Chapter 4: Environmental Indicators for the development of a corporate strategic decision tool

4.1 Environmental Concerns

The environmental problems faced by the world today are the consequence of the economic and social paradigms that existed in society since the late eighteenth century (Chapter 1). The scarcity of natural resources has been an issue since the beginning of time and is not a contributing factor to the immensity of the experienced environmental crisis. This is best summarized by Helm 1991 (as cited in Blignaut 1995):

"*Growing population and the development of modern industrial economics have resulted in a process of environmental degradation. Human behaviour must change if the damage is to be contained.*"

In order to align strategic business practices to address the environmental concerns of the global society, decision makers should have a basic understanding of what these concerns imply.

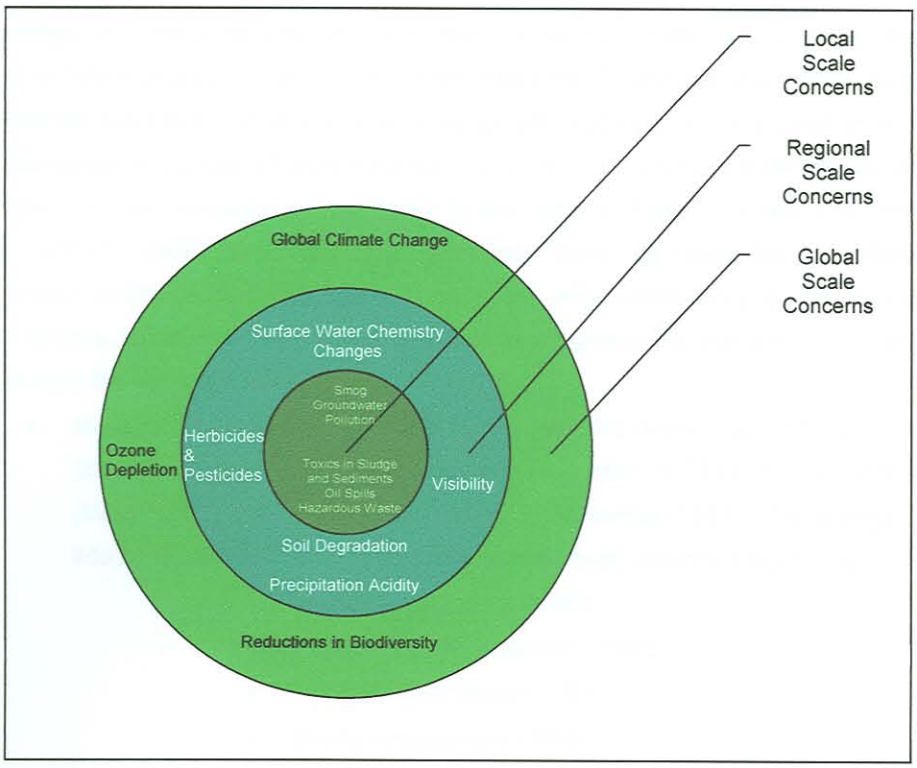

Figure 4.1: Classification of Environmental Concerns

Source: Graedel & Allenby, 1995.

As is shown in Figure 4.1, it is possible to distinguish between environmental concerns by spatial scale of impact, whereby the specific environmental impact categories can be grouped. Detailed descriptions of some of the major environmental concerns are given in Appendix D and include:

- Global climate change
- Ozone depletion
- Reduction in biodiversity
- Surface water chemical changes
- Soil degradation
- Precipitation acidity
- Visibility
- Herbicides and pesticides
- Smog
- Groundwater pollution
- Toxics in sludge
- Oil spills
- Hazardous waste sites

4.1.1 Reaction to Environmental Concerns

The identified environmental problems and concerns can be classified as impacts on either Land, Air or Water or a combination of the three resources. Businesses and governments use environmental checklists and sustainable development indicators in an attempt to minimize their contribution to causes of environmental concerns. The environmental degradation in South Africa is also measured or monitored by the national State of Nation Environmental Reports (DEAT, 2002). Governments worldwide have indicated the importance of environmental problems by committing their countries, and subsequently their business and industry sectors, to various international protocols and agreements that aim to address and minimize environmental problems, e.g.:

