Tool Selection in South African Integrated Environmental Management: Comparing Cost Benefit Analysis and Simple Multi-Attribute Ranking Technique in terms of Sustainability-Thinking Principles

by

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ABSTRACT

The goal of this study was to add to the body of knowledge on tool selection for environmental managers in South Africa. To this day, tools in Integrated Environmental Management (IEM) are not being applied appropriately and not informing development decisions in line with the principles set out under this environmental management system. The study was concerned with a particular decision context involving the ranking of a set of project alternatives which render environmental impacts. Cost Benefit Analysis (CBA) and Simple Multi-Attribute Ranking Technique (SMART) are seen to be two suitable tools for this decision context, however there has been much debate as to which tool may be more appropriate. In this study, the two tools were compared from a sustainability-thinking perspective which was thought to be appropriate given that the goal of South African IEM is sustainable development.

Sustainability-thinking is value-laden and therefore needed to be outlined according to South African IEM as the context in which the two tools would be applied. Sustainability-thinking principles were elicited from the body of IEM policy and legislation using content analysis. These principles could be structured into two groups, 'Philosophical Principles' and 'Procedural Principles'. The principles were then transformed into a framework of objectives, phrased as qualitative questions and were directed at the 'guidelines' of each tool in order to evaluate the theoretical and procedural underpinnings. This rendered the analysis purely theoretical. According to the framework of objectives, it was concluded that SMART was the better aligned tool with IEM sustainability-thinking. SMART proved to hold an advantage in its ability to balance technicality and accuracy with simplicity and transparency, as well as reaping the benefits of integrating qualitative information in the model.

OPSOMMING

Die doel met dié studie was om by te dra tot die kennisgebied van gebruiksmetodes vir omgewingsbestuurders in Suid-Afrika. Tot op datum, word gebruiksmetodes in Geïntegreerde Omgewingsbestuur (IEM) nie tersaaklik toegepas nie en steun ook nie ontwikkelingsbesluite in oorleg met die beginsels wat onder hierdie omgewingsbestuurstelsel uiteengesit word nie. Die studie het te make gehad met ’n spesifieke besluit-konteks waarby die rangorde van ’n stel projekalternatiewe, wat omgewingsimpakte oplewer, betrokke was. Kostevoordeel-analise (CBA) en Eenvoudige Multi-bate Rangordetegniek (SMART) word as twee geskikte gebruiksmetodes vir dié besluit-konteks beskou, maar daar was al heelwat meningsverskil oor watter gebruiksmetodes die toepaslikste sou wees. Hierdie twee gebruiksmetodes is in dié studie uit ’n volhoubaarheidsdenke-perspektief vergelyk, wat as toepaslik beskou is, gegewe dat die doel van Suid-Afrikaanse IEM volhoubare ontwikkeling is.

Volhoubaarheidsdenke is waardebelaai en moes derhalwe volgens die Suid-Afrikaanse IEM uiteengesit word aangesien dit die konteks is waarin die twee gebruiksmetodes toegepas sou word. Beginsels rakende volhoubaarheidsdenke is met gebruikmaking van inhoudsanalise uit IEM-beleid en wetgewing ontleen. Dié beginsels kon in twee groepe, ‘Filosofiese Beginsels’ en ‘Prosedure Beginsels,’ gekonstrueer word. Daarna is die beginsels omgesit in ’n raamwerk van doelwitte, bewoord as kwalitatiewe vrae, en aan die ‘riglyne’ van elke gebruiksmetode gerig ten einde die teoretiese en prosessuele onderstutte te evalueer. Dit het die analise pure teorie gemaak. Volgens die raamwerk van doelwitte is tot die slotsom geraak dat SMART die geskikter werksmetode was met IEM-volhoubaarheidsdenke. SMART het bewys ’n voordeel te hê weens sy vermoë om tegniek en akkuraatheid met eenvoud en deursigtigheid te balanseer, sowel as om die voordele te pluk van die integrering van kwalitatiewe inligting in die model.

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ACRONYMS

CBA	-	Cost Benefit Analysis
CONNEP	-	Consultive National Environmental Policy Process
CVM	-	Contingency Valuation Method
DEA	-	Department of Environmental Affairs
DEAT	-	Department of Environmental Affairs and Tourism
EIA	-	Environmental Impact Assessment
EIAMS	-	Environmental Impact Assessment and Management Strategy
EIAR	-	Environmental Impact Assessment Report
IAP2	-	Interested and Affected Parties2
IEM	-	Integrated Environmental Management
MAUT	-	Multi-Attribute Utility Theory
MAVT	-	Multi-Attribute Value Theory
NEMA	-	National Environmental Management Act
PPP	-	Public Participation Process
SEMA	-	Specific Environmental Management Act
SEA	-	Strategic Environmental Assessment
SMART	-	Simple Multi-Attribute Ranking Technique
TEV	-	Total Economic Value
TCM	-	Travel Cost Method
WTA	-	Willingness to Accept
WTP	-	Willingness to Pay

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Introduction

Background and Motivation

"Integrated Environmental Management (IEM) provides a suite of principles and tools to guide South Africa on a path to sustainable development" (Department of Environmental Affairs and Tourism (DEAT), 2004e). However, after almost 20 years since the adoption of IEM as South Africa's environmental management system, many development decisions are being implemented without being appropriately informed by IEM tools and principles. Whilst there is a myriad of issues that feed into this problem, this study is concerned with the inappropriate application of IEM tools and instruments which features as a prevalent theme in the Environmental Impact and Assessment Management Strategy report (DEA, 2014a). The goal of this study is to add to the body of knowledge on tool selection for environmental managers in South Africa.

The tools studied in this thesis are Cost Benefit Analysis (CBA) and the Simple Multi-Attribute Ranking Technique (SMART), a Multiple Criteria Decision Analysis (MCDA) method. These two tools are commonly implemented as decision-aid tools for project appraisal. Decision aid tools are emphasised as CBA and SMART outputs are brought together with other information sets to inform the most preferred project alternative from a set of alternatives. The tools assess the properties of the project alternatives against development objectives and provide a ranking of the projects as the output. CBA is also able to provide an indication of the feasibility of a project with no alternatives. These objectives are multidimensional in nature and require the tools to be holistic in the sense that they may accommodate multidimensional information relating to the development objectives.

Previously the Environmental Impact Assessment (EIA) has been applied in this decision context but has been criticised for its weak structuring of information. Poorly structured information complicates decision-making and has led to a search for more appropriate alternatives. Based on the IEM guidelines, CBA is a more widely suggested tool for this decision context, but it has been contested by many academics that SMART may be more appropriate. There have been many studies on comparing the advantages and disadvantages of the CBA and SMART in environmental management. However, the majority of these studies seem to be conducted within a first-world context, which in general holds different development objectives compared to those in the third-world. The nature of the development objectives influences the appropriateness of the tool. Similar studies in the South African context were conducted by Joubert (2002). She compared the paradigms associated with each tool in terms of four criteria in a general environmental decision-making context. The four criteria were; resonance with and validity within the prevailing political and decision-context, general validity and reliability, ability to include equity and sustainability criteria and practicality.

The study focuses on the value-laden concept of sustainability is represented in South African IEM. The tools are evaluated and compared in terms beyond their abilities to include sustainability criteria, and onto their abilities to adopt the principles and axioms of sustainability-thinking. Such emphasis on sustainability-thinking seems appropriate because of IEM's goal of achieving sustainable development. Although the tools may not have been originally developed to meet all the principles and axioms of sustainability-thinking, they are applied in a decision context characterised by multiple objectives and are therefore inherently applied as holistic tools.

The method of the study began by using content analysis to elicit the sustainability-thinking principles embedded in South African IEM policy and legislation. The principles were divided into two categories; 'Philosophical Principles' and 'Procedural Principles'. They were then transformed into objectives to create a framework for evaluation. The theoretical underpinnings and procedures of the tools, based on what could be considered as the 'guidelines' or 'user manuals', were then evaluated according to the framework of objectives. The evaluations of the tools were then compared, and a conclusion was drawn.

Overview of the chapters

The aim of chapter 1 is to orientate the reader in the decision context. The chapter begins by providing a basic map of the IEM body of policy and legislation relating to the decision context. A brief overview of IEM in South Africa is then discussed and looks at the changes in its characteristics through time. A fundamental characteristic of contemporary IEM is the emphasis on stakeholder engagement which is described here. The focus then shifts to the nature of project-level of IEM. This section will explain why CBA and SMART are applied as decision-aid tools, and not decision-making tools. Finally, the chapter will explain why the EIA is suggested to be insufficient for this decision context, and discuss the components of CBA and SMART which make these tools more appropriate alternatives.

Chapter 2 outlines the sustainability-thinking principles embedded in South African IEM. These principles are then transformed into objectives which will be used to evaluate and compare the two decision aid tools. The chapter begins by outlining the logic and method on how the principles were elicited and transformed into objectives, and how the objectives are to be used for evaluation and comparison. A description of the literature, policy and legislation from which the principles were elicited is also provided. The chapter proceeds to outline and discuss the eight sustainability-thinking principles which can be structured into two groups, 'Philosophical Principles' and 'Procedural Principles'. At the end of the discussion the respective evaluation objectives for each principle is provided.

Chapter 3 provides a literature review of the two decision-aid tools; CBA and SMART. It is important for the reader to understand the theory and procedure of the tools as this is what is being evaluated in terms of sustainability-thinking principles. The chapter first reviews CBA, and begins by describing the economic/social CBA which is an extension of the financial CBA to include societal effects and is the type relevant to this study. The procedure of the tool is then outlined and should be referred back to throughout the thesis. The chapter then proceeds to discuss the fundamental concepts and theories that underpins the CBA. The content on the CBA ends with objections to the tool. The objections highlight some of the flaws in the theoretical underpinnings of the CBA and provides the motivation behind the search for alternative tools such as SMART. The chapter then moves to the review of the SMART tool. This section starts broad and introduces the reader to the MCDA approach. In the introduction, it is explained that MCDA comprises a body of methods that are to be applied in accordance with a specific decision context. The general procedure for using MCDA methods is then outlined, followed by the theoretical and conceptual underpinnings of the approach. A focus is then given to SMART, by which the steps in the process are outlined and described to give the reader an understanding of how the previously discussed theory and concepts manifest within the tool.

The evaluation and comparison of the tools in terms of the framework of objectives is discussed in chapter 4. Each principle is discussed individually with a short reintroduction, followed by an evaluation of CBA and SMART separately, and concluded with a comparison of the tools in terms of that principle. A basic comparative table is provided for ease of illustration.

Chapter 5 begins by making some concluding remarks on themes that recurred throughout the evaluation and comparison in chapter 4. These recommendations, limitations and conclusions are streamlined to produce a conclusion as to which tool is better aligned with the sustainability-thinking principles outlined in this study. It is concluded that SMART maintained an advantage over CBA based on its ability to balance technicality and accuracy with simplicity and transparency, as well as being able to integrate qualitative information into the model. Limitations to the research is then discussed, and pertained mainly to the content analysis, and the purely theoretical nature of the study.

Chapter 1: Decision context

1.1 Introduction

The decision context in this study is defined by a very specific set of characteristics. This is relative to the vast number of contexts and actions which may be subject to IEM. The chapter begins by providing a summarised map of the various South African IEM policy and legislation relevant to the decision context. IEM and the concept of sustainable development in South Africa is then described by looking at the history of IEM, its contemporary principles and a guide to the general environmental authorisations process. A discussion on the dynamics of stakeholder engagement is also provided here. IEM decision-making can be divided into the strategic-level and the project-level. The next section describes the decision context in terms of the project-level, and what characterises the 'Plan and Design' phase of the IEM project process. Finally, the chapter will elaborate on why the EIA is believed to not be an adequate tool for this decision context, and why CBA and SMART are seen as more appropriate alternatives.

1.2 Outline of the South African IEM policy and legislative body

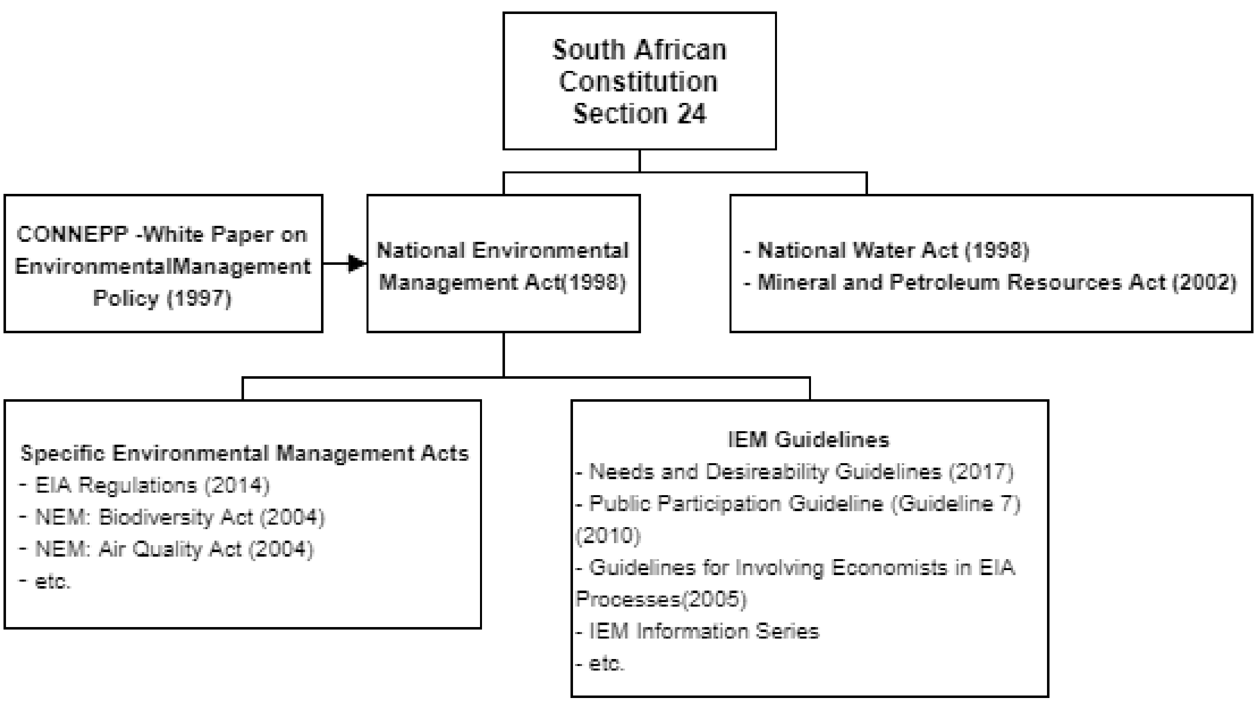

Figure 1.1: Map of the South African IEM Policy and Legislative Body (Own compilation)

Figure 1.1 shows a basic map of the South African IEM policy and legislation body. At the top is 'Section 24' which is the 'Environmental Right' in the 'Bill of Rights' chapter of the South African Constitution (Republic of South Africa, 1996). The level below holds the National Environmental Management Act (107 of 1998) (NEMA) (Department of Environmental Affairs (DEA), 2014c) which is the overarching statute governing environmental matters in South Africa. The drafting of this statute was informed by the White Paper on Environmental Management Policy (DEAT, 1998) which was formulated during the Consultive National Environmental Policy Process (CONNEP). The White Paper (1998) gives a good indication of the values that underpin NEMA's content. Alongside NEMA are two examples of statutes which hold environmental provisions and cross-references with NEMA to regulate various operations governed under the respective statutes. Below NEMA are Specific Environmental Management Acts (SEMAs) and IEM Guidelines. The various SEMAs are endorsed by NEMA and hold provisions for specific environmental-related themes such as biodiversity, air quality, protected areas, etc. The IEM Guidelines, drafted by the DEA, are used to help practitioners integrate the provisions of NEMA into the IEM process. Although the body of IEM policy and legislation is a lot more expansive, these classes are mostly referred to throughout this study.

1.3 South African Integrated Environmental Management

1.3.1 Overview of integrated environmental management and sustainable development in South Africa

Environmental management as a practice was first formally institutionalized in 1970 with the promulgation of the National Environmental Policy Act in the United States (Sowman *et al.*, 1995). This statute adopted a proactive, informed approach which sought to identify and evaluate the impacts that a proposed activity could potentially inflict on the receiving environment (DEAT, 2004e). Information describing the impacts was outlined in an EIA which was used as a tool for project approval.

This formal adoption of environmental concern into US national policy marked the shift from an expansionist economic view to the acknowledgement of the finiteness of natural resources and the constraints on economic growth (DEAT, 2004e). By the end of the 1970's, environmental management and assessment had spread globally among developed and developing countries, being adopted both formally and informally (Sowman *et al.*, 1995). By the mid-1980's, social issues and societal values had been integrated, mainly through a participative approach which consulted the affected public (DEAT, 2004e).

The first world concept of the EIA was seen to be mostly unsuccessful in developing countries due to contrasting development and environmental priorities, for example, emphasis on basic needs opposed to conservation (Audouin, 2009). This lead South African policy-makers to question the wholesale adoption of these first world characterised policies, noting that unless highly structured and regulated, environmental assessment may constrain development potential (Preston *et al.*, 1992). In 1984, the Council for the Environment established a committee to develop a process which integrated environmental concerns into development decisions (Preston *et al*., 1992). This process is known as 'Integrated Environmental Management' (IEM). It was only in 1989 that the Environmental Conservation Act (73 of 1989) made provisions for the determination of environmental policy to guide decision-making (Sowman *et al*., 1995). South Africa was therefore relatively late in the formal institutionalisation of these values.

Today, IEM provides a suite of principles (table 1.1) and tools to guide South Africa on a path to sustainable development (DEAT, 2004e). According to Hattingh (2001), the concept of sustainable development in this sense comprises of a variety of its own principles left for interpretation by the user. This inherently localizes the values that laden the concept to a South African context. Nevertheless, the substance of the concept is still derived from the general, international philosophy as "common elements include the need to integrate social, economic and [ecological] features as well as to address intra- and inter-generational equity" (DEAT, 2004e: 4).

Table 1.1: IEM principles (DEAT, 2004e: 9)

1) Accountability and responsibility	2) Adaptive
3) Alternative options	4) Community empowerment
5) Continual improvement	6) Dispute resolution
7) Environmental justice	8) Equity
9) Global consideration	10) Holistic decision-making
11) Informed decision-making	12) Institutional co-ordination
13) Integrated approach	14) Polluter pays
15) Precautionary approach	16) Rigour
17) Stakeholder engagement	18) Sustainability
19) Transparency	-

"A basic tenant of the IEM philosophy is environmental assessment of [a proposal] at all stages from conceptualization to decommissioning" (Spinks *et al.*, 2003: 307). The procedure for environmental authorisations is eloquently illustrated by the flow diagram in Figure 1.2, adapted from Preston *et al*. (1992). According to this diagram, IEM recognises three stages in the life-cycle of any proposal. Firstly, the development and assessment of the proposal, secondly, the decision, and lastly, the implementation stage. At the project-level, if the proposal is classified to incur a "significant impact" on the environment or is identified as one of the 'listed activities', the mandated tool used implemented to inform the authorisations process is the EIA.

However, if the competent authority who holds power over the decision to approve or reject a proposal, believes that the EIA does not provide sufficient information to guide an informed decision, he/she may request the assessment of the proposal according to additional tools, such as CBA or SMART. This request may be made pre- or post- EIA.

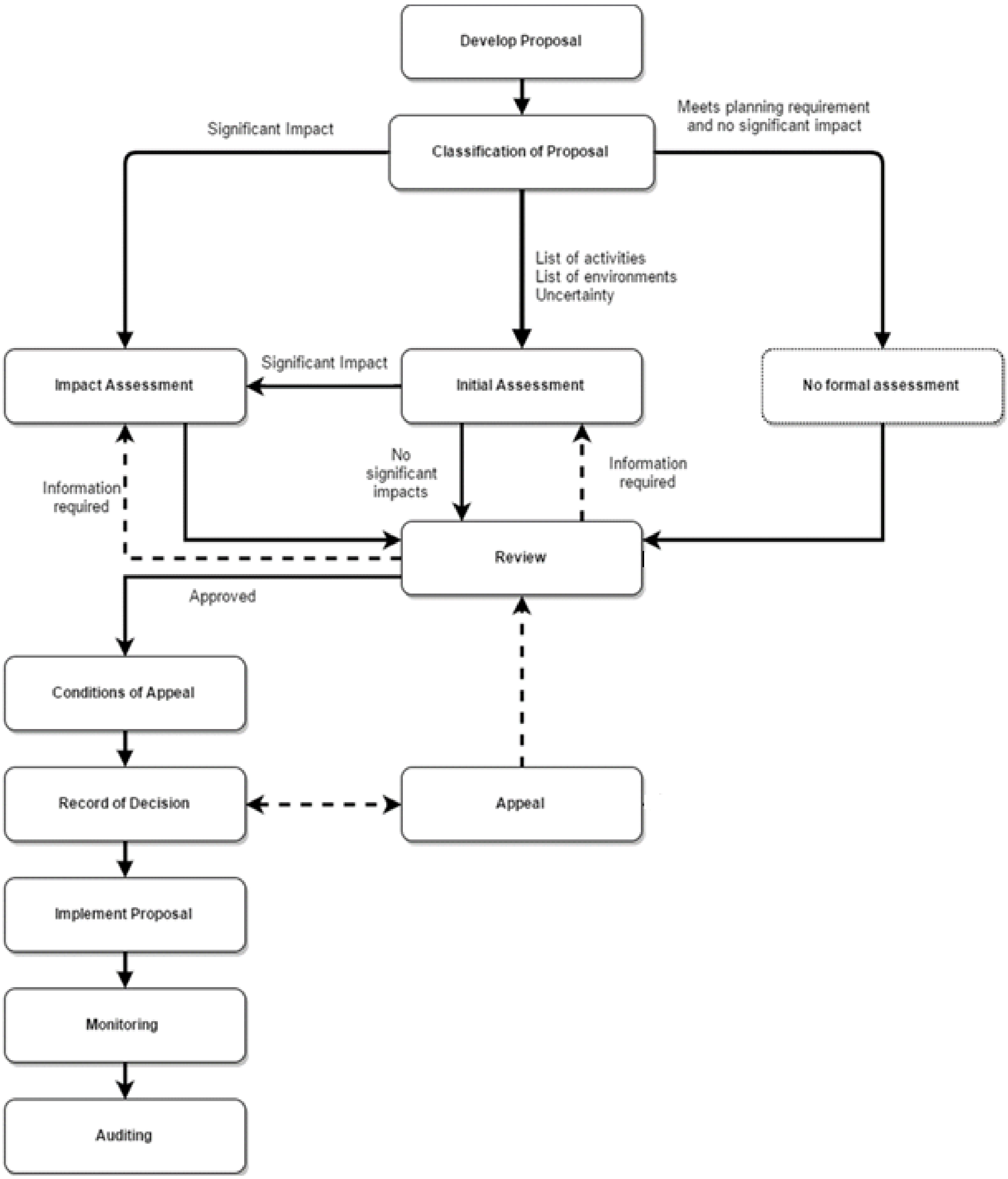

Figure 1.2: The Environmental Authorisations Procedure (Adapted from: Preston *et al.*, 1992:750)

1.3.2 Engagement with stakeholders

IEM decisions and activities are in the public context and have the potential to affect the public directly and indirectly on different scales. In order to give influential power to people who are affected by these decisions and activities, the 'Public Participation Process' (PPP) has been made a legal requirement of the environmental authorisations process. The PPP is seen as one of the most important processes of IEM and can be described as "a process leading to a joint effort by stakeholders, technical specialists, the authorities and the proponent who work together to produce better decisions than if they had acted independently" (Greyling cited in DEAT, 2002: 6). Figure 1.3 provides an illustration of the typical structure of the public within the IEM context.

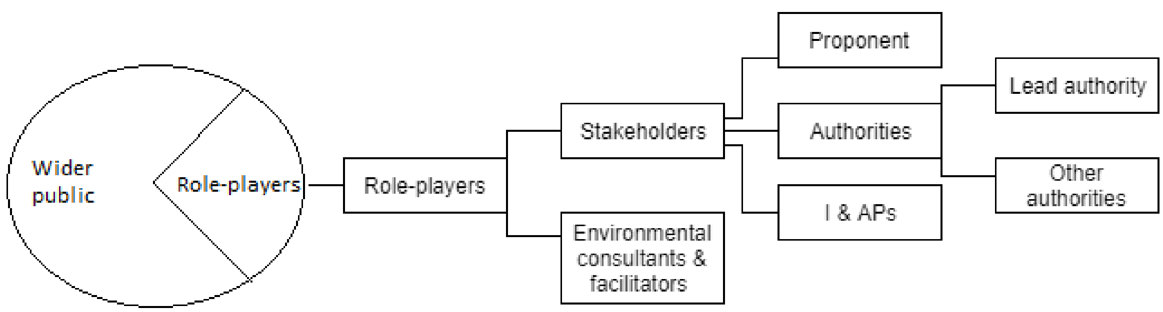

Figure 1.3: Role-players in the stakeholder engagement process (DEAT, 2002: 6)

This study brings together the concept of public participation, as represented in the academic literature, and how it is represented in the South African body of policy and legislation. A few semantic inconsistencies arise when bringing together these two bodies of literature. These inconsistencies are to be aligned here. Firstly, the parties that are included as stakeholders is consistent with Figure 1.3. Where South African policy and legislation speaks to the concerns of "interested and affected parties" it implicitly speaks to the concerns of all other stakeholders as well.This issue is relevant in chapter 4, under the principle 'Intragenerational Equity'.The second inconsistency refers to the conceptual difference between 'stakeholder engagement' and 'public participation'. Compared to public participation, stakeholder engagement is perceived as having connotations further along the 'Interested and Affected Parties 2 (IAP 2) spectrum" (DEAT, 2002). The IAP2 spectrum, shown in figure 1.4, describes a spectrum of increasing levels of public participation, where it is implied that that under reasonable conditions, the higher the level of involvement of stakeholders, the more likely the achievement of development success (Theron *et al.*, 2009). In this study, public participation and stakeholder engagement is referred to interchangeably and maintains the connotations associated with stakeholder engagement. The text will therefore also refer to the 'stakeholder engagement process' and the 'public participation process' interchangeably as well, even though it is formally known as the 'Public Participation Process' in South African IEM policy and legislation.

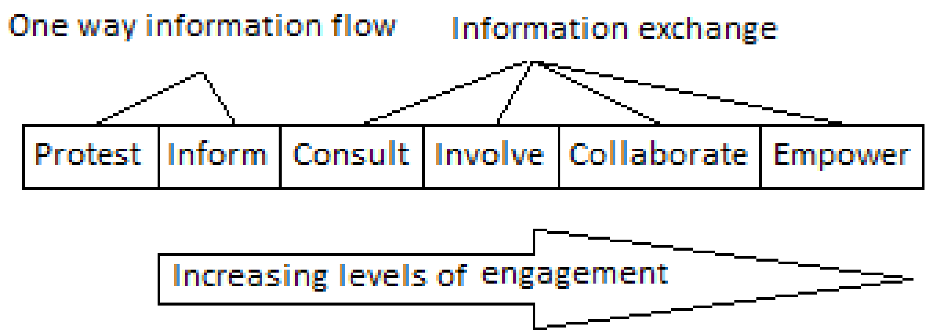

Figure 1.4: IAP2 spectrum (Taken from IAP2 in DEAT, 2002: 7).

1.4 Project-level decision context

1.4.1 Description of the project-level

"The choice of tools is informed by the needs expressed by stakeholders and decision-makers, the hierarchy of the activity being undertaken (e.g. project, plan, programme or policy) and the stage of the activity life cycle" (DEAT, 2004e: 10). The hierarchy can be broadly divided into two levels; the 'project level' and the 'strategic level'. The study addresses the 'need' for ranking project alternatives at the 'project level' which appropriates the tools of CBA and SMART.

Figure 1.5 illustrates the combination of the IEM process and project management cycle. The figure gives a good idea of how the project-level can be divided into phases and how different tools may be implemented according to the requirements of the phase. It is noted that although the Figure 1.5 may portray definite boundaries between the different phases, the appropriateness of a tool to a phase is not absolute and that some tools may be suitable to more than one phase (Oosthuizen *et al.*, 2011). The EIA is implemented in the 'Plan and Design' phase which is the phase of interest in this study. 'Primary Data Collection and Knowledge Creation' tools are appropriate to this phase and should "aim to gather status quo information about the presence or absence of various [economic], social [and/or] environmental resources or elements, with no data processing other than for the purposes of simplified representation" (Oosthuizen *et al.*, 2011).

