Chapter 2: Environmental Management Tools

2.1 Introduction to Environmental Management

Society has identified various valid reasons *why* attempts must be undertaken to protect and conserve the environment, while the concept of "Sustainable Development" answers *what* needs to be done to achieve these goals. Environmental Management represents *"a set of practical tools that attempts to answer HOW this will be done"* (UNDP, 2002).

Environmental Management is defined as *"the process of allocating natural and artificial resources so as to make optimum use of the environment in satisfying basic human needs, if possible for an indefinite period, and with minimal adverse effects"* (Barrow, 1997).

It is a relatively new discipline for two reasons. Firstly, environmental issues were usually dealt with by engineers and technical people and not at management level. Secondly, until recently, companies believed that their environmental responsibilities ended at contributing to environmental endeavours, e.g. publishing books on environmental topics such as wildlife or endangered species and sponsoring ecological projects, and it was not integrated in the overall business practices. The development of extensive environmental regulations and the constant growth in environmental awareness, however, caused industry to rethink the role of environmental management in business practices. Engineers and technical people no longer possessed all the competencies needed to manage environmental issues; a more pro-active approach was needed. This resulted in the specialised field of environmental management (Tibor,1996, Labuschagne, 2002).

The increase in the cost of environmental protection as well as legal liabilities led to the development of a more system-oriented approach to environmental management. Governments across the globe promoted environmental management tools as well as the concept of integrated environmental management (IEM). An integrated Environmental Management System (EMS) can help a company manage, measure and improve the environmental aspects of its operations (Tibor, 1996).

Various standards were and are being developed in an effort to standardize procedures in environmental management. Table 2.1 (Grace, Grace, Perez & Maywah,1999 and Barrow, 1996) provides a comparison of the three major standards namely: the British Standard BS7750, the European Union's EMAS and ISO 14000.

	BS 7750	EMAS	ISO 14000
Focus Area	Whole organization, can be applied to any sector or activity	Specific sites an/or industrial activities	Whole organization, covers all activities, products and services
Frequency of Audits	Not specified	Maximum audit frequency at three years	Not specified can be negotiated
Focus on Environmental Performance	Audit is not concerned with environmental performance	Auditing is concerned only with environmental performance and compliance with relevant environmental legislation.	It is a process standard; this implies that the standards does not tell companies what environmental performance they must achieve but it offers building blocks for an environmental management system that will assist companies in achieving their own performance goals
Information that must be publicly available	Environmental policy programme and management system	Environmental Policy	Environmental Policy
Countries	UK and a few other	European Union	Internationally
Application	Open to non-industrial activities[1]	Non-Industrial Activities included on experimental basis	Applicable to non-industrial activities
Date of Acceptance of Standard	1992	1993	1996
Criticized Aspects of standard	1. Standard can be obtained by *promising* to improve. 2. Small companies find cost a problem.	1. Auditing Criteria are too vague. 2. It costs too much. 3. It badly disrupts activities of organizations. 4. It may generate hostility from the public and workforce.	1. Standard does not require sufficient public disclosure of company's environmental impacts. 2. Standard does not guarantee environmental performance or compliance with applicable national environmental legislation.

Table 2.1: Comparison between BS 7750, EMAS and ISO 14000

Sources: http://www.gdrc.org/uem/iso14001/info-3.html
Grace, Grace, Perez & Maywah, 1999.
Barrow, 1996.

[1] Non-Industrial activities are activities like transport, local government, etc.

2.2 ISO 14000

The growing need for one international EMS standard as well pressure on companies to demonstrate better environmental stewardship and accountability led to the development and publication of the ISO 14000 standards within two years. ISO 14000 thus aims to achieve "*standardization in the field of environmental management and tools*" (Tibor, 1996).

The Technical Committee 207 (TC 207) of the International Organization for Standardization (ISO) remains the driving force behind the ISO 14000 standards and has clearly distinguished two main focus areas of an EMS (See the internal organization for TC 207, Figure 2.1):

- Focus on organization evaluation
- Focus on product and process evaluation

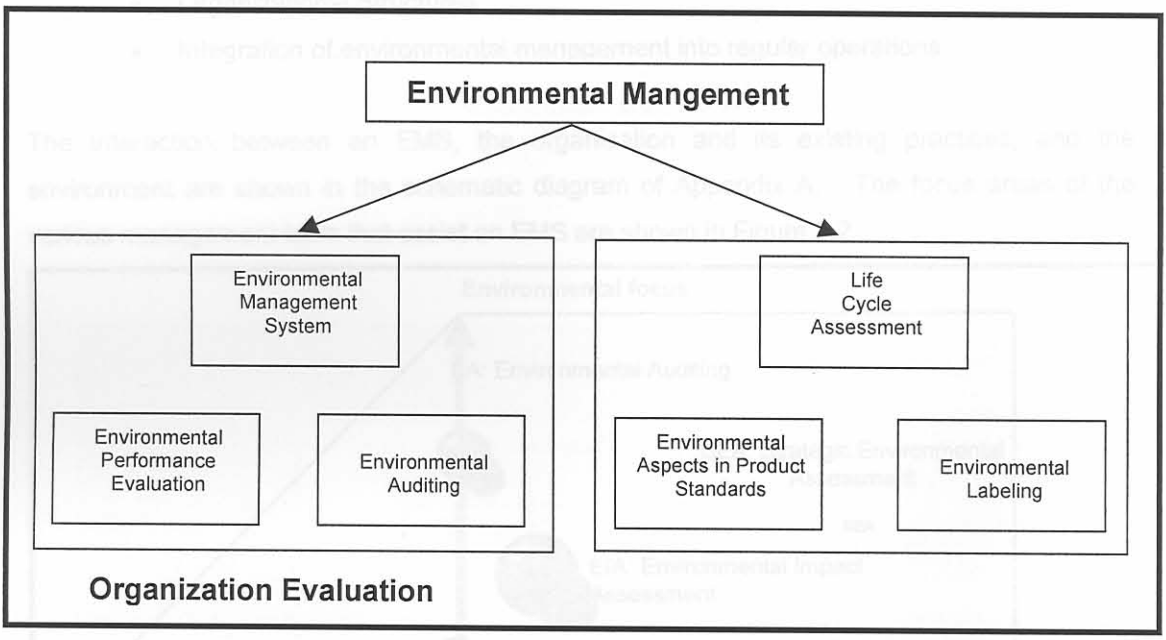

Figure 2.1: Focus areas of TC 207 committee

Source: Tibor, 1996

Tibor (1996) believes that the ISO 14000 standards are based on the simple equation that better environmental management will lead to better environmental performance, which will result in increased efficiency and a greater return on investment. The ISO 14000 family of standards clearly distinguish between environmental management systems and environmental management tools. The standards take the view that the implementation of an EMS is of central importance in determining an environmental policy, objectives and targets for a company. The recommended environmental tools can assist a company in realizing these targets and objectives (ISO, 1998).

2.3 Incorporating ISO 14000 in existing business practices

2.3.1 Environmental Management System (EMS)

ISO 14000 defines an Environmental Management System as *"that part of the overall management system which includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the organization's environmental policy"* (Tamura, 2002). Specific activities related to environmental protection and compliance can thus be effectively and efficiently carried out within the structure provided by an EMS. Tamura (2002) identified the following four core elements of any effective EMS:

- Environmental Policy
- Environmental Programme or Action Plan
- Organizational Structures
- Integration of environmental management into regular operations.

The interaction between an EMS, the organisation and its existing practices, and the environment are shown in the schematic diagram of Appendix A. The focus areas of the various management tools that assist an EMS are shown in Figure 2.2.