- Montreal Protocol on substances that deplete the ozone layer: This protocol laid down a schedule for cutting the use and production of CFCs, HCFCs and halons (Moss, 2000) and was agreed upon on 16 September 1987. The protocol came into force on the 1st of January 1989 and has been amended four times:
    - London Amendment –1990
    - Copenhagen Amendment – 1992
    - Montreal Amendment – 1997
    - Beijing Amendment –1999

- Kyoto Protocol: The protocol contains a political agreement by which industrial nations undertake to reduce gaseous emissions affecting the climate by 5.2% by the year 2012. It was signed in December 1997 in Japan.

4.2 Sustainable Development Indicators to address environmental concerns

Since the popularisation of the concept of Sustainable Development in 1987, society has been seeking for ways to measure its performance with regards to sustainability. In support of this effort various "indicators for sustainable development" have been developed focusing on different aspects of sustainable development. Veleva, Hart, Greiner and Crumbley (2001) define indicators as *"typical numerical measures that provide key information about a physical, social or economic system"* and identify three key objectives of indicators as:

- To raise awareness and understanding
- To inform decision-making
- To measure progress towards established goals.

4.2.1 United Nation's Indicators of Sustainable Development

The United Nations has developed a theme indicator framework to address sustainable development issues as defined by Agenda 21. The framework addresses the four aspects of sustainable development: Social, Environmental, Economic, as well as Institutional. Each of the aspects is divided into themes with sub-themes and indicators were developed for the sub-themes. The breakdown for Environmental Aspects is shown in Figure 4.2 and Table 4.1.

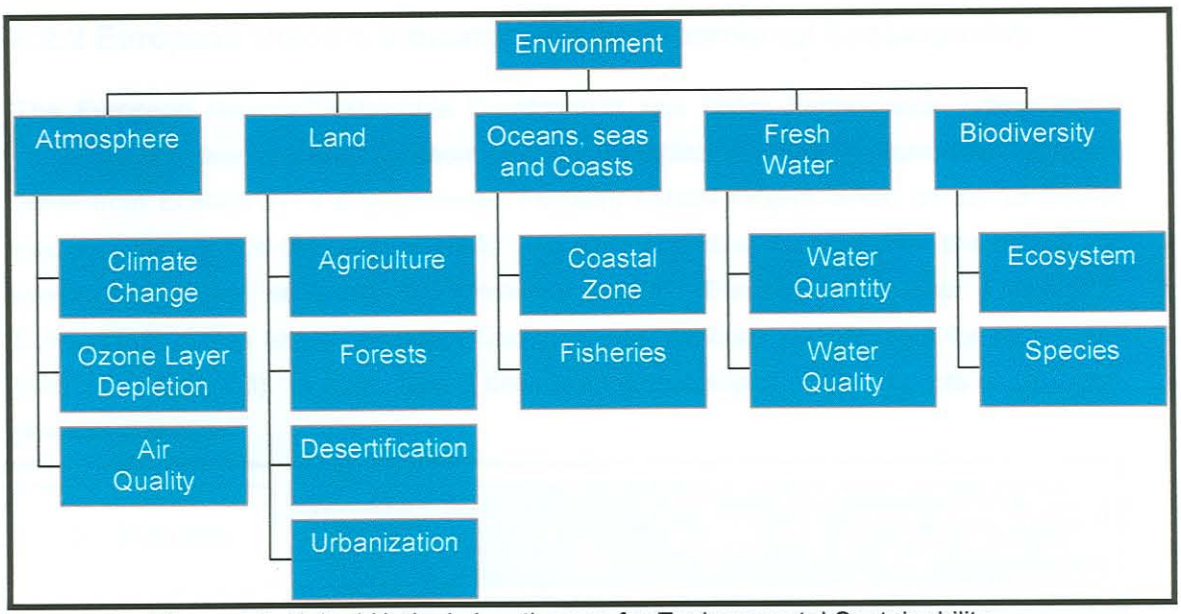

Figure 4.2: United Nation's key themes for Environmental Sustainability

Source: United Nations, 2002.