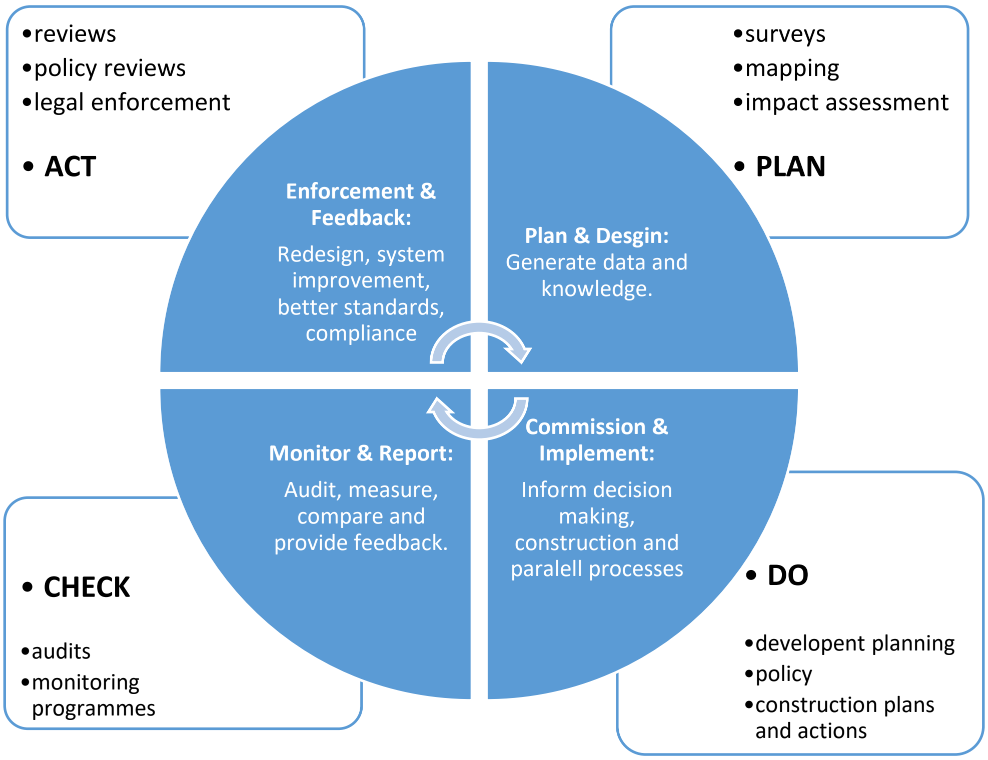

Figure 1.5: Integrated Environmental Management and Project Cycle (DEA, 2014a)

The information gathered by the tools implemented in the 'Plan & Design' phase will inform the decision that is made in the next 'Commission & Implement' phase. Because the CBA and SMART will be implemented strictly as decision aid tools, the information provided by these tools will be synthesized together with other sources of information in order to inform the final project-decision. The information flow between the tools of this study and the final project decision is illustrated in figure 1.6.

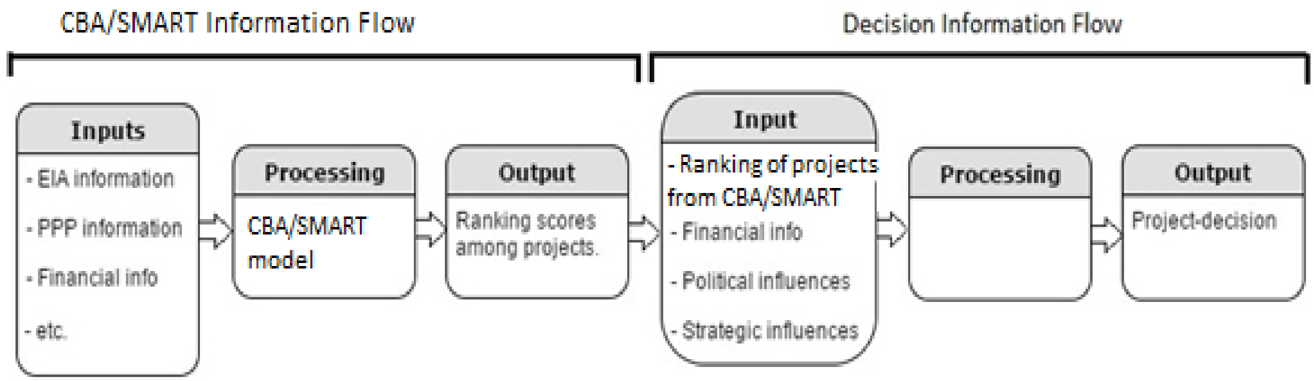

Figure 1.6: Flow of information in the decision context (Own compilation)

1.5 The ranking of project alternatives

1.5.1 Why the EIA is not sufficient

The EIA "aims to predict both positive and negative environmental impacts of a proposed project and find ways to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers" (DEAT, 2004g: 11). The impacts assessed in the EIA are often grouped and reported on as separate sections which are broadly categorised as ecological, social and economic (Audouin & De Wet, 2010). Although it is not specifically stated that impacts should be divided into these categories, a guideline to the layout of an EIA report is provided in Appendix 3 of NEMA, as amended[1]. The EIA report "should inform the criteria upon which review is conducted" (DEAT, 2004f: 10), but the fragmented structure of the report makes rational decision-making according to these criteria difficult (Joubert *et al.*, 1997).

The EIA as a single report may not be appropriate to rank a set of project alternatives, but the information on the impacts is still valuable. This information can be used as input data for CBA and SMART, but may require some manipulation to suit the requirements of the tool. The two tools then offer a means to structure this data to make decision-making easier. Although the EIA

[1] The amended version of NEMA refers to (DEA, 2014c).

may not be sufficient in providing a final outcome in this decision context, it can still be used to inform the process.

1.5.2 Why CBA and SMART are appropriate alternatives

The solution to improved decision-making in this decision context lies in the application of tools with the ability to handle the multiplicity of environmental assessment, as well as the ability to structure the information in a manner that provides for rational decision-making. In order to provide evidence that CBA and SMART meet these two meta-criteria, three components of the tools will be summarised in this section. The three components are; the process of the tool, the model of the tool and the report which records the operations and outcomes of tool's process.

The processes of the tools are adaptable to the decision context and will change on a case-to-case basis. Whilst the formal procedure of each tool is outlined in the respective literature reviews (see chapter 3), many sub-processes feed into the different stages of the procedures. These sub-processes can be separated into the three phases (inputs, processing, outputs) that make up the CBA/SMART Information Flow shown in figure 1.6. The sub-processes typically associated with each phase is as follows:

- Inputs: conducting of specialist studies, formulation of the EIA report, conducting of the Public Participation Process, making various augmentations to these sub-processes in order to suit the requirements of the tools, etc.
- Processing: using the models of the tools to calculate outputs in the form of project ranking, conducting sensitivity analysis, etc.
- Outputs: writing the report which records the outcomes of the process, group-learning, improved social cohesion, etc.

The models of the tools are where the structuring of the information takes place and will be discussed in much more detail throughout the rest of this study. The sub-processes and models are designed in such a way to include multiple information sets -which may be denominated in different forms- in an algorithm constructed to suit the preferences and decision rules of the decision-maker. The algorithm calculates a single, value-based output for each project alternative which can be used to rank the set of project alternatives. An important property of the mathematical algorithms used by each tool, is the ability to compensate different information sets which essentially mimics the trading-off of different impacts among the three systems (ecological, social and economic).

The trading-off among these systems gives rise to a philosophical debate between two camps; those who adopt 'Weak Sustainability Principles', and those who adopt 'Strong Sustainability Principles'. The two principles and associated perspectives are concerned with the allocation of scarce capital which can take on different forms, for example natural capital, human capital and physical capital. Sustainability from the weak perspective aims to maintain the real value of the overall capital stock where "any one form of asset or capital can be run down provided proceeds are reinvested in other forms of asset or capital" (OECD, 2006: 240). Environmental management is generally concerned with the substitution of natural capital for physical capital, and it is shown that CBA and SMART adopt Weak Sustainability Principles by allowing for these trade-offs. Furthermore, the Weak perspective advises that substitution is allowed as long as humanity doesn't breach a natural capital threshold by which the depletion of natural systems cannot be compensated by any amount of alternative capital (Sáez & Requena, 2007).

In contrast, a 'strong' sustainability perspective assumes that future well-being is derived from natural capital stock and calls for the full maintenance of its stock levels (Goodstein, 2005). The Strong perspective questions the substitutability among the different forms of capital and pays particular concern to the irreversibility of natural capital degradation (Sáez & Requena, 2007). If the natural capital stock is depleted beyond its critical threshold, it may not be able to rejuvenate and provide benefits to the future generations.

The final component of the tools is the report in which their outcomes will be recorded in. This will include the rankings of the project alternatives, as well as information on the input data, calculations of the models, outcomes of the sensitivity analysis, assumptions, etc. It would be valuable to include a guideline that advises the decision-maker on how to use this knowledge and how to integrate it with other knowledge to inform the final decision.

The summary of the three components of CBA and SMART show that the two tools can integrate the multiple information sets involved in environmental management, and structure these information sets in such a way to appropriately inform rational decision-making.

Chapter 2: Principles of South African Integrated Environmental Management as a framework for evaluating and comparing the tools in terms of sustainability-thinking

2.1 Introduction

Integrated Environmental Management is a philosophy which provides a suite of principles and tools intended to guide South Africa along a desired environmental trajectory toward the goal of sustainable development (DEAT, 2004e). This section is specifically interested in the values and principles that form the basis of sustainability-thinking in the IEM philosophy. Oosthuizen and Komen (2011) suggest that information should be linked to the broader goals and priorities of sustainable development in South Africa, and explain clearly how the proposed activity would add to or detract from such goals. IEM principles will be refracted through the relevant tools and instruments involved in the practice and used to inform the decisions intended for sustainable development. This justifies the method of examining the internalisation of these principles in the tools (CBA and SMART), in order to evaluate and compare which tool is more suitable in terms of sustainability-thinking.

The following sections outline the fundamental principles of South African IEM that relate specifically to sustainability-thinking, and have been drawn from a variety of environmentally and sustainability-related policies, legislature and literature. The intention is to transform these principles into a set of objectives which can be used to evaluate and then compare the two tools according to their potential to manage information and knowledge in a manner which is aligned with IEM sustainability-thinking. It is assumed that the better the tools are aligned with sustainability-thinking, the better the tools are suited to achieve sustainable development.

The chapter begins by explaining the methodology according to which objectives were created and are intended to be used to evaluate and compare the two tools. An outline of the literature used to elicit the principles is then listed. The main body of the chapter describes the sustainability-thinking principles which are divided into two categories; Philosophical and Procedural.

Philosophical Principles include; Integration of Systems, Uncertainty and Long Run Impacts, Intragenerational Equity and Intergenerational Equity. Procedural Principles include; Robustness, Phase in the Project Process, Stakeholder Engagement and Transferability of Information. At the end of the discussion of each principle the set of respective objectives for comparison and evaluation are provided.

2.2 Method for the evaluation and comparison of the tools

An ‘environmental ethic’ has been enshrined in South African IEM policy and legislation. This ethic provides a framework according to which development decisions are made in order to guide South Africa along the desired environmental trajectory which is underpinned by the goal of sustainable development.

Within this environmental ethic there will be a body of principles and values related to sustainability. Because the concept of sustainability is value-laden, South African IEM will be made up of a specific variety of principles and values which may differ to other frameworks held by companies, regimes and other countries. To evaluate the tools CBA and SMART in terms of sustainability-thinking in the South African IEM context, the principles and values according to the South African IEM framework has to be used. The environmental ethical framework for South African IEM can be constructed using content analysis of relevant IEM policy and legislation.

The framework was required to be operationalised to allow for the evaluation and comparison of the tools. This was done by transforming principles and values into objectives. The theoretical underpinnings and procedures of the tools were then analysed in terms of their ability to fulfil these objectives. Although the tools may not have been originally designed to fulfil all the objectives completely, the tools are applied in a holistic manner and are therefore able to be evaluated in terms of these objectives.

2.3 Application of the objectives to the tools

The objectives were phrased as questions and were answered qualitatively. It was determined that a qualitative analysis would provide a more substantial conclusion rather than a quantitative scoring-type basis. Given the flexible nature of the tools, the qualitative answers discussed each tool's *potential* to meet the objectives to allow for a fair comparison. The full potential of the tools was deduced from guideline-type documents according to which these tools may be implemented. It was noted that various adaptions to extend each tools potential is able to be made. Specialists were consulted on the feasibility of some adaptions, but it is generally acknowledged that both tools are relatively flexible in their implementation and depend highly on the context in which they are to be implemented.

Consulting the guidelines was a strategy chosen over the analysis of a defined case study. It is assumed that every application of a tool in reality is not always implemented according to its full potential which may be due to a variety of constraints such as; context, time and cost. A defined case study would therefore not be able to encompass the full potential of each tool thus inhibiting a fair analysis.

CBA is a more widely applied tool in South African IEM and therefore has a more established body of guidelines specific to the context. The documents used as guidelines in this study included:

- Mullins, D., Botha, J. P., Mosaka, D. D., Jurgens, F. X. & Majoro, T. J. 2014. *A Manual for Cost Benefit Analysis in South Africa with Reference to Water Resource Development (3ed)*. [RSA]: Water Research Commission.
- Belli, P., Anderson, J., Barnum, H., Dixon, J. & Tan, J. 1998. *Handbook on economic analysis of investment operations*. Washington, DC: World Bank.
- DEAT. 2004a. *Cost Benefit Analysis, Integrated Environmental Management, Information Series 8*. [Pretoria]: Department of Environmental Affairs and Tourism.

For SMART, there are no formal guidelines specific to its application in South Africa. The Editor-in-Chief for the 'Journal of Multi-Criteria Decision Analysis', who has much experience applying MCDA to natural resource management in South Africa, was consulted to recommend a body of literature that may be used as 'guideline documents'. The following was recommended:

- Belton, V. & Stewart, T. J. 2003. *Multiple Criteria Decision Analysis: An Integrated Approach*. United Kingdom: Kluwer Academic Publishers.
- Goodwin, P. & Wright, G. 2004. *Decision Analysis for Management Judgement (3ed)*. West Sussex: John Wiley & Sons Ltd.

2.4 Literature from which the principles were elicited

The content of the literature can be grouped into three categories; academic, South African legislation and guidelines, and international policy and guidelines. The literature informed the analysis for three sub-sections; "Position in Sustainability Thinking", "Manifestation in South African IEM", and "Description of Principle".

The academic literature was used throughout all three sub-sections. Academic articles, books and reports derived from the South African and international context were referred to where appropriate. The majority of the content is made up of literature related to Sustainability Science and Sustainability-Thinking, as well as articles discussing frameworks for selecting sustainability assessment approaches and tools. Much of the selection criteria from these frameworks was applicable on a theoretical level when scrutinizing the tools from a sustainability-thinking perspective in a general decision aid.

South African legislation and guidelines were used for discussion in the sub-headings of 'Position of Sustainability Thinking' and 'Description of Tool'. To provide evidence for the presence of a specific principle, formal legislation clauses were used, and to describe the nature of the principle more informal guidelines and strategic documents were used. For formal regulation and legislation, references were made in accordance with the hierarchy in which it is enforced; the apex being section 24 in the Constitution (Republic of South Africa, 1996), descending down through the White Paper on Environmental Management Policy for South Africa (DEAT, 1998) developed in CONNEP to NEMA (as amended). The White Paper was of much value as it outlines the philosophy, theories and concepts which went into the drafting of the original version of NEMA (DEAT, 1998). Although not fully and formally applied in contemporary practice, principles and suggestions were taken from the document, Applied Integrative Sustainability Thinking (2010), as well the Environmental Impacts Assessment and Management Strategy (2014). These documents provide very valuable insight into improving the IEM process.

It must be noted that there are many documents that appeal to sustainable development in South Africa but were not deemed as especially relevant for the purpose of this study. Examples of these documents include; the National Framework for Sustainable Development, the National Development Plan and the Medium Term Strategic Framework.

Caring for the Earth (1991) and Our Common Future (1987) made up the majority of International Policy referenced in the study. It was relevant to the sub-headings 'Position in Sustainability Thinking' and 'Description of Principle'. This body of literature was used to discern the fundamental underpinnings of the concept of sustainable development, as they provide a framework upon which much of sovereign policy is developed. Other international policy documents related to an 'African-context', such as "Agenda 2063", etc., were consulted but not made use of.

2.5 Principles for evaluation and comparison

This section outlines the sustainability-thinking principles, as well as the objectives for evaluation after these principles have undergone transformation. There are two parts to this section that can be used to evaluate the tools. The first part describes the philosophical principles that will be used to evaluate the suitability of the tool in terms of the philosophy of sustainability-thinking. The section includes:

- Outlining the principle
- Describing how the principle relates to sustainability-thinking
- Describing how the principle manifests in the relevant South African legislation and literature
- Transforming the principle into evaluative criteria

The second part relates to procedural principles, elicited from South African IEM policy and legislation, as well as other relevant forms of literature. The goal here is to create objectives for evaluating the procedural suitability of the tool according to its ability to implement the prior principles. It includes:

- Outlining the principle
- Describing how the principle is represented in the relevant legislation and literature
- Transforming the principle into evaluative criteria

Figure 2.1 shows a diagram of the principles for evaluation and comparison.

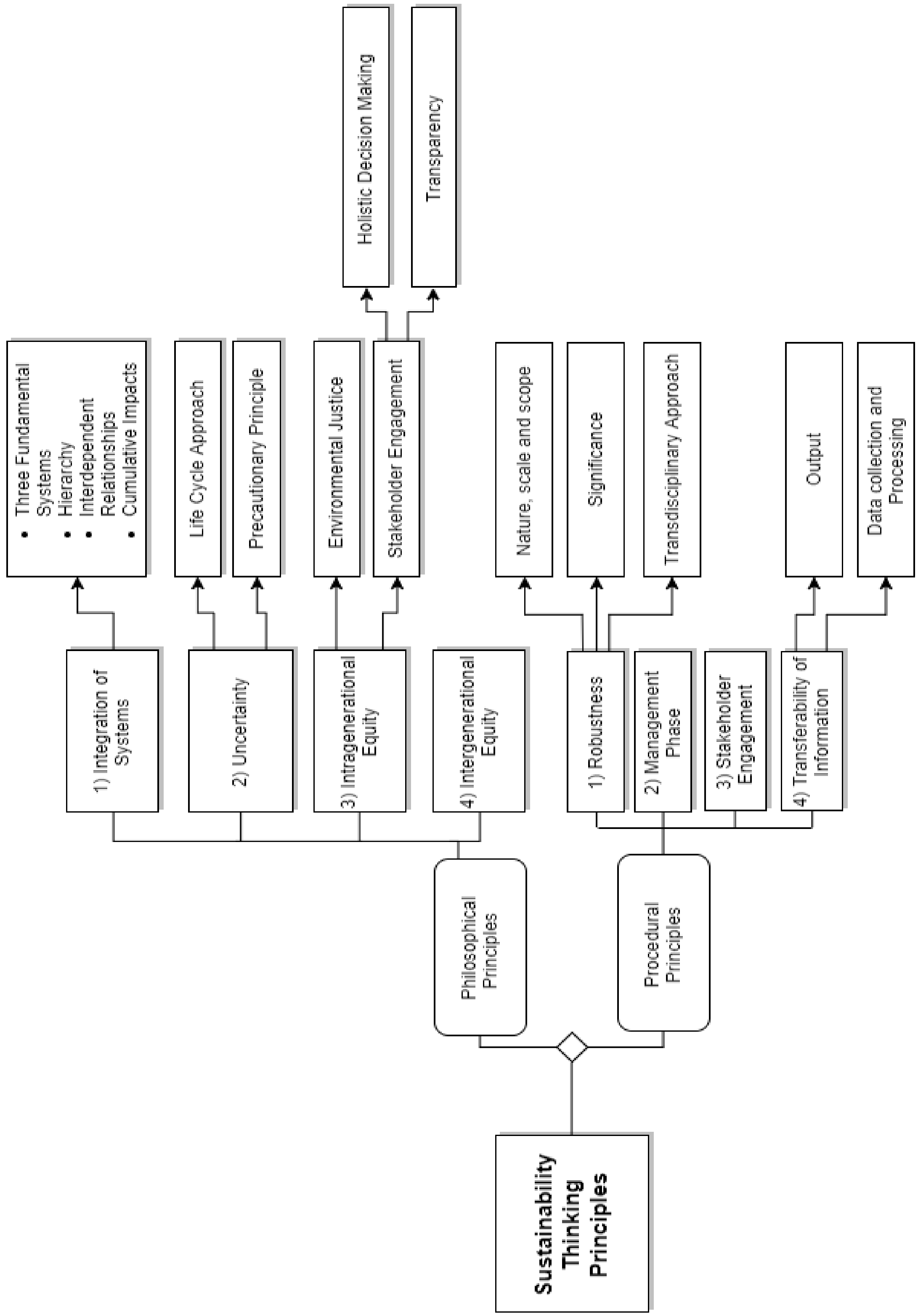

Figure 2.1: Diagram of the sustainability-thinking principles for evaluation and comparison (Own compilation from the body of South African IEM policy and legislation)

2.5.1 Philosophical Principles

2.5.1.1 Integration of Systems

Position in sustainability-thinking

Sustainability-thinking adopts a system dynamics approach as developed in accordance with Complexity Theory. Sustainability-thinking therefore conceptualises sustainable development as attending to three systems; ecological, social and economic, which will be referred to as the 'three fundamental systems' throughout the rest of this study. These systems are perceived to affect each other in an interdependent manner through a variety of feedback loops (Mebratu, 1998). To illustrate the dynamics of their interdependent relationship, Mebratu (1998) uses a holistic-reductionist-holistic approach[2] which renders the Cosmic Interdependence Model shown in figure 2.2.

The Cosmic Interdependence Model portrays a pronounced hierarchical structure where it perceives the ecological system, made up of biotic and abiotic factors, to form the basis on which social human-beings survive. These social human-beings are able to interact on this ecological foundation, and through these interactions economic contracts are formed. Economic contracts then have the ability to affect the dynamics of the ecological system, thus closing the system as a whole.

[2] A model building approach which aims to capture the interdependent relationships among systems by describing each component (as a system in itself) as part of a greater system.

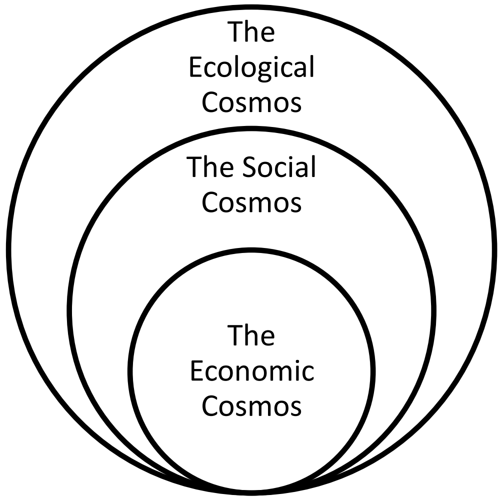

Figure 2.2: The Cosmic Interdependence Model (Mebratu, 1998: 513)

“Emergent properties … arise as a result of the relationships between the [fundamental systems] and therefore the functioning of the system as a whole” (Cilliers cited in Audouin & de Wet, 2012). Emergent properties can be explained as phenomena’s that arise from the relationships between the parts within a system when functioning in a system as a whole, and cannot be attributed to one particular part in isolation (Cilliers cited in Audouin & de Wet, 2012). The emergent properties are a fundamental element in the functioning of the entire system and ought to be considered in decision-making in order to ensure a holistic approach. An example of an emergent property may be the enhanced ‘sense-of-place’ held by a community who has been empowered to protect their culturally-rich and natural surroundings. On the other hand, increases in the occurrence of smog within a valley following the addition of more factories may qualify as another emergent property.

The relationships among the fundamental systems and their emergent properties are able to be studied at different spatial and temporal scales. The changing of the scale at which these two elements are studied requires the defining of system boundaries. Although a boundary is defined, it is still acknowledged that the system under scrutiny is open and effects systems beyond its boundary. The system within a defined boundary will maintain its own context in comparison to the adjacent systems defined by a different spatial and temporal scales. This is practiced in environmental management and assessment to make the study of the decision context easier.

Within the defined system boundary, environmental management and assessments study the effects of proposed human activity on the system. The effects of human activity cumulate within the system and have the ability to effect and even change the state of that system (Folke *et al.*, 2010). The transformation of that system caused by human activity may have cascading effects into adjacent systems, in turn transforming the systems at larger scales (Folke *et* al., 2010). This calls for the assessment of impacts according to a dynamic perspective which scrutinize these cumulative impacts and what effects they may have in a wider systems context. Essentially the goal of IEM is maintaining a system that is most preferable for the humans who reside in it, hence 'sustainable development'. This involves the promotion of activities that enhance the resilience of the system, and the mitigation of the activities that degrade the system.

Decisions aiming to achieve sustainable development through IEM need to take into consideration the entire context which the decision is going to affect. This is to ensure that decisions intending to improve the state of one system do not cascade into negative effects on other systems and more importantly the larger system. A study by Faasen and Watts (2007) on the creation of a Marine Protected Area (MPA) with a 'no-take' policy in the Tsitsikamma National Park, 2001 can be used a case example. The creation of the MPA was intended to protect the biodiversity of the coastal region, but resulted in the constraining of the local fishing communities to reach their subsistence and cultural requirements, subsequently engaging in illegal fishing. Biodiversity continued to be degraded and a hostile relationship emerged between the community and SANPark authorities, tarnishing the sustainability prospects of the MPA and its 'no-take policy'.

It is required by the decision-maker to pay consideration to the content of the fundamental systems, their interdependent relationships and emergent properties, and the hierarchy according to which they exist. IEM decision-aid tools should be able to record information on these aspects and internalize the information when it is processed. The tools also need to be able to account and internalize the scale at which the study is being conducted and the effects of its output in a wider dynamics-system perspective.

Manifestation in South African IEM and related literature

This section will outline how the principle of ‘Integration Among Systems’ manifests in South African environmental policy and legislation. This localizes the principle to a South African context and will govern the development of criteria which will be used to evaluate and compare the tools intended to aid decisions in a South African context.

The three fundamental systems

The principle of integrating the fundamental systems is immediately presented in the definition of sustainable development which “means the integration of social, economic and environmental factors into planning, implementation and decision-making so as to ensure that development serves present and future generations” (DEA, 2014c: 15). If South African IEM is intended to achieve sustainable development, it needs to provide for the integration of these three systems.

There is however one slight difference between sustainability-thinking presented in academic literature and sustainability-thinking engrained in NEMA (as amended). The difference is the conceptual distinction between an ‘ecological system’, as referred to by the former, and an ‘environmental system’, referred to by the latter. Conceptually, ‘ecology’ is a branch of biology and is specifically concerned with the interaction between biotic and abiotic factors (Mebratu, 1998; DEA, 2014c), whereas the ‘environment’, as it is defined in NEMA (as amended) is the abiotic and biotic elements and their interactions which make up the surroundings in which humans exits, as well as human relationships with these elements and their interactions that influence human health and well-being (DEA, 2014c). Essentially, the concept of the environment involves an interdependent relationship between ecological systems and social systems. This difference is semantic in nature. Essentially the South African concept of sustainable development is still made up of the three systems; ecological, social and economic. However, the concept of the ‘environment’, as referred to in the NEMA (as amended) definition, in the place of ‘ecological’ is making explicit the acknowledgement of the interdependence among the ecological and social systems.

Hierarchy

The definition of sustainable development above only refers to the integration of the three systems, but does not imply any sense of hierarchy in terms of the structure of their integration. In response to this, other areas in the body South Africa's environmental policy and legislation needed to be analysed in order to outline the hierarchy.

According to the analysis, the ecological system is clearly placed at the foundation of the hierarchy when the most fundamental piece of environmental legislation, Section 24 of the Constitution (Republic of South Africa, 1996:11), makes specific reference to preventing "ecological degradation" and securing "ecological sustainable development" as characteristics of measures that ensure the environment is protected. Ecologically sustainable development is defined in DEA (2014a:5) as "the selection and implementation of a development option which allows for appropriate and justifiable social and economic goals to be achieved without compromising the natural system on which it is based". Hence, ecological systems form the base upon which social and economic developments are promoted.

The next step was to distinguish the positions of social and economic systems in the hierarchy. It seems justifiable to say that the social system follows the ecological system where the 'environment', as conceptualised in the body of policy and legislation, involves the integration of ecological and social factors without reference to any economic factors. Beyond this, the level of content analysis involved in this study implies an equal level of importance given to social and economic systems. The author believes that the full hierarchy according to the Cosmic Interdependence Model should be internalised by the tools implemented under South African IEM.

Interdependent relationships

Environmental policy and legislation in South Africa evidently considers the fundamental systems of sustainability-thinking according to a very similar conceptual hierarchy as described in the academic literature. Referring back to the definition of sustainable development as stated in NEMA (as amended), it is also clear that an interdependent relationship between the fundamental systems is conceptualised when the definition calls for their "integration". This section will explore the nature of this 'integration' as embedded in South African IEM and will also give a good idea of the extent of the relationships and trade-offs within the hierarchy.

Ecological systems form the base for social and economic development. Any economic or social development will more than often render some form of negative impact on the ecological system and therefore require a trade-off[3] among the systems. A trade-off is provided for in NEMA (as amended) where it states in section 2(4)(a)(viii) that where social and/or economic development involves a negative impact on people's environmental rights and on ecological systems, the impact should be anticipated and prevented, and if unable to be prevented should be minimized and mitigated, as consideration for sustainable development.

It could be argued that the trade-offs are governed according to two considerations. The first consideration is the first environmental right in Section 24 of the Constitution (Republic of South Africa, 1996), where the environment should be protected, so as to not be harmful to the health or well-being of any member of the public. The second consideration involves the extent to which ecological integrity can be traded-off for appropriate and justifiable social and/or economic goals and is expected to remain within the limits of non-negotiable ecological thresholds so as to not compromise the ecological systems upon which developments are based (DEA, 2014a). Instances where projects breach these ecological thresholds are known as "fatal flaws".