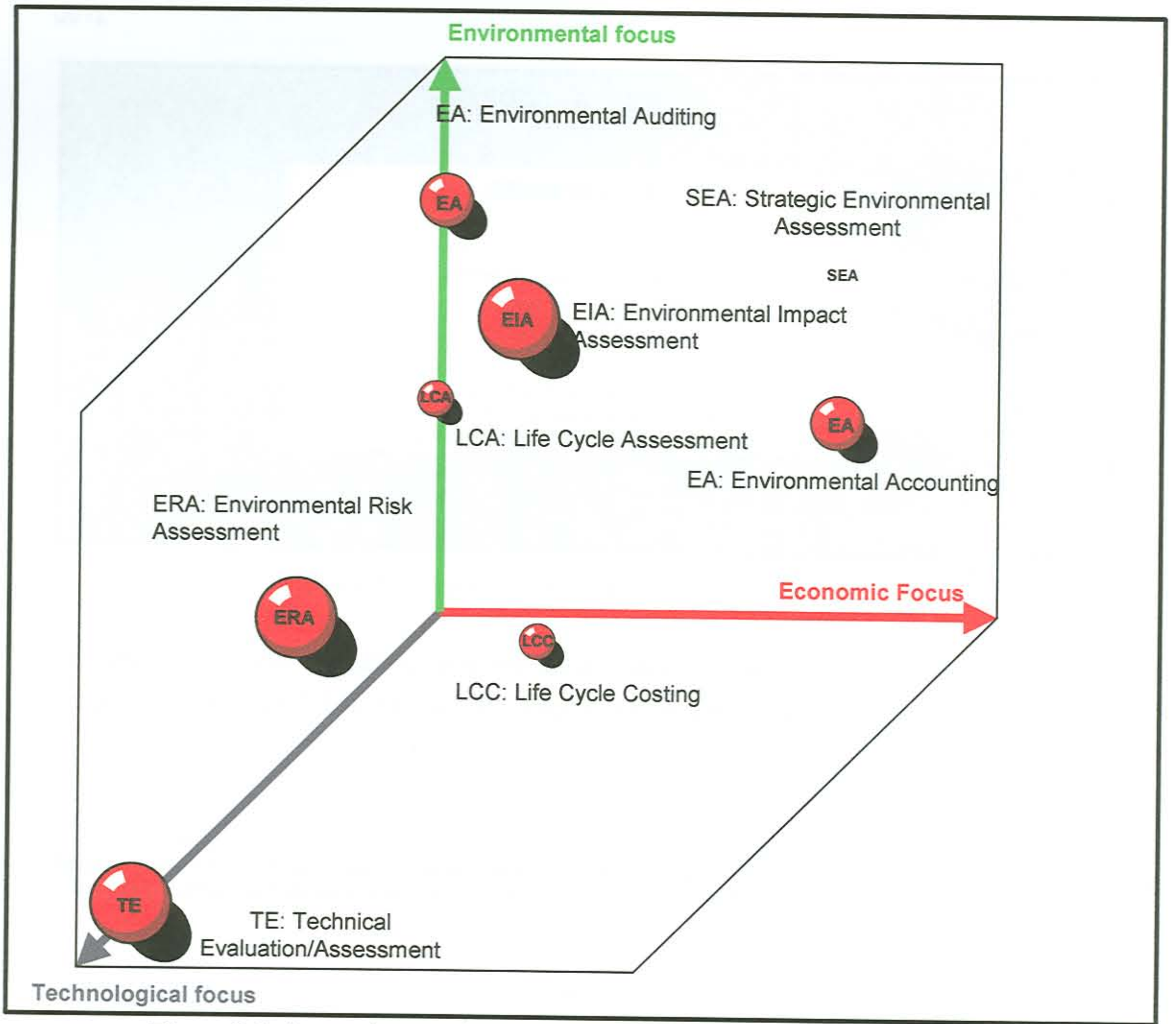

Figure 2.2: Focus Areas of different management tools for an EMS

Figure 2.2 shows that not one of the environmental management tools has a balanced economic, environmental and technological focus. Some of the tools do, nevertheless, incorporate certain economic and technical fundamentals. An understanding of concepts that integrate the economical, environmental and technical evaluation dimensions is therefore required.

2.3.2 Integrated concepts in environmental management tools

a) Environmental Costs

There is no universal definition for environmental costs (Ditz, Ranganathan & Banks, 1995). Although the United States' Environmental Protection Agency (EPA) states that each company can have a unique definition for environmental cost, it distinguishes between two dimensions of environmental costs:

- Private Costs: Costs that have a direct impact on a company's bottom line
- Societal Costs: Costs to individuals, societies and the environment (e.g. cleaning actions) for which a company is not accountable.

The relationship between these two dimensions is illustrated in Figure 2.3 (USEPA 742-R-95-001).

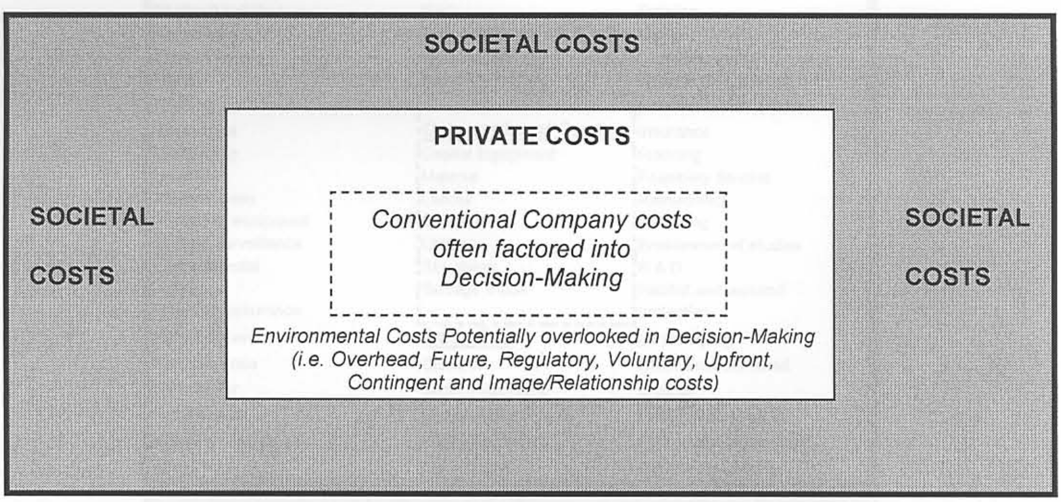

Figure 2.3: Private and Societal Environmental costs[2]

Source: USEPA 742-R-95-001

The US EPA further classified environmental costs incurred by companies into main categories (see Table 2.2 for definitions thereof and examples of each in Figure 2.4).

[2] Adapted by EPA from White, Becker, Savage, 1993, Environmentally Smart Accounting: Using Total Cost Assessment to Advance Pollution Prevention. *Pollution Prevention* Summer: 247-259

Type of Environmental Cost	Definition
Regulatory Costs	Also known as "compliance costs", it is all the costs incurred by a company in order to comply with national or local environmental laws.
Upfront costs	Pre-acquisition or pre-production costs incurred for new processes, products, facilities or systems.
Voluntary costs	Costs incurred by the company to go beyond compliance with environmental laws.
Conventional Costs	Costs typically recognized in capital budgeting exercises.
Back End costs	Environmental costs that arise following the useful life of processes, products, systems or facilities. It can thus be all the costs that must be incurred for proper closure, decommissioning and clean-up at the end of the useful life of a process, system or facility.
Contingent Costs	These are environmental costs that might occur in the future but depend on uncertain future events. Also referred to as "environmental liabilities", "liability costs" or "contingent liabilities".
Image and Relationship Costs	Also termed "Less tangible costs". It refers to costs incurred for corporate image purposes or for maintaining or enhancing customer relationships or relationships with the general public, regulators and suppliers.

Table 2.2: Environmental Cost Definitions

Source: USEPA 742-R-95-001

Potentially Hidden Costs

Regulatory
- Notification
- Reporting
- Monitoring/Testing
- Studies/Modelling
- Remediation
- Recordkeeping
- Plans
- Training
- Inspections
- Manifesting
- Labelling
- Preparedness
- Protective equipment
- Medical surveillance
- Environmental insurance
- Financial assurance
- Pollution Control
- Spill response
- Stormwater mangement
- Waste Management
- Taxes/fees

Upfront
- Site studies
- Site Preparation
- Permitting
- R&D
- Engineering and procurement
- installation

Conventional Costs
- Capital Equipment
- Material
- Labour
- Supplies
- Utilities
- Structures
- Salvage Value

Back End
- Closure/ decommissioning
- Disposal of inventory
- Post closure care
- Site Survey

Voluntary (Beyond Compliance)
- Community Relations/ outreach
- Monitoring/testing
- Training
- Audits
- Qualifying suppliers
- Reports (e.g. annual environmental reports)
- Insurance
- Planning
- Feasibility Studies
- Remediation
- Recycling
- Environmental studies
- R & D
- Habitat and wetland protection
- Landscaping
- Other Environmental projects
- Financial Support to environmental groupd and/or researchers