ENVIRONMENTAL		
Atmosphere (9)	Climate Change	Emissions of Greenhouse Gas
	Ozone Layer Depletion	Consumption of Ozone Depleting Substances
	Air Quality	Ambient Concentration of Air Pollutants in Urban Areas
Land (10)	Agriculture (14)	Arable and Permanent Crop Land Area
		Use of Fertilizers
		Use of Agricultural Pesticides
	Forests (11)	Forest Area as a percent of Land Area
		Wood Harvesting Intensity
	Desertification (12)	Land affected by desertification
	Urbanization (7)	Area of Urban Formal and Informal Settlements
Oceans, Sea and Coasts (17)	Coastal Zone	Algae Concentration in Coastal Waters
		Percent of Total Population Living in Coastal Areas
	Fisheries	Annual Catch by Major Species
Fresh Water (18)	Water Quantity	Annual Withdrawal of Ground and Surface Water as a percent of Total Available Water
	Water Quality	BOD in Water Bodies
		Concentration of Faecal Coliform in Freshwater
Biodiversity (15)	Ecosystem	Area of selected key ecosystems
		Protected area as a percentage of total area
	Species	Abundance of selected key species
*Numbers in brackets indicate relevant Agenda 21 chapters.		

Table 4.1: United Nation's Theme Indicator Framework for Environmental Sustainability

Source: United Nations, 2002.

Appendix E contains the complete theme indicator framework. Various countries are participating with the United Nations and have developed or are developing national sustainable development indicators.

4.2.2 European Union's Indicators for Environmental Sustainability

The European Union's Sustainable Development and Policy Performance Indices are a combination of environmental, economic and social indicators. The environmental indicators result from EUROSTAT's *Environmental Pressure Indices Project,* which aimed *"to provide decision makers and the general public with the information necessary for the design and monitoring of an adequate environmental policy"* (European Statistical Laboratory). EUROSTAT makes use of ten policy fields and has identified six indicators for each policy field (see Figure 4.3). A policy field is defined as a grouping of similar impacts or an overall problem pressure.

Air Pollution	Emissions of nitrogen oxides (NOx)	Emissions of non-methane volatile..	Emissions of sulphur dioxide (SO2)	Emissions of particles	Consumption of gasoline & diesel oil by road..	Primary energy consumption
Climate Change	Emissions of carbon dioxide (CO2)	Emissions of methane (CH4)	Emissions of nitrous oxide (N2O)	Emissions of chloro-fluoro-carbons..	Emissions of nitrogen oxides (NOx)	Emissions of sulphur oxides (SOx)
Loss of Biodiversity	Protected area loss, damage and..	Wetland loss through drainage	Agriculture intensity: area used for..	Fragmen-tation of forests & landscapes..	Clearance of natural & semi-natural..	Change in traditional land-use practice
Marine Environment & Coastal Zones	Eutrophi-cation	Overfishing	Develop-ment along shore	Priority habitat loss	Discharges of heavy metals	Oil pollution at coast & at sea
Ozone Layer Depletion	Emissions of bromo-fluoro-carbons..	Emissions of chloro-fluoro-carbons..	Emissions of hydro-chloro-fluoro..	Emissions of carbon dioxide (CO2)	Emissions of nitrogen oxides (NOx)	Emissions of chlorinated carbons
Resource Depletion	Water consumption per capita (incl...	Use of energy per capita	Increase in territory permanently occupied by	Nutrient-bala of the soil (nutrient input/..	Electricity production from fossil fuels..	Timber balance (new growth/..
Dispersion of Toxic Substances	Consumption of pesti-cides by agriculture	Emissions of persistent organic..	Consumption of toxic chemicals	Index of heavy metal emissions..	Index of heavy metal emissions..	Emissions of radioactive material
Urban Environmental Problems	Energy consumption	Non-recycled municipal waste	Non-treated wastewater	Share of private car transport	People endangered by noise emissions	Land use (change from natural to..
Waste	Waste landfilled	Waste incinerated	Hazardous waste	Municipal waste	Waste per product during a number of..	Waste recycled/ material recovered
Water Pollution & Water Resources	Nutrient (nitrogen & phosphorus - N + P) use..	Ground water abstraction	Pesticides used per hectare of agriculture..	Water treated/ water collected	Index of heavy metals emissions	Emissions of organic matter as biochemical..