There are a variety of means and considerations when intending to protect the ecological systems and their respective thresholds as suggested in the policy and legislation. One of the key documents that guides this intention is the Needs and Desirability Guidelines (2017) which requires EAPs to describe and quantify how developments will impact on the ecological system, and what measures were used to quantify and apply the Mitigation Hierarchy[4]. This information is to be reported on in the Environmental Impact Assessment Report (EIAR). The decision-aid tools of this study need to internalise this information in order aid decisions that abide by the constraints placed upon these

[3] This tradeoff among systems implies the adoption of Weak Sustainability Principles (see section 1.5.2).
[4] For more on the Mitigation Hierarchy refer to DEA's Needs and Desirability Guidelines (2017: 11). The hierarchy follows an impact management strategy of: Avoid > mitigate > remediate > compensate > optimize the positive.

tradeoffs. Project appraisal based on the relationship between impacts and critical ecological thresholds will be managed under the general EIA process. Where a proposal contains fatal flaws, the proposal will be rejected.

Another means to ensure developments do not exceed the limits of ecological degradation which may be of relevance in this study is inter-ecological system trade-offs. This is provided for in the policy and legislation body when NEMA (as amended) pays specific attention to threatened, sensitive, vulnerable, highly dynamic or stressed ecosystems when they are subject to human resource use and development pressure (s2(4)(r)). This implies the ability to discriminate among ecological systems in order to abide by the respective constraints.

It would prove to be an advantage if tools could internalize the nature of interrelationships among the three fundamental systems, whilst considering the limits placed on the tradeoff among the systems with regards to wellbeing and ecological thresholds. This would require a smooth transmission of information from the EIAR and other specialist inputs to the decision-aid tools. It would also be beneficial if the tools could discriminate among different ecological systems, with a higher weighting placed upon systems that are considered as 'sensitive, vulnerable, highly dynamic or stressed'.

Cumulative Impacts

Reporting on the cumulative nature and impacts of human activities, DEA (2014a: 215) insists that "impacts which extend beyond the physical boundaries of a site or area, brought about through the accumulation of effects from past, present and future projects, must be explained and evaluated in terms which allow the public to understand the nature of these impacts through space and time". This implies two ideas; firstly, the boundaries of the system at this level of analysis are defined by what is determined as 'the site'. Secondly, cumulative impacts that may arise from the project should be evaluated.

The need to report on and internalize the cumulative impacts of a development are requested per the DEA (2017:14) – "describe the positive and negative cumulative ecological/biophysical impacts bearing in mind the size, scale, scope and nature of the project in relation to its location and existing and other planned developments in the area". Much like the information on the description and quantification of positive and negative impacts provided by the EIA, the tools should also be able to account for the information on the cumulative impacts that the proposal inflicts on the greater system.

Objectives for Evaluation

1. **Three fundamental systems**: Does the tool have the ability to recognise the three fundamental systems?

2. **Hierarchy**: Does the tool have the ability to emphasize the importance among the systems according to the conceptual hierarchy?

3. **Interdependent relationships and emergent properties:**

   (i) Does the tool have the ability to internalize the quantitative and qualitative information on the positive and negative impacts that an alternative inflicts on the three systems and structure these impacts to provide a single output for ranking?

   (ii) Does the tool consider the interdependent relationships among the three systems and account for emergent properties that arise from these relationships?

   (iii) Does the tool have the ability to discriminate among ecosystems where threatened, sensitive, vulnerable, highly dynamic or stressed ecosystems are given preference?

4. **Cumulative impacts:** Does the tool have the ability to internalise the information on the positive and negative cumulative impacts that the development may render under a wider systems context?

2.5.1.2 Uncertainty and Long-Run Impacts

Position in sustainability thinking

The complexity in the relationships among the three systems creates much uncertainty for the practice of environmental management. To manage this uncertainty, environmental management tools are required to as accurately as possible, assess and predict the impacts of a project on its receiving environment throughout the project's life-cycle. The life-cycle in this sense refers to the existence of a project in terms of the impacts on its surroundings. This is different to the life-span which refers to the duration of the projects activities represented as a quantitative measurement. The life-cycle of a project can therefore extend way beyond the lifespan of a project depending on the nature of its impacts which may relate to the inputs and outputs of the project.

The reason for this life-cycle approach is both ethical and practical and arises from the inherent uncertainty in the aim to predict and control for future occurrences. The activity will impact on a variety of people throughout its life-cycle and is therefore the decision-maker's responsibility to consider and best predict the nature of impacts on these people through time (Gasparatos *et al*., 2008). If the impacts during the life-cycle extend to those deemed as 'future generations', concern for these people is referred to as the principle of 'intergenerational equity'. In the short-run, the prospects of a decision may indicate a positive utility and thus be constituted as moral, however, a decision cannot be considered moral if the circumstances change in the future, then resulting in a negative net utility. Sustainability and sustainable development is very much a moral goal as it is a pragmatic goal and must therefore be 'right' according to its own philosophy with a futurity focus. More on this moral perspective will be discussed under the principle of 'Intergenerational Equity'.

Due to the often irreversible and lock-in nature of human activities (Gasparatos *et al.*, 2008), the utility rendered from an activity is dynamic in nature and is consumed throughout its life-cycle. The tools used to assess the nature of these impacts should provide information as to which decision alternative will maximise utility over the entire life-cycle. If the allocation of resources is made only according to short-run efficiency without long-term considerations, as soon as there is a deviation from the strategy behind this allocation, the utility derived from that allocation would no longer be maximised and would result in a waste of consumed resources (OECD, 2006: 189). A deviation from the strategy would arise from the inherent uncertainty in future occurrences.

Analytical tools are usually able to internalise *risk* in order to manage information that extends over longer periods and when potential outcomes are not fully known. An important distinction between risk and uncertainty must be made here. Risk is a matter of probability and can be estimated with a high degree of confidence using statistical methods (Harris, 2006). The relationship of the measurement of an impact and its respective risk can be incorporated into an analytical tool as an 'expected value'. Uncertainty, in contrast, is when there is much less understanding of the possibility of an outcome to the point where outcomes can simply not be known (Harris, 2006). How decision-making methods manage uncertainty will be discussed shortly.

Practices in contemporary environmental management and assessment, and given the complexity as discussed above, limit the formulation of knowledge that is used to inform decisions. Environmental management tools (e.g. EIA) have traditionally reduced systems that make up the environment into separate components which are then studied individually by their respective specialists (Audouin & de Wet, 2010). This fragmented information is then brought together, intended to reconstruct the system as a whole, and is then required to be interpreted by the environmental manager. Within this reductionist-holistic method, the emergent properties that arise from the interdependent relationships among the systems are lost (Audouin & de Wet, 2012). As mentioned previously, these emergent properties form a fundamental component of the systems functioning in its present state, and therefore the future state of the system as well. The omission of these emergent properties in the reductionist-holistic approach exposes a knowledge gap in the reporting of the impacts of proposed activities on the receiving environment. This knowledge gap at the point of departure is then expected to be exacerbated through time given the complex and cascading nature of systems.

An acknowledgment and response to these knowledge gaps is embedded in the 'Precautionary Principle' and is widely adopted as one of the fundamental principles in sustainability-thinking (Gasparatos & Scolobig, 2012; Sala *et al.*, 2015). The adoption of this principle ensures responsible decision-making that respects uncertainty and avoids poorly understood risks of serious or irreversible damage to the foundations of sustainability (Gibson, 2006). Responses to uncertainty according to the Precautionary Principle could be the application of a 'no-go' alternative, or choosing an alternative that may not have as a high utility, but more certainty about the outcome, specifically negative outcomes. The tools under scrutiny should therefore be able to embed the Precautionary Principle in the output it provides to aid decisions.

In the light of such complexity discussed above, IEM tools should pay respect to the presence of uncertainty and account for its implications on decision-making. This includes adopting a life-cycle approach to the evaluation of impacts and applying the Precautionary Principle when significant knowledge gaps exist.

Manifestation in South African IEM and related literature

South African policy and legislation views the impacts of human activities according to a life-cycle approach when it states, as a principle in section 2(4)(e) of NEMA (as amended), that "responsibility for the environmental health and safety consequences of a policy, programme, project, product, process, service or activity exists throughout its life cycle".

The boundary of the life-cycle approach is determined by the scope of the life-cycle assessments conducted under the approach. According to DEAT (1998: 11) the scope of the life-cycle approach can be defined as from the point of "conceptualization and planning and runs through all stages of implementation to reuse, recycling and ultimate disposal of products and waste or decommissioning of installations". This statement however only describes the scope of the life-cycle approach in terms of the project-cycle. Mentioning the "ultimate disposal of products and waste or decommissioning of installations" presents an idea as to where the assessment may end, but the definition does not provide an indication as to when the life-cycle assessment should begin. If a "Detailed Life Cycle Assessment"[5] is applied to a development activity, the beginning of the assessment would typically include impacts on the environment derived from the sourcing of

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[5] See Life Cycle Assessment, Integrated Environmental Management, Information Series 9 by the DEAT (2004d).

inputs into the development. This could extend to reporting on the extraction of sand for the manufacturing of concrete, for example. However, as stipulated under Appendix 3 in the EIA Regulations (2014) section 2(f), "the objective of the environmental impact assessment process is to, through a consultative process… identify, assess, and rank the impacts the activity will impose on *the preferred location*" (DEA, 2014b: 61-62). Defining the boundary of reporting to "the preferred location", implies a site-specific focus and therefore may not require the reporting of impacts created by the sourcing of inputs on locations beyond the site. The site-specific focus is however not applied to impacts, as outputs of an activity, that extend beyond the site, as guidelines call for the reporting on the nature of these impacts as well as cumulative impacts. From the content analysis, there does not seem to be any requirements or suggestions for the reporting on impacts derived from inputs outside the activity-site, and is therefore not expected to be included in any form of impact reporting or analysis.

The life-cycle approach implies a long-term concern for impacts derived from the development activity which are inherently complex when viewed in a dynamic context. To grapple with the complexity and uncertainty in this long-term view, South African IEM adopts the Precautionary Principle. The Precautionary Principle pertains mainly to uncertainty surrounding negative impacts in decision-making (DEA, 2017). Uncertainty manifests through incomplete knowledge brought about by the complexities surrounding environmental management, as discussed in the previous section. It is made explicit as one of the IEM Principles in DEAT (2004e).

According to the DEA (2017: 13), the application of the Precautionary Principle is triggered by two conditions. The first condition is if there is a threat of irreversible environmental damage, and second, if there is scientific uncertainty as to the nature and scope of the threat of environmental damage. To grapple with the threats of serious or irreversible environmental damage the Mitigation Hierarchy is applied. After the mitigation hierarchy, if the competent authority still feels as if there is the possibility of a 'fatal flaw', the Precautionary Principle is adopted and he/she has the responsibility to restrict the granting of an authorization as contemplated in section 24 (2A)(a) of NEMA (as amended) (to comply with section 24b of section 24).

The application of the Precautionary Principle with regards to the processes of CBA and SMART, mainly pertain to the (un)certainty of the scientific information as inputs into the tools. The tools therefore have three objectives when aiming to best grapple with uncertainty. The first objective is to ensure that an alternative is penalized if the information describing its impacts is not of a sufficient standard of certainty. Negative impacts are of more importance here given the threat of irreversibility. The second objective, is for the tool to maintain internal theory and procedure that does not introduce any uncertainty into the outputs. Although tools are intended to be simplifications of reality, they must not be too simple and introduce inaccuracy. The third and final objective, is to ensure that the standard of information as an input is not reduced to an unacceptable quality when processed by the model of the tool. This may occur if the properties of the model manipulate the input information in ways that do not suit reality and will render an output that may not be acceptable to use. The tool which is better at meeting these objectives, is assumed to better adopt the Precautionary Principles in terms of greater certainty in scientific information.

Objective for Evaluation

1. **Life-cycle Approach:** Does the tool accurately measure the value of the alternative throughout its life-cycle?

2. **Precautionary Principle:** Does the tool have the ability to significantly penalize alternatives with highly uncertain knowledge on its negative impacts?

3. **Precautionary Principle:** Does the theory or structure of the tool introduce uncertainty?

4. **Precautionary Principle:** Does the tool maintain a sufficient amount of certainty in its output after processing the input information? i.e. not too much information lost in the processing phase.

2.5.1.3 Intragenerational Equity

Position in sustainability thinking

Fundamentally the concept of sustainable development has been the result of the growing awareness of, and concern for, the links between mounting environmental and socio-economic issues (Hopwood *et al*., 2005). Two socio-economic issues that have been given much attention in sustainability thinking and the environmental debate are poverty and inequality. South Africa has an extremely high prominence of these two issues which will be considered as inextricably[6] linked in this study, and will be referred to collectively under the term inequality. The systemic nature of these issues results in their emanation across different spatial scales (local to global), and temporal scales (current to future generations). Differentiation between the temporal scales can result in two categories of equity, mainly intragenerational and intergeneration, the prior concerning equality among current generations and the latter, future generations. The focus of this section is on intragenerational equity, mainly at a local scale given the decision context.

"Bringing together environmental and socio-economic questions was most famously expressed in the Brundtland Report's (1987) definition of sustainable development as meeting the needs of the present without compromising the ability of future generations to meet their needs" (Hopwood *et al*., 2005: 39). The responsibility of not infringing on the ability of present generations to meet their needs is both a moral and practical one. Many would agree that development that sustains or exacerbates the inequality gap between the rich and poor is morally wrong and is substantiated by a variety of theories.

Inequality is mainly grappled with as a socio-economic issue. Sustainability-thinking understands the systemic effects of inequality across the three systems and therefore introduces environmental and ecological relations into the discourse and can be used to explain how inequality results in the degradation of these respective systems. According to Agyeman *et al*. (2002), the link between environmental quality and human equality was first exposed in a study by Torras and Boyce (1998)

[6] In South Africa, there is a large equality gap between the rich and poor. Therefore, if South Africa is defined as one system, there are both citizens that do not live in poverty, and those that do live in poverty, hence inequality. Those that live in poverty are seen as having unequal opportunity in the country.

which showed that countries with more egalitarian characteristics, such as equal income distribution, greater civil and political rights and higher literacy levels, maintained higher environmental quality[7].

Ecological problems are derived from the consumption patterns of ecological services by the two socio-economic classes, subsequently resulting in more social issues arising from how the burdens of over-consumption are unequally distributed between socio-economic classes. This issue is reflected at both a global and local scale. More affluent socio-economic classes can afford to consume resources in excess, accounting for the majority of the earth's resource consumption (Munasinghe, 2011), and then often protect themselves against the externalities that occur from this excessive consumption. These externalities are then often passed on to the poorer socio-economic classes and further infringe on their quality of life. In addition, the shift in consumption burdens fails to create an incentive structure that pressures the rich to change their consumption behavior. This unequal distribution of burdens enlightens environmental justice issues due to the many cases where the environmental rights of the poor are breached.

Poorer socio-economic classes often have to tradeoff their conservation ethics and practices in order to sustain themselves from a day-to-day basis. This is in accordance with the 'Vicious Circle Thesis', where the poor are "perceived as having a short time horizon, discounting the future benefits from conservation [of natural resources] rather heavily owing to the urgency to make a livelihood and avoid hunger" (Nadkarni, 2000: 185). This degrades their immediate environment which further degrades their quality of life. The rate at which the process occurs and degrades can be further exacerbated by the cumulating externalities derived from the affluent's over-consumption. Although the 'Vicious Circle Thesis' is subject to many criticisms, for example "not all environmental degradation can be attributed to poverty or the poor, [and] not all poverty can be attributed to environmental degradation (Nadkarni, 2000: 1185), it does provide a clear description as to why poverty and inequality should be a concern in sustainability-thinking and the environmental debate.

[7] Measured in terms of pollution, water cleanliness and sanitation (Agyeman *et al*., 2002).

These two consumption patterns of the high and low socio-economic classes illustrate the interdependent relationship between inequality and environmental degradation, and the reason as to why sustainability-thinking calls for their collective targeting. Environmental management tools need to integrate these considerations into their model in order to produce ethical and practical outcomes that abide by the principle of 'Intragenerational Equity'.

Manifestation in South African IEM and related literature

During the Apartheid era in South Africa, environmentally-related policy and legislation was predominantly focused on the preservation of natural systems for the benefits of the white minority (Faasen & Watts, 2007). This implied for example the relocation of 'blacks' from areas zoned for National Parks, to other areas designated under the Group Areas Act (41 of 1950) (Watts cited in Faasen & Watts, 2007). One of the facets in the transition towards democracy in South Africa was shifts in the environmental ethic; from preservation towards conservation, and public exclusion to public inclusion. This was undertaken in order to gain a broad-based acceptance of conservation objectives (Cock & Koch cited in Khan, 2002).

The current environmental policy and legislation embodies the democratic management of the environment mainly through two approaches. The first approach is top-down in nature and applies the principle of 'Environmental Justice' in IEM. Although this principle was first conceptualised at a grassroot, community level, its manifestation in South African IEM is essentially top-down in nature as policy and legislation aims to ensure the principle is embedded in all decisions. The second approach is bottom-up in nature which applies the principle of 'Stakeholder Engagement' in the decision-making process. It was previously mentioned that stakeholder engagement is implemented through the Public Participation Process (PPP).

Environmental Justice

The concept of 'Environmental Justice' began with the 'Environmental Justice Movement' pushed by environmentally conscious, African Americans in the late 1970s (Higgins, 1993; Khan, 2002). The movement challenged the white, elitist dominance over environmental management practice and discourse which focused on preservationist values and the unequal distribution of environmental degradation on the black minority (Khan, 2002). The objectives of the movement were mainly multi-dimensional in nature attending to the environment, society, local economies, civil rights and people living in poverty conditions (Higgins, 1993).

According to Khan (2002), there were close similarities between the US environmental justice movement in the 1980s and the rise of the same movement in South African during the transition in the 1990s. The manner in which the 'Environmental Justice' sub-principle manifests in contemporary South African IEM is also concerned with distribution, but takes on a broader approach[8] in that it calls for equal access to the benefits of environmental goods, services and resources (DEAT, 2004e).

In section 24 of the Constitution (Republic of South Africa, 1996) everyone is given the right to an environment which is not harmful to their health or well-being and a duty is placed on the government to protect the public's environment through conservationist and sustainable development[9] measures. The right is given to "everyone" in a completely equal and democratic manner, in contrast to the previous regime which would have neglected the rights of 'blacks'. The clause also reflects the movement towards a human-centered approach where the environment is protected for the public and where conservationist and sustainable development measures are deemed more inclusive and human-oriented.

Although section 24 in the Constitution (Republic of South Africa, 1996) is phrased as giving everyone among the different races and classes equal rights, scope to give preference to the previously disadvantaged and vulnerable groups does exist in other South African environmental policy and legislation documents. In NEMA (as amended), section 2(4)(d) states that "equitable access to environmental resources, benefits and services to meet basic human needs and ensure human well-being must be pursued and special measures may be taken to ensure access thereto by categories of persons disadvantaged by unfair discrimination".

[8] "…environmental justice (which is aimed at promoting the fair and equitable distribution of environmental goods, services and resources)" (DEAT, 2004e: 6).

[9] "[Securing] ecologically sustainable development and use of natural resources [whilst] promoting justifiable economic and social development" (Republic of South Africa, 1996: 11).

Another matter of environmental justice in which disadvantaged and vulnerable groups are given specific concern is with regards to the distribution of adverse environmental impacts. In both section 2(4)(c) of NEMA (as amended), and in DEAT (2004e: 9), it is insisted that adverse environmental impacts should not be distributed in such manner that unfairly discriminates against any person, "particularly vulnerable and disadvantaged persons". The 'Polluter Pays Principle' is aligned with this issue of distribution and is adopted in DEAT (2004e:10). This principle insists that the "costs of remedying pollution, environmental degradation and consequent adverse health effects and of preventing, controlling or minimising further pollution, environmental damage or adverse health effects must be paid for by those primarily responsible for causing these effects" (DEAT, 2004e:10).

Stakeholder Engagement

According to the DEAT (2002), the goal of stakeholder engagement in IEM is to improve communication between all stakeholders with the aim of ensuring better decision-making to achieve sustainable development. The argument that underpins this goal is that the involvement of stakeholders in development decisions will improve the legitimacy of these decisions and have a better chance at being sustainable due to wider acceptance (Theron *et al.*, 2009). It also provides a medium for gathering different forms of knowledge and values which can be integrated to inform better decisions. This is assumed to be why the principle is so widely called for in Sustainability Assessment Frameworks.

The first movement toward stakeholder engagement, is through 'Holistic Decision-Making[10]'. As featured in DEAT (2004e), this sub-principle is made up of two parts. The first part seeks to account for the interests, needs and values of all interested and affected parties, and is given effect under section 2 (4)(g) of NEMA (as amended), where "decisions must take into account the interests, needs and values of all interested and affected parties…".

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[10] "Decisions must take into account the interests, needs and values of all interested and affected parties and all relevant forms of knowledge, including traditional knowledge" (DEAT, 2004e:9).

The second part of section 2 (4)(g) of NEMA (as amended) is its account for the relevant forms of knowledge held by the interested and affected parties. This part of the principle states that "decisions must take into account the interests, needs and values of all interested and affected parties, and this includes recognising all forms of knowledge, including traditional and ordinary knowledge". The emphasis on traditional knowledge is assumed to be a response to the previous dominance of scientific and specialist knowledge in environmental management at the expense of the value found in traditional knowledge. This is stated as a prevalent issue in environmental assessment and management according to Audouin and de Wet (2010). The inclusion of interests, needs and values and the engagement with traditional knowledge all takes place within the regulated Public Participation Process conducted by the Environmental Assessment Practitioner. In addition, section 2(4)(q) of NEMA (as amended) makes special provision for interests, needs, values and knowledge held by women and youth in this process due to their vital role in environmental management.

Although the reality of stakeholder engagement in South Africa is to be found at all levels along the spectrum (see figure 1.4 in chapter 1), policy and legislation documents talking about 'community well-being and empowerment' create the expectation for stakeholder engagement to be at the stronger ends of the spectrum, ones of "involvement", "collaboration" and "empowerment". "Community well-being and empowerment", which features as another one of the 'IEM Principles' in the DEAT (2004e) and as a 'Strategic Goal' in DEAT (1998), is promoted in order to build the capacity of people to participate effectively in the public participation process, thus managing their environment and contributing to sustainable development. This is promoted through "environmental education, the raising of environmental awareness, the sharing of knowledge and experience and other appropriate means" according to section 2(4)(h) of NEMA (as amended). The derived value from these motions contributes to another sub-principle of 'Transparency'.

The decision process is made more transparent by developing the capacity of stakeholders to engage with the process, and the more technical aspects thereof, for example; the calculations and concepts underpinning the decision-aid tools. From this, trust and credibility in the decision is more likely to be established. This view is shared in the IEM guidelines as it notes that "greater transparency in the decision-making process, along with the opportunity for interested and affected parties to play a role in this process, helps to build the credibility of environmental assessment and management processes" (DEAT, 2002: 5). If credibility is held in the decisions, the actions derived from the decision are more likely to be sustainable.

According to Sala *et al.* (2015), transparency may be improved in two ways. First, there must be transparent access to relevant information, and second, results and impacts should be communicated in a clear way. This is adopted in section (4)(k) of NEMA (as amended) where it states that "decisions must be taken in an open and transparent manner, and access to information must be provided in accordance with the law". The transparency of the tool should therefore be evaluated in two respects. Firstly, the tool's engagement with the public participation process, and secondly, the transparency of the technical side of the tool which should of a standard that is easy enough to understand after empowerment.

In the context of democratic IEM, the tools used to aid decision-making should be able to encompass both the top-down and bottom-up approaches of Environmental Justice and Stakeholder Engagement. As a requisite for Environmental Justice, the tools should be able to account for the balanced distribution of environmental services between the socio-economic classes in terms of access to these services and burdens derived from the consumption of these services. In addition to accounting for these distributional concerns, higher weighting should be given to the benefits of the disadvantaged and vulnerable as well as women and youth, as provided for in the body of policy and legislation. With regards to Stakeholder Engagement, tools should take on a holistic approach which is able to integrate the interests, needs and values of all interested and affected parties as well as their respective forms of knowledge, including traditional knowledge. During the implementation of the tool, there should be initiatives to empower communities through the suggested means, in order to build their capacity to provide input into the tools which together open access to information and communication of results and impacts will improve the transparency of the tools within the IEM process.

Objectives for Evaluation

1. **Environmental Justice:** Does the tool have the ability to discriminate among alternatives according to their distribution of environmental services? In this case favouring alternatives which distribute positive and negative impacts towards and away from 'vulnerable and previously disadvantaged persons'.

2. **Stakeholder Engagement:** Does the tool have the ability to integrate stakeholders; interests, needs and values?

3. **Stakeholder Engagement:** Does the tool have the ability to integrate the relevant forms of knowledge[1] held by the different stakeholders?

4. **Stakeholder Engagement:** How transparent is the tool from a technical side?

2.5.1.4 Intergenerational Equity

Position in sustainability thinking

The coining of the concept "Sustainable Development" reflected a new paradigm with a futurity outlook. This outlook is underpinned by the morally loaded concern for the rights of future generations dubbed 'intergenerational equity'. According to Partridge (2001) the concern rose around 1976 in Rawls' article "Rawls and the duty to posterity", and became particularly popular with the emergence of the environmental movement. Its relationship with the environmental movement was sparked through the realisation that human activity has the potential for long-term environmentally degrading impacts such as climate change and species extinction. Furthermore, these impacts will be born mainly by generations in the future, unfairly degrading their quality of life. It is essentially the 'Intergenerational Equity' principle that extends the need to maximise, or at least maintain a positive utility throughout the life-cycle of a project, especially if the impacts extend to those deemed as ‘future generations’[11].

The most widely used definition for sustainable development is development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987). As also represented in many other definitions of the concept, the objective of the concern is to preserve the ability and potential of future generations in meeting their needs. The abstract and vague phrasing of this duty is derived from the uncertainty surrounding what the needs and preferences of the future generations will be. Hattingh (2001) makes a point that these ‘needs’ refer more towards the quality of life for human beings through time rather than the survival of the human species. He justifies this by pointing out the focus on quality of life in the “Nine Principles for Sustainable Living” outlined by Caring for the Earth Report (IUCN, UNEP & WWF, 1991). Quality of life is still however a relative standard and is therefore still somewhat vague.

Different narratives underpin the sense of duty to posterity. Resistance, as the first narrative, arises from the inherent vagueness, along with other roots of scepticism surrounding the concern for futurity. Philosophers have contested the foundations for concern and as to whether future generations should have standing in current democratic societies. Questions have also been raised as to whether the current generation has the capability of making just provisions for future persons even if they are of their kin (Partridge, 2001). This introduces the second narrative based on the idea of inheritance. Hattingh (2001) makes the assumption that if there is a strong emphasis placed on sustaining quality of life, it would entail that this is inherited by future generations. In this narrative, decision power is held by the present generation with discretion over how much the future generation would inherit. The third narrative takes on a ‘rights’ perspective, where it is believed that present and future generations ought to have equal standing.

[11] See earlier discussion on ‘Uncertainty and Long Run Impacts’ and the inclusion of a life-cycle approach in impact assessment, in section 2.4.1.2.

One of the more relatable lines of logic motivating a 'rights' perspective is posed by Rawls (1971)[12] in "A Theory of Justice", and summarised by Partridge (2001). Partridge (2001:431-432) explains that:

> "Rawls proposes a 'contractarian' approach to the question of what he calls 'justice between generations'. …the 'contract' must be 'hypothetical' and constructed through an elaborate thought-experiment which [Rawls] calls 'the original position'. …[T]he 'contractors', in drawing out the rules of 'justice between generations', are denied knowledge of which generation in human history they belong to. Thus, the rules of intergenerational justice are devised in the original position to apply to all generations. Accordingly, the parties in the original position do not know whether, in the conditions of their actual lives, the rules of 'just savings' will turn out to be a burden or a benefit. All they know is that, in either case, due to the conditions of the 'original position', the rules will be 'fair'".

Put in the "original position" the current generation is expected to wish for all generations to be able to meet their sufficient quality of life. Because the current generation has the knowledge that their actions are detrimental on the ability of future generations in meeting needs, and have the capacity to change their actions to be less detrimental – they ought to do so. This is a moral duty.

If it is not known what the needs of the future generations will be and what will entail a sufficient quality of life, what should be protected now? Some definitions of sustainable development call for the preservation of specific nature-based, environmental and cultural items, but it can be agreed with Solow (1991) that this strategy is unfeasible and restrictive. Solow (1991), and evidently South African IEM, take on a weak sustainability perspective, allowing for the substitution among different forms of capital to a certain extent. Instead of preserving specific objects, there should be a focus preserving the resilience in systems and properties that aid them to adapt without collapse. The ideal is to maintain systems that are diverse, adaptive and resilient enough to provide human beings with sufficient services as their needs evolve through time. This backs Edith Weiss' (1989) logic, cited in Partridge (2001:432), "who stipulates as a fundamental principle of intergenerational

[12] Rawls, J. 1971. *A Theory of Justice*. Cambridge: Harvard.

equity that each generation leave to its successor a planet in at least as good a condition[13] as that generation received it".