Contingent Costs
- Future Compliance costs
- Penalties/fines
- Responses to future releases
- Remediation
- Property Damage
- Personal Injury damage
- Legal expenses
- Natural resource damage
- Economic loss damages

Image and Relationship Costs
- Corporate Image
- Relationships with customers
- Relationships with investors
- Relationships with insurers
- Relationship with professional staff
- Relationship with workers
- Relationship with suppliers
- Relationship with lenders
- Relationship with host communities
- Relationship with regulators

Figure 2.4: Environmental Costs incurred by companies

Source: USEPA 742-R-95-001

Evidence presented in case studies of the World Resource Institute (WRI) show that environmental costs can account for up to 20% of total cost of a project, process or product. Traditional accounting practices tend to hide these environmental costs, due to the following practices:

- Costs are "buried" in non-environmental accounts.
- Costs are not linked to the activities that generate them (Ditz, Ranganathan, & Bank,1995).

b) Environmental Impact

Julien, Fenves & Small (1992) define an environmental impact as "*a cause-effect relationship between a source, the cause of the impact, and a receptor, the environmental element affected by the impact*". The impact can either be direct or indirect, both of these can also be cumulative impacts. An indirect impact is an impact between interacting environmental elements. The Council on Environmental Quality (CEQ) regulation section 1508.7 (1978) defines a cumulative environmental impact as *"the impact on the environment that results from incremental impact of the action when added to other past, present, and reasonable foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions"* (as cited in Canter & Kamath, 1995).

Environmental impacts are often described in terms of cause-effect chains that link emissions and activities to the consequences (Figure 2.5) (Finnveden, G.; Andersson-Sköld; Samuelsson, M.O.; Zetterberg, L.; Linfors, L.G. (1992) as cited in Brent, 2002). These chains show that impacts can be described at different levels of effects, e.g. a direct impact is a primary effect. The example of greenhouse gas release is used in Table 2.3 to illustrate the different levels of effects (Baumann, H.; Tillman, A.M. (1999) as cited in Brent ,2002).

Graedel & Allenby (1995) stress the important fact that *"most sources of emission to the environment have multiple effects, and most effects have multiple causes"*

ISO 14000 Terminology	Level	Cause – Effect
Aspect	Activity	Combustion processes, e.g. electricity generation from coal
	Pollutants emitted	Carbon dioxide (CO_2), methane (CH_4), etc.
Impacts	Primary effect	Radiative forcing, i.e. absorption of thermal infra-red radiation in the atmosphere
	Secondary effect	Increase in global temperature
	Tertiary effect	Ice-melting, rising sea levels, change in weather patterns
	Further effects	Specific changes in ecosystems

Table 2.3: Different levels of effects caused by greenhouse gas release

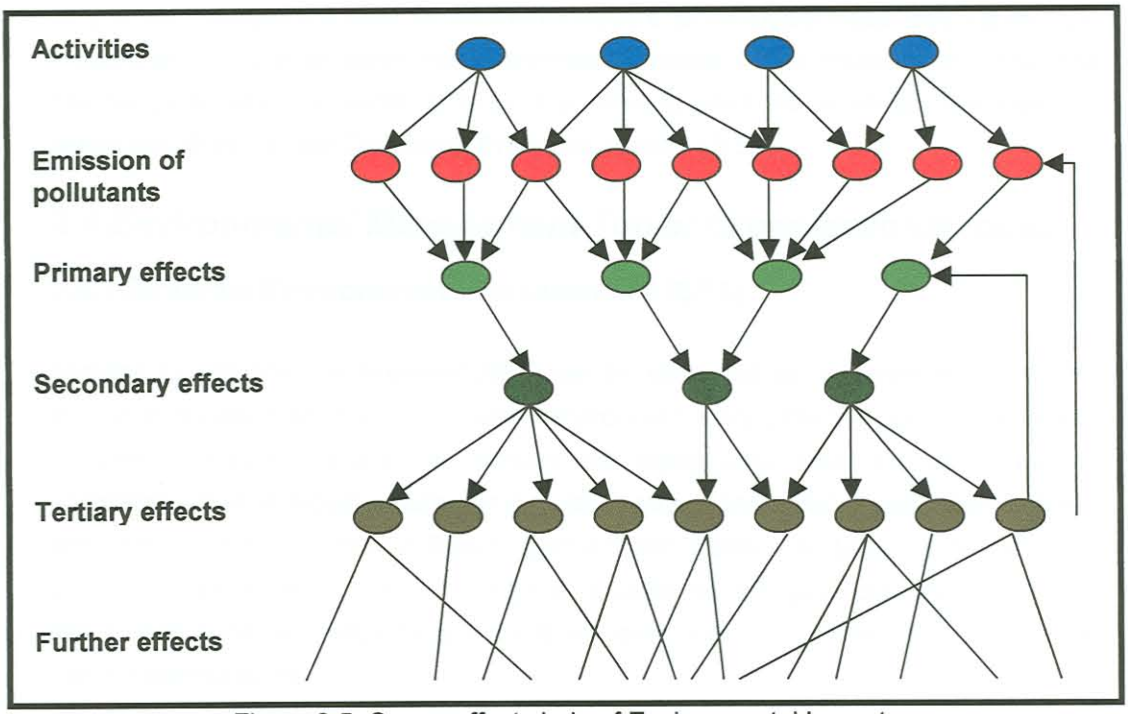

Figure 2.5: Cause-effect chain of Environmental Impacts

Source: As cited in Brent, 2002.

c) Technology Aspects

Van Wyk (1988) defines technology as *"created capability: it is manifested in artefacts, the purpose of which is to augment human skill."* Pretorius (2002) distinguishes between four types of technology (see Table 2.4) and states that technology progresses through different stages (see Table 2.5).

Technology type	Definition of Technology Type
Product Technology	Technology directly related to performance of product
Process Technology	Technology directly related to manufacturing process
Support Technology	Technology indirectly related to manufacturing, e.g. distribution
Information Technology	Technology associated with gathering, storage and access to information related to product, manufacture and support

Table 2.4: Types of Technology

Source: Pretorius (2002)

Technology Stage	Definition of Technology Stage
Emerging Technology	New technology, not widely known
Pacing Technology	A few companies make use of the technology
Key Technology	Technology is known and essential to the business
Base Technology	Technology is widely applied across the industry

Table 2.5: Technology Stages

Source: Pretorius (2002)

Only a few management tools for an EMS include a technological focus (see Figure 2.2). Those that do focus on either the environmental impacts of the chosen technology (see Technology Assessment, section 2.5.4) or the extent to which the technology can meet the design specifications (see Technology Evaluation, section 2.5.5.c))

2.4 Environmental Management Tools: Organizational focus

2.4.1 Strategic Environmental Assessment (SEA)

Strategic Environmental Assessment (SEA) can be interpreted as *"a systematic process for evaluating the environmental consequences of proposed policy, plan or programme initiatives in order to ensure they are fully included and appropriately addressed at the earliest appropriate stage of decision-making on par with economic and social considerations"* (Sadler and Verheem (1996), as cited in Dalal-Clayton & Sadler, 1998). An SEA can include socio-economic impacts, macro-economic impacts, impacts on biological diversity and human health, institutional and instrumental impacts and even cumulative impacts on e.g. resource use or water resources.

The aim of an SEA is to contribute to the achievement of sustainable development by promoting integrated environment and development decision-making. Consideration towards best practice environmental options and alternatives for the design of sustainable policies and plans is promoted through the tool. Furthermore, it is not necessary for an SEA to fulfil the same procedural obligations of a typical environmental impact assessment (Partidário, 2000). The purpose of an SEA is to provide a framework within which EIAs can be performed as well as to add value to the decision making process.

A study initiated by the European Union and conducted by ICON (2001) identified four broad models of SEAs:

- EIA-inspired SEA: Originated from ecological and/or resource management disciplines. This type of SEA is used at programme level and includes a systematic assessment procedure with more emphasis on technical methodologies.
- Policy analysis/appraisal-inspired SEA: This type of SEA does not include a baseline survey, has little or no public involvement and appraises options against objectives. It originated from political science.
- Integrationary SEA: This is a combination of an EIA inspired SEA and an appraised-inspired SEA. It has public participation as a vital component and impacts are appraised against a combination of the environmental baseline survey and the objectives.
- Ad hoc SEA: There is no systematic process and practices like environmental auditing and state of the environment reports are used to provide information.