Figure 4.3: European Union's framework for Environmental Sustainability Indicators

Source: http://esl.jrc.it/envind/

Each one of the six indicators contributes to the overall problem, and all six should be measured to ensure that enough information is provided to make an informed decision.

4.2.3 South Africa's Indicators for Environmental Sustainability

South Africa's Department of Environmental Affairs and Tourism (DEAT) has developed a core set of environmental indicators for national State of the Environmental reporting purposes (DEAT, 2002). The process involved the selection of priority environmental issues for reporting purposes and grouping these issues into themes (DEAT, 2002). Figure 4.4 shows the eight themes and the specific issues that are addressed under each theme.

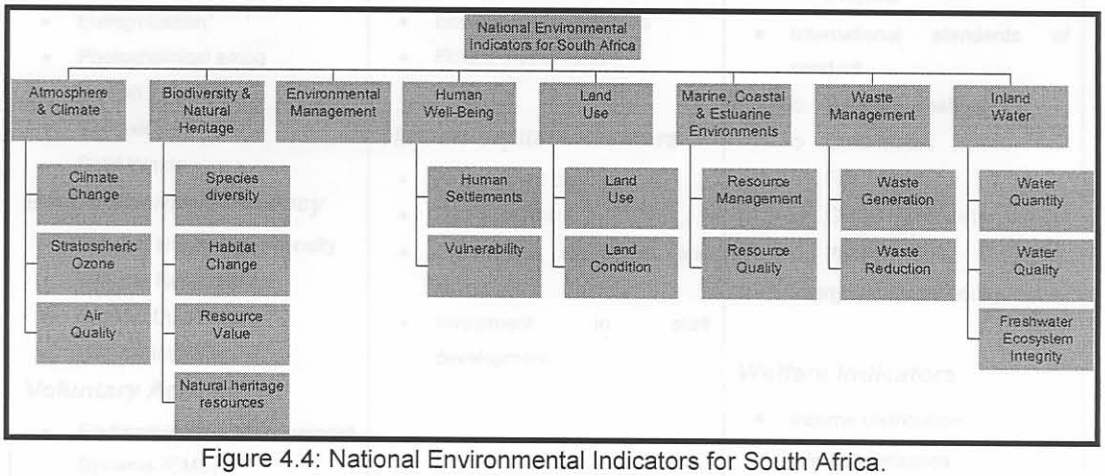

Figure 4.4: National Environmental Indicators for South Africa.

Source: DEAT, 2002

Indicators to measure each issue have been developed and a complete list of the indicators is attached in Appendix E.

4.2.4 Indicators of Sustainable Development for Industry

a) Azapagic & Perdan's Framework

The above-mentioned indicators, however, only address the sustainability of a region, country or continent and cannot be directly applied to business practices. Azapagic and Perdan, 2000 have suggested a sustainable development indicator framework for industry (Table 4.2) but states that *"...not all of them (indicators) will be appropriate for all companies and types of analysis"* and that *"more specific indicators for different sectors have to be defined separately"*.