Adopting effective, forward looking environmental management practices targeted at sustaining social-ecological system services that provide for the needs of human beings, will help carrying out the moral duty of protecting the right and capacity of future generations to meet their own needs. A sufficient adoption of these environmental management practices will require a drastic cultural change by the current generation in order to institutionalise and implement these practices at a rate and effectiveness that will cease and eventually correct the damage that has already been done. The next section will outline how the principle of 'intergenerational equity' manifests in South African IEM and which actions, duties and obligations are institutionalised to ensure that this principle is given effect.

Manifestation in South African IEM and related literature

It is evident that the principle of 'Intergenerational Equity' is enshrined in South African IEM. The two most important references to this principle are in Section 24 of the Constitution where it states that everyone has the right "to have the environment protected, for the benefit of present and future generations" (Republic of South Africa, 1996: 8), and in the NEMA (as amended) definition of sustainable development: "…ensure that development serves present and future generations" (DEA, 2014c: 15).

All references to intergenerational equity in South African IEM, much like in the international body of literature, are phrased relatively vaguely. The IEM principle for 'equity' states that "equitable access should be provided to environmental resources, benefits and services to meet basic human needs, and promote human well-being for both present and future generations" (DEAT, 2004e: 9). The body of policy and legislation does not state exactly what entails "environmental resources, benefits and services", or "basic human needs" and "well-being". It is assumed that development which adheres to the concept of sustainable development and its

[13] As defined by weak sustainability principles.

embedded principles will result in a state of the environment with the capacity -in the sense of access and abundance- to provide the public with these things.

It makes sense for the government of a developing nation such as South Africa to adopt the principles of sustainable development, especially when the goal of development is to improve the quality of life and achieve well-being for its public (Republic of South Africa, 1998). The process of development is a slow one, and in developing countries, the time-frame expected to achieve this goal is over many generations. Sustaining the achievement of the goal requires planning for the future which provides for a foundation of the concern. Because rights are held equal among the generations, the foundation of concern for ‘Intergeneration Equity’ in South African IEM implicitly follows the ‘rights-based narrative’.

With specific reference to IEM’s contribution to achieving development goals, holding a “vision of environmental policy where society lives in harmony with the environment” (Republic of South Africa, 1998: 6), there does not seem to be any specific items of concern that need to be protected in order to achieve this goal. The definition of the environment as it stands in policy and legislation takes on a holistic systems approach and does not make reference to any specific social or environmental entities. As previously discussed, there is also scope for trading-off different entities according to the weak sustainability perspective. To some extent there are conservation priorities given to some ecological and social amenities, for example; wetlands, national parks and cultural heritage, but these amenities also seem to be given importance according to a systems perspective and not as absolute entities. The same applies for “sensitive, vulnerable, highly dynamic or stressed ecosystems” as discussed under the ‘Integration of Systems’ principle which are also given priority in policy and legislation. Even if there were amenities that were to be wholly preserved for the sake of sustainable development, any proposal which suggests an unacceptable level of impact (fatal flaw) on the amenity would be rejected in the EIA process and not needed to be included as a factor in either of the tools’ operations.

Due to the complexity of the topic, the principle of 'Intergenerational Equity' in South African IEM remains rather vague. In the context of IEM decision-aid tools the inclusion of this principle can be seen as an augmentation of the concern for a 'Life-Cycle Approach' featured under the principle of 'Uncertainty and Long-Run Impacts'. The Life-Cycle Approach is simply the reporting on impacts throughout the life-cycle of a proposal, measuring how the value of impacts change through time. It is therefore the principle of 'Intergenerational Equity' which will introduce the concern for how the value of these impacts changes through time and how these changes should be managed. Because there is no specified quality of life which an extent of capacity needs to achieve or specific objects of concern, no specific criteria come to mind upon which the tools can be evaluated. The study will therefore simply provide a general discussion on how the principle of 'Intergenerational Equity' manifests in within each tool.

Objective for Evaluation

1. **Intergenerational Equity**: How does the principle of Intergenerational Equity manifest in the tool?

2.5.2 Procedural Principles

2.5.2.1 Robustness

Description of principle

A good tool should remain applicable in a variety of situations. It must provide the decision-maker with confidence in the outcome to ensure that the analysis is worth the invested resources. This feature of appropriateness is referred to as 'robustness' and will be used as a 'Procedural Principle' in this study. The 'Robustness' principle is made up of three components.

The first component refers to the robustness of the tool in terms of the 'nature, scale and scope' of the proposal at hand. Different tools will be interested in different facets of the proposal and therefore characteristics may be portrayed differently according to the perspective of the tool. For example, the financial analysis for a large-dam development will be concerned with a significantly smaller nature, scale and scope relative to the ecological analysis for that development. The characteristics of the 'nature, scale and scope' of a proposal referred to in this study are:

i. Nature: The decision between the alternatives in the proposal require information relating to more than one of the three fundamental systems, and is thus multidimensional in nature. This usually exaggerates the complexity involved in the decision and requires tools which can sufficiently grapple with this complexity.
ii. Scale: The proposal is being analysed at a project level, which refers to the cycle of Plan, Do, Check and Act (DEA, 2014a). This is opposed to a strategic level which is seen more as guiding the assessment and decision-making process.
iii. Scope: The tool is aiming at aiding a decision between two or more alternatives of the proposal. In this sense, the objectives of each alternative remain the same, but the means through which these objectives are met differ according to the alternative.

The second component of 'Robustness' will evaluate the appropriateness of a tool in terms of the 'significance of the anticipated impacts', where the tool should "[provide] for a scoped yet comprehensive analysis of potentially significant environmental effects" (DEA, 2014a). Paying respect to the significance of impacts in this respect is essentially informing whether the 'Precautionary Principle' should be implemented based on severe impacts or uncertain knowledge. The more significant the impacts, and the higher probabilities of those impacts, the more information and higher processing power of the tool is required. This is in order to reduce the uncertainty surrounding the decision, making it more accurate and sustainable as discussed in the prior section.

The third and final component which contributes to the 'robustness' of a tool, relates to the nature of the knowledge[14] that is used as an input into the tool. The main concern here pertains to the 'availability of knowledge' and 'correctness of knowledge'. If these qualities of the knowledge are inadequate the tool can only render a low-quality outcome. A low-quality outcome can be assumed to inherently raise uncertainty in the decision thereby degrading the merit of the tool.

[14] The literature -mainly Retief (undated), Robinson and Ryan (2002) cited in Oosthuizen *et al.* (2011)-similarly refer to the 'availability of information' and the 'correctness of information'. In this study, 'knowledge' was substituted for information as to adapt to the linguistics used in Sustainability Science.

In Sustainability Science, a transdisciplinary approach is taken in order to gather and manage knowledge in the aim to understand reality (Burns *et al*., 2006; Audouin & de Wet, 2012). The characteristics of this approach will therefore be used to analyse the two tools in this respect. Max-Neef, cited in Burns *et al.* (2006), explains that transdisciplinary functions across four hierarchical layers. The first two layers are in the objective domain which consist of science and technology, mathematics and engineering as respective examples. The second two layers include the "subjective and normative dimensions of society pertaining to value and ethical issues such as the ends to which scientific knowledge should be applied and the institutional settings through which this is affected, for example, planning, politics and law" (Burns *et al.*, 2006). Audouin and de Wet (2012) add to this by mentioning that the approach is able to engage with practical and contextualized knowledge and ethics. They believe this is particularly applicable to environmental management as it is action-oriented and engages with value-based questions[15] (Audouin & de Wet, 2012).

The benefit of taking on this approach is to provide a more holistic understanding of reality by improving the balance between objective and subjective based knowledge. To apply this in the practice of environmental management, it requires dialogue both within the scientific community, i.e. among the different specialists, and between this community and the interested and affected parties (Burns *et al.*, 2006). This suggestion therefore elaborates on the practical benefits of stakeholder engagement and the inclusion of traditional knowledge.

[15] Audouin and de Wet (2010: 23) use the following questions as examples; "what direction are we moving?", "is this desirable?" and "what ought we to be doing?".

In order for the tools to be considered as 'robust', it should be appropriate in terms of the nature, scale and scope of the proposal, and the significance of the impacts involved in this proposal. These two characteristics will be highly dependent on the context of the proposal at hand. A 'robust' tool will also maintain an adequate level of certainty in its outcome under a variety of circumstances, and this can be enhanced through a Transdisciplinary approach to knowledge generation.

Objective for Evaluation

1. **Nature, scale and scope:** How suitable is the tool for the nature, scale and scope of the proposal in this study?

2. **Significance:** How appropriate is the detail of knowledge as an input into the tool in terms of the significance of the anticipated impacts of the proposal?

3. **Transdisciplinary Approach:** Does the tool take on a transdisciplinary approach by having the ability to process a variety of input types?

2.5.2.2 Phase in the Project Process

Description of the principle

The second Procedural Principle refers to the appropriateness of the tools in terms of the phase in the IEM project-level process in which they are going to be applied. Tools need to be implemented effectively and efficiently in order to meet the objectives of the project phase ensuring a smooth transition among the phases, and a timeous and cost-effective completion of the project. This principle featured strongly in the EIAMS report (DEA, 2014a) and in much of the literature on Sustainability Assessment Frameworks. Figure 2.3, is an illustration of the combination of the IEM process and project management cycle taken from the EIAMS report (DEA, 2014a), and gives a good idea of the different contexts in which an array of IEM tools can be applied. Although figure 2.3 may portray definite boundaries between the four phases, it is acknowledged that the appropriateness of a tool to a phase is not absolute and that some tools may be suitable to more than one phase (Oosthuizen *et al.*, 2011).

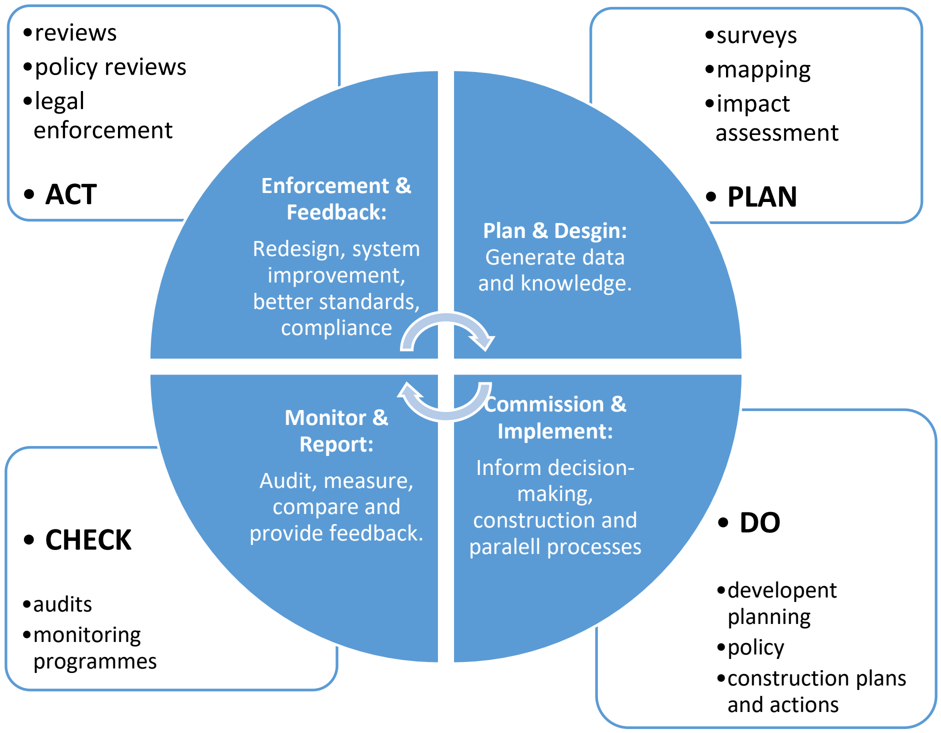

Figure 2.3: Integrated Environmental Management and Project Cycle (DEA, 2014a)

This study is interested in the 'Plan' phase as the tools are intended to aid decision-making surrounding the appraisal of a project, and not be the final output on which the decision is made as stressed in the previous chapter. According to Oosthuizen *et al.* (2011), 'Primary Data Collection and Knowledge Creation' tools are appropriate for this phase of the project process. These tools should "aim to gather status quo information about the presence or absence of various [economic], social [and/or] environmental resources or elements, with no data processing other than for the purposes of simplified representation" (Oosthuizen *et al.*, 2011).

Objective for Evaluation

1) **Phase in the Project Process:** Does the tool meet the reporting requirements for the 'Plan' phase in the IEM and project management cycle?

2.5.2.3 Stakeholder Engagement

Description of principle

To reiterate, "the goal of stakeholder engagement is to improve the communication between stakeholders (including the proponent) in the interest of facilitating better decision-making and more sustainable development" (DEAT, 2002:9). IEM tools are seen as the vehicle for integrating the value of stakeholder engagement into environmental management decision-making (DEA, 2014a). The tools in this study augment the standard IEM stakeholder engagement process -also known as the Public Participation Process- in order to meet their information requirements. If the stakeholder engagement process under each tool is aligned with the principles of sustainability-thinking, then their processes may be of more value. It is important that sustainability-thinking principles are streamlined throughout the entire process of the tool.

The objectives for the stakeholder engagement process are shown below (DEAT, 2002):

1. raising awareness, educating and increasing understanding between stakeholders (a two-way information exchange);
2. assisting in the identification of key issues of concern that need to be considered;
3. raising a diversity of opinions and perspectives and obtaining a balanced perspective of key issues;
4. identifying common interests and opportunities for meeting these;
5. identifying sources of information and the knowledge of local and other stakeholders;
6. learning from the knowledge and understanding of the environment of local and other stakeholders;
7. commenting on the findings of technical studies;
8. identifying reasonable alternatives;
9. managing and minimising conflict;
10. identifying creative solutions to problems or deadlocks;
11. informing and improving decision-making;
12. ensuring greater credibility and legitimacy in the decision-making process;
13. establishing trust and cooperation;
14. generating a sense of joint responsibility and ownership for the environment;

15. assisting in the review and monitoring of activities that may negatively affect the environment;
16. contributing to the development of appropriate policy, legislation and regulations; and
17. promoting democracy.

In order for a tool's stakeholder engagement process to be appropriate, it should be able to achieve the above objectives. These objectives can therefore be used as evaluation instruments. It can be seen that objectives; 2, 3, 4, 5, 6, 8, 10, 12, 13 and 14 relate to Holistic Decision-Making and Transparency, and are already being used to evaluate the tools under the 'Philosophical Principle' of 'Intragenerational Equity'.

To meet the remaining objectives (1, 7, 9, 11, 15, 16 and 17) the tool's stakeholder engagement process will be expected to operate towards a 'stronger' level on the IAP2 spectrum (Collaboration and Empowerment) which is aligned with a specific set of mechanisms. These mechanisms are shown in DEAT (2002:15) and include workshops, focus groups or key stakeholder meetings. The remaining objectives will be referred to as 'universal objectives' as they are able to be achieved by any of these mechanisms, irrelevant of which tool is being used. CBA and SMART commonly use workshops as a stakeholder engagement mechanism and by making use of this mechanism the tools implicitly meet the 'universal objectives'.

The onus of achieving the 'universal' objectives will depend on the operations of the workshops on a case to case basis and therefore the tool cannot be held responsible for achievement. The objective governing the score of a tool according to the 'Stakeholder Engagement' principle therefore depends on the tool's ability to integrate information on Holistic Decision-Making and its level of Transparency as discussed under the 'Intragenerational Equity' principle (see section 2.4.1.3). As a minimum, a tool to score on this procedural principle only requires having an opportunity for stakeholder engagement which maintains the potential to encompass the 'universal' objectives.

Objectives for Evaluation

1. **Stakeholder Engagement:** Does the tool provide an opportunity for stakeholder engagement that does not compromise the 'universal' objectives?

2.5.2.4 Transferability of Information

Description of principle

There is a growing trend in South African IEM looking to broaden the focus of tools to higher levels of strategic decision-making (DEAT, 2004e). These decisions mainly pertain to policies, plans and programmes, and are thus beyond a project level focus. In accordance with this approach, there is expected to be an application of a combination of IEM tools intended to complement and supplement each other. DEA (2014a) refers to this combination as a "Progression of Tools". The interest of this sections looks at the characteristics of CBA and SMART in the context of a "Progression of Tools".

Based on the literature, the most dominant example of this broader approach surrounds the interactive application of the EIA and the Strategic Environmental Assessment (SEA). This example will be used to give a general idea of the relationship for all project-level and strategic-level tools. The "EIA is used to evaluate the impacts of development on the environment and socio-economic conditions, while SEA can be used to evaluate the opportunities and constraints of the environment and socio-economic conditions on development" (CSIR cited in DEAT, 2004g:4). Whilst the SEA is used as a framework to guide development decisions which will require EIAs, the information produced by the EIA is used as an input to guide the development of the framework. This is illustrated in figure 2.4. Information from the EIA may be used to inform the Scoping and Situation Assessment phases of the SEA, and could be used to draft Sustainability Guidelines and Parameters. According to the DEAT (2004g), this information may include; specialist input and stakeholder engagement, determining the progress towards sustainability objectives and criteria and their measurement, identifying ecological and socio-economic opportunities and constraints to the plan and programme, among others.

The benefit of this approach is to ensure that IEM tools are used correctly and consistently, and to fill the gaps based on the strengths and weaknesses of the different tools at different levels (DEA, 2014a).

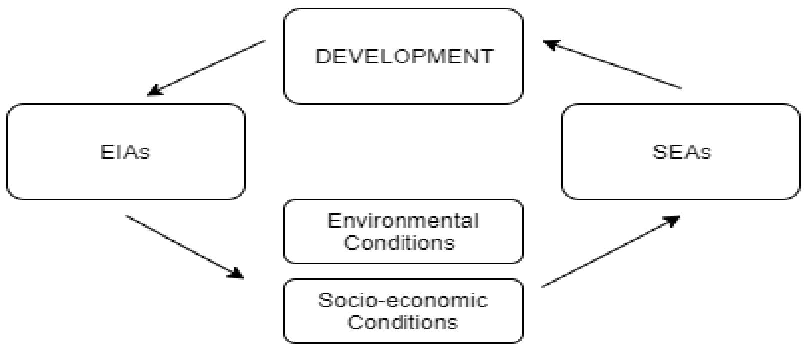

Figure 2.4: Flow of information within the relationship of the EIA and SEA (DEAT, 2004g: 4)

Due to the objective of the CBA and SMART in the IEM process being the provision of decision-aid information at a project-level, the key "thread" linking these two tools in a 'progression of tools' is the contents and state of their information. Information will be the unit of interest under this 'Procedural Principle' and can be categorised into two forms in accordance with the tools.

The first category of information relates to the outputs produced by each tool. The objective relevant to this category will evaluate how applicable the Net Present Value (NPV) of the CBA, and the value score of the SMART, is among a progression of tools. The objective will determine if these output forms are of value when applied within strategic IEM tools. The second category of information relates to the data collected as an input into the tool and how it is transformed in order to be made processable by the tool. The objective relevant to this category will evaluate the applicability of the data and its transformed state within a 'progression of tools'.

Objectives for Evaluation

1. **Transferability of Information**: How applicable is the output of the tool in a 'progression of tools'?
2. **Transferability of information**: How applicable is the data collected as an input into the tool, and the manner into which it is transformed, within a 'progression of tools'?

Chapter 3: Literature review on the decision aid tools: Cost Benefit Analysis and Simple Multi-Attribute Ranking Technique

3.1 Introduction

This chapter provides a literature review on the procedure, theory and concepts behind CBA and SMART. It is these aspects which the framework established in the previous chapter seeks to evaluate and compare. Without a thorough understanding of the tools, one will not be able to draw conclusions on the ability of each tool to align with sustainability-thinking principles. The CBA is discussed first, followed by SMART. The discussions on each tool was structured in such a way to make the tools comparable by theme.

3.2 Cost-Benefit Analysis

The aim of this section is to outline the theoretical underpinnings of the CBA. The tool measures the aggregate gains and losses of a project in order to meet two objectives. First, to indicate as to whether a project is feasible (gains exceed losses), and second, to rank project alternatives in terms of how much their gains exceed the losses.

The outline of CBA begins by describing the type of CBA applied in the environmental management context and the procedure for its application. The theory that underpins the tool is then described. Objections to the use of the CBA tool are then discussed which provides motivation for the search for alternative tools.

3.2.1 Types of cost-benefit analysis

The Cost-Benefit Analysis presents itself in two types. The first type is the ‘financial’ Cost Benefit Analysis, mainly used by firms in the private sector which only accounts for direct financial gains and losses accruing to the firm (DEAT, 2004a). The second type is the ‘economic’ or ‘social’ Cost

Benefit Analysis[16]. The economic and social CBA goes beyond measuring financial flows and in addition aims to account for "societal effects, like: pollution, environment, safety, travel times, spatial quality, health…etc." (Decisio, 2017). By considering these additional societal effects, the analysis takes into account the 'true worth' of a project (Brent, 1998; DEAT, 2004a; Mullins *et al.*, 2014). "The art of the analysis process comes in the measurement of these impacts, their adjustment for market failure, and for the effects of time, income distribution, incomplete information and potentially irreversible consequences" (DEAT, 2004a: 4).

3.2.2 Procedure for performing a cost-benefit analysis[17]

The content of each step will become more apparent when elaborated on in the theoretical foundations.

1) Define the project and a set of alternatives.

This is conducted at the opening stages of the project, the analyst should be briefed by the decision-maker as to the purpose, scope, stakeholders and parameters of the analysis (Ingle, 2014). The impacts of the different project alternatives will also be defined and will then be used to determine if an economic/social CBA is required.

2) Measure costs and benefit streams.

The impacts identified in step one of the process are categorized into costs and benefits. Costs and benefits are then measured, first by determining the functional relationship between the project and the impacts, and second, assigning a monetary value to the impacts (Belli *et al.*, 1998). According to Mullins *et al.* (2014: 60), "the analyst should also, as far as possible, quantify the social consequences of a project, and where such quantification is not possible they should be reported qualitatively".

Social consequences such as distributional effects and redistribution of resources between income and populations groups are of particular concern in the South African context. To internalise these concerns in the output of the tool, the analyst may choose to add 'income distributional weights'

[16] When referring to CBA, it is referring to the 'economic' of 'social' Cost Benefit Analysis. The 'financial' Cost Benefit Analysis will be referred to as the financial CBA.
[17] The procedure was adapted from those outlined by (Ingle, 2014; Joubert *et al.*, 1997; DEAT, 2004a; Mullins *et al.*, 2014).

to impacts. The goal of these weights is to give vulnerable and previously disadvantaged individuals more importance in decision-making.

3) Convert all streams to a single net present value.

The impacts that will have been measured through time will need to be brought to a NPV in order to be made commensurable. This is conducted through the method of discounting at a specified discount rate. The NPV is the outcome of the calculation after the difference between benefits (B) and costs (C) have been measured and discounted at rate (r). The conventional[18] formula for this calculation is shown below:

$$NPV = \sum_{i}^{n} \frac{B_{\mathrm{i}}}{(1+r)^{i}} - \sum_{i}^{n} \frac{C_{\mathrm{i}}}{(1+r)^{i}}$$

4) Conduct a sensitivity analysis.

A sensitivity analysis is performed on the discount rate, income weights and other parameters of the analysis. It is used to expose how the change in values of a certain parameters may affect the overall value of the project. The analyst can then report on the sensitivity analysis and use it to aid decision-making.

3.2.3 Utility and distribution

The measurement of society's net utility gains derived from capital intensive projects first originated from Dupuit's 1844 paper, 'On the Measurement of the Utility of Public Works'. CBA has its roots in the 'Neo-Classical Welfare Economics' school of thought. In the past, this school was a branch of 'Utilitarian Philosophy' and thus builds upon those principles in its theoretical foundations today. The 'Principle of Utility' states that; "what is [morally] right maximizes the total amount of net utility" (Van De Veer & Pierce, 2003: 24). In economic terms, an allocation of resources that maximizes utility is referred to as 'efficient'. Utility is shown in people's preferences and choices (OECD, 2006). In CBA, preferences are measured through a variety of techniques and are expressed in monetary form (i.e. prices). The prices reflect peoples' willingness to pay to receive the benefits or avoid the costs of a project. Negative impacts are taken as costs, and positive

[18] Using an exponential discounting approach.

impacts are taken as benefits. The prices of costs and benefits are compared to form a NPV as a proxy for net utility gains (or losses) to society. The NPVs of the different project alternatives allow for their comparison and ranking. How the monetary value of social costs and benefits are determined will be elaborated on under the 'Measurement' section.

The 'Pareto Efficiency Principle' states that "an allocation of goods is Pareto efficient if no alternative allocation can make at least one person better off without making anyone worse off" (Boardman *et al*. cited in Mullins *et al.*, 2014). The appraisal of a project in CBA rests on this rule. However, the rule that an alternative is only 'efficient' if no individuals suffered a loss and at least one individual benefitted from a gain makes the application of the Paretian Principle close to impractical where most changes induced by a developmental project result in some parties 'losing'. To overcome the Pareto 'efficiency' restriction, the CBA endorses the application of the 'Kaldor-Hicks compensation principle' (Joubert *et al*., 1997). OECD (2006) explains that this compensation principle concerns mainly the distribution of 'goods' and 'bads' derived from project benefits, and seeks to mimic the Pareto Principle by making two important provisions. First, the 'benefactors' of the project need to receive a gain that has the ability to compensate the 'losers' without actually distributing this compensation. Second, interpersonal comparisons of benefits are not required because compensation is assumed as a form of bargaining where the 'losing' party decides how much they need to be compensated for their original level of welfare to remain unchanged. The application of Kaldor-Hicks Principle within CBA is used to mimic the Pareto Principle and justify project decisions based on the NPVs of the CBA.

Another morally significant consideration having to do with the distribution of 'goods' and 'bads' in the context of development projects, is which parties receive the benefits of the project and which parties incur the costs (Van De Veer & Pierce, 2003). This concerns the principle of intragenerational equity embedded within the concept of sustainable development and becomes especially relevant in a developing world context where the well-being of poorer individuals is of significant importance.

In the light of inequitable distribution, especially between the upper and lower economic classes, Joubert *et al*. (1997: 126) cautions the adoption of the Kaldor-Hicks principle:

> "Although CBA attempts to mimic the market, even perfect 'laissez-faire' does not guarantee a general equilibrium that maximizes aggregate social welfare, merely one that achieves efficiency given the current distribution[19]. It may consequently accentuate any distributional asymmetries already in existence. This may be exacerbated by the fact that the compensation principle has the potential for a pro-rich bias" (Joubert *et al*., 1997: 126).

The potential for a pro-rich bias is rendered in three ways. Firstly, the comparison of prices used to calculate the net social utility does not consider the law of decreasing utility of income. The reflection of a change in utility denoted in monetary form is distorted by the relative purchasing power between richer and poorer demographics. In general, the richer would be able and therefore willing to pay more for smaller changes in utility compared to the poorer. Secondly, if these pro-rich biases exist, compensation does not have to be paid and is only hypothetical in nature. Lastly, services rendered by the environment fall differently between the economic classes. In third world countries, services mainly deliver subsistence to the poor and recreation to the rich, therefore "the [monetary] value of the livelihood offered by the environment is then not the issue, rather it is the lack of any viable alternative" (Joubert *et al*., 1997: 126).

It is evident that the CBA framework implies a potential tradeoff between efficiency and equity (OECD, 2006). For CBA to remain a conducive tool for ranking projects with multiple-objectives, including equity, adaptions need to be made. A pragmatic means of internalising distributional concerns is by adding 'income distributional weights' to the measured benefit and cost streams. The different frameworks by which income weights can be included are outlined by Brent (1998) and Mullins *et al.* (2014). OECD (2006:15) notes that weights are interpreted as "providing a numerical description about the preferences of society regarding distribution". In this light, poorer individuals usually receive a positive weighting. Remaining objective can however become an issue in the attempt to reflect these societal preferences which calls for the use of proxies or

[19]The values attached to preferences have taken form in the context that is not social welfare efficient in terms of distribution and thus only show the values that are efficient given the distribution of wealth in that context (Joubert *et al*., 1997).

standards to ensure consistency. OECD (2006) suggests that the values of weightings be based on governments behaviour with regard to redistributive policies; using the marginal tax rates of a progressive tax system as an example. Another means as suggested by the DEAT (2004a), is to incorporate the distributional weights into a sensitivity analysis matrix.

3.2.4 Measurement

3.2.4.1 Willingness to pay & willingness to accept

An individual's utility or well-being is able to be measured by the maximum amount of money they are willing to pay (WTP) or the minimum amount of money they are willing to accept (WTA) in compensation, for a change in their living conditions incurred through the implementation of a project (OECD, 2006). The WTP/WTA, denominated as a price, will essentially reflect the change from their initial utility to their new utility due to a change in their living conditions.

The theoretically correct measurement of welfare change is measured with reference to the constant real income demand curve (Hicksian demand curve). However, the standard consumer surplus measured in terms of the Marshallian demand curve, provides a good approximation of the Hicksian welfare measurement (Perman *et al.,* 2003)[20]. For more detail on the measurement of welfare using the Hicksian and Marshallian demand curves refer to OECD (2006:45-46) and Perman *et al*. (2003:403-411).

[20] The 'Willig Approximation' is a well-known theoretical result in welfare economics (Willig, 1976).