The relationship between the four models is graphically shown in Figure 2.6.

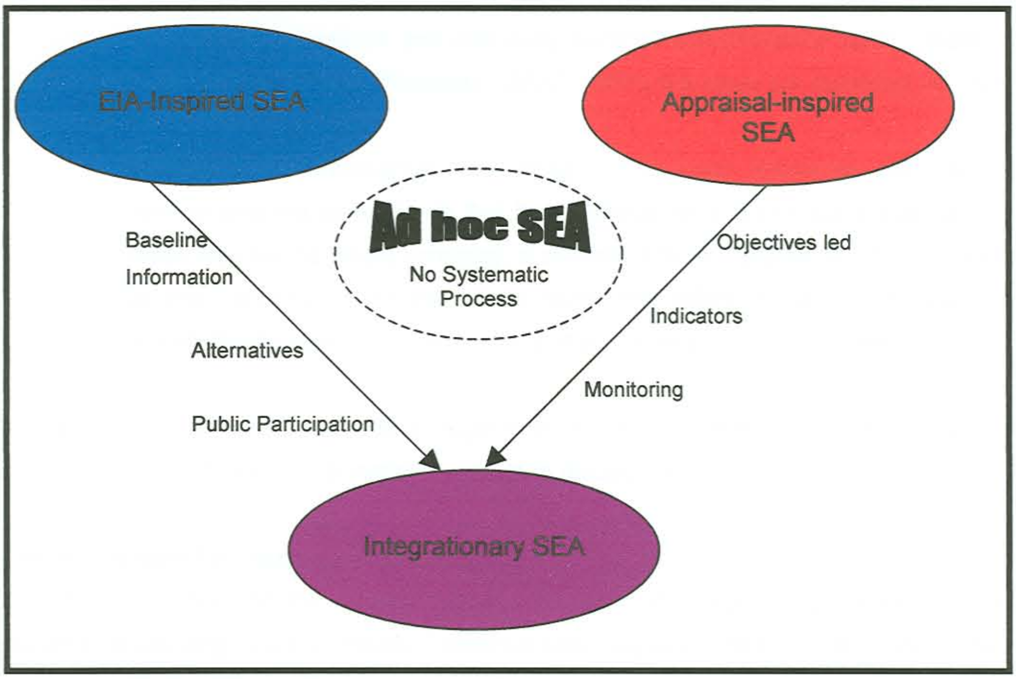

Figure 2.6: Relationship between different SEA Models

Source: European Commission Contract B4-3040/99/136634/MAR/B4; 2001

An SEA considers environmental and economic aspects in broader terms through a holistic approach and lacks a technology specific analysis. An SEA is not designed for purposes of assisting in detailed process or product designs.

2.4.2 Environmental Accounting

a) Definition & Goal of Environmental Accounting

The inability of economic theory and traditional accounting practices to address environmental costs was already identified by Tinbergen in 1976 (Blignaut, 1995). This led to the emergence of a whole new field in accounting, i.e. environmental accounting. Numerous definitions for the term environmental accounting exist. Blignaut (1995) defines it as "*the act of ascribing a value, a monetary unit, to what was previously conceived as free (or as unimportant) – the environment and natural resources.*" The United States' Environmental Protection Agency (EPA) distinguishes between three different types of environmental accounting namely:

- Natural Resource Accounting: This is a macro-economic measure where the focus is on the nation. This field can be used to express the consumption of the nation's natural resources (both renewable and non-renewable) in physical or monetary units. Indicators include Gross Domestic Product taking environmental costs into consideration.

- Environmental accounting in the context of financial accounting: In this context the focus is a company and it refers to the estimation and public reporting of environmental liabilities and financially material environmental costs. Generally Accepted Accounting Principles (GAAP) forms the basis for reporting within this context.
- Managerial Environmental Accounting: The main difference between this context and the other two is that the audience for this context is internal. The focus may be the whole company, a division, a facility, a specific product, system or line. Managerial Environmental Accounting refers to the use of data about environmental costs and performance in business decisions and operations.

The goal of Environmental Accounting, regardless of which context, remains to increase the amount of relevant financial information available to decision makers.

b) Problems with Environmental Accounting

After the publication of the United Nation's "System of Integrated Environmental and Economic Accounting" (SEEA), Holub, Tappeiner and Tappeiner(1999) identified the following two main problems with environmental accounting:

- The fundamental incompatibility of economic and ecological scales.
- The questionable emphasis placed on data artificially generated with hypotheses instead of making use of empirical observational data.

Environmental Accounting does not bring economic and environmental considerations successfully together for all aspects and consequently does not fully incorporate environmental issues into decision-making. However, the results from the application of the tools can be useful at certain points in the decision-making process.

2.4.3 Environmental Auditing

United States' Environmental Protection Agency defines Environmental Auditing as *"a systematic, documented, periodic and objective review by a regulated entity of facility operations and practices related to meeting environmental requirements."* Barrow (1996) specifically refers to the multidisciplinary approach of environmental auditing and states that it is used to assess environmental performance of an organization, authority or even a region.

Auditing is a total voluntary process and it assesses *actual* impacts and effects of existing activities. This information can be used as "Hindsight Knowledge" in future developments and environmental assessments and provides feedback to an EMS.

Establishing standard procedures for the environmental auditing process is one of the tasks of TC 207, i.e. ISO 14010; ISO 14011 and ISO 14012. Fava, 1994 (as cited in Barrow) defined the following types of Environmental Audits:

- Site or Facility audit
- Compliance audit
- Issues audit
- Property Transfer audit
- Waste Audit
- Life Cycle Audit – process or product focus

Environmental Auditing marked the growing shift from companies merely complying with regulations to companies developing forward-looking sustainable environmental management strategies. Environmental Auditing can be economically justified, as practice has shown that it leads to more favourable insurance rates, improved public image and avoided legal action for environmental damage (Barrow, 1996).

The tool is divided into two broad categories:

- Industrial or private sector corporate environmental audits.
- Local authority or higher-level government environmental audits.

Barton and Bruder (as cited in Barrow) distinguish between two phases in environmental auditing:

- External – this refers to the collection of available data and the output of this phase should be a state-of-the-environment-report.
- Internal – this refers to the assessment of current policies and practices against the state-of-the-environment report.

Environmental Audits can be performed by consultants, government agencies or even "in-house". These audits start to play a key role in environmental management (ISO, 2002).

2.5 *Environmental Management Tools: Product/Process Focus*

2.5.1 Environmental Labelling

Barrow, 1996 defines an environmental label as *"a marker on goods indicating that those goods are 'environmental friendly'"*. Environmental Labelling is hence the assessment of a product by an independent judge. This tool does not require an environmental audit, but it does access the environmental impacts of a product and communicates this information to customers or consumers. The focus is therefore primarily on the product, while the process and organizational issues are taken into consideration some of the times.

Examples of environmental labelling the European Union that introduced an environmental labelling scheme in the 1990s. This scheme awards a label for a product if the impacts associated with the product is less than that for similar products.

This tool is criticized for the fact that it is not backed by adequate legally enforced standards and that it can consequently easily become a mere marketing gimmick (West, 1995 as cited in Barrow, 1996). The ISO 14020 standard is an attempt to standardise the general principles of environmental labels and declarations (ISO, 2002).

Within the South African context, the tool is only applicable where product export is considered, as no labelling scheme exists in South Africa. The tool also does not add value for internal decision-making purposes, as it does not focus on the processor's organizational issues. For these reasons, it is not currently formally applied or included in South African environmental management systems. However, the procedure of Environmental Labelling, does interact strongly with other tools, e.g. Life Cycle Assessment (LCA).

2.5.2. Environmental Risk Assessment (ERA)

Risk is defined as the likelihood that a harmful consequence will occur as the result of an action or condition. Risk Assessment is therefore defined as *"the process of assigning magnitudes and probabilities to adverse effects of human activities (including technical innovation) or natural catastrophes… This process involves identifying hazards and using measurement, testing and mathematical or statistical methods to quantify the relationship between the initiating event and the effects "* (Combined definition by Horlick-Jones and Suter as cited in Barrow, 1996). Risk assessment goes one step beyond hazard evaluation as it includes the quantitative estimate of the probability of occurrence of the hazard (Finizio & Villa, 2002).