ENVIRONMENTAL INDICATORS	ECONOMIC INDICATORS	SOCIAL INDICATORS
Environmental Impacts	***Financial Indicators***	***Ethics Indicators***

• Resource Use
• Global Warming
• Ozone Depletion
• Acidification[1]
• Eutrophication[2]
• Photochemical smog
• Human Toxicity
• Ecotoxicity
• Solid Waste
	• Value Added
	• Contribution to GDP
	• Expenditure on environmental protection
	• Environmental Liabilities
	• Ethical Investments
		• Preservation of cultural values
		  ○ Stakeholder inclusion
		  ○ Involvement in Community Projects
		• International standards of conduct
		  ○ Business dealings
		  ○ Child labour
		  ○ Fair prices
		  ○ Collaboration with corrupt regimes
		• Intergenerational equity

Environmental Efficiency	***Human-capital indicators***	***Welfare Indicators***
• Material and energy intensity • Material Recyclability • Product Durability • Service Intensity	• Employment contribution • Staff turnover • Expenditure on health and safety • Investment in staff development	• Income distribution • Work Satisfaction • Satisfaction of social needs
Voluntary Actions		
• Environmental Management Systems (EMS) • Environmental improvements above the compliance levels • Assessment of suppliers		

Table 4.2: Indicators of sustainable development for industry: a general framework

Source: Azapagic & Perdan, 2000

Although these indicators can assist in measuring a company's sustainable performance, it cannot be applied directly to measure the sustainability of a project. The indicators do, nonetheless, show what must be taken into consideration when the environmental, economic and social performance of a project is measured.

b) Global Reporting Initiative

The Global Reporting Initiative (GRI) is a joint initiative between the non-government organisation Coalition for Environmentally Responsible Economics (CERE) and the United Nations Environment Programme (UNEP). It was launched in 1997 with the goal of *"enhancing the quality, rigour and utility of sustainability reporting"* (GRI, 2002). The mission of the organisation is to *"develop and disseminate globally applicable sustainability reporting guidelines"* (GRI, 2002). Businesses worldwide are using these reporting guidelines when

[1] Process whereby the concentration of free hydrogen ions increase in the ambient water resources.
[2] *A lack of accessible oxygen due to excess biological activity triggered by an oversupply of nitrogen and phosphorus"* Graedel & Allenby (1995).

reporting on corporate sustainability. Five companies in South Africa namely: ESKOM, SASOL, SAB, Umgeni Water and Hillside Aluminium are currently supporting the initiative.

The GRI divides the environmental category of sustainability into 10 aspects. Core and additional environmental performance indicators are suggested for each aspect (see Table 4.3).

Aspect	Core Indicators	Additional Indicators
Materials	• Total material used other than water by type • Percentage of material used that are wastes from sources external to the reporting organisation	
Energy	• Direct energy use segmented by primary source • Indirect energy use	• Initiatives to use renewable energy sources and to increase energy efficiency • Energy consumption footprint of major products • Other indirect energy use and implications
Water	• Total water use	• Water sources and related ecosystems/ habitats significantly affected by use of water • Annuals withdrawals of ground and surface water as a percent of annual renewable quantity of water available from the sources • Total recycling and reuse of water
Biodiversity	• Location and size of land owned, leased or managed in biodiversity-rich habitats • Descriptions of the major impacts on biodiversity associated with activitiesbitat and/or products and services in terrestrial, freshwater and marine environments	• Total amount of land owned, leased or managed for production activities and extraction use • Amount of impermeable surface as a percentage of land purchased or leased • Impacts of activities and operations on protected and sensitive areas • Changes to natural habitats resulting from activities and operations and percentage of habitat protected or restored • Objectives, programmes and targets for protecting and restoring native ecosystems and species in degraded areas • Number of IUCN Red List species with habitats in areas affected by operations • Business units currently operating or planning operations in and around protected or sensitive areas
Emissions, effluents and waste	• Greenhouse gas emissions • Use and emissions of ozone-depleting substances • NOx, SOx, and other significant air emissions by type	• Other relevant indirect greenhouse gas emissions • All production, transport, import or export or any waste deemed "hazardous" under the terms of the Basel Convention Annex I, II, III