3.2.4.2 Market imperfections and techniques for correction

Measured prices and the calculation of net social utility that follows is assumed under perfect market conditions. Neoclassical Economic law governs that under perfect market conditions, firms set the price of goods and services equal to the marginal cost of supplying those goods and services (Dasgupta & Pearce, 1978). This means that the price expresses the marginal economic value of that good or service in the market which can be used as the bases for allocation. For a social efficient allocation of resources, price must be equal to marginal social cost. Real-world markets however have many imperfections which result in the market failing to correctly reflect full marginal social costs (DEAT, 2004a). This is illustrated neatly in figure 3.1 where the distance between the marginal social cost (MSC) and the marginal private costs (MPC) represent the market imperfections. Decisions do not maximise social net utility as they are made according to distorted prices.

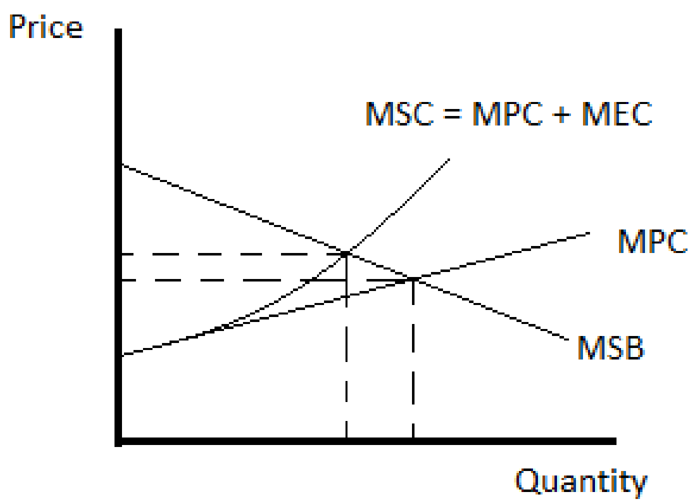

Figure 3.1: Illustration of the unaccounted social costs in real world markets[21] (DEAT, 2004b: 6)

Bearing market imperfections in mind, Van Zyl *et al*. (2005: 27) asks the following questions in sequence, as to determine whether a project remains economically viable after these imperfections have been accounted for by the techniques used within CBA:

1) Is it still viable after correcting for state distortions (taxes, subsidies and tariffs)?

[21] MEC – Marginal External Costs. MSB – Marginal Social Benefit.

2) Is it still viable after correcting for market distortions (monopoly, unfair competition)?
3) Is it still viable after correcting for missing markets (externalities)?

Economic techniques applied to correct for question one are relatively simple, but becomes more technical for questions two and three. These latter two questions are corrected through the application of 'shadow pricing' techniques which aim to provide "[correct] estimates of the underlying marginal opportunity cost of goods, services and factors of production" (DEAT, 2004a: 9). Decisions according to market prices can only be made once these corrections have taken place and total economic value (TEV) is reflected correctly.

According to OECD (2006: 86), the TEV of a change in living conditions due to a project, is the net sum of all the relevant WTPs and WTAs for the project outcome. It is intended to capture the TEV of an environmental good or service or an impact on that good or service derived from the project. The TEV of environmental goods and services is limited to instrumental values[22]. These can be divided into use value, made up of direct and indirect use values, and non-use[23] (or passive) values, which are "values conferred by humans on the [natural or social] system regardless of its use" (DEAT, 2004a: 11). Intrinsic values[24], are however not included in TEV, and are typically associated with the inherent 'rights' of natural systems or their perceived spiritual properties. For more information on what constitutes TEV refer to the DEAT (2004a: 11), and the OECD's "Cost-Benefit Analysis and the Environment: Recent Developments), chapter 6 (Total Economic Value) (2006: 88).

The application of CBA in environmental management calls for a specific variety of shadow pricing techniques to represent TEV. The variety of techniques are particularly suited to an environmental management context where development-related impacts often do not have obvious financial values. The most common valuation techniques mentioned in the literature on

[22] Instrumental value is when something is valued according to how it can create more value i.e. a means to an end.
[23] An example of non-use values are 'option' and 'bequest' values which involve the future use of resources and in this sense is not related to current use. South African environmental policy and legislation is dominated by an anthropocentric view (Hattingh, 2001), and therefore would not typically consider intrinsic values.
[24] Intrinsic value is when something is valued for its own sake i.e. an ends in itself.

environmental management are as follows (DEAT, 2004a; Mullins *et al.*, 2014; Hanley & Spash, 1993, School of Public Leadership, 2015):

- **Contingent Valuation Method (CMV)** – CVM involves establishing how much a stakeholder is WTP or WTA for a change in their living conditions derived from an impact (positive or negative) relating to an environmental good or service. This is conducted through survey method.
- **Hedonic Pricing Method** – The method uses information on a set of variables, including an environmental variable to determine the price of a marketed good. From this, the implicit price of the environmental variable can be derived. An example of this could be the influences of an open-space on nearby real-estate prices (DEAT, 2004a).
- **Travel Cost Method (TCM)** - "The travel cost method seeks to place a value on non-market environmental goods by using consumption behaviour in related markets" (Hanley & Spash, 1993:83). It typically measures how much people are WTP for the consumption of an environmental good or service by taking account of how much it costs people to consume the resource. This method is typically used to value recreational attributes by analysing how far people have travelled and how much they have paid (petrol, park-fees, etc.) to get to the recreational area.
- **Production Function Approaches** – These approaches "link environmental quality changes to changes in production relationships" (Hanley & Spash, 1993:98). The production relationships would typically depend on the ecological functioning or services of that system. In cases where environmental quality decreases, the value of the loss can be measured by taking cognizance of the costs to avoid, mitigate or replace the loss to remain on the same level of welfare.

3.2.5 Discounting

Comparing costs and benefits over time in CBA requires the procedure of discounting whereby "a lower weight is put on the future than on the present" (OECD, 2006: 183). The practice can be justified by environmental economists on both moral and theoretical grounds, but has received much backlash from the environmentalist community. Environmentalists point out that in the case of high discount rates, economic feasibility of environmentally-degrading projects such as mining and nuclear energy is improved by depreciating their long-term costs, as well as exerting pressure on the feasibility of environmental projects due to their typical characteristics of short-term costs and long-term benefits (DEAT, 2004a). Although economic theory justifies discounting, it is often seen as an infringement on the rights of the future generations and in conflict with sustainability-thinking.

CBA is rooted in the Neoclassical School of Thought and therefore adopts the procedure of discounting. For arguments in favour of discounting, one can refer to OECD (2006), and those provided by Olsen and Bailey (1981), and Heal (1986) in Hanley and Spash (1993: 133). The next section will discuss the moral argument surrounding the practice of discounting in more detail and how the discount rate is determined.

3.2.5.1 Moral debate

The moral debate on discounting natural capital seems to ultimately be a divide between two economic camps with differing perspectives on sustainable development and the nature of capital. Those for discounting who adopt 'Weak Sustainability Principles' or no sustainability principles at all, and those against discounting the value of natural systems i.e. a zero-discount rate, who adopt 'Strong Sustainability Principles'.

The weak perspective believes that the future value of natural capital is able to be offset by future developments in physical capital. This allows for natural capital to be discounted in the same manner as physical capital. In contrast, the strong sustainability perspective believes that future well-being is derived from natural capital stock which is not able to be substituted for physical capital, and calls for maintenance of its total stock levels (Goodstein, 2005). The future value of natural capital therefore would not lose value.

3.2.5.2 Approaches to determining the discount rate

The literature on CBA predominantly makes reference to two approaches when setting the social discount rate. The two approaches are; the Social Rate of Time Preference school, mainly concerned with the value of consumption, and the Social Opportunity Cost School, mainly concerned with the return on capital.

Social rate of time preference (SRTP)

For the Social Rate of Time Preference School, “the social discount rate is inherently concerned with the preference of consumption today relative to the preference of consumption in the future” (Brent, 1998:83). Dasgupta and Pearce (1978) give two alternative reasons as to why time preferences may arise. The first reason is a positive one; that society genuinely prefers current consumption to future consumption on the basis of pure myopia. The second reason is normative; because future generations are assumed to have higher levels of income relative to current generations, policy makers should discount according to the principle of diminishing marginal utility of income. The debate between the two sets of reasoning is well discussed by Dasgupta and Pearce (1978).

The literature implies that there are two main methods for the calculation of the social rate of time preference. The first method relates to the principles of the Capital Asset Price Model (CAPM). The principle behind using this model is representing the SRTP as the real long term interest rate. An appropriate proxy may be the rate paid on risk-free government bonds (Mullins *et al.*, 2014). Using this rate as a proxy is attractive as it differentiates itself from the private rate of time preference (PRTP) by excluding a risk and profit premium that would be included in private sector rates (Dasgupta & Pearce, 1978). The only issue is that adjustments will have to be made for distortions brought about through market imperfections which is proved to be complex.

The second proxy for the SRTP is through the calculation of the ‘consumption rate of interest’. This is represented by the Ramsey Equation (OECD, 2006: 187):

$$s = p + u.g$$

In the Ramsey Equation, (s) is equal to the sum of the pure rate of time preference (p) and the growth rate of consumption subject to the laws of diminishing marginal returns on utility $(u.g)$. “g” represents the growth rate of consumption and “u” represents the rate at which utility diminishes in accordance with higher consumption i.e. elasticity of marginal utility of consumption. OECD (2006), critiques this model on the fact that the calculation of these rates are inherently complex, and that the model does not account for uncertainty.

Social opportunity cost school

The public sector's budget much like that of a private firm is also constrained. The Social Opportunity Cost school insists that public spending should seek to maximise its net benefit gained from each investment. Investment into any project involves the opportunity cost of the returns gained from the next most profitable investment alternative, including private sector opportunities (Dasgupta & Pearce, 1987). At the margin, the rate of these returns is known as the 'opportunity cost of capital' (Hanley & Barbier, 2009) and "[reflects] society's valuation of the returns obtained" (Dasgupta & Pearce, 1978:145).

The interest rate on capital shows that current generations make decisions regarding the tradeoffs between present and future consumption. Brent (1998) uses dissimilarities between the private sphere and the public sphere to explain why this interest rate cannot be used as the Social Discount Rate and how the SRTP differs to the Social Opportunity Cost Rate. Under perfect market conditions, the rate at which individuals substitute present consumption for future consumption (Private Rate of Time Preference) would equal the rate at which it is technically possible to substitute present consumption for future consumption (the Opportunity Cost Rate), this is known as the Ramsey Condition (Hanley & Barbier, 2009). The outcome of these two rates would be offered as the interest rate in the capital market and be used as the discount rate for the firm. This is however not the case in the public sphere where a social discount rate is used. Brent (1998) identifies that the SRTP will not equate to the PRTP because, as for one example, not all the returns on investment will be directly received by the saver's kin. He also identifies that in the case of imperfect market conditions, for example the existence of a capital gains tax, both rates of time preference (private and social) will not equate to the Opportunity Cost Rate. Dasgupta and Pearce (1978) suggest correcting for the added risk-premiums and unaccounted externalities that exist in the private sector, in order to show the Social Opportunity Cost of Capital. This rate can then be used as the Social Discount Rate.

Imperfections in capital market conditions and the inconsistency between individual time preference and social time preference result in the market interest rates, the SRTP and the Social Opportunity Cost rate being different. A point of contention arises when the Opportunity Cost of Capital is larger than the SRTP which Dasgupta and Pearce (1978) imply to often be the case.

Assume a public project is being discounted at a rate of four percent, calculated according to the social rate of time preference, but a private sector investment opportunity (e.g. buying of shares) is offering a return of eight percent. This means that the resources invested into the public project could be earning a return of four percentage points more if invested into the private sector. It would thus make more sense to invest into private sector prospects if evaluating projects according to Internal Rate of Return[25]. However, investment decisions may be influenced differently if opportunities were evaluated according to NPV.

Approaches to discounting

Once a discount rate has been determined through which ever of the above methods, it is required to be established in the CBA model. The traditional CBA model, as previously shown, uses a constant discount rate and is exponential discounting. However, there seems to be an increasing number of researchers defending the hypothesis of people discounting the future at a factor that declines through time (Sáez & Requena, 2007). As an example, an opinion-based survey conducted by Weitzman (2001:260) on 2 160 economists concluded that; "even if every individual believes in a constant discount rate, the wide spread of opinion on what [the discount rate] should be makes the effective social discount factor decline significantly over time". This time-declining application is known as 'Hyperbolic Discounting' and is described by the following formulae:

$$PV = \frac{FV}{(1 + r.t)}$$

<u>Where:</u>

PV - Present value

FV - Future value

r - Discount rate

t - Time

Hanley and Barbier (2009) summarise the two main reasons for time-declining discount factors as argued by Hepburn and Koundouri (2007) and Groom *et al*. (2005). The first reason seems to be

[25] The Internal Rate of Return is a discount rate at which the cash flows (positive and negative) of a project produce a NPV of zero. If the actual discount rate used to evaluate the project is greater than the Internal Rate of Return, it implies that the project will produce a positive NPV.

based purely on time preference, and the second reason, is a response to uncertainty with regards to the future social rate of discount. The OECD (2006) identifies two forms in which this uncertainty manifests; uncertainty about interest rates argued by Weitzman (1998, 1999), and uncertainty about growth in the economy argued by Gollier (2002). An example made by Hanley and Barbier (2009), as well as the OECD (2006) of a response to uncertainty is precautionary saving according to future risk which lowers the discount factor through time.

A problem with the approach of time-declining discount factors is the issue of time inconsistency. Where individuals in the future have the incentive to deviate from strategies set in the past. The following hypothetical is given by the OECD (2006: 189):

> "Time consistency requires that generation A chooses a policy, and generation B acts in accordance with it. Generation B does not revise what generation A planned. If generation A's plans are revised by generation B, then generation A will not have optimised its behaviour – what it intended for generation B will turn out to have been wrong".

Sáez and Requena (2007) however insist that they do not consider the argument of time inconsistency as strong enough to discourage the increasing acceptance of the benefits arising from time-declining discount factors. Because hyperbolic discounting involves applying a discount factor that does not decline as steeply towards the end of the programming period (Mullins *et al.*, 2014), long term environmental costs are more thoroughly considered in the analysis. It is for this reason that Mullins *et al*. (2014) suggest applying two discounting models to projects characterized by different time-frames. The two discount models are referred to as 'intra-generational discounting' which applies exponential discounting to projects with time-frames in terms of decades, and 'inter-generational discounting' which applies hyperbolic discounting to projects with time-frames that extend over more than one generation or even hundreds of years (Mullins *et al*., 2014: 63).

3.2.6 Objections to cost benefit analysis

On moral grounds, ecocentrists and many other non-economists have rejected the utilitarian consequentialist ethic that underpins CBA. These parties are in disagreement with the act of judging consequences on the basis of human interest, implying that not only humans should have moral standing in development decisions (Perman *et al*., 2011). They consider ecosystems and their respective entities to have rights in themselves which need to be respected. Embedded within the same debate is the moral contention of pricing natural systems and other complex issues such as human life and time (Harris, 2006). Perman *et al*. (2011: 398) states that "some economists and others, argue, and provide evidence to support the argument, that [humans seeing the environment as an economic commodity][26] is not satisfied, in that people do not, in fact, generally relate to the environment in this way".

On a more applied level, one needs to question the reliability and accuracy of the measurement techniques involved in the CBA. This relates specifically to the limitations of shadow pricing and the immense amount of complexity needed to be considered. These techniques are also criticised as being highly technical and not very transparent, going against the strong agenda of public participation in South African IEM which has arisen as a result of the injustices in the past.

A final objection towards the CBA involves the act of discounting and refers back to the limitations of only maximizing a single objective. A single discount rate does not have the ability to satisfy a variety of objectives involved in development projects (Harris, 2006). A change in the discount rate will impact differently among commercial viability and ecological sustainability for example, and even render different impacts among stakeholder groups. This makes the already difficult and controversial task of setting the discount rate more sensitive. One can attend to this issue by conducting a sensitivity analysis which involves applying different discount rates and reporting on the different effects to better inform decisions (Joubert *et al*., 1997). Even if this is carried out, those who uphold strong sustainability principles would argue that the value of natural capital cannot be replaced and should not devalue through time at all. The purposeful devaluing of natural capital would be seen as an infringement on the rights of future generations according to this view. These problems with the CBA have led to the consideration of some alternative tools used to inform decision-making such as SMART.

[26] Assumption: environmental impacts are not suitable in well-behaved utility functions.

3.2.7 Cost-benefit study illustrating the quantification of some environmental impacts in a hydropower project [27]

3.2.7.1 Background

The study was conducted on the Kukule Ganga (River) hydropower project which began construction in 1999. The objective of the project was to meet the need for additional energy supply to the national grid at the least cost. The aim of the study was to "select an economically optimal alternative for power generation, within the limits of 'acceptable impacts' to the environment, by examining the layout of major structures, scale of storage and power plant" (Ranasinghe, 1994: 244).

From the preliminary screening of information in the pre-feasibility study, 42 alternatives for financial analysis, and six alternatives for economic and environmental assessment were selected. These alternatives are shown in table 3.1.

Table 3.1: Alternatives for economic and environmental assessment (Ranasinghe, 1994: 245)

Project Alternatives	**Key**	**Economic**	**Environmental**
Waterways		2	2
Intake-Kukule; outfall-Kukule	K-K		
Intake-Kukule; outfall-Peleng	K-P		
Full supply level(metres above sea-level)		3	3
Run of River – 206	ROR		
Low Dam – 230	LD		
High Dam - 242	HD		
Capacity factors		7	
Total		42	6

[27] This section is based on: Ranasinghe, M. 1994. Extended benefit-cost analysis: quantifying some environmental impacts in a hydropower project. *Project Appraisal*, 9(4): 243-251.

An economic analysis based on preliminary benefit and cost estimates concluded that the preferred alternative was the run of river configuration with intake and outfall of water at the Kukule Ganga (K-K ROR) and having an installed capacity factor of 1.5. The environmental impact assessment also suggested that K-K ROR was the most preferred option from an environmental perspective. The observed impacts of this alternative according to the environmental assessment were:

1) The disruption of migration patterns for fish and other aquatic animals by the weir.
2) The disturbance of natural habitats for fauna and vegetation due to flooding. This was however determined to be almost negligible.
3) Risks of eutrophication in in a small regulatory pond. This was also determined to be almost negligible.
4) The resettlement of approximately 100 people due to the inundation of land.
5) It was determined that no cultural or archaeological sites would be affected.
6) Increased risk of malaria. This was also determined to be negligible.

The information from the feasibility study and the environmental impact assessment was used to inform the CBA. Given that the need for energy needed to be fulfilled, a key consideration of the project and study was the opportunity costs arising from thermal energy as the next most preferred alternative. It was estimated that thermal energy was more expensive and more environmentally degrading than hydropower. The avoided costs of thermal energy (economically and environmentally) were included as benefits in the extended benefit-cost analysis.

3.2.7.2 Description of method

“The objective of the extended benefit—cost analysis [was] to analyse and quantify the two important issues that were ignored in the feasibility study for the Kukule Ganga hydropower project” (Ranasinghe, 1994: 246). Firstly, the economic feasibility of the K-K ROR alternative was analysed and estimated only from the feasibility analysis. When the full financial analysis using market prices compared the costs of the project with the benefits of the project -being the sale of power tariffs and avoided costs on thermal energy- a 9.28% rate of return was rendered. This rate of return was below the hurdle rate of 10% required for investment into infrastructural projects. For a 10% discount rate (as suggested by the World Bank) a negative net present value calculated. However, when the financial analysis was adjusted using shadow prices, the K-K ROR alternative proved to be economically feasible as well as the most environmentally friendly.

The second issue was to quantify the environmental impacts and integrate them into the economic analysis. Impacts were determined by comparing the 'with project' and 'without project' scenarios, and assumed that costs in an environmental sense would be avoided by using hydropower instead of thermal power. These avoidance costs were used as benefits for the hydropower project.

With regards to the environmental costs of the hydropower project, resettlement of people and the opportunity cost of lost production was included in the engineering costs as standard practice. Other significant impacts which were not accounted for were; the loss of carbon dioxide (CO2) sequestration from the inundation of 70ha of land, and the impacts on fish affected by the weir. These impacts were not included due to lack of information on sequestration rates and the costs of CO2, and because the affected fish were suggested to have a very low economic value and that fishing was not an established economic activity in the project area.

In response to the inability to quantify the costs of the hydropower project, the benefits of avoiding the costs of the thermal project were assumed to offset. It was assumed that "the environmental cost of air pollution caused when generating… from the best capacity thermal plants is assumed to be the equivalent environmental benefit to Kukule Ganga hydropower project, due to the cleanness of the hydropower generation".

The first step taken to approximate the environmental cost of air pollution was to define the emission coefficients for the main thermal-power pollutants of sulphur-dioxide (SO2), nitrous-oxide (NOx), CO2, and particulates. The second step was to estimate the damage costs related to the pollutants in the Sri-Lankan context by defining the relationship between air pollution and health effects. To quantify the costs of SO2 and NOx, the 'loss of human earnings (human capital) approach' was used. This involves adopting the 'dose-response function' which is interpreted as "the probability that an individual will contract bronchitis in any one year if exposed to a unit of per volume of particulates for the entire year" (Ranasinghe, 1994: 249). To overcome a lack of epidemiological data, the researcher made a reverse calculation by estimating the per case cost for a Sri Lankan hospitalised for bronchitis. To value the costs of CO2 pollution, a 'shadow project approach' was used. This was based on the cost of reforestation for an area with the equivalent sequestration of CO2.

The calculated costs of thermal pollution were used to value the different thermal energy alternatives; gas, diesel and coal. Finally, the costs of the best thermal expansion were used to offset the environmental costs of the hydropower project. The extended net present value of the project with environmental benefits at a discount rate of 10% held a positive value and satisfied the hurdle rate for investment in infrastructural projects. The results were further seen to be underestimated as the costs of discharged heated cooling water from the thermal powerplants was unaccounted for.

3.3 Multiple Criteria Decision Analysis (MCDA) and the Simple Multi-Attribute Ranking Technique (SMART)

3.3.1 Introduction

SMART is suggested as an alternative tool to CBA for ranking a set of project alternatives with environmental impacts. SMART is one of the many techniques and methods applied under the Multiple Criteria Decision Analysis approach. This next section will give a definition of the MCDA approach, as well as a brief background on its growing interest in academia and why it is suited to environmental management. The theoretical foundation of the approach will then be discussed followed by a description of the general process according to which MCDA techniques and methods are implemented. An overview of SMART and its methodology will then be given.

MCDA is applied for the purpose of "[evaluating] and [choosing] among alternatives based on multiple criteria using systematic analysis that overcomes the limitations of unstructured individual or group decision-making" (Kiker *et al*., 2005: 97). "[The] process holds a similar logic to one that occurs in the human brain but has the ability to process more information" (Herath & Prato, 2006:2). The processing power lies in the ability to record a large information set and integrate its compendium of values using an algorithm defined by relevant axioms that reflect the desired decision-making logic. An important distinction made by Munda (1993), which aids in the understanding of the approach, is that between Multiple Criteria Decision-Making (MCDM) and MCDA. Munda (1993:43) states that "MCDM models assume that the decision-maker's preferences are made perfectly explicit, so that the only thing left to do is to consider a well-formulated mathematical model". This is different to MCDA as it's "principle aim is not to discover a solution but to construct or create something which is viewed as liable to help an actor taking part in a decision process either to shape, and/or to argue, and/or to transform his preferences" (Roy cited in Munda, 1993).

According to a bibliometric analysis presented on the International Society on MCDM's website, which encompasses both MCDM and MCDA, the field of study became exponentially popular in the academic community around the 1990s. With specific reference to its adoption in environmental management, a study of applications and trends by Huang *et al*. (2011) showed that there was significant growth in the application of MCDA in the two decades leading up to the year in which the article was published. They believe that the growth could have been "attributed to both increased decision complexity and information availability and regulatory and stakeholders push for transparency in the decision-making process" (Huang *et al*., 2011:3583).

It is widely agreed that environmental management decisions are inherently complex, especially so in a third world context where much emphasis is placed on the involvement of stakeholder views that often maintain different priorities and interests. Herath and Prato (2006) are in agreement with the beliefs of Huang *et al.* (2001) and insist that as this complexity increases, so does the demand for analytical methods that can consider a variety of attributes and objectives. They also highlight the need to bring legitimacy to bureaucratic processes, resolve conflicts and reduce public distrust. Munda (1993) suggests that this is the main advantage of MCDA techniques and methods as they are able to create common scales according to which heterogenous attributes can be compared and initiate a democratic process that integrates all stakeholder views.

3.3.2 Procedure for conducting a multiple criteria decision analysis

The procedure of MCDA described here is based Belton and Stewart (2003) and Joubert *et al*. (1997). The former authors discuss the process of MCDA which is more broadly divided into three phases; problem structuring, model building and developing an action plan. Joubert *et al*. (1997)

give a more detailed outline of the procedure which can be integrated into these three phases as follows.

Phase 1: Problem structuring

'Problem structuring' is regarded as one of the most important tasks in the MCDA process as it will wholly determine which MCDA method is used, the rules of the model and what content the model will process. It is considered a scoping exercise and is therefore to be conducted at the beginning of the project process. The analyst is required to identify the project alternatives, decision-makers and the affected stakeholders, as well as facilitate the setting of project goals and objectives.

Phase 2: Model building

After the project and its respective goals and objectives have been outlined, the stakeholders can decide on which criteria and respective weightings will be used to evaluate the different alternatives. The stakeholders score and weigh these criteria which are then processed according to a specific method that is theoretically and practically suited to the content of the study. After the method produces an outcome, the analyst has the option of conducting a sensitivity analysis on the allocated weights to observe how these weights affect the different stakeholders. The information derived from the sensitivity analysis can be used as additional information to aid the decision-maker.

Phase 3: Developing an action plan

Once the outcome of the MCDA method is finalized, it is combined with other information sets used to aid the decision-maker with the project problem.

3.3.3 Theoretical foundations

The following section has been structured to make the two tools' (CBA and SMART) theoretical foundations more easily comparable. The contrast of the theoretical foundations between CBA and MCDA already points to certain strengths and weaknesses in terms of sustainability-thinking principles. A conclusion can only be drawn once the framework developed in chapter 3 has been applied.

3.3.3.1 Value

Much like CBA, MCDA is also rooted in utilitarian precepts and on a theoretical level relies upon the assumptions that the stakeholders of the tool are rational, have perfect knowledge, are consistent in decision-making and have preferences that do not change after the model has been constructed (Kiker *et al.*, 2005). In MCDA, the term utility is referred to when using models that manage uncertainty probabilistically. This is not a property of the SMART model and therefore the term 'utility' is substituted with the term 'value'. Value is backed by preferences according to which project alternatives are scored.

The manner in which utility is maximised for CBA is however significantly different to how value is optimised in MCDA. The CBA seeks to maximize a single objective (NPV) by which the additive function compensates attributes that add to or detract from the NPV. The NPV is then compared among alternatives and also gives an indication as to whether the project is worth pursuing. In contrast, MCDA aims to optimize the value of an alternative by compensating its value between multiple objectives. This results in an overall value score of the alternative which is then used for comparison and ranking among the set of alternatives. Without additional augmentations, for example the inclusion of a satisficing model[28], the tool is limited by its ability to only compare alternatives relatively and not give a good indication of feasibility.

MCDA models present themselves in the form of compensatory, optimization algorithms that represents a specific mathematical theory with a determined set of axioms (Munda, 1993). These axioms are structured to represent the preferences of the decision-maker. The value score derived from the processed inputs is a measure of the overall benefit of the investigated alternative, relative to the other options in the selection set (Hajkowicz & Higgins, 2008). The different MCDA methods will be briefly discussed later in this section. Munda (1993) describes these methods as prescriptive in nature as they "[do] no more than propose a series of rules which the decision-

[28] A satisficing model is suggested by Simon (1976) in Belton and Stewart (2003: 104). "Satisficing is a decision-making strategy that aims for a satisfactory or adequate result, rather than the optimal solution" (Investopedia, 2017). It can be integrated into a decision-making model by setting minimum standards of achievement.

maker should respect if he/she wishes to reach a specific [decision] objective". It does not provide the decision-maker with a final decision.

One of the main attractions of MCDA methods is that they are "inherently participatory in a number of senses" (Stewart *et al*., 1997: 51). An example of this is in cases where a project alternative may hold the highest value score, but may be rejected through the negotiation process as the alternative is of the lowest possible value for one of the interest groups (Joubert *et al*., 1997). Only once value is perceived to be distributed to a satisfactory standard among all stakeholders involved, can an outcome be presented. Engaging in participation improves public understanding and increases the capacities of government and assessment practitioners to respond to public needs and demands (Herath & Prato, 2006). This implicitly enhances the ability of projects to provide a higher overall value to all stakeholders by enhancing the knowledge base that can contribute to the provision and evaluation of inputs.

Value scores have to be measured for each stakeholder group, as well as how the project alternatives score according to a variety of objectives, for example, economic, social and ecological. This multiplicity exacerbates the complexity in the decision-making context and has to dealt with by the MCDA methods. The manner in which MCDA methods handle multiplicity is discussed in the following section.