Environmental Risk Assessment (ERA) is viewed as a sub-field of risk assessment and assesses the risks to the environment resulting form industrial activity, product usage, new developments or any other human intervention. It typically evaluates the probabilities and magnitudes of harm that can result from environmental contaminants.

The United Nations distinguish between two components of Environmental Risk Assessment:

- Human Health Risk Assessment
- Ecological Risk Assessment

The tool aims to minimize environmental impacts as well as impacts to humans while maximizing sustainability for any development or concept being assessed (Cardenas, 2002). In order to achieve these aims Environmental Risk Assessment should be incorporated into the decision-making process. The US Environment Protection Agency's definition of ERA also emphasises that risk assessment should be a decision-making process that promotes sound environmental decisions and not only a computational technique (Barnthouse, 1995 (as cited in Finizio & Villa, 2002).

The growing importance of environmental risk assessment causes management focus to fall on environmental risk management, i.e. these potential consequences that were assessed should be managed. Environmental Risk Management is defined as *"the process whereby decisions are made about whether an assessed risk needs to be managed and the means for accomplishing it"* (Linghurst et al, 1995 as cited in Finizio & Villa, 2002). Figure 2.7 illustrates the relationship between Risk Assessment and Risk Management.

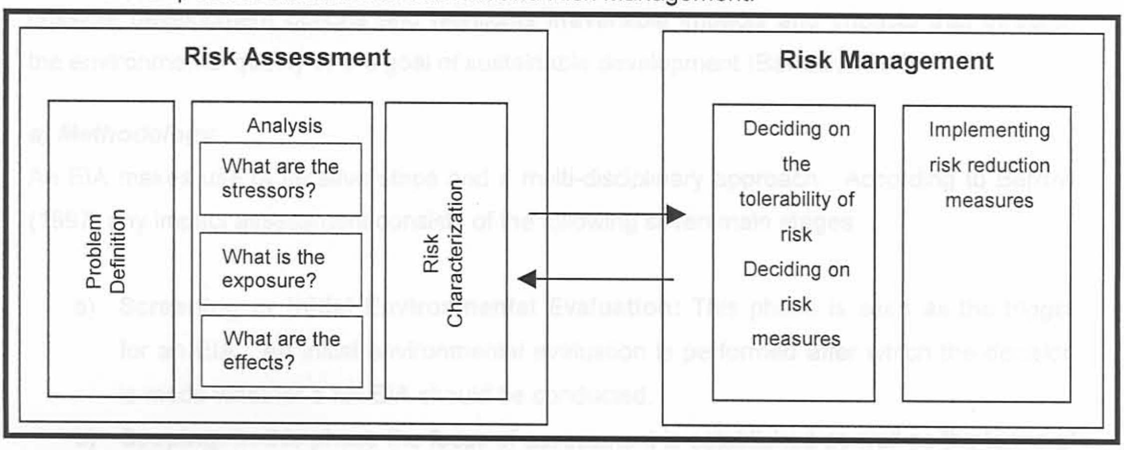

Figure 2.7: Relationship between Risk Assessment and Risk Management

Source: Health Council of the Netherlands
As cited in Eduljee, 2000.

Effective environmental risk assessment and risk management have economic benefits for a company as *"poor environmental risk management can undermine a firm's financial position and reduce stakeholders' confidence in the firm"* (Sharratt and Choong, 2002).

2.5.3. Environmental Impact Assessment (EIA)

Recorded history indicates that commissions were often charged with the task of examining the effects man's actions had or would have on the environment, society and human health. Similarities between these commissions and the modern environmental impact assessments (EIA) do exist. As an example, the Royal Commission's investigation into Weald Iron Mills and furnaces in Southern England in AD 1548 can be seen as an early version of an EIA (Fortlage (1990) as cited in Barrow, 1997). *"The EIA concept is rooted in the common sense wisdom that it is better to prevent a problem than to cure it"* (Kozlowski as cited in Barrow, 1997).

The concept of EIA was developed in reaction to the identification of the need to internalize environmental considerations in planning, programming and decision making processes in order to improve the quality of decisions with respect to environmental matters (Armour, 1991). The 1969 National Environmental Protection Act (NEPA) of the USA is recognized worldwide as the formal inception of the environmental impact assessment (EIA) procedure (Sowman, Fuggle & Preston, 1995) and EIAs are now required in one form or another in more than half the nations of the world (Ortolano & Shepherd, 1995). The procedural, methodological and institutional arrangements as well as the scoping and quality of EIAs do, however, differ from country to country and an EIA is even viewed as a philosophy with little practical value by some (Ofori, 1991, Ortolano & Shepherd, 1995).

Environmental Impact Assessment (EIA) is defined as an accurate, critical and objective assessment of the likely environmental impacts of a development by making use of a multidisciplinary approach. The EIA usually compares the environmental impacts of various possible development options and highlights irreversible impacts and impacts that threaten the environmental quality or the goal of sustainable development (Barrow, 1997).

a) Methodology

An EIA makes use of iterative steps and a multi-disciplinary approach. According to Barrow (1997) any impact assessment consists of the following seven main stages:

a) **Screening or Initial Environmental Evaluation:** This phase is seen as the trigger for an EIA. An initial environmental evaluation is performed after which the decision is made whether a full EIA should be conducted.

b) **Scoping:** In this phase the focus of assessment is established as well as the terms of relevance for the Impact Assessment. Some countries, for example Canada, even have scoping legislation. Scoping can be done from different perspectives for example: bio-geophysical, socio-economic, physical, ecological etc.

c) **Consideration of alternatives:** The different alternatives considered by the project and on which the EIA should focus are decided on.

d) **Identification and Quantification of Impact:** An impact is a result caused by human activity and is not a natural effect. In this phase possible direct, indirect and cumulative impacts are identified; the significance of each impact is assessed, the likelihood of occurrence is evaluated and a forecast is made of how or when these specific impacts might manifest themselves. This stage is viewed as the core stage of an Impact Assessment.

e) **Mitigation and Avoidance Recommendations:** Suggestions of mitigation or avoidance measures are made during this phase.

f) **Communication of EIAs to Interested and Affected Parties (IAPs)**

g) **Review of the Impact Assessment**

In South African the Government Gazette of 5 September 1997 (DEAT, April 1998) published a list of activities for which an EIA is required in terms of sections 21, 22 and 26 of the Environment Conservation Act, 1989. The application and EIA process procedure that is suggested by the South African Department of Environmental Affairs and Tourism (DEAT) is shown in Appendix B.

b) Economical Aspects in Environmental Impact Assessment

The fundamental goal of incorporating economics in environmental impact assessments is to ensure that the cost of environmental effects is internalized and that minimal externalities[3] arise. The only difference between a traditional EIA and an EIA that incorporates an economic approach is the method in which significance is assigned to individual impacts. In traditional EIA's significance is assigned in an ad hoc manner while an economic approach measure the social and other costs and benefits of the impact rigorously and then expresses the significance in terms of one unit: monetary value (James, 1994).

The importance of economic analysis as a planning and evaluation method in environmental impact assessments is increasing due to the fact that this inclusion provides the process with a framework for the collection, analysis and interpretation of information. Advances in valuation methods make it easier to place an economic value on an environmental impact (see section 7.2). This type of information can then be incorporated into benefit-cost appraisals. The most practicable approach when economic approaches are incorporated into an EIA is thus to conduct the whole EIA as a cost-benefit analysis (James, 1994).

The appropriateness of these economic valuation methods for environmental impacts are, nevertheless, widely criticized and disputed (See 2.4.2).

[3] Cost of a company's impacts on the environment and society for which the business is not financially responsible.

c) Social Impacts in EIA or Social Impact Assessment

Social Impact Assessment (SIA) can be viewed as a subdivision of EIA or alternatively as the opposite end of the same spectrum of activities. SIA is defined as an assessment that it concerned with the impact of development on people, individually and/or groups, ranging from households up to global society (Barrow, 1996). SIA are also concerned with the impact of people on the development and the environment. Changes in the social paradigm can have direct consequences for development and an SIA must therefore take it into consideration.

Technology Assessments (TA) and Risk Assessments are other techniques that can either support an EIA or be integrated with EIA. Figure 2.8 shows the interrelationship of EIA, TA, SIA and Risk Assessment.