	• Total amount of waste by type and destination • Significant discharges to water by type • Significant spills of chemicals, oils and fuels in terms of total number and total volume	and VIII
Suppliers		• Performance of suppliers relative to environmental components of programmes and procedures as described by GRI
Products and services	• Significant environmental impacts of principal products and services • Percentage of the weight of products sold that is reclaimable at the end of the products' useful life and percentage that is actually reclaimed	
Compliance	• Incidents and fines for non-compliance with all applicable international declarations/conventions/treaties, and national, sub-national, regional and local regulations associated with environmental issues	
Transport		• Significant environmental impacts of transportation used for logistical purposes
Overall		• Total environmental expenditure by type

Table 4.3: GRI's Environmental Performance Indicators

Source: GRI, 2002.

4.3 Environmental Checklists

Environmental checklists are mostly used to identify impacts on the environment or key environmental factors for further analysis. It is often used as part of an environmental impact assessment or to determine whether a project justifies an environmental impact assessment. The advantages of checklists are its straightforwardness and user-friendliness as well as the fact that it can easily be amended. Although checklists provide a convenient summary of proposed activities and potential impacts, it does not consider the scale of impacts and cumulative impacts are often ignored. Examples of environmental checklists are attached in Appendix F.

The study of environmental checklists gives a clear indication of what the key environmental concerns or factors are that can be affected by industrial activities as well as the industrial actions that cause the effects. Table 4.4 summarizes the factors the different checklists focus on.

Canter & Karmath (1995).	***California Environmental Checklist (http://ceres.ca.gov/topic/env_law/ceqa/guidelines/appendices.html***	***Washington State: Department of Ecology (http://www.ecy.wa.gov)***

• Physical environmental landform
• Air/Climatology
• Water
• Solid Waste
• Noise
• Hazardous Waste
• Biological Environmental flora
• Fauna
• Recreation
• Aesthetics
• Archeological sites
• Health & Safety
• Cultural Patterns
• Local services
• Public Utilities
• Population
• Economic
• Transportation
• Natural Resources
	• Aesthetics
	• Agriculture Resources
	• Air Quality
	• Biological Resources
	• Cultural Resources
	• Geology/Soils
	• Hazards & Hazardous Materials
	• Hydrology/Water Quality
	• Land Use/Planning
	• Mineral Resources
	• Noise
	• Population/Housing
	• Public Services
	• Recreation
	• Transportation Traffic
	• Utilities/Service Systems
	• Mandatory Findings of Significance
		• Earth
		• Air
		• Water
		  o Surface
		  o Ground
		  o Water Runoff
		• Plants
		• Animals
		• Energy & Natural Resources
		• Environmental Health
		• Land and Shoreline Use
		• Housing
		• Aesthetics
		• Light and glare
		• Recreation
		• Historic and Cultural Preservation
		• Transportation
		• Public Services
		• Utilities

US General Service Administration (http://hydra.gsa.gov/)	***US Department of Energy (http://www.id.doe.gov/doeid)***	
• Subsurface Conditions • Hydrology • Landforms • Wildlife • Land Use • Natural Hazards • Cultural Resources • Utilities/Services • Transportation • Hazardous Materials	• Air Emissions • Asbestos • Work Force Adjustments • Excess Noise levels • Utility Modification • Soil Disturbance • Water Treatment • Water/Well Use • Water Course Modification • Pesticide Use • Chemical Use/Storage	• Petroleum Storage • Solid Waste • PCBs • Hazardous Waste • Radioactive Waste • Mixed Waste • Radiation Exposure • Liquid Effluent • Sensitive Resources • CERCLA/RCRA Site

Table 4.4: Focus Areas of Environmental Checklists

The Environmental Checklists provides guidance in formulating the relevant type of questions that a gate review (as discussed in Chapter 3) should typically address. It gives a clear indication that a framework for environmental factors is necessary to provide structure to typical gate review questions.