3.3.3.2 Multiplicity

Formal MCDA is only required when multiplicity is a major feature of the decision-making problem and human intuition cannot be used (Belton & Stewart, 2003). Multiplicity is introduced by the complexity involved in projects with environmental impacts and the need to integrate and manage ecological, social and economic systems with the aim of achieving sustainable development. It manifests in the variety of objectives, information sets and stakeholder views and expectations.

One of the first attempts to structure this multiplicity is through the creation of an organised hierarchy, as suggested by Stewart *et al*. (1997). The hierarchy can be described as having broad societal goals at the top -such as sustainable development- followed by higher level objectives for example; economic efficiency, social prosperity, ecological integrity. A hypothetical example of this is given in figure 3.2. Below these objectives are intermediate criteria which can be broken down into measurable attributes. Measurable attributes are attributes that are measured in scientific form which are then transformed into value scores according to preferences (see section 3.3.4.2). This can be considered as the counter-part of shadow-pricing for CBA as the aim is to integrate information from different domains making it comparable for decision-making. These components of the hierarchy would be determined as part of the "problem structuring phase" of the MCDA, as developed by Belton and Stewart (2003). The categories will be determined by the different stakeholder groups and therefore stands as one of the main components of the participation process. Negotiation on the content of these categories involves trade-offs among stakeholder views and their preferred criteria, provided there is a willingness to compromise.

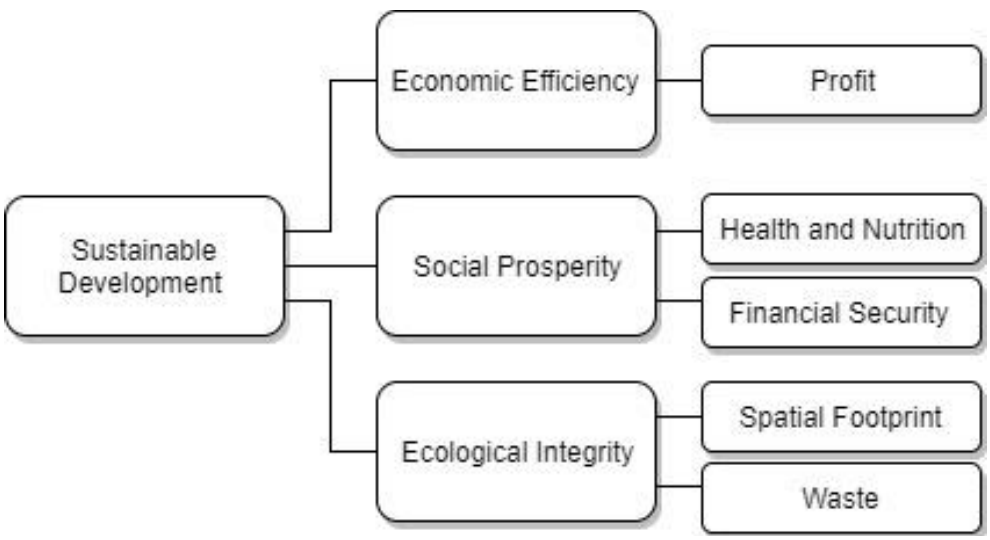

Figure 3.2: Hypothetical example of an organised hierarchy for MCDA methods (Own compilation)

Alternatives (m), criteria (n) and scores (a) are usually formatted in an "evaluation matrix" (Hajkowicz & Higgins, 2008), as illustrated in figure 3.3. According to Kiker *et al.* (2005) almost all decision analysis methodologies use this form of matrix, after which "each MCDA methodology synthesizes the matrix information and ranks the alternatives by different means" (Yoe, cited in Kiker *et al.*, 2005). Scores are represented as real numbers. Munda (1993) outlines four scales of measure; nominal scale, ordinal scale, interval scale and ratio scale. He also helps simplify these scales by categorising them into quantitative (interval and ration) and qualitative (nominal and ordinal).

$$A = \begin{bmatrix} a_{1,1} & \cdots & a_{1,n} \\ \vdots & \ddots & \vdots \\ a_{m,1} & \cdots & a_{m,n} \end{bmatrix}$$

Figure 3.3: Format of the 'Evaluation Matrix' used in MCDA methods

Quantitative scores for these criteria are gathered through research, monitoring, estimated through expert judgment, and survey studies with relevant stakeholders (Kiker *et al*., 2005: 96). Some examples of quantitative scores for criteria could be capital cost in Rands for economic criteria or particulate matter per cubic metre for water pollution criteria.

Qualitative information may be required in some environmental management cases. An example of this may be a description of a community's level of subsistence on a water body, or what the value of an alternative is in terms of an environmental impact criterion (Triantaphyllou, 2000). Difficulties arise when aiming to combine qualitative information and quantitative information in order to make decisions. Both quantitative and qualitative measurements are denominated in their original units. These units then need to be standardised in order to be made commensurable. Various techniques are able to transform qualitative data into numerical scales which allows for comparison with quantitative data (Munda, 1994).

The final, generic component of the algorithm is the addition of weights to each criterion. These weights perform two functions; conjoint scaling[29] of criteria to make them comparable, and giving an indication of the relative importance of each criterion (Joubert *et al*., 1997). Munda (1993:44) states that these functions are strictly aligned with the concept of compensation and that "there should be a consistency between the aggregation procedure used and the questions asked of the decision-maker in order to elicit a set of weights". If this is not done, one runs the risk of combining

[29] Conjoint scaling is described in Step 3 of the SMART process.

a weighting technique which is not theoretically compatible with the aggregation model (Munda, 1993). After weights have been established, a sensitivity analysis can be applied to allow for exploration of alternative perspectives on the matter and provide aid to the decision-maker on which final weighting scheme is most suitable (Belton & Stewart, 2003).

3.3.4 Overview of the MCDA method analysed in this study: Simple Multi-Attribute Ranking Technique (SMART)

Introduction

A variety of MCDA methods exist and are applied in accordance with the decision-making context. Best practice involves the selection of the method best suited to the decision context and will be assumed to produce the best outcome to aid decision-making. Only the Simple Multi-Attribute Ranking Technique will be scrutinized and compared with the CBA. This method was considered as the best suited method for the decision-making context used in this study.

The Simple Multi-Attribute Ranking Technique (SMART) is classified under Value Function Methods[30], and is more specifically an example of a Multi-Attribute Value Theory (MAVT). Value Function Methods use compensatory optimisation in the aim to represent the merit of each alternative with a real number, as an indication of its value or utility. The models present a preference order among alternatives, reflecting the decision-maker's value judgements (Belton & Stewart, 2003). A typical MAVT function can be illustrated by figure 3.4.

$$V(A) = \sum_{i}^{n} a_i . w_i$$

Figure 3.4: Typical MAVT function

<u>Where</u>:

$V(A)$ - Value score for Alternative A.

a_i - Preference score for attribute i.

w_i - Weight for attribute i.

[30] Also includes Multi-Attribute Utility Theory (MAUT) which considers the preferences for risk.

The advantages of SMART lie in its simplicity in understanding, and its allowance for a deeper level of engagement with the parties affecting its inputs. This makes SMART one of the most commonly applied methods in environmental management cases (Joubert *et al*., 1997; Kiker *et al.*, 2005). Steps in the process, such as scoring and weighting, requires the application of additional techniques which can be chosen to best suit the decision context.

The explanation of the SMART process in this study was mainly adapted from Goodwin and Wright (2004)[31]. Given the flexible nature of the technique, the process has been fine-tuned to suit the environmental management context. It has been adapted to include multiple stakeholders and will be described as including a public participation process with multiple rounds of workshops. For axioms and assumptions upon which the technique relies, please see Goodwin and Wright (2004: 48). All examples used in this section are purely hypothetical and are used for illustrative purposes.

Steps in SMART

Step 1: Scoping of parameters.

The scoping stage seeks to establish the parameters of the analysis that fit the context of the study. This involves identifying the decision-maker(s), a set of alternatives, stakeholders and the set of impacts relevant to the decision problem. The scoping step should also include the first-round of the public participation process. In the participation process, stakeholders are given the opportunity to identify which impacts are of greatest importance and will be used as evaluative criteria for the alternatives. It is important to mention here that the term “impacts” include both negative and positive outcomes of the project alternatives.

Criteria established in the participation process may be vague at first, and are required to be decomposed into more specific measurable attributes. Goodwin and Wright (2004) suggest that the construction of a ‘Value-Tree’ (figure 3.5) can be useful here and is seen as a clear method of structuring the decision problem. Within the value-tree, higher-level criteria are phrased as

[31] Chapter 3 - Decisions involving multiple objectives: SMART

objectives which need a direction of movement e.g. increasing or decreasing. The performance of alternatives are measured in relation to the direction of higher-level criteria. Keeney and Raiffa (1976) also suggest the following five criteria to ensure that the value-tree is accurate and a useful representation of the decision problem (Goodwin & Wright, 2004).

1) Completeness – all attributes should fully represent the decision problem.
2) Operability – lowest level attributes in the value-tree are specific enough to be measured and compared among alternatives.
3) Decomposability – ensuring mutually preferential independence. This is where the judgement of an attribute is independent of all other attributes i.e. there are no casual relationships.
4) Absence of redundancy – the are no inherent variables in the different attributes which may result in double-counting when being measured.
5) Minimum size – ensuring that lower-level attributes are not decomposed beyond necessary.

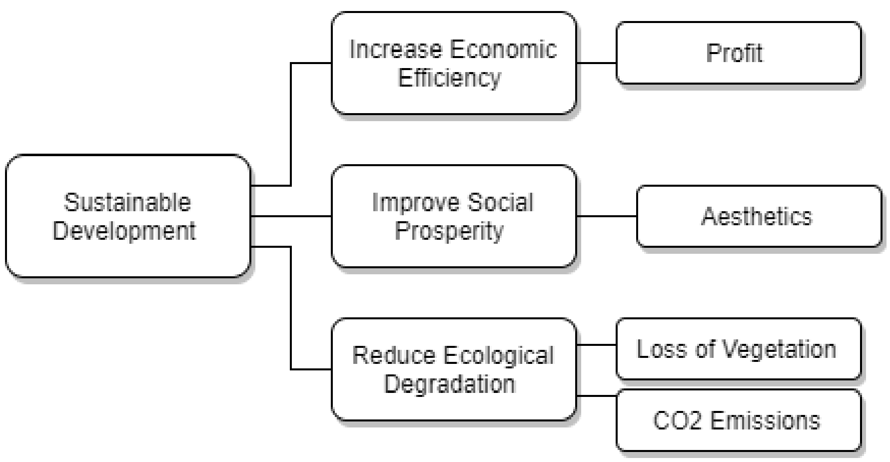

Figure 3.5: SMART Value-Tree (Own compilation)

Step 2: Measure the performance of each alternative in terms of each attribute.

After lower-level, measurable attributes have been established, the next step is to identify variables which will be used as the measuring units. For example, for the objective 'Minimising ecological degradation', the attributes of 'loss in indigenous vegetation' and 'increase in pollutive emissions' could be measured in metres-squared and parts per million, respectively. Descriptive scales may be used to transform qualitative data into quantified units, for example the Beaufort Scale. These measurements are taken across alternatives for all attributes. Measures should be conducted by specialists within a discipline relevant to the impact.

At this stage, measures in their scientific form are denominated in different units which make comparison rather difficult. Measures are required to be transformed into value scores in order to represent relative performance on an attribute and make the scores commensurable. This is carried out in the second round of the participation process where stakeholders are given the opportunity to score measurements. Goodwin and Wright (2004) suggest two methods in order to transform measures into value scores; direct rating and value functions. Both methods may make use of 'thermometer scales' where the maximum score on an attribute is given a value score of 100 and a minimum score is given a value of 0. Any unit scale of this can be used as long as it is simple and logical e.g. 0 – 10.

The Direct Rating method may be applied to attributes that do not have easily quantifiable variables (Goodwin & Wright, 2004), and when the use of descriptive scales may not be necessary. An example of this could be 'aesthetics'. Stakeholder groups are required to first rank alternatives in terms of aesthetics and then directly apply a value score to each alternative in terms of an interval scale. An example of a Direct Rating method for the attribute 'aesthetics' on a thermometer scale for alternatives; A, B, C and D is given in figure 3.6.

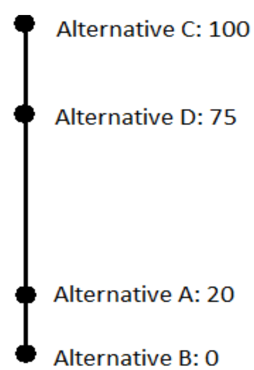

Figure 3.6: Direct Rating method using a thermometer scale[32]

[32] All figures and tables in this section are hypothetical examples for illustrative purposes.

According to Goodwin and Wright (2004), the value function technique can be used for attributes which have more easily quantifiable variables. The attribute used as an example here will be 'loss of indigenous vegetation'. This technique also begins by ranking the alternatives in order of their measurement on the attribute. It is important to note here that the above objective was phrased as 'Minimising Ecological Degradation' which implies that the alternatives with the least indigenous vegetation loss will be ranked the highest. For illustrative purposes refer to table 3.2.

Table 3.2: Scientific measurements for the loss of indigenous vegetation of each alternative.

Loss of Indigenous Vegetation		
Rank	**Alternative**	**Attribute measurement**
1	Alternative B	$100m^2$
2	Alternative D	$150m^2$
3	Alternative C	$300m^2$
4	Alternative A	$350m^2$

Goodwin and Wright (2004) then apply the "Bisection Technique" which divides the thermometer scale by setting a midpoint between the highest and lowest scores, and two quarter points as shown in table 3.3. Stakeholder groups determine which value is attached to each bisection point according to their preferences (see figure 3.7), and not the scale of scientific measures on the attribute. It is noted that there are alternative methods to construct a value function, but establishing five points in the value functions is seen to be sufficient (Goodwin & Wright, 2004). Scientific measures can be integrated into the value function to produce value scores which can then be used to construct the thermometer scale. An example of the value function and thermometer scale can be shown in figure 3.8 and figure 3.9, respectively.

Table 3.3: Values of a bisection technique

Maximum	$100m^2$
High quarter	$120m^2$
Mid-point	$175m^2$
Low quarter	$200m^2$
Minimum	$350m^2$

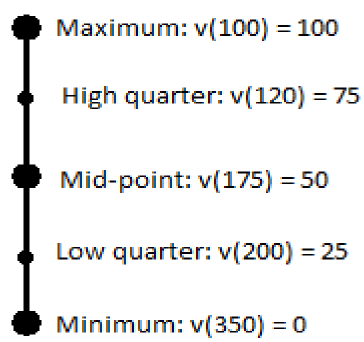

Figure 3.7: Thermometer scale showing the values of a Bisection Technique

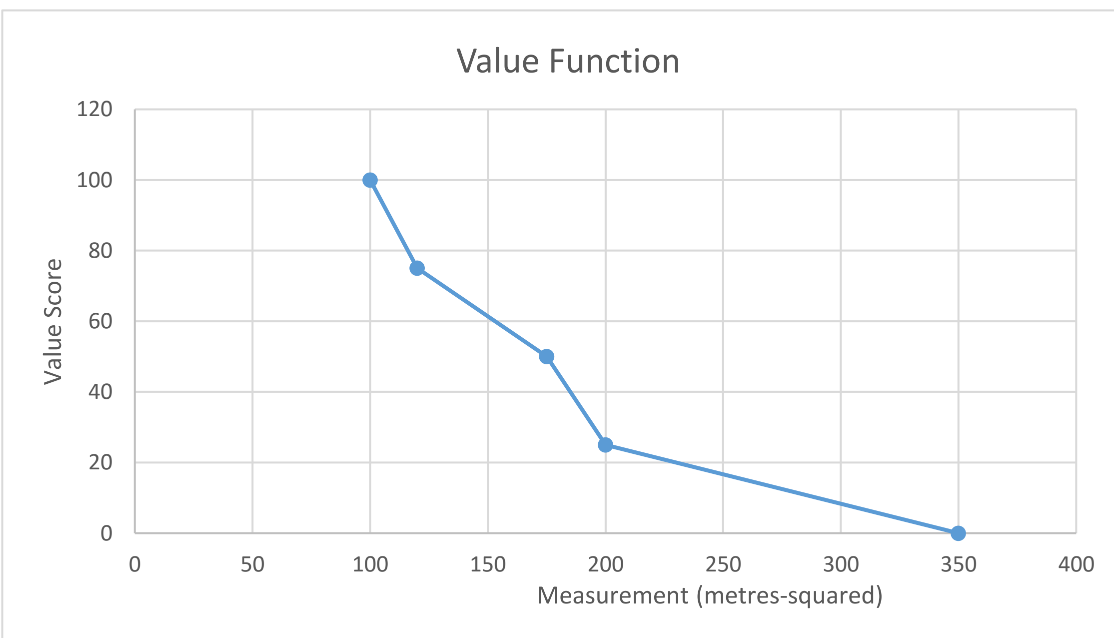

Figure 3.8: Line Graph illustrating a Value Function

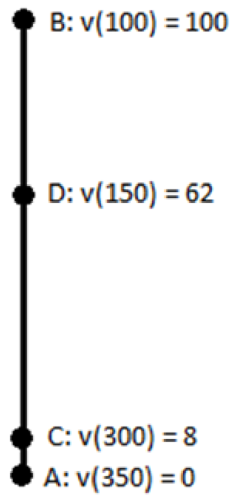

Figure 3.9: Thermometer scale showing the value score outcomes according to the Value Function

Step 3: Determine weights for the attributes.

The attachment of weights in SMART performs two functions. The first function is for 'conjoint scaling' which makes all values scores which were previously denominated in different units commensurable. For example, the value range of 100-0 for $100m^2$ to $350m^2$ for indigenous vegetation cannot be compared with a value range of 100-0 for $2 000 000 to $1 700 000 in profits. The second function is to instil relative importance among criteria that reflects the preference of the stakeholder groups. For example, changes in profit which are equal to the relative changes in vegetation loss may be more important for the stakeholder group.

The weighting technique applied in Goodwin and Wright (2004) to perform these two functions is called "Swing Weighting". Swing weights are derived by "asking the [stakeholder group] to compare a change (or swing) from the least-preferred to the most-preferred value on one attribute to a similar change in another attribute" (Goodwin & Wright, 2004: 41). The technique starts off by ranking the attributes into an order of preference. Stakeholders groups are asked to imagine all attributes at their lowest measurements and then rank which attribute they would improve to their maximum level first, second, third, and so on, to form an order of ranking. The attribute which is ranked first is given a weighting score of 100.

Next the stakeholder group is required to compare, in percentage terms, the importance of the swing from maximum (100) to minimum (0) score for the second ranked attribute, with the swing of the first ranked attribute. The percentage score will be set as the weighting score. From then on, each lower ranked attribute of importance is compared with the first ranked attribute according to the same method to derive the respective weights. Weights are then normalised to the nearest whole number to form a sum of 100. This process is illustrated in table 3.4.

Table 3.4: Outcome of a SMART swing weighting process

Preference Ranking of attribute	**Max (100) measurement**	**Min (0) measurement**	**Importance of Swing (%)**	**Weight**
1) Profit	$2 000 000	$1 700 000	100	38
2) Loss of vegetation	$100m^2$	$350m^2$	80	31
3) Aesthetics	8	2	50	19
4) CO2 Emissions	141 metric tonnes/pa	235 metric tonnes/pa	30	12

Weights then transcend the value-tree cumulatively where the weights of higher level objectives are a sum of their lower-level attributes as shown in figure 3.10. It must be noted that a weight given to an attribute is sensitive to whether or not the attribute has been split into lower-level sub-attributes. Goodwin and Wright (2004) suggest that to combat this, stakeholder groups are asked to compare the hypothetical weight given to the attribute in isolation, and the weighting calculated by the sum of its sub-attributes, all with the aim of resolving the inconsistencies.

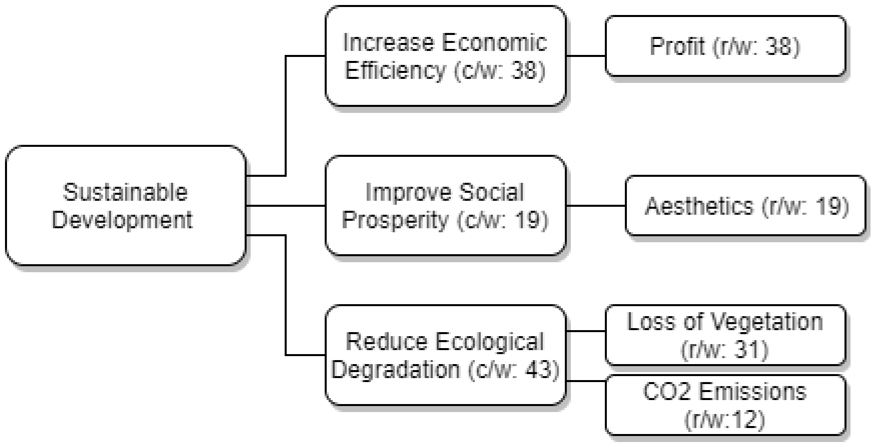

Figure 3.10: Value-tree showing the outcomes of a SMART swing weighting process[33]

Step 4: For each alternative, take a weighted average of the values assigned to that alternative.

This stage of the technique is where the overall value of each alternative is calculated per stakeholder group. For each alternative, the value scores for an attribute are multiplied by the weight of that attribute, and then summed across all attributes to form a final product as shown by the algorithm:

$$V(A) = \sum_{i}^{n} a_i . w_i$$

Value scores calculated per alternative for each stakeholder group can then be summed across all stakeholder groups. The final value scores can then be used to rank the preference order of the alternatives. Examples of the inputs and outputs of the algorithm is illustrated in table 3.5.

[33] Cumulative weight (c/w) and relative weight (r/w).

Table 3.5: A hypothetical example of the inputs and outputs of the SMART algorithm

	Profit (r/w: 0.38)	**Aesthetics (r/w: 0.19)**	**Loss of vegetation (r/w: 0.31)**	**CO2 Emissions (r/w: 0.12)**	**Value Score**	**Project Ranking**
Alternative A	75	20	0	45	37.7	**3**
Alternative B	30	0	100	0	42.4	**2**
Alternative C	100	100	8	100	71.48	**1**
Alternative D	0	75	62	20	35.87	**4**

Step 5: Conduct sensitivity analysis

"Sensitivity analysis is used to examine how robust the choice of an alternative is to changes in the figures used in the analysis" (Goodwin & Wright, 2004). In this model, it may be useful to apply the sensitivity analysis to the parameters of the value functions, scores and weights (Belton & Stewart, 2003). Particularly useful information on the preferences among stakeholder groups may be derived from this analysis and will can be helpful when considering equity-related objectives.

3.3.5 A MCDA process of the conflict between forestry and reindeer herding in Finnish Upper Lapland.[34]

3.3.5.1 Background

This study aimed at increasing the overall understanding of a conflict situation surrounding the logging of old-growth forests in the Upper Finnish Lapland. The conflict had existed for decades and included those wanting to capitalise on the economically viable logging potential of the old-

[34] Based on Saarikoski *et al*. (2016) and Mustajoki *et al*. (n.d.).

growth forests, and the indigenous Sámi people who had free access to use the forests as reindeer pastures in the winter. The reindeer depended on the hanging tree lichens when the ground lichens were covered in snow. In addition to this, the forests were also valuable wilderness areas which attracted tourism.

3.3.5.2 Description of method

A participatory MCDA process, using a MAVT approach was carried out and began by identifying the 15 key stakeholders involved in the conflict situation. These stakeholders included; forest sector representatives, reindeer herders, Sámi organisations, local municipalities and Environmental Non-Governmental Organisations. Five preferred alternatives for the area of forestry were established:

- Alternative 1: 300 000m^3
- Alternative 2: 150 000m^3
- Alternative 3: 115 000m^3
- Alternative 4: 80 000m^3
- Alternative 5: 30 000m^3

The criteria covered the ecological, socio-cultural and economic aspects of the debate and are shown in figure 3.11. Criteria scores were informed by an impact assessment which was carried out by the Finnish Forest Research Institute. It was decided that the impacts of the logging were to be included over the long-term (30-year time span). The decision was made because logging is planned on a strategic level as it is affected by various external factors. Also, the impacts of logging could only be seen after some time and therefore a long enough time span was needed to estimate the effects.

The criteria weights were elicited from stakeholders using interactive interview software. In the interview, stakeholders were briefed on the objectives of the interview, the background material, the MCDA approach, and then preceded to input their preferences into the tool. Stakeholders were engaged with at two rounds; the scoping stage and the scoring and weighting stage.

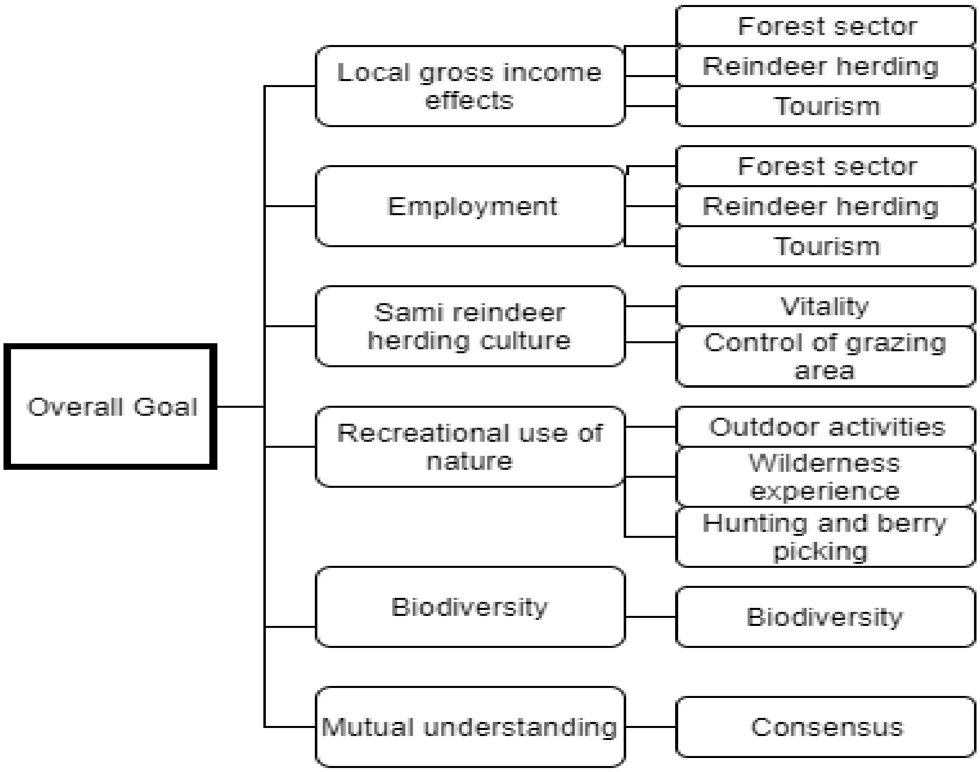

Figure 3.11: Value-tree showing the criteria and sub-criteria for the case study (Saarikoski *et al.*, 2016)

Once the criteria had been allocated scores and weights they were input into the MAVT model for each stakeholder group:

$$v(x) \sum_{i}^{n} w_i . v_i(x_i)$$

<u>Where:</u>

$v(x)$ – Value score for Alternative X.

v_i - Preference score for attribute i

w_i - Weight for attribute i.

Although the final results of the model in this case study was unable to find an agreement among the stakeholder groups, the study did achieve its main objective of increasing an overall understanding of the problem. Other observations relating to the process showed a promotion of learning and reflection, as well as the importance of stakeholder engagement at multiple rounds.

Chapter 4: Evaluation and comparison

4.1 Introduction

In this chapter, CBA and SMART will be evaluated in terms of its ability to meet the IEM sustainability-thinking principles and the respective objectives as set out in chapter 2. After each tool has been evaluated on their *potential* abilities to fulfil the objectives they will be compared. This will be done for each principle individually. Given the flexibility of the tools in application, various adaptions were suggested for each of tools in order illustrate their full potential in terms of sustainability-thinking. The author only attempted to suggest more simple adaptions given the fine-line between simplicity and accuracy issues that characterises the decision context. A comparative matrix is provided at the end of each principle to summarise the evaluation and comparison.

4.2 Philosophical principles

4.2.1 Integration of Systems

The integration of systems implies that the tools ought to abide by four considerations in order to best align itself with sustainability-thinking. The first consideration refers to the tools ability to recognise the three fundamental systems being the ecological system, the social system and the economic system. The second consideration, surrounds the reality that these systems manifest in a sort of hierarchical structure. The ecological systems comprise the basis upon which social interactions are formed, and through these social interactions, economic contracts are developed. Although the systems can be identified to form this hierarchical structure, the three systems maintain interdependent relationships which results in additional emergent properties. These two properties make-up the third consideration. The final consideration refers to the spatio-temporal dynamics of the systems mainly concerning the cumulative impacts of human activity in a wider systems perspective and the need to maintain the resilience of the relevant interconnected systems.

