest share of the total emission of GHGs by volume, accounting for 88.4% in Korea which is much higher than the global level of 77% and 83.2% in industrialized countries. This environmental evidence demonstrates that the rapid economic growth has been accompanied with more energy consumption and more CO_2 emissions. This means again that CO_2 emissions are highly correlated with energy consumption which enables rapid economic growth and more convenient lifestyles.

Korea has drawn global attention because of her unique situation and rapid growth of GHGs emissions. Although Korea is a member of the OECD, she is classified with the non-industrialized countries which have no obligation to reduce GHGs emissions during the first commitment period of the Kyoto Protocol.

Korea reached the 10th place in the world in 2004 in terms of energy-related CO_2 emissions. Her CO_2 emissions have doubled (rising 104.6%) from 1990 to 2004. This is the highest among the members of the OECD. With regard to the absolute amount of CO_2 emission growth, she ranks fourth during 1990 to 2002.

Korea's energy consumption has sharply increased since the middle of the 1970s accompanied with the rapid economic growth driven by heavy and chemical industries. The increasing rate in energy consumption has almost outpaced the growth rate of GDP for the last 40 years. Concerning per capita energy consumption, Korea of 4.43 tons of oil equivalent (TOE) exceeded Japan of 4.18 TOE, Germany of 4.22, and most EU countries of 3.91 in 2004 (Yun 2007:4-5).

During the 20th century, the world temperature increased by 0.6 Celsius, while in Korea it increased 1.5 Celsius owing to the effect of urban heat islands through urbanization. Korea is very vulnerable to climate change because she is a peninsula with long coastal lines. So, Korea should actively set up a reduction target for CO_2 emission and set an example by fulfilling it before the first year of a post-Kyoto treaty.

Table 4.13: Emission Trends of GHGs in South Korea.

Index	Unit	1990	1995	2000	2004	Annual Growth Rate: '90-'04
GHG	million ton	310.6	452.8	528.6	590.6	4.0%
CO_2	million ton	239.0	366.9	432.2	482.5	5.1%
GDP	billion Won	320,696	467,099	578,665	693,424	5.7%
GHG/GDP	ton/million Won	0.97	0.97	0.91	0.85	-0.9%
CO_2/GDP	ton/million won	0.75	0.79	0.75	0.70	-0.5%

Source: Yun, Sun-Jin, "Climate Change Test for Korean Adaptability," The Korea Herald, December 7, 2007, p. 4.

4.9. Environmental Impact from Nuclear Power Plants in Korea.

Some scientists assert that human history is a chronicle of taking advantage of nature's power to improve the quality of life by the development of science and technology. The power of fire was used to illuminate the darkness, and wind power drove ships to discover new worlds. In more detail, what would we do without electricity today? What if power went out at a hospital? What if office elevators stopped working?

Such opinions and questions make us all appreciate the development of science and technology and a stable electricity supply. However, they are only meaningful because of the existence of human beings and nature. All these assumptions can be overwhelmed by the question, "What if there were no users?" How if there is no nature?

Furthermore, energy is neither created nor destroyed, which is the same total amount as created by the Creator God. This is known as the principle of energy conservation. Ultimately, electrical power generation is simply the transformation of natural energy into electrical energy useful to people. Thus, being environmental-friendly not only for the current generation but also for future generations, this is not a choice but a necessity for all power generation projects.

Therefore, we should minimize the negative impacts from the operation of existing nuclear plants on human beings and environments through assessing the environmental impact and changes in the ecosystem around the plants transparently, objectively and regularly. We should also improve sewage and wastewater treatment and waste-reduction facilities to protect marine resources, reduce discharge of nuclear pollutants and prevent leakage of any radioactive materials into the environment.

4.9.1. Nuclear Plant Technology.

In the not-too-distant past, Koreans did not even have adequate electricity for lighting. Virtually no one then imagined that power generation would become one of the nation's leading industries. It is certain that Korea cannot tap into non-existent petroleum reserves, but technology serves as a power for self-reliance. It also is agreed that Korean nuclear power technology has already caught the world's attention. Few people doubt today that Korean power generation technology is world class. However, Korea should not stop research and development (R&D), keeping in mind the dangerous stigma of nuclear plants.

We should note that Korea is not a safe land from earthquakes which occurs more than 100 times with a low magnitude annually. Japan had been proud of its safe operations of their nuclear plants from her frequent and powerful earthquakes. But we should pay special attention to the fire and releasing accident of radioactive materials at Gasiwajaki-Gariwa nuclear plant by the magnitude 6.8 earthquake which occurred in Nigata Province July 16, 2007 (Park$_{(a)}$ 2007:7).

4.9.2. Nuclear Waste Treatment.

South Korea finally decided on a site to build disposal facilities for low to medium level radioactive waste in 2005 after a long struggle with serious opposition against the site decision. However, she still has a serious dilemma to deal with the high level waste (HLW) from Kori Unit #1 which will close down in the near future, maintaining more than 10,000 years and having no precedent treatment in the world as mentioned in 3.3.2.

The original life span of the reactor of Kori Unit #1 was 30 years which finished in April 2008. However, after serious disputes concerning the prolongation in light of the safety of the plant in 2008, she finally decided to expand 10 to 20 years (Cho 2008:1-2). No matter how long it will prolong from now on, the 10 to 20 years is too short to prepare its treatment for 10,000 years.

4.9.2. Plant-building Plan.

After starting the establishment of a nuclear plant in 1978 without opening discussions with the citizens by the Korean military government at that time, she is now operating 20 plants with 6 plants under construction. Furthermore, she declared the first national energy basic plan to build 10 plants more by 2030 in a small land of 99,117 km with public concern about nuclear technology and also without citizen consensus for further plant development.

This is a very serious ethical problem as well as the environmental impact which will definitely give serious burdens to the next generations and even neighboring states in the light of long, huge and the dangerous stigma of nuclear plants. This is obviously to be met with strong opposition from civic groups that have been against the use of nuclear power, only leading to increasing energy consumption and producing massive nuclear waste (Cho 2008:3).