4.4 Framework to evaluate Environmental Impacts within Projects

Based on the study of environmental concerns, environmental checklists, sustainable development indicators and environmental performance indicators, four main environmental factors or themes were chosen: Land, Air, Water and Mined resources. The themes are used to configure a framework to classify possible environmental impacts of projects (Figure 4.5).

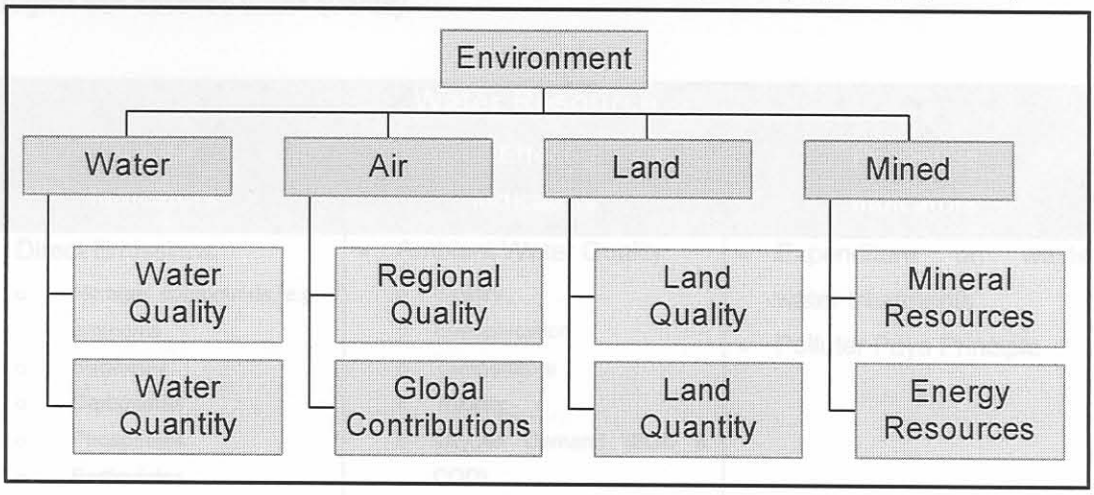

Figure 4.5: Framework to classify possible environmental impacts of projects

Possible measurable causes of environmental effects for each main factor are determined, and in addition, suitable indicators are identified to measure these environmental effects. The framework focuses on direct environmentally measurable effects and possible responses to these environmental effects are listed in the form of response indicators. It must be noted that only anthropogenic causes, i.e. human induced, typical of the process industry have been considered, i.e. natural or other human activities are not included in the framework.

Environmental impacts can have an end-point effect on either human health quality or ecosystem quality (see cause-effect chain of environmental impacts in section 2.3.2b). The framework does not focus on end-point of impacts such as economic costs, which are often paid for by society and not the company. The possibility of specific end-point impacts sometimes justifies response expenses. The focus of the following tables are on specific environmental effects of the process industry and economic and social consequences of end-point effects are not taken into consideration.

4.4.1 Water

The availability of adequate water resources in a region is a function of the quality and quantity of these resources. Water quality is described by the physical characteristics of the water resources, e.g. pH, concentration of key pollutants in water, the actual smell, the appearance of the water, etc. In turn, the groundwater levels and surface water availability in a region can describe water quantity.

Water Resource		
Cause Indicators	**Effect Indicators**	**Response Indicators**

• Direct Emissions :
  ○ Nitrogen compounds, e.g. ammonia
  ○ Sulphates
  ○ Carbonates
  ○ Phosphates
  ○ Particulates
  ○ Organics, differentiated as CxHy, aromatics, halogen aromatics (AOX), etc.
  ○ Metals, e.g. Hg, Pb, Ni, etc.
• Indirect Emissions:
  ○ Leachate from Waste Material discharged into ground
  ○ Accidental Spills
  ○ Air emissions with final impact on water quality, e.g. nitrogen oxides, sulphur dioxide (see air resources table)
• Water Use:
  ○ Annual withdrawal of ground water supplies
  ○ Annual withdrawal of surface water
	• Ambient Water Quality
	  ○ Salinity
	  ○ Eutrophication
	  ○ Temperature
	  ○ Toxicity
	  ○ Oxygen Demand (BOD & COD)
	  ○ Acidification (acid drainage or acid rain)
	  ○ Total dissolved solids (TSS)
	• Ambient Water Quantity
	  ○ Change in surface flow pattern
	  ○ Water table depth
		• Expenditure on waste water treatments
		• Polluter Pays Principle