4.2.1.1 Cost Benefit Analysis

The CBA is able to recognise the three fundamental systems (ecological, social and economic). This recognition is first established in the scoping stage of the tool when the impacts of each alternative are identified. Common practice is to take cognisance of the impacts on the three fundamental. The second stage of the process measures the costs and benefits of the project in terms of the impacts TEVs, first by determining the functional relationship between the project and the impacts, and second, assigning a monetary value to the impacts. The aim of the monetary value is to represent the TEV of the impacts as reflected by a perfect market. However, due to the externalities that surround ecological goods and services, the monetising process may experience various limitations. Mullins *et al.* (2014: 31) make special reference to the existence of environmental externalities which are seen as “the effects of a project on the environment, ecology, or general standard of living of a community which are not reflected by the prices of inputs or outputs”, and thus do not have their TEV represented in the market. In order to correct for these market imperfections shadow pricing methods are used with the intention to represent the TEV for impacts in each system.

CBA has the ability to internalise the hierarchical structure of the three systems, but is limited to only the instrumental values accruing from each system. The tool relies on the preferences behind stakeholders’ WTP for the goods and services produced by each system to structure them according to the hierarchy. The accuracy of stakeholders’ preferences is bolstered on three assumptions. Firstly, it is assumed that the hierarchy of the systems is in itself theoretically correct. Secondly, it is assumed that stakeholders are rational actors intending to maximise their utility. Third and finally, that perfect information is held by these stakeholders who make informed decisions. Bringing these three assumptions together implies that stakeholders would, upon information, understand that the amount of utility derived from each system is in general governed by the hierarchy. In turn, they should be more likely to favour improvements per system according to the hierarchy with the aim of maximising their utility.

In the CBA process, it generally should be shown that stakeholders are willing to pay relatively more for the improvement of each system according to the hierarchy. As a general example, negative impacts in ecological systems, like deforestation, would cost relatively more than negative impacts in economic systems, like the loss of revenues from ceased timber-products. This is provided that the assumptions discussed above hold. Given the complexity of the three fundamental systems, it is reasonable to doubt that the assumption of perfect information is upheld in reality. This flaw would subsequently misalign preferences with the hierarchy and compromise the ability of the tool to meet this objective.

The accuracy of information can however be improved through the PPP, where stakeholders are provided with the opportunity to learn from one another. This enhances capacities for improved and informed decision-making. Adopting this process will subsequently improve the ability of the tool to better meet this objective.

The objective relating to the interdependent relationships among the three systems and emergent properties comprises of three components. The first component looks at the CBA tool's ability to internalize the quantitative and qualitative information on the positive and negative impacts that development may inflict on the three systems.

As previously discussed, the CBA quantifies impacts by determining the functional relationship between the project and the impacts and then representing these impact in monetary form (prices). Positive impacts are recorded as benefits and negative impacts are recorded as costs. Scientific information on the impacts may be taken from the EIA and various other studies after which this information is transformed into prices using shadow-pricing methods and valuation techniques. These valuation techniques seek to correct existing prices or construct missing markets to ensure that impacts are priced correctly.

The CBA manuals have acknowledged the heavy reliance on quantitative data and the limitations of the valuation techniques' abilities to internalise qualitative information (Mullins *et al.*, 2014; Belli *et al.*, 1998). Mullins *et al.* (2014: 60) state as a practical step in the CBA process that "impacts, which are difficult to measure should nevertheless be recorded in qualitative terms and if possible ranked in order of importance". This also applies to social consequences which cannot be quantified and could include information on intrinsic values here if required. The model therefore only partially achieves this component of the objective but still includes the qualitative information in the body of the report. The separation of this information may challenge the decision-maker's ability to integrate the two bodies of knowledge when needing to make decisions.

To meet the second component for the 'interdependent relationships and emergent properties' objective, the model should be structured to internalise the feedbacks among impacts where relevant. This implies that a change in the value of one impact has the potential to change the value of another impact to the estimated proportion as that represented in reality.

Transforming impacts into prices enables these impacts to become commensurable, even though they may accrue to the three systems separately. Making these impacts commensurable is a movement towards the integration of the three systems. In the additive CBA model, values accruing to each of the three systems are able to compensate one another and provide an overall value. However, the CBA model does not internalise feedbacks among impacts, as the measurements of impacts are taken in isolation and input into the model in the isolated form. This reductionist approach makes sense when using an additive model for compensation, where linkages need to be severed to avoid biases arising from double-counting. However, according to Audouin and De Wet (2010: 1), sustainability requires an understanding of the interactions between the systems, where the reduction of the environment into ecological, social and economic components is seen as a constraint to incorporating sustainability-thinking into environmental management. Interdependent relationships are therefore not internalised in the model, and without these there can be no consideration of emergent properties derived from these relationships. The tool does not meet this component of the objective.

The isolation and measurement of emergent properties is also restricted by the guidelines that govern the implementation of the CBA. In the guidelines, there is a restriction placed on the measurement of secondary benefits and multipliers which in essence are emergent properties. This has implications for accounting 'cumulative impacts' which can be considered as a multiplier. DEAT (2004a:8) recommends that "multiplier [effects]…has no place in a CBA" and that "only undisputable secondary [impacts] that would not be induced by alternative project or policy should be included". It can be understood that these restrictions are put into place given the difficulties in determining the boundaries of the analysis. The potential for CBA to consider cumulative impacts does however exist. Specialists are able to measure and report on cumulative impacts which are then able to be priced as an input into the model. Belli *et al.* (1998) makes the suggestion of extending the project boundary and considering a package of closely related activities as a useful exercise under these concerns. The same author makes the example of a soot-emitting factory's operations impacting on neighbouring buildings. By treating the soot-emitting factory and neighbouring buildings as if they belong to the project entity, the cumulative impact of an additional soot-emitting factory could be represented by the exponential maintenance cost borne by those buildings.

The last component of this objective is on how well the tool is able to discriminate among ecosystems. CBA would again rely on monetary values placed on the state of each ecosystem according to preferences. This, as previously explained, is subject to the assumption of perfect information. It would be expected that there is a higher willingness to pay for the protection of threatened, sensitive, vulnerable, highly dynamic or stressed ecosystems. CBA would be able to improve its ability to meet this component of the objective when coupled with a PPP.

4.2.1.2 Simple Multi-Attribute Ranking Technique

SMART has the ability to recognise the three fundamental systems in the problem-structuring phase of the tool. The systems are able to be modelled as three separate objectives which contribute to the overall goal of the project. The objectives can be structured according to a Value-Tree where an example is given in figure 4.1. The objectives are unidirectional and can be decomposed into lower level criteria and eventually measurable attributes.

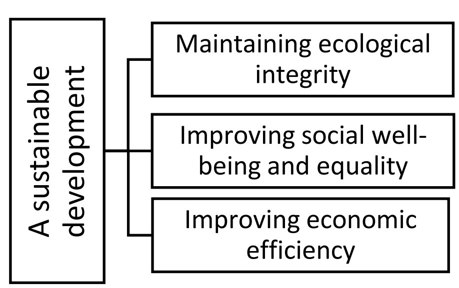

Figure 4.1: Example of a value-tree which integrates the three fundamental systems as project objectives (Own Compilation)

Much like CBA, SMART is able to internalise a hierarchical structure among the three systems through preferences as inputs into the model. Again, these preferences are bolstered on three assumptions; sustainability-thinking is theoretically correct, stakeholders are rational actors aiming to maximise their value, and stakeholders hold perfect information which they use to inform their decisions. However, in SMART, preferences manifest in the relationship between value scores and the weighting system instead of a willingness to pay as in CBA.

The hierarchy will be embedded into the model during the model-building phase when scientific measurements are given value scores and the relative weights for each attribute are defined. Assuming the three assumptions hold, when using the swing-weighting method, the relative weights for attributes contributing to each of the three systems should reflect the hierarchy. For example, stakeholders would be expected to weigh the swings in ecosystem changes as of a relatively higher importance than the swings of economic changes.

Belton and Stewart (2003:79) suggest that the SMART model will reflect the preferences of stakeholders and not the behaviour of ecological or economic systems for example. Stakeholder preferences would more than likely not be informed by perfect information and will misalign them with the behavioural characteristics of the systems, such as the hierarchy in which they exist. Again, the accuracy of information upon which people base their preferences can be improved through the PPP which will improve the tool's ability to meet this objective.

SMART is able to complete the first component of the 'interdependent relationships and emergent properties' objective through the presence of 'measurable attributes' (Goodwin & Wright, 2004). Impacts are quantified in accordance with the relevant discipline of the system. For example, if the objective is to minimise the loss of indigenous vegetation, the loss of vegetation will be measured in metres-squared by an ecologist. This information may be taken from the EIA and other relevant reports.

An advantage of the MCDA and SMART is that it is able to make use of various techniques which allow for the inclusion of qualitative information as well. Belton and Stewart (2003) explain the construction of an appropriate qualitative value scale using descriptive measurements, from which quantitative values can be inferred and integrated into the model. The example used in their text is the Beaufort Scale for measuring wind speeds. This practice is applicable because values scores on the scientific measures of impacts are created abstractly and do not seek a real-life proxy like that of prices used in CBA.

In terms of the second component to the 'interdependent relationships and emergent properties' objective, SMART is unable to internalise interdependent relationships and emergent properties. This is because the technique also uses an additive model for compensation. The limitations are made explicit by the assumption of "mutual preference independence" (Goodwin & Wright, 2004: 49), which governs that there should be no interaction between the scores on measurable attributes when aggregation takes place. Again, with no consideration of interdependent relationships, there can be no inferred consideration of emergent properties.

The literature does not seem to give guidance on the handling of secondary impacts and multipliers in MCDA/SMART. Secondary impacts and multipliers could be recorded as emergent properties in isolation. Joubert (2017) advised that secondary impacts should be included if; it seems reasonable to do so, the issues are important to those affected, or for other reasons they are raised by specialists, etc., as long as they abide by the laws of the practice, for example, are mutual preference independent.

SMART is able to meet the third component of the 'interdependent relationships and emergent properties' objective. The tool is able to carry this out by creating separate criteria for each ecosystem in the value tree if the structuring of the problem allows. An example of this is shown in figure 4.2 below. Each ecosystem will be scored and weighted accordingly.

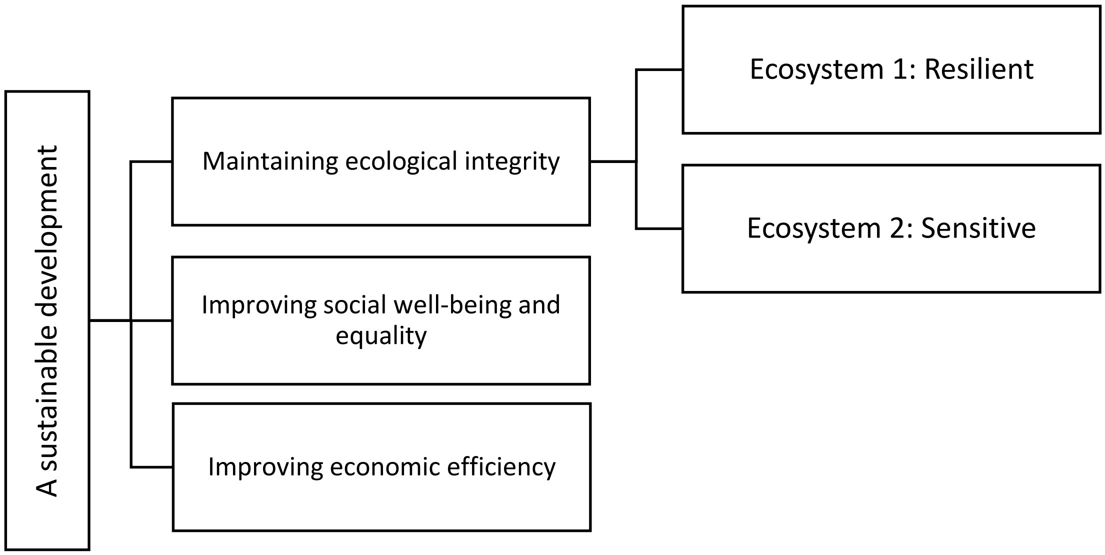

Figure 4.2: Example of a Value-Tree allowing for the discrimination among different ecosystems (Own compilation)

SMART effectively meets of the objective of internalising the information on cumulative impacts. Although the consulted literature did not mention the consideration of cumulative impacts, because the cumulative nature of impacts is able to be reported on by specialists, the information is able to be included in the analysis. How the cumulative nature of the impact is represented and the manner in which it is made comparable among alternatives is context specific and will depend on how the problem is structured. What is important here is that the potential exists.

4.2.1.3 Comparison

The evaluation above shows that both tools perform well against the objectives set out under the 'Integration of Systems' Principle. Whilst both tools' abilities to meet these objectives are relatively similar, SMART may have a slight advantage with its ability to integrate qualitative information into its model.

Both tools recognise the existence of the three fundamental systems. This recognition takes place during what is essentially the scoping stages of each tool -problem structuring for SMART. The tools are also able to emphasise a hierarchy among these three systems and is established through preferences as inputs into the models. The reliance on preferences subject the tools to the same assumptions upon which preferences are bolstered, and are thus both threatened by the assumption of perfect information. To improve the accuracy of information both tools should make use of a PPP.

Interdependent relationships and emergent properties are fundamental to sustainability-thinking, and as an objective was made up of three components. With reference to the first component of the objective, both tools are able input quantitative information into the model, but only SMART is able to input qualitative information. Although information on the three systems is able to be integrated in both models, and compensate these impacts to provide a net worth, the models are constrained by an additive structure. The additive structure limits each tool's ability to account for the interdependent relationships among impacts, and in turn, are unable to account for emergent properties which arise from these relationships. Where relevant, emergent properties may however be measured in isolation in cases where they take the form of secondary impacts or multiplier effects. Although the CBA manuals place restrictions on this, to improve the potential of the tool, the restrictions may be ignored or over-turned to an extent which places CBA on the same level of flexibility as SMART with regards to the managing of secondary impacts.

In terms of the third component of the objective, both tools have the ability to discriminate among ecosystems. Because both tools are unable to account for interdependent relationships and emergent properties they unfortunately both fail to meet this objective overall.

Whilst both tools fail to meet this objective overall, SMART maintains a slight advantage in its ability to integrate qualitative information. This advantage arises because SMART creates a value score for the scientific measure of an impact abstractly, unlike CBA which requires to find a real-life proxy (price) for the value of an impact which in some cases is impossible. The aim of creating a model for decision-maker's preferences is to help the decision-maker synthesise large amounts of information. The more the tools separates bodies of information, in this case as CBA does with quantitative and qualitative information, the more difficult the entire body of information is to synthesise.

As for the final objective of this principle, both tools are able to fully internalise the cumulative impacts of an activity. This is as long as the cumulative nature of an impact is able to be measured. Once the impacts have been measured, they may be integrated into the model of each tool accordingly.

Table 4.1: Differences between CBA and SMART in terms of the Integration of Systems principle

	CBA	**SMART**
Three fundamental systems	✓	✓
Hierarchy	✓	✓
Interdependent relationships and emergent properties	X	X
i) Internalising impacts	✓ Without qualitative information.	✓ With qualitative information.
ii) Interdependent relationships and emergent properties	X	X
iii) Inter-ecosystem discrimination	✓	✓
Cumulative impacts	✓	✓

4.2.2 Uncertainty and Long-Run Impacts

The complex and dynamic properties of the systems involved in environmental management creates much uncertainty within the practice. Decision-makers should aim to manage uncertainty when making decisions on projects which have significant impacts that extend over long periods of time and are subject to the complex properties of the systems in which they exist. In South African IEM, uncertainty is managed through two means. Firstly, through a Life-Cycle Approach, which acknowledges the changes of impacts throughout their life-cycle. The approach involves accounting for the change in the value of impacts through time and how these changes influence the overall value of the project. Secondly, the Precautionary Principle is adopted, which relates to the uncertainty of knowledge surrounding the nature and scope of environmental damage. The principle advises that alternatives with uncertain knowledge on significant negative impacts should be avoided. This section will evaluate and compare how well each of the tools meet the objectives laid out under the principle of 'Uncertainty and Long Run Impacts'.

4.2.2.1 Cost Benefit Analysis

The CBA scores well on the objective relating to a Life-Cycle Approach as the tool typically measures impacts on a per annum basis over its entire life-cycle. These measurements are added together and then discounted to a NPV. The future values of impacts are forecasted according to an informed relationship between the impacts quantitative measure in its scientific form and economic forecasting methods which influence its shadow price. Mullins *et al.* (2014) make the example of using macroeconomic forecasting techniques which infer the future demand for irrigated water in an area from the expected demand for the agricultural products from that area made possible through the irrigation scheme.

Belli *et al.* (1998) makes special reference to the treating of environmental impacts with life-cycles that extend beyond the lifespan of the project. Situations like these may be seen in in acid mine drainage or the disposal of nuclear waste. The manner in which these environmental impacts are integrated into decision-making can be done according two approaches. The first approach looks at "adding to the last year of the project the capitalized value of that part of the environmental impact that extends beyond the project's life" (Belli *et al.*, 1998:50). The second approach is by extending the cash flow analysis of the cost or benefit in accordance with the life-cycle of the impact. In both instances, the value captured would be subject to discounting.

With regards to scientific information and the Precautionary Principle, the first step to reducing uncertainty is by correctly and fully identifying the impacts of the project. CBA should then be able to penalise alternatives with highly uncertain knowledge on their negative impacts to score well on the second objective. In order for CBA to internalise uncertainty surrounding negative impacts, the discussion would have to return to the nature of preferences and the aim of representing TEV through shadow pricing methods. It would have to be assumed that those who influence the decision are risk averse and would be willing to pay premiums for certainty.

Premiums could be integrated into the analysis through the inclusion of 'quasi-option values'[35] as an example. Other than this, there is no obvious amendments that could be made to the CBA model to internalise uncertainty. It should be mentioned that the model has the ability to include the expected values of impacts on a risk basis, and commonly makes use of a sensitivity analysis to provide information under different circumstances (Harris, 2006).

The next objective in terms of the Precautionary Principle is to scrutinise the theory and procedure surrounding the tool that introduces gaps of uncertainty into the output. In this light, there has been much criticism of the valuation techniques used in CBA, suggesting that they may fail to represent the TEV of environmental impacts.

According to Belli *et al.* (1998), the valuation of impacts can be broadly broken down into a two-step process. The first step involves determining the functional relationship between the project and the environmental impact. This relationship is expected to be outlined by the relevant specialist e.g. ecologist, etc. The second step involves assigning a monetary value to the environmental impact. How this monetary value is assigned depends on which valuation technique is used.

'Stated preference' valuation techniques, such as CVM, are based on the relationships that exist between environmental changes and the market prices of the environmental services. 'Direct market valuation' and 'Revealed Preference' techniques, such as; Production Function Approaches, Hedonic Pricing and TCM, are based on behavioural relationships where prices for environmental goods and services are inferred from the value of an already existing marketed good (Bellie *et al*., 1998). The price inferred from existing markets are known as 'surrogate prices' and belong to what is called the 'surrogate market' of the environmental good or service.

Aside from the problems of assuming perfect information, the ability of surrogate markets to capture the TEV of environmental impacts has been widely criticised (Perman *et al*., 2011; Ludwig, 2000). From examples mentioned in the literature, the surrogate markets usually entail

[35] "The premium decision-makers would be willing to pay to know more about a project's impacts" (DEAT, 2004a:11).

only the function of the good or service accruing to direct human use and may not include any less obvious, indirect human use benefits that arise from healthy ecosystems. For example, Hedonic Pricing and the use of real estate prices explained by DEAT (2004a: 12).

> "The logic is that since house prices capture relevant amenities (is the house close to the shops, schools, bus routes etc), they should also reflect environmental amenities and disamenities ('goods' like open space close by, view of a pristine area, and "impacts" like traffic noise and air pollution). The characteristics of houses are collected and regressed against house prices, the result enables such characteristics to be valued".

Indirect human use values of the "open-space" which accrue to the wider public, such as its connection in a 'urban-green-corridor' or carbon sequestration, may not be captured by the technique. These amenities are of a 'public goods' nature which would not be included in private housing market prices.

On the supply side, the goods and services in the surrogate market are dependent on ecologically irrelevant cost functions which include variables such as; available technology, brand-premiums, etc. In most cases, the decision on which valuation technique is to be used will depend on the objectives of the analysis. For example, if the objective of the analysis is to measure the impact of noise-pollution from an airport development on the surrounding public, the cost of noise pollution could be inferred from the amount of noise proofing one's home (Mullins *et al.*, 2014). However, decision-making in South African IEM aims to account for the full impact on the environment which the TEV should aim to capture in cases where CBA is applied.

Take a development on a mangrove as another hypothetical example, where the aim is to evaluate the full impact on the environment. Whilst the development may impact primarily on the water purification services of the mangrove, the cost of replacing this service with a man-made filtration system, will firstly vary according to what technology is used, etc., and secondly maintains a cost function that does not reflect the full value of additional impacts on services such as managing wave action and the provision of a habitat for bird-life. To improve CBA's attempts to capture TEV in these cases, the specialist has the option to apply a collection of techniques to the different impacts as long as there is no double-counting. Following the mangrove example, other techniques may include applying avoidance cost approaches for flood mitigation to reflect the value of managing wave action, and applying the TCM to reflect the value of bird-life in the mangrove. Although these options are possible, one may doubt that a sufficient collection of techniques is always applied in practice due to the time and cost constraints that the specialist may be subject to.

It is acknowledged that the purpose of a model is to most simply and accurately reflect reality. In this sense, it is impossible to ensure full accuracy in all instances. There are however limitations as to how far a model can deviate from reality. It will therefore only be noted here that additional gaps of uncertainty are also introduced into the model through the setting of a discount rate, the lack of including some qualitative data, and the addition of income weights.

The final objective for this principle will be discussed under the 'Comparison' section; the tool's ability to maintain the certainty in its output after processing the input-information.

4.2.2.2 Simple Multi-Attribute Ranking Technique

The 'guideline documents' on MCDA and SMART covered topics such as uncertainty and risk, there was however no mention of handling changing measurements through time. This means that the ability of SMART to adopt a Life-Cycle Approach was not specifically mentioned or made example of. Additional literature needed to be consulted to provide insight on the concerns for impacts over time.

Department for Communities and Local Government (2009:38), agree with the inclusion of a life-cycle approach in MCDA where it is stated that "good decision facilitating practice would ensure that participants in any decision-making exercise had their attention drawn to time-differentiated impacts and gave thought to how these were to be consistently accommodated in the assessment". The authors reinforce that all assessments of criteria should be made on the same grounds and if some criteria are differentiated by time it should be explicitly recognised in the scoring as the means for reinforcement. Examples recognising long-term considerations in criteria can be taken from various case studies; "annual radiation dose" (Department for Communities and Local

Government, 2009: 93)[36], "NPV of forestry output" (Stewart *et al*., 1997: 75)[37], "formal income [per annum]" and "soil erosion" (Joubert, 2002: 95-97)[38]. Although this is shown in practice, the Department for Communities and Local Government (2009) report mentions that the aggregation of all effects over time into a single measure is a difficult task and that the need for tackling time-distributed impacts in MCDA would be relatively limited.

It is suggested in this study that where necessary, time considerations should be made explicit and structured in such a way to influence preferences according to the changes in impacts over time. The next step would be to decide if impacts in the future should receive a lower weighting and how this would be carried out. This would introduce the moral debate as discussed under discounting in the literature review on CBA (see section 3.2.5.1) which will be further elaborated on under the evaluation and comparison of the 'Intergenerational Equity' principle (see 4.2.4.2).

If the value scores on criteria are made dynamic in accordance with the above discussion, the weights are required to be made dynamic as well. This implies that the weight for a criterion will have to be set in accordance with how stakeholders expect their preferences for the criterion to change through time[39]. It was shown that stakeholders in the Finnish Upper Lapland case study found it difficult to understand strategic ideas like this (Mustajoki *et al*., n.d.). Suggesting a method to carry out the procedure is beyond the scope of this study, and it can be expected that whichever method is used would introduce uncertainty into the tool. However, the potential for this approach does exist and has been attempted in practice (see 3.3.5).

With regards to the objective relating to the Precautionary Principles, again the literature did not provide much insight on how SMART could penalise alternatives with uncertain knowledge. The Department for Communities and Local Governments (2009), suggests a potential method which

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[36] Analysis included the appraisal of potential sites for radioactive waste repositories (Department for Communities and Local Governments, 2009: 90)
[37] Analysis included forestry land-use alternatives (Stewart *et al.*, 1997: 70).
[38] Analysis included the formation and evaluation of catchment management land-use alternatives (Joubert, 2002:89).
[39] It is still assumed however that once these preferences are determined and integrated into the model, that they will remain unchanged.

involves creating separate criteria for different likely scenarios at the highest end of the value tree. The scenarios are set according to the consequences of alternatives under each scenario. Each scenario will comprise of the same structure of lower-level criteria. Alternatives will be scored according to the criteria under each scenario and will be summed across all scenarios to provide an output that suggests the best alternative across all scenarios. At the higher levels of the value tree, "scenarios can be weighted to reflect their relative plausibility or likelihood of occurring (Department for Communities and Local Government, 2009:72). The higher end of the value tree can be illustrated by figure 4.3.

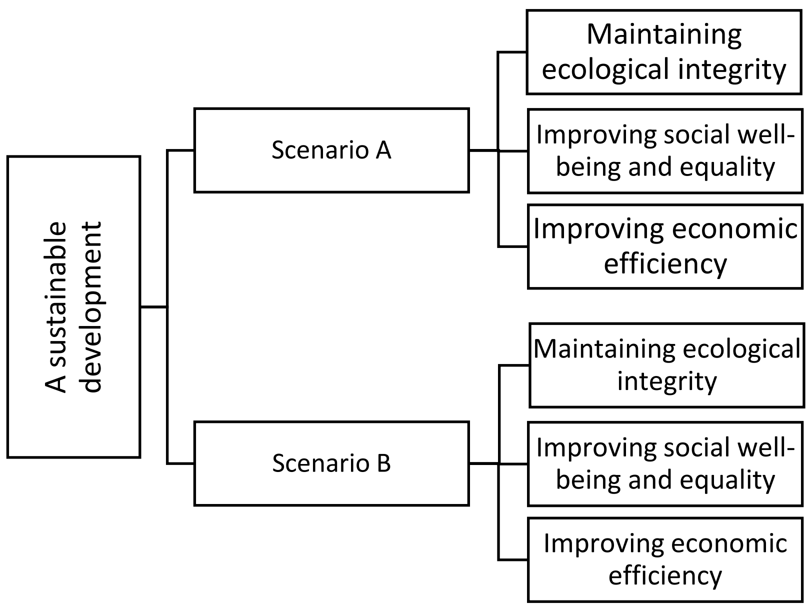

Figure 4.3: Value-Tree integrating different scenarios to manage uncertainty (Own compilation based on Department for Communities and Local Government, 2009:72)

The above method would be limited in cases where there is a high amount of variability surrounding the uncertainty of different impacts. For example, alternative A may have uncertainty surrounding the impacts in the ecological and social criteria, whereas alternative B may have uncertainty surrounding the impacts in the ecological and economic criteria. In cases like these, it would become unfeasible to attempt to model every scenario.

Another attempt to aid the handling of uncertainty and long run impacts in SMART could be through the use of expected values. In order to simplify this addition, it is perhaps easiest to make decisions purely on the expected values and not aim to include stakeholder's preferences regarding risk. For example, some stakeholders may prefer a certainty of 100 job opportunities instead of the potential for 200 job opportunities with a 50% probability. Preferences for risk can be included in Multi-Attribute Utility Theory (MAUT) which is an alternative technique under the body of Value Function Methods. This technique is however considered to be more technical and is therefore not widely implemented in environmental management (Joubert *et al*., 1997). It should also be mentioned here that SMART also applies a sensitivity analysis to provide information on relationships surrounding the values under different scenarios.

The SMART method involves measuring the level of impacts in scientific form, and then transforming these measurements into value scores according to preferences. Quantitative and qualitative criteria are able to be created in order to capture a variety of impacts. These criteria can then be weighted according to preferences. Gaps of uncertainty may be introduced when transforming scientific measures into values scores and weighing the criteria. The process behind transformation and weighing assumes that the preferences involved in this are backed by perfect information. In instances where this assumption does not hold, the preferences used to score impact measurements and set weights may limit the accuracy of the output of the model. These 'preferences' may also be subject to 'Strategic Bias'[40] which would further inhibit the accuracy of the output.

The final objective of this principle will be discussed under the 'Comparison' section; the tool's ability to maintain the certainty in its output after processing the input-information.

4.2.2.3 Comparison

Both tools hold the potential to internalise the full life-cycle of impacts and therefore meet the objective of a life-cycle approach. This is however seen to be more commonly practiced in CBA which uses discounting to transform effects over time into a single value. Although less widely practiced in SMART, to solidify the life-cycle approach in the tool it is suggested that time-

[40] "Strategic bias arises when the respondent does not provide a true answer in order to influence a particular outcome" (Logar, n.d.).

differences among criteria are explicitly recognised and structured in such a way to influence the preferences used to score alternatives.

Uncertainty is always a prominent and sensitive theme in decision-making. The theme becomes even more of an issue in circumstances such as IEM where technical methods to reduce uncertainty need to be traded-off for simplicity and transparency. In accordance with this concern, it can be argued that CBA and SMART achieve the objective of discriminating against uncertain knowledge on negative impacts relatively well. Both tools have a diverse set of mechanisms which may inform the application of the Precautionary Principle. For both tools, preferences can give a premium to alternatives with certain information, expected values can be used to manage information pertaining to risk, and each can conduct a sensitivity analysis. SMART is able to make use of an additional method through the creation of scenarios and evaluate the alternatives across all scenarios, similar adaptions could more than likely be made to CBA as well.