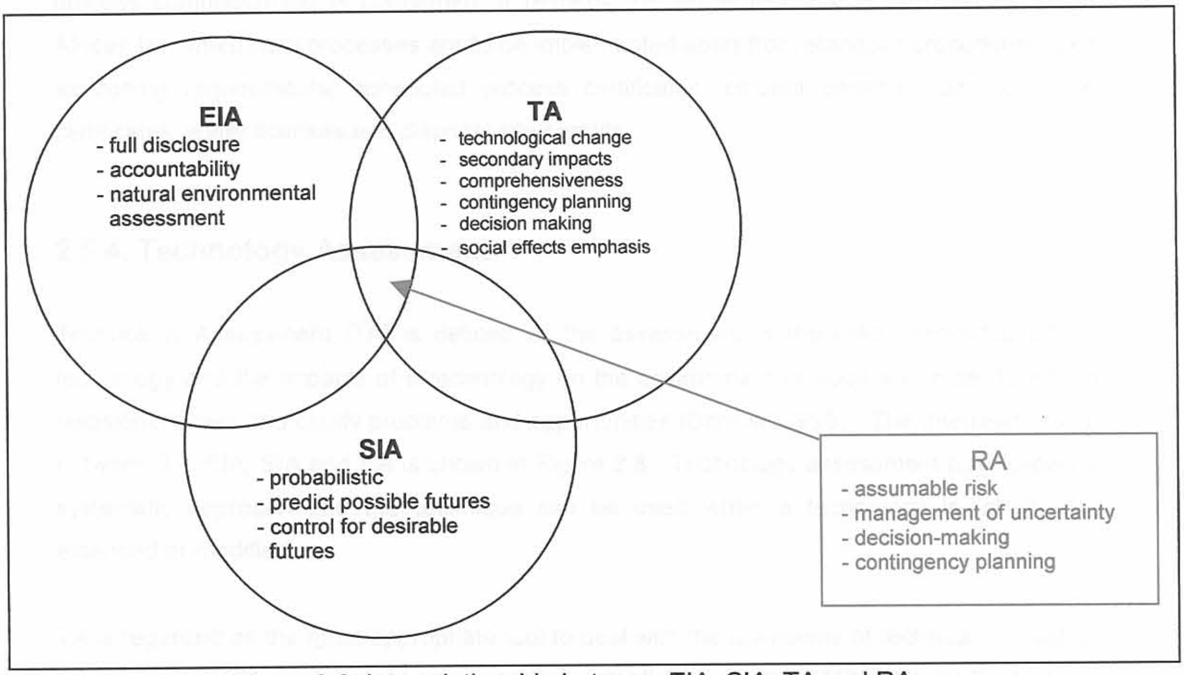

Figure 2.8: Interrelationship between EIA, SIA, TA and RA

Source: Barrow, 1997. Based on Covello et al (1985)

Social Impact assessment and risk assessment are, however, frequently omitted from EIAs as social impacts and other non-biophysical effects are not fully included in EIA legislation. EIA is accordingly in practice often narrowly focused on biophysical impacts (Ortolano & Shepherd, 1995).

d) Problems with the EIA process

One of the main problems with EIAs is that it is still not effectively utilized in the decision-making process neither integrated into the planning process, although various legislation are bringing EIA procedures into force. The reason for this can be the over-preoccupation with the process as too much focus on procedural requirements causes the contribution of impact assessment to be lost (Armour, 1991). Another major weakness of environmental impact assessments is the fact that it is still conducted on a reactive, project-by-project, short-term basis (Rees, 1988). Strategic Environmental Assessments attempt to address this weakness.

Barrow (1997) identifies the following problems with the EIA process:

- Cumulative Impacts are not assessed adequately and a Cumulative Impact Assessment (CIA) is necessarily for this purpose.
- Public Participation is often inadequate.
- EIA Monitoring is seldom conducted.
- Assessment of risk as well as social impacts is often omitted.
- EIA fails to ensure that developments are environmentally sound.

The contribution of EIAs to decision-making, albeit limited, cannot be overlooked where process commissioning is concerned. It remains the single tool that is required by South African law when new processes are to be implemented apart from standard procedures such as zoning requirements, scheduled process certificates, effluent permits, hazardous site certificates, water licenses and disposal site permits.

2.5.4. Technology Assessment

Technology Assessment (TA) is defined as the assessment of the risks associated with a technology and the impacts of a technology on the environment or society in order to inform decision-makers and clarify problems and opportunities (Barrow, 1996). The interrelationship between TA, EIA, SIA and RA is shown in Figure 2.8. Technology assessment also follows a systematic approach and the technique can be used when a technology is introduced, extended or modified.

TA is regarded as the most appropriate tool to deal with the unknowns of technical innovation as a hazard or risk assessment only examines established practices (1985 World Bank report as cited in Barrow, 1996). The history of TA dates back to approximately 1967 and as early as 1973 the United States Congress created the Office of Technology Assessment (OTA) with the objective of promoting the use of the tool.

A technology impact is a function of a variety of factors which include technology failure, operator failure, poor maintenance, poor design, faulty installation, natural or human accidents as well as adaptations prompted by innovation (Barrow, 1996). The focus of technology assessment is progressively shifting towards threats relating to morbidity or mortality and incorporates civil liberties and social impacts.

Coates and Porter (as cited in Barrow, 1996) promote the view that technology assessment supports sustainable development as the assessment can help to identify appropriate technology and practices for promising development paths while it also identifies potential and actual threats. On the other hand Porter and Rossini (1980) are of the opinion that EIA, SIA, TA an RA as well as other related approaches that support sustainable development should all be integrated into one tool (Barrow, 1996).

2.5.5 Life Cycle Engineering

The aim of life cycle engineering is to ensure holistic decision assistance by characterizing a product, process or technology by three dimensions: **ecology**, **economy** and **technology**. The whole life cycle of a product, process or system is considered in order to identify the phase that contains the relevant parts of a potentially negative effect in terms of environmental or economical impacts. Life Cycle Engineering consists of three supporting techniques, which are used to obtain interpretable results from available data:

- Life Cycle Assessment (LCA) that focus on ecologically relevant effects. The focus is thus on environmental objectives.
- Life Cycle Costing that focus on cost structures and economical implications of a product, process or system.
- Technology Evaluation that analyses processing and operating information.

The Life Cycle engineering methodology is shown in Figure 2.9.

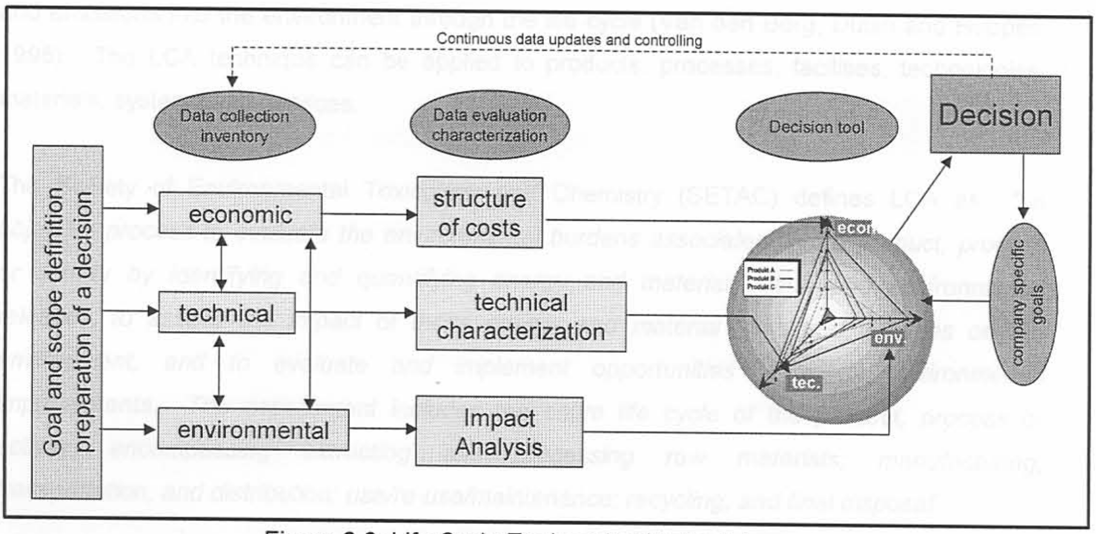

Figure 2.9: Life Cycle Engineering Methodology

Source: GaBi Software, 2002

The differences between LCC and LCA are summarized in Table 2.6.