Table 4.5: Indicators for Water Resource

4.4.2 Air

As a resource, air impacts can be divided in terms of regional air quality effects i.e. visibility, smell, noise levels and pollution concentrations in air, and global effects which are concerned with environmental problems such as global warming and ozone depletion.

Air Resource		
Cause Indicators	**Effect Indicators**	**Response Indicators**
• Direct Emissions i.e. gas residues(point source and fugitive): o Nitrogen oxides o Methane o Non-methane volatile organic compounds o Metals o Sulphur oxides o Reduced Sulphur Compounds o Ammonia o Carbon oxides o Chlorofluorocarbon-type compounds • Indirect Emissions o Accidental spills o Long term emissions from waste disposal facilities • Non-material emissions: o Noise	• Regional Air Quality effects: o Summer smog (Photochemical ground level ozone formation) o Noise levels o Winter smog (particle concentration) o Smell o Acidification o Toxicity • Global effects o Stratospheric ozone Depletion o Global Warming	• Expenditure on air pollution impact abatement options • Expenditure on climate change impact abatement options

Table 4.6: Indicators for Air Resource

4.4.3 Land

Land resources can be described as a function of land quality and land quantity. Land quantity is described by characteristics such as soil degradation, natural forests area as a percentage of land area, area of urban formal and informal settlements as well as arable and permanent cropland area. In turn, the reduction in biodiversity and soil conditions can be used to describe land quality.

Land		
Cause Indicators	**Effect Indicators**	**Response Indicators**

• Direct emissions:
  ○ Organics
  ○ Metals
• Indirect emissions:
  ○ Solid waste
  ○ Accidental spills
• Land use:
  ○ Occupied land
  ○ Contaminated land
  ○ Topsoil removed
	• Land Quality
	  ○ Heavy metal concentration in topsoil
	  ○ Organics concentration in topsoil
	  ○ Nutrient concentration
	  ○ Biodiversity
	• Land Quantity
	  ○ Land conversion/transformation
	  ○ Loss of topsoil
		• Percentage of designated protected areas

Table 4.7: Indicators for Land

4.4.4 Mined Resources

Mined resources focus on mineral and energy resources. Renewable options are preferred and therefore mined resources can be described by the reserve or availability of non-renewable mineral and energy resources.

Mined Resources		
Cause Indicators	**Effect Indicators**	**Response Indicators**
• Consumption of non-renewable mineral resources • Consumption of renewable energy resources • Intensity of energy use	• Minerals reserve/availability • Fuels reserve/availability	• Capital expenditure to increase materials and energy efficiency

Table 4.8: Indicators for Mined Resources

4.5 Conclusion

Four main environmental factors that can be affected by projects have been identified. A framework of possible environmental impacts has been constructed by focusing on each resource separately using the following methodology:

- Determining causes of possible impacts on the various resources
- Identifying effect indicators to monitor the resulting impacts
- Listing possible responses that can minimize the impacts.

This framework provides guidance in identifying impacts for each one of the three critical phases of the process being implemented, as identified in Chapter 3 (Construction, Operation and Decommissioning). The environmental feasibility of the project should be evaluated at each gate review and the information in the framework provides the basis from which questions for the gate reviews with regards to the specific themes can be formulated.

The environmental framework is the basis from which the scoring guidelines used in the corporate strategic decision-making tool, proposed in this document, are developed and thus forms an integral part of the methodology.