Tool/Method	LCA	LCC
Purpose:	Compare relative environmental performance of alternative product systems for meeting the same end-use function, from a broad, societal perspective.	Determine cost-effectiveness of alternative investments and business decisions, from the perspective of an economic decision maker such as a manufacturing firm or a consumer.
Activities which are considered as part of the "Life Cycle"	All processes causally connected to the physical life cycle of the product, from pre-usage supply chain to processes supplying end-of-life steps.	Activities causing direct costs or benefits to the decision maker during the economic life of the investment, as a result of the investment.
Flows considered	Pollutants, resources and inter-process flows of materials and energy.	Cost and benefit monetary flows directly impacting decision maker.
Units for tracking flows	Primarily mass and energy; occasionally volume or other physical units.	Monetary units (e.g. $, R, euro)
Time treatment and scope	Timing of processes and their releases or consumption is traditionally ignored although the impact assessment can address a fixed time window. Future impacts are however generally not discounted.	Timing is critical. Present valuing of costs and benefits. A specific time horizon scope is adopted and any cost or benefits that occurs outside that scope is ignored.

Table 2.6: Differences between LCA and LCC

Source: Norris, 2001

a) Life Cycle Assessment (LCA)

Life Cycle Assessment deals with the environmental impacts of an activity over its entire life cycle (cradle-to-grave); these impacts are formed by all the extractions from the environment and emissions into the environment through the life cycle (Van den Berg, Dutilh and Huppes, 1995). The LCA technique can be applied to products, processes, facilities, technologies, materials, systems and services.

The Society of Environmental Toxicology and Chemistry (SETAC) defines LCA as *"an objective process to evaluate the environmental burdens associated with a product, process or activity by identifying and quantifying energy and material usage and environmental releases, to assess the impact of those energy and material uses and releases on the environment, and to evaluate and implement opportunities to effect environmental improvements. The assessment includes the entire life cycle of the product, process or activity, encompassing extracting and processing raw materials; manufacturing, transportation, and distribution; use/re-use/maintenance; recycling; and final disposal"*

The interaction between the main phases of LCA (as identified by SETAC) is shown in Figure 2.10.

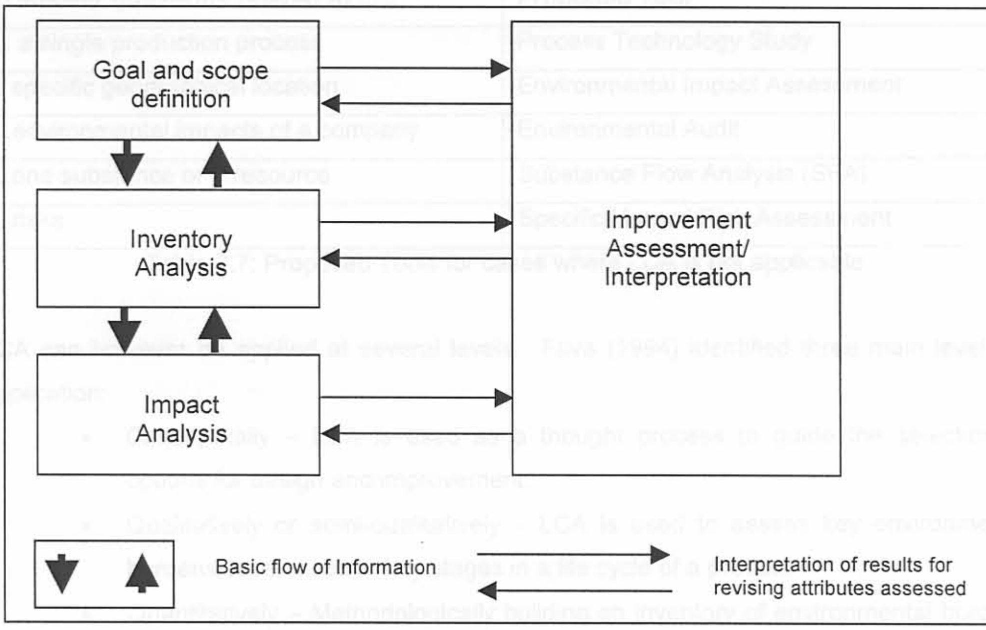

Figure 2.10: LCA Framework

Source: SETAC as cited in Graedel (1998)

The possible reasons for executing an LCA according to Van den Berg, Dutilh and Huppes (1995) are:

- To depict in as detailed way as possible the interaction of a product or activity with the environment.
- To ensure a thorough insight into the interdependent nature of the environmental impacts of a human activity.
- To supply decision-makers with information on the environmental impacts of activities and the possibilities for improvement.
- To compare the environmental impacts of different products with the same function or of one product with a reference or standard.
- To indicate strategically the direction of development and to assist in the design of new products and services.
- To identify the environmentally most dominant stage in a product or process life cycle and to then indicate the main routes to environmental improvements of existing products.

Table 2.7 summarizes situations in which LCA is not applicable and suggests better environmental management tools to use: (Van den Berg, Dutilh and Huppes, 1995).

To answer questions related to	***Proposed Tool***
.... a single production process	Process Technology Study
... specific geographical location	Environmental Impact Assessment
....environmental impacts of a company	Environmental Audit
....one substance or a resource	Substance Flow Analysis (SFA)
....risks	Specific Hazard Risk Assessment

Table 2.7: Proposed Tools for cases where LCA is not applicable

LCA can however be applied at several levels. Fava (1994) identified three main levels of application:

- Conceptually – LCA is used as a thought process to guide the selection of options for design and improvement.
- Qualitatively or semi-qualitatively – LCA is used to assess key environmental burdens or releases or key stages in a life cycle of a product.
- Quantitatively – Methodologically building an inventory of environmental burdens or releases, evaluating the impacts of those burdens or releases and considering alternatives to improve environmental performance.

According to Frankl, Rubik & Bartolomeo (2000) there is a wide range of other Life Cycle instruments that can also be used for the purpose of environmental management:

- Life Cycle Inventory (LCI) - this is a single phase in LCA and should be combined with improvement analysis in order to provide useful information to managers. In the past many "LCAs" carried out by companies were actually limited to LCI.
- Streamlined Life Cycle Assessment (SLCA) and Bottleneck LCA – both of these are simplified LCA's. Graedel (1998) discusses various approaches for SLCA's for example: Migros Concept, Dow Chemical Company Matrix, Monsanto Matrix and Jacob's Engineering Approach to name a few.
- Material Intensity Per Service unit (MIPS) and eco-point evaluations – these are methods that present a single aggregated number to describe the use and impacts of a product.

The major disadvantage of LCA is the fact that the methodology is time-consuming and may result in an expensive exercise. A wrongly defined system-boundary can cause the methodology to underestimate environmental effects (Hendrickson, Horvath, Joshi & Lave; 1998). Graedel (1998) regards the choice of a functional unit as another obstacle in the LCA process. An LCA without an LCC also limits the influence and relevance of the LCA for decision-making and results in an inability to capture the relationship between the environmental and cost consequences (Norris, 2001).

b) Life Cycle Costing

In 1976 White and Ostwald defined Life Cycle Costing as *"the sum of all funds expended in support of the item from its conception and fabrication through its operation to the end of its useful life"* (as cited in Woodward, 1997).

The Royal Institute of Chartered Surveyors identified the following four objectives for LCC in 1983:

- Enable more effective evaluation of investment options.
- Consideration of the impact of all costs and not only initial capital costs.
- Assist in the effective management of completed projects.
- Facilitate choice between competing alternatives.

In order to achieve the above mentioned objectives the following seven elements must be considered in LCC: initial capital costs, life of the asset, the discount rate, operating and maintenance cost, disposal cost, information and feedback and uncertainty and sensitivity analysis.

Life Cycle Costing methods is applied during product, process or system design and development by means of Life Cycle Cost Analysis (LCCA). A LCCA is defined as *"a systematic analytical process for evaluation various designs or alternative courses of actions with the objective of choosing the best way to employ scarce resources*" (Durairaj, Ong, Nee & Tan, 2002). Various LCCA methodologies exist and Table 2.8 compares nine different LCCA methodologies (Durairaj, Ong, Nee & Tan, 2002):

A. LCCA Model of Fabrycky and Blanchard
B. LCCA Model of Woodward
C. LCCA Model of Dahlen and Bolmsjo
D. Activity Based Costing (ABC) Model
E. Economic Input-Output (EIO) LCA Model
F. Design to Cost (DOC) Model
G. Product Life Cycle Cost Analysis (PLCCA) Model
H. Total Cost Assessment (TCA) Model
I. Life Cycle Environment Cost Analysis (LCECA) Model

The methodologies are discussed in more detail in Appendix C.

No	Features	Life Cycle Cost Analysis (LCCA) Methodologies								
		A	B	C	D	E	F	G	H	I
1	Objective	Cost Alternates	LCC of Assets	LCC of Labour	Cost Reduction	EIO Analysis	Cost Evaluation	LCC Estimates	TC Calculation	Eco-design
2	Identification of Alternatives	A	A	A	A	NA	A	NA	NA	A
3	Development of CBS & CBRs	E	E	E	E	G	G	G	A	E
4	Identification of Suitable Cost Model	E	G	G	E	A	A	A	A	E
5	Generation of Cost Estimates	E	E	E	E	NA	A	NA	A	G
6	Availability of Cost Profiles	G	A	A	A	NA	A	NA	NA	G
7	Break Even Analysis	A	A	A	A	NA	NA	NA	NA	A
8	Determination of High Cost Contributors	A	NA	NA	A	A	NA	NA	NA	A
9	Total Cost Determination	A	A	A	A	A	A	A	G	A
10	Incorporation of Eco-costs	NA	NA	NA	NA	NA	NA	NA	NA	G
11	Correlation with Design Changes	NA	NA	NA	A	NA	A	A	NA	A
12	Implementation of a Design solution	NA	NA	NA	A	NA	A	A	NA	A
13	Quality Aspects	NA	NA	NA	NA	NA	A	E	NA	NA
14	Inclusion of Supplier Relationships	NA	NA	NA	NA	E	NA	NA	A	A
15	Trade-offs	NA	E	NA	A	A	A	A	A	A
16	Employment Cycles	NA	NA	E	NA	A	NA	NA	A	NA
17	Sensitivity Analysis	A	A	A	A	NA	NA	NA	NA	A
18	Risk Analysis	A	A	A	A	NA	A	A	NA	A
19	De-manufacture Concept	NA	NA	NA	A	NA	A	A	NA	A
20	Any Special Feature	Holistic Model	Asset Model	Human Factor	Uncertainty	LCA Upgrading	Product system design	Redesign	For projects	Eco-design

A : Available; NA: Not Available; G: Good; E: Excellent

Table 2.8: Comparison of Existing LCCA Methodologies

Source: Durairaj, Ong, Nee & Tan (2002)

c) Technology Evaluation

Technology Evaluation as a technique focuses on the extent to which the technology can meet the design specifications. In order to determine whether technology can meet specifications technical data like process engineering and physical product properties must be determined and analysed (GaBi Software, 2002). The technique therefore relies on essential eco-design principles that must be applied within the constraints of the design. Technology evaluation can be seen as applying basic engineering principles; but the value there-off should not be underestimated as technology have a direct influence on cost, quality as well as competitiveness (Eversheim, Hachmöller & Rosier 2002).

d) Conclusion

The concepts behind LCE provide industry with new paradigms to build upon and the tool has a definite role to play in environmental management. The use of the three dimensions (economy, environment and technology) as points of consideration "*makes it possible to compare reasonably different technologies and to evaluate a project under the aspect of an overall optimum or an optimal compromise respectively*" (GaBi Software, 2002). Life Cycle Engineering enhances decision making by weaving cost, environmental and technological information into the decision-making process. Procedures to weigh the results of different aspects, i.e. environmental, economic and technical, and its implications on decision-making processes is part of on-going research (Petrie, Basson, Stewart, Notten & Alexander, 2001). One of the shortcomings of LCE, although much debated, is the lack of social considerations, especially in the LCA component (Sonnemann, Solgaard, Saur, Udo de Haes, Christiansen & Jensen, 2001).

2.6 Conclusion

The chapter aimed to clarify the unique focus of each one of the environmental management tools on environmental, economical and technological aspects (Figure 2.2). These tools are nonetheless not applicable in all phases of a system's life cycle and Figure 2.11 illustrates the application of the different tools through the life cycle of a system.

It is evident from Figure 2.11 and the discussion that the necessary environmental management tools to address environmental sustainability criteria do exist. Companies will have to decide which tools or part of the different tools the business needs to implement in order to achieve business sustainability. Concepts such as Life Cycle thinking and the sustainability paradigm must become part of business culture and cannot only be part of separate activities or processes. The same applies to tools such as environmental accounting that have to be implemented in the entire business. Business must apply the available environmental management tools and concepts to all core business practices and processes. A proactive approach is necessary to ensure future sustainability.

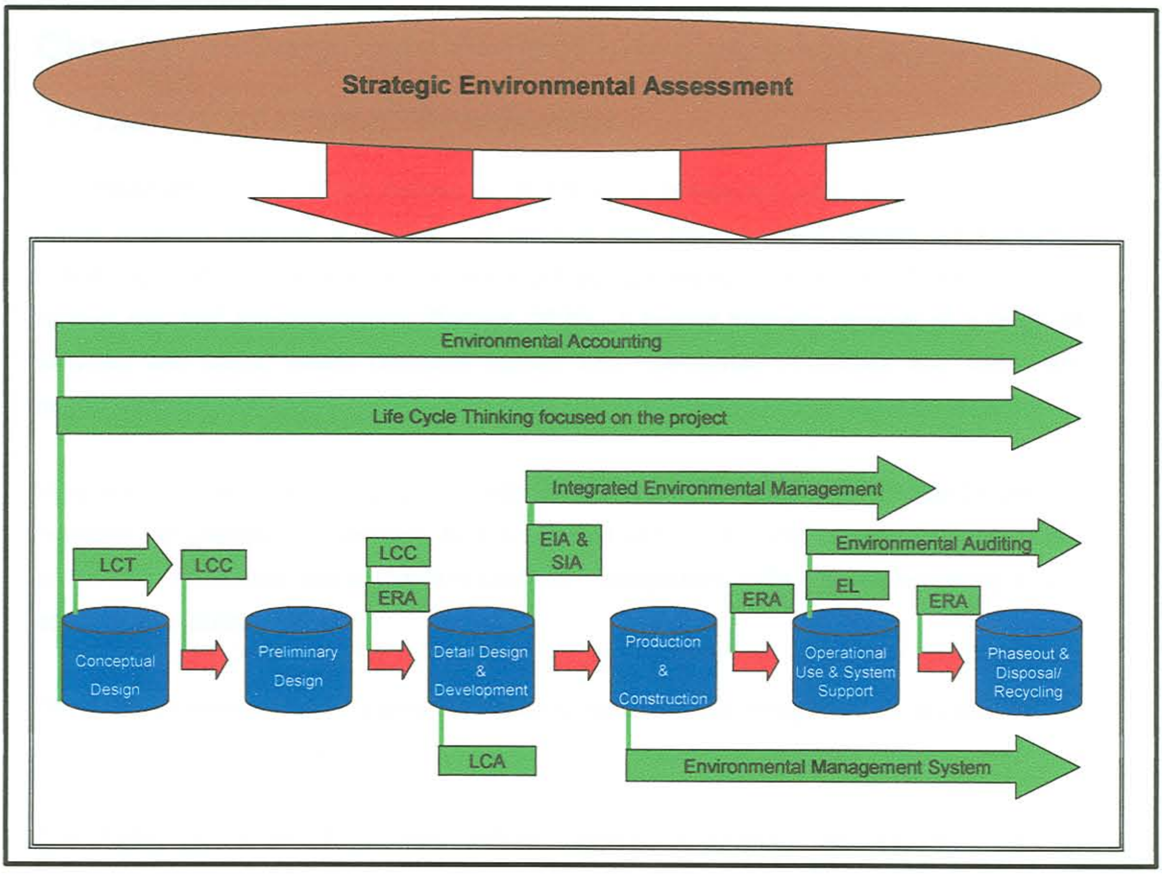

Figure 2.11: Environmental Management Tools applied over a generic System Life Cycle

In order to stay competitive companies need to be innovative and must be able to adapt speedily to any new challenges. Projects enable companies to accommodate new ideas for improvement and are often implemented as a means of achieving the company's strategic plan. In the South African process industry most new business practices or processes are driven by means of projects. A proactive approach can thus be achieved if corporate project management, as a core competency, incorporates business sustainability criteria.