All models aim to provide a concise yet comprehensive representation of reality. This inherently introduces gaps of uncertainty into the model and its output which may pose a threat to the Precautionary Principle. CBA is seen to have a higher potential for uncertainty to be introduced into the model in this respect. Besides uncertainty in terms of the scientific measurement of impacts (positive and negative) over the lifespan of the project, monetary valuation adds another element of uncertainty. This is because the technique requires the representation of preferences through prices. The problems with inferring prices from surrogate markets that are external to ecological factors were discussed. Associated techniques were criticised for their likelihood of failing to capture less obvious, indirect use values and therefore the TEVs of impacts. It was suggested that by applying a collection of valuation techniques, the specialist may better account for TEV, but it is believed that time and cost constraints may limit this practice. The issue is more thoroughly discussed in Joubert (2002:176), and what implications this has on the "general validity and reliability" of the tool. Joubert (2002:183) explained that the valuation technique (TCM) used in her study only captured direct use values in the WTP, and argued that SMART is able to create a variety of criteria to better capture both direct and indirect use values. In addition to this, Joubert (2002:175) also suggested that the stated preference method used in SMART is simpler than CVM used in CBA, and essentially produces a similar outcome in principle. It is acknowledged that

SMART succumbs to the limitations associated with strategic bias and the assumption of perfect information that introduce gaps of uncertainty into the tool. It is however safe to conclude that SMART maintains less gaps of uncertainty surrounding its theory and procedure based on the above findings in Joubert (2002) who scrutinised the more technical aspects of the tool.

The final objective of this principle relates to how well the tools maintain certainty in their output after processing the information. Both tools in this regard only lose information by separating input-information into separate categories in order to suit the additive structure of the model. This issue was discussed under the previous principle and how this practice fails to consider the interdependent relationships between systems and emergent properties. Information on these two phenomena are unable to be integrated into the model which creates a gap for uncertainty.

Table 4.2: Differences between CBA and SMART in terms of the Uncertainty and Long Run Impacts principle

	CBA	**SMART**
Life-Cycle Approach	✓	✓
Precautionary Principle: Penalise negative impacts	✓	✓
Precautionary Principle: Uncertainty in Theory and Procedure	X	✓
Precautionary Principle: Information lost in processing	X By not including interdependent relationships and emergent properties.	X By not including interdependent relationships and emergent properties.

4.2.3 Intragenerational Equity

Sustainable development, and its principle of 'Intragenerational Equity', was born from the relationship between mounting environmental and socio-economic issues. In the past, the burdens of environmental degradation fell mainly on poor-black communities which motivated the Environmental Justice Movement. The principles behind this movement have been adopted internationally and in South Africa, and calls for accountability over environmental degradation and equal access to environmental services. In addition, Environmental Justice as represented in South African IEM insists on redistributive measures in favour of 'vulnerable and previously disadvantaged persons'.

Stakeholder engagement and the public participation process, is another means through which Intergenerational Equity is embedded in South African IEM. Stakeholder engagement provides for holistic decision-making which seeks to integrate stakeholders' interests, needs, values and knowledge types into development decisions. This not only informs the decision-making process to make better decisions, but also improves the transparency of the process thus making decisions more acceptable and sustainable.

4.2.3.1 Cost Benefit Analysis

The CBA experiences difficulties in its attempts to fully achieve the objective of Environmental Justice. Difficulties arise from the failure of the tool to consider the presence of pro-rich biases in its output. To reiterate, these are utility biases between stakeholder groups arising from income differences when using WTP as a proxy for utility. Because the richer demographics have higher incomes they are able and willing to pay relatively more for their preferences compared to those who are poorer. By failing to consider this, net utilities based on WTP as a proxy, bias decisions in favour of the rich and therefore contradicts redistribution as aimed for by the Environmental Justice objective.

Although pro-rich biases exist in the model, the addition of income weights can be practiced as a commitment toward redistribution. These weights intend to give more importance to the needs of lower income groups in decision-making. According to Mullins *et al.* (2014), the weights allocated to the different income groups depend largely on political decisions and should be related to the marginal utility that additional income provides for each group. "The best-known form of weighting involves a simple formula which assumes that the social value placed on a unit of income, declines at a constant rate for all income levels" (Mullins *et al.*, 2014: 47). This formula is shown below:

$$d_i = (Y_a/Yi)n$$

Where:

d_i is the weight for group or individual i

Yi is per capita income for i

Y_a is the reference income

n is the elasticity parameter

Mullins *et al.* (2014) suggests the following practice when adopting this formula to calculate income weights in the South African context:

- The reference level of income, which carries a weight of unity, should be based on the average per capita income in the South African economy.
- The proposed elasticity of the social utility function for income should be set at a conservative level of 2.0. This factor is governed by the percentage allocation in respect of government tenders to previously disadvantaged individuals and portrays the priority that government has given to income redistribution.

Income weights are attached to the costs and benefits appropriate to each income group, and are then aggregated together. It should be noted that income weights are targeted at general redistribution and not specifically at correcting for pro-rich biases. The income weights need compensate for pro-rich biases first, thus placing all stakeholders on an equal level before the weights begin to take redistribution effects. The weights can be subject to sensitivity analysis which will give the decision-maker important insight on how the weights effect the decision outcome.

With regards to stakeholder engagement, the factors of interests, needs, values and relevant knowledge types are captured during the mandatory PPP in IEM. The CBA augments this process to suit the needs of the model and is able to integrate these factors as preferences accordingly. Whilst the manuals do not provide guidance on best practice in this respect, it is suggested that the procedure for the tool should involve dividing its participation process into a series of workshops. This will help inform the needs of each stage of the tool’s process appropriately.

The scoping process of the CBA begins by identifying the stakeholders which need to be engaged with. Once all stakeholders are identified, a workshop can be held to give stakeholders the opportunity to discuss which impacts of the project are of interest to them, and perhaps preliminary ways to mitigate these impacts. Traditional knowledge may be of significant value in the latter. The views discussed here will shed light on the motives behind the valuations expected to be attached to impacts and provide for a shared understanding and transparency. An issue which arises for CBA at this stage is the reluctance of some individuals to place a monetary value on ecological systems in the belief that these systems hold 'immeasurable' intrinsic and aesthetic values (DEAT, 2004a). This fundamentally contradicts the requirement to include all ethical values into the tools processing. Throughout the tools process, preferences are only able to include instrumental values.

A second round of the participation process could take place during the second stage of the tool where impacts are measured and are then transformed into monetary values. The level of engagement at this point will be determined by the valuation methods applied in the project. Methods that require stakeholders to state their preferences in order to form a demand curve, such as the CVM and related measures, is a form of direct engagement. In these instances, stakeholders are given the opportunity to directly input their interests, needs, (partial) values and knowledge as preferences into the model. This may enlighten a form of empowerment for the stakeholders in accordance with the IAP2 spectrum. Valuation techniques that rely on surrogate markets are seen to indirectly and partially integrate stakeholders' interests, needs, values and knowledge. It is suggested as an indirect form as it infers prices of the impact from existing markets which act as a proxy and supposedly embody stakeholders' interests, needs, values and knowledge. These surrogate prices can be argued to be only a partial representation of the variable as there are assumed to be disparities between the proxy's market and the actual market of the impact. Furthermore, as suggested by Joubert *et al*. (1997), much of the population in developing countries are not included in the market setting.

Other indirect conduits which can be argued to theoretically include stakeholders is through the calculation of income weights and the real social discount rate when the Ramsey method is used. With respect to the income weights conduit, the elasticity of the social utility function for income can be argued to introduce stakeholder variables as it based on "societies preference for income equality" (Mullins *et al.*, 2014:47). Whilst these more indirect methods theoretically integrate stakeholders' interests, needs and values, it does not provide the tool's process with transparency because stakeholders are not thoroughly engaged with.

One of the main motives behind exploring alternatives to CBA is due to its lack of transparency. Inferring inputs from external sources, such as market prices and calculations derived from the general market setting is a technical process. This is assumed to make it relatively more difficult for stakeholders to understand the process of the tool as they are not expected to be familiar with the involved economic concepts and theories. In addition, levels and conduits through which stakeholders are directly engaged with are only in the scoping stage and if techniques such as the CVM are used. The ability to establish trust and transparency with the tool is inhibited by these two issues.

4.2.3.2 Simple Multi-Attribute Ranking Technique

The typical SMART process, does not include redistributive properties but does maintain an equal standing among stakeholders throughout the model. Value scoring and weighting among the stakeholder groups is carried out on equal scales which will be aggregated together to imply an equal effect on the net value scores per alternative.

Much like the CBA model, adaptions to the SMART model for redistribution purposes may be made. If these adaptions are made, SMART would meet the Environmental Justice objective. Adaptions should involve attaching importance weights to the scores of different income groups before total aggregation. The weights could be calculated according to the same method as the income weights used in CBA. The underlying principle is that the needs of lower income groups are given higher importance in decision-making in proportion to societies preferences for redistribution. Another means of ensuring redistribution could be through the creation of such a criterion. What the criterion would exactly comprise of would be context dependent. Each alternative would be scored on this criterion and stakeholders would be given the opportunity to weigh the criterion thus encompassing 'societies' preferences.

SMART scores relatively well on the objective of stakeholder engagement. Like CBA, the tool also requires an extension of the PPP and it is also recommended that this process be divided into a series of workshops suited to the tools procedure. The level to which stakeholders are engaged with throughout the SMART process is considerably more than that of the CBA and takes place in the majority of the phases. During the problem structuring phase stakeholders are given the opportunity to identify impacts which affect them, and formulate objectives and criteria according to which these impacts will be measured.

The second round of the participation process takes place during the model building phase. In this phase stakeholders are able to directly input their interests, needs, values and knowledge into the model via preferences and is done in two ways. Firstly, through stakeholder scoring of impact measurements in order to create a value function. Secondly, by stakeholders weighting the importance of criteria through the swing weighting method. Depending on the size of these groups, it may be more manageable to consult a representative of the group. Scores and weights are then aggregated for all alternatives per stakeholder group, and then aggregated across stakeholder groups to calculate the model's output for each alternative.

It could be suggested that SMART is better equipped to account for a variety of ethical values in comparison to CBA. SMART is advantaged by not needing monetary values, which are strictly instrumental, to assess impacts (Joubert *et al*., 1997; Stewart *et al*., 1997). This avoids the moral debates surrounding this practice. Instead, SMART attaches preference values more abstractly which along with qualitative methods, could better structure criteria to include a variety of ethical values. A hypothetical example of such criterion could be: "How strongly does the project conflict with the cultural needs of the affected community?".

The high engagement with stakeholders throughout the SMART process allows the tool to score relatively higher in the objective of transparency. The process of the tool is also relatively simple and easy to follow as there are no external inferences and external-based calculations. Instead, the tool specifically focuses on the structuring, formulation and understanding of the problem in order to aid decision-making (Belton & Stewart, 2003). High engagement and relative simplicity helps stakeholders own the process and should implicitly strengthen the transparency of the tool and acceptability in its output.

4.2.3.3 Comparison

Using WTP as a proxy for preferences has proven to create many limitations for the CBA tool. In the case for Environmental Justice, the presence of pro-rich biases inhibits the tool's ability to fully achieve this objective. In contrast, the SMART method ensures completely equal standing among stakeholders throughout the tool. Because the 'Environmental Justice' objective implies the characteristics of redistribution in favour of 'vulnerable and previously disadvantaged persons', equality among all stakeholders is not sufficient. Both tools have the potential for the addition of a weighting system that gives more importance to 'vulnerable and previously disadvantaged persons' in decision-making as a commitment towards redistribution. An alternative method to importance weights for SMART may be through the creation of a criterion depending on the problem and decision context.

Essentially SMART scores higher on the Environmental Justice objective as it would apply income weights as a redistributive mechanism from an equal standing, unlike CBA which applies income weights from an unequal standing due to pro-rich biases. For example, if one was to apply the same distributional weighting system in both tools, there would be more value derived from the weighing system under SMART because there are no biases that the weights have to correct for first, before redistribution takes place from an equal standing.

With regards to the objectives related to Stakeholder Engagement, both tools require a PPP, and would augment the mandated PPP to suit its technical and procedural needs. In the PPP, stakeholders are able to shed light on their interests, needs, values and knowledge types. SMART was seen to better account for a variety of ethical values whereas CBA could only include instrumental values in its model. Information on these factors can be integrated into the tools directly as preferences as well as aiding the procedure of collaborative learning which will help improve the accuracy of these preferences.

It is recommended that both tools divide their PPP into a series of workshops with a minimum of two rounds. For the first round, both tools engage with stakeholders in what is essentially the scoping phase of the tool. The aim of engagement in this workshop is the same for the tools where stakeholders are given the opportunity to identify the parameters of the study and which impacts are most important to them. In this workshop, all stakeholders should be brought together to stimulate collaborative learning.

The second round of the PPP for each tool is however significantly different. It is in this round where both tools elicit the preferences of the stakeholders and transform these preferences into suitable inputs for the tool. From the evaluation, it was seen that SMART has a significantly higher level of engagement in this round. Stakeholders are required to directly score and weight criteria according to their preferences. This implies that the entire input-base is derived directly and wholly from stakeholders. Essentially, CBA valuation techniques that require stakeholders to state their preferences in order to form a demand curve, such as the CVM and related measures, is a similar technique used in SMART scoring. However, this is only one technique out of the body of techniques which CBA makes use of. The majority of the other techniques rely on indirectly eliciting preferences, and thus interests, needs, values and knowledge, by inferring market prices from the market-setting. Under these techniques stakeholders are not directly asked to make their preferences explicit.

A full understanding of the valuation techniques, discounting and other technical aspects of CBA, requires a higher level of knowledge of economic theory. In the third world context, characterised by a generally low standard of education, it would be unreasonable to expect all stakeholders to be able to sufficiently understand the CBA process. The high technicality of the CBA tool as well as a relatively lower level of stakeholder engagement results in a relatively lower achievement for the objective of Transparency. In comparison, SMART has a more thorough engagement with stakeholders throughout the tool where these stakeholders are able to develop an understanding of the tool's process which is also relatively simple. It is therefore assumed that SMART will be viewed as more transparent and implicitly better trusted by stakeholders.

It is evident that SMART scores better in the objectives of Environmental Justice, Stakeholder Engagement and Transparency in comparison to CBA. SMART is therefore more fully aligned with the principle of 'Intragenerational Equity'.

Table 4.3: Differences between CBA and SMART in terms of the Intragenerational Equity principle

	CBA	SMART
Environmental Justice	✓ But with pro-rich biases.	✓
Stakeholder Engagement: interests, needs and values.	✓ But only includes instrumental ethical values.	✓
Stakeholder Engagement: knowledge types.	✓ But often includes using indirect methods.	✓
Transparency	X	✓

4.2.4 Intergenerational Equity

A fundamental principle in sustainability-thinking is 'Intergenerational Equity' which introduces a moral concern for the rights of future generations. The definition and manifestation of this principle within the sustainability-thinking paradigm is rather vague and has subsequently been met with much criticism since its enlightenment. This vagueness poses much difficulty when aiming to integrate the principle into decision-making goals and objectives. The concern for the rights of future generations is founded in the development objective of improving quality of life. It is believed that if quality of life is held to be a right for present generations, it ought to be a right for future generations as well. The concern is particularly prevalent in contemporary development as this development is often seen to conflict with the quality of life for future generations when it significantly degrades the environment.

Given the fact that South Africa is a third-world nation, and development in the country is a long-term goal, it makes sense for legislation and policy to give equal rights to present and future generations. South African IEM sets out to protect the rights of future generations by attempting to preserve the resilience of environmental systems in order for future generations to meet their basic needs and well-being. Because there were seen to be no clear-cut rules for integrating this principle into South African IEM decision-making, this section will only discuss how the principle may be attended to by each tool.

4.2.4.1 Cost Benefit Analysis

The CBA is typically applied according to the weak sustainability perspective and attends to intergenerational concerns with an 'inter-generational discounting' approach. The approach is applied when the impacts of a project extend over longer periods of time and across generations. It makes use of hyperbolic discounting thereby giving more weight to costs and benefits extending into these periods (Mullins *et al.*, 2014).

Mullins *et al*. (2014) proposes two methods according to which a discount rate could be set for inter-generational discounting. The first method is based on existing individuals' time and consumption preferences. The approach rejects the view that interests need to be balanced across generations and instead the choice depends on present generations and how they want to allocate scarce resources (Mullins *et al*., 2014). This follows an inheritance perspective on intergenerational equity and is not in accordance with a rights-based perspective as held by IEM policy and legislation. The approach is therefore not theoretically appropriate for application in South African IEM.

The second method to setting a discount rate is the Social Welfare Planner Approach which rests on the assumption that generations in the future are to be relatively richer, lowering their marginal utility for consumption and implicitly the future value of scarce resources (Mullins *et al.*, 2014). According to Mullins *et al.* (2014), the social rate of discount usually equals the sum of two factors:

1) The discount rate for pure time preference – measuring the degree to which the social planner balances the needs of present generations with the needs of future generations.
2) The rate at which marginal utility of consumption declines over time as consumption per capita increases.

The Social Welfare Planner Approach seems more aligned with the rights-based perspective if the social planner acts accordingly, and is therefore seen to be more appropriate than the previous approach. It is proposed by Mullins *et al*. (2014) that projects with environmental impacts in South Africa should be discounted at a rate of 8 percent and applied using hyperbolic discounting. This method of discounting would be applied along with the ‘fatal flaws’ enforced under the EIA process.

4.2.4.2 Simple Multi-Attribute Ranking Technique

It was mentioned under the evaluation of the ‘Uncertainty and Long-Run Impacts’ principle that the literature on SMART was limited in its inclusion of temporal factors. The attendance to the concerns for future generations was also not present in the ‘guidelines’ and so the Department for Communities and Local Governments (2009) report was referred to again. Although the ‘guidelines’ did not specifically mention concerns for future generations, it does not necessarily mean that SMART is less aligned with the ‘Intergenerational Equity’ principle.

Where the criteria in SMART account for impacts occurring over time, the tool is bound to consider the changes in the values behind those impacts over time. In this instance, the same debate between weak and strong sustainability principles apply. Because MCDA allows for the trade-offs among capital stocks it would be inclined to attach lower weightings to future impacts based on the decreasing marginal utility of future consumption. According to the Department for Communities and Local Governments (2009:38), there are no techniques in MCDA equivalent to discounting used in CBA. However, “in principle the conventional discounting of money values can be accommodated and it can also be applied to physical impact indices other than monetary values” (Department for Communities and Local Governments, 2009:38). If this were to be practiced, the principles behind an ‘inter-generational discounting’ approach could essentially be applied as a means to align with the ‘Intergenerational Equity’ principle.

Although the inter-generational discounting approach, with a hyperbolic discounting method, is an improvement relative to using the exponential discounting method, the act of discounting devalues irreplaceable natural capital that could be held by future generations and can be argued as an infringement on their rights (Sáez & Requena, 2007). On the grounds of irreplaceability, it is reasonable to doubt that physical capital and natural capital devalue at the same rate through time. A potential means for both tools to better align with the 'Intergenerational Equity' principle would be to apply 'stronger' sustainability principles and choose not to discount certain impacts, or tailor the discount approach to place a higher weighting on natural capital. These suggestions follow Krutilla and Fisher (1975)[41] who argue that the value of natural capital stock instead increases over time as income rises, new physical capital is developed, and scarce natural capital diminishes (DEAT, 2004a).

There are two additional adaptions to SMART which are desirable, but are not exactly theoretically aligned with sustainability-thinking in South African IEM. The first adaption may be to source specialists to represent future generations in the decision-making process. These representatives would contribute to the scoring and weighing of criteria with the same standing as different stakeholder groups. The addition of importance weights to this group could also be made. The theoretical issue however is that the preferences of future generations are not able to be predicted and could therefore be argued to be a false representation and not very transparent. The second adaption follows a suggestion made by Joubert *et al*. (1997), and involves the creation of a criterion which aims to represent the interests of future generations. The criterion could avoid the reliance on predicting future generations' preferences by measuring properties of the project which preserve the resilience of systems. According to Folke *et al*. (2010) two properties which typically preserve resilience are 'adaptability'[42] and 'transformability'[43] and could potentially make up this criterion. Theoretical issues arise when the criterion is needed to be scored according to the preferences of present generations and weighed against adjacent criteria. Present and future generations ought to have equal rights in the decision process and therefore should not compensate each other in the model.

[41] For more information on Krutilla and Fisher see: Krutilla and Fisher (1975), Fisher and Krutilla (1985), and Porter (1982).

[42] "Adaptability has been defined as the capacity of actors in a system to influence resilience" (Walker *et al*. cited in Folke *et al*., 2010:21)

[43] Transformability - "The capacity to transform the stability landscape itself in order to become a different kind of system, to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable" (Folke *et al*., 2010:22).

4.2.4.3 Comparison

The ability of the tools to integrate the principle of 'Intergenerational Equity' could only be managed according to the weak sustainability perspective and could be met with decisions surrounding the application of different discounting approaches.

When aiming to integrate the 'Intergenerational Equity' principle according to strictly weak sustainability principles, the approach of 'inter-generational discounting' can be applied and should follow the Social Welfare Planner Approach. If the decision-maker would prefer to adopt a 'stronger' sustainability perspective, he/she may tailor the discounting approach to place a higher weighting on the natural capital stock. Although both tools may not apply these principles in exactly the same manner, the potential to apply the principles are possible.

It is agreed with Perman (1996) that trying to set a discount approach and rate which provides for an ethical distribution of resources among generations will never fully satisfy the goal. Instead, the focus should be placed on "incorporating ethical positions that we believe are right as constraints over acceptable behaviour" (Perman, 1996: 46). A means to implement this could be to place more emphasis on the intergenerational equity principle in the EIA process and constrain behaviour using 'fatal flaws'. It is suggested here that embodied in the 'fatal-flaws' as a constraint, require meeting a minimum standard of 'adaptability' and 'transformability', to ensure that the rights of future generations are included as a minimum standard.

The aim here was to discuss how the intergenerational principle could be attended to by each of the tools. Other than the above, and the adoption of inter-generational discounting, the author could not propose any further adaptions to integrate the 'Intergenerational Equity' principle into the tools.

4.3 Procedural Principles

4.3.1 Robustness

The Robustness principle speaks to the applicability and appropriateness of the tools in a variety of situations, and is made up of three components. The first component seeks to evaluate the tools in terms of the 'Nature, Scale and Scope' of the project context, which in this study, refers to the choosing between a set of project alternatives according to a variety of development objectives. The second component relates to the tools ability to handle projects with significant impacts, which is required to maintain decision-makers' confidence in the respective tool. The third and final component relates to the nature of knowledge that is used as an input into the tool. The tools will be evaluated according to their ability to provide a holistic understanding of reality by integrating both 'objective' and 'subjective' knowledge forms.

4.3.1.1 Cost Benefit Analysis

The first objective of this principle evaluates the tool's ability to align with the nature, scale and scope of the project context. The project context in this study involves development projects with environmental impacts and are therefore multi-dimensional in nature. It was agreed under the 'Integration of Systems Principle' that CBA is able to internalise multiple dimensions (ecological, social and economic) and is therefore suitable to the nature of the project context. In terms of scale and scope, the tool may be used to evaluate or rank the feasibility of project alternatives and therefore meets these two components of the objective as well. The CBA should be commended on its dynamic ability to extend across both strategic and project scales, with the ability to provide decision aid to policy setting and project appraisal respectively. The tool can even be used so far as to analyse the effects of regulation (DEAT, 2004a).

It is evident that the CBA is viewed as a robust tool in terms of its ability to deal with projects that render significant impacts. This is deduced from the fact that it is a relatively widely adopted tool in South African environmental management and has in the past been used to assess projects and programmes with significant impacts. Examples of such projects and programmes include the Baboon Management Programme in the South Peninsula area of Cape Town (CBA conducted by Independent Economic Researchers in 2013), and the CBAs used to inform climate change adaption in the 'Sustainable Urban Resilient Water for Africa: Developing Local Climate Solutions' project by ICLEI which commenced in 2012. The tool has however been criticised for gaps of uncertainty and inaccuracy which was discussed under the principle of 'Uncertainty and Long Run Impacts'. Uncertainty and inaccuracy tests the tools ability to fully meet the objective relating to Significance. Nevertheless, the scientific and economic community continue to apply the tool despite their awareness of the tool's limitations in this regard.

To fully meet the objective of adopting a Transdisciplinary Approach, the tool should hold the ability to integrate and internalise objective knowledge, for example science and technology, and subjective knowledge, for example values, ethics and the institutional setting. This will provide for a fuller body of knowledge to inform decision-making. The CBA internalises objective knowledge during the process of determining the functional relationship between the project and its impacts and then placing a monetary value on these impacts. This knowledge is mainly gained through scientific methods and denominated in quantitative form. Because the CBA process includes a stakeholder engagement process, it is able to engage with knowledge types beyond science such as traditional knowledge systems. This may however be limited by the ability to use monetary units as a proxy for the information derived from these knowledge systems. Where CBA is able to internalise traditional knowledge in the model, it is progress towards adopting a Transdisciplinary Approach.

According to Audouin and De Wet (2012), more subjective knowledge forms can be engaged with through value-based questions and is therefore denominated in more qualitative form by nature. CBA was previously criticised for its limited ability to engage with a variety of ethical values and process qualitative information within its model. It was suggested that such information be noted under a separate section in the report. Whilst the tool is able to record information derived from subjective knowledge, separating this information from the model output limits the tool's ability to fully achieve the objective of a transdisciplinary approach.

4.3.1.2 Simple Multi-Attribute Ranking Technique

SMART is suited to the nature of development projects with environmental impacts and has the ability to deal with multiple dimensions. As discussed under the 'Integration of Systems Principle', the tool is able to allocate specific criteria to each dimension once the objectives and relevant impacts have been identified. SMART is also suitable to the scale and scope of the decision context in this study as the tool is able to evaluate the characteristics of project alternatives against specified criteria in order to rank the alternatives. Based on this, the tool is able to be implemented at a project-level and aid the decision-maker in deciding between project alternatives.

MCDA tools are commonly applied by the Water Research Commission to inform decisions regarding water resource and catchment management projects and programmes (Stewart *et al.*, 1997; Pietersen, 2006). This shows that decision-makers maintain confidence in the ability of the tools to manage projects with significant impacts and therefore meets the objective relating to 'significance'.

One of the advantages of SMART is in its ability to internalise qualitative information in the model. This can be through the construction of descriptive scales that can then be converted into quantitative scales. An example of the Beaufort Scale was previously used. The tool therefore has the potential to include more subjective knowledge forms which would typically be denominated in qualitative form. By being able to integrate both objective and subjective knowledge types into the model, the model can be considered as complete and therefore scores relatively higher on the objective of a Transdisciplinary Approach. The SMART process also includes a stakeholder engagement process which provides the opportunity to engage with a variety of knowledge types including traditional knowledge systems.

4.3.1.3 Comparison

The first objective of the 'Robustness' Principle evaluates how suitable each tool is to the nature, scale and scope of the decision context. From the evaluation, it was seen that both tools are able to internalise multiple dimensions which typically arise from projects with environmental impacts, and rank project alternatives. Both tools therefore fully meet this first objective.

The second objective relates to the suitability of the tools in a decision context which may potentially involve significant impacts. Decision-makers should be confident in the processing power of the tool and its ability to provide a scoped yet comprehensive analysis of the decision problem. CBA continues to be applied in general environmental management and MCDA continues to be applied in water resource and catchment management. This shows that decision-makers hold confidence in the robustness of the tool. Both tools score evenly on this objective as they have both been applied to projects with significant environmental impacts in the past.

The final objective under this principle evaluates how well each tool is able to adopt a Transdisciplinary Approach. Essentially the application of a Transdisciplinary Approach will depend on the analyst and their ability and willingness to engage with different knowledge forms.

According to Audouin and de Wet (2010) environmental management has been over reliant on objective knowledge types such as science and technology. These knowledge types are seen to be typically denominated in quantitative form which both tools are fully equipped to handle. In order to adopt a Transdisciplinary Approach in environmental management, these authors suggest engaging and integrating subjective knowledge forms which may include traditional knowledge systems. These knowledge forms typically involve asking value-based questions and are therefore assumed to be typically denominated in qualitative form. SMART shows an advantage over CBA in this respect, as it is able to internalise qualitative information into its model, and is therefore also more likely to be able to engage with a variety of ethical values. In comparison, CBA is mostly able to record qualitative information in a separate section under the same report. Although both tools have the ability to record qualitative information, and thus subjective knowledge, SMART was seen to hold an advantage through its ability to internalise qualitative information into its model.

Table 4.4: Differences between CBA and SMART in terms of the Robustness principle

	CBA	**SMART**
Nature, scale and scope	✓	✓
Significance	✓	✓
Transdisciplinary Approach	✓ But without qualitative information.	✓ With qualitative information

4.3.2 Phase in the Project Process

The ‘Robustness’ principle acknowledges that both tools are suitable to the nature, scale and scope of the decision context. It was shown that the tools are subject to the project-level which involves the Project-Cycle; Plan, Do, Check and Act. The tools are expected to be implemented in the ‘Plan and Design’ phase of the Project-Cycle which requires tools that collect data and generate knowledge. This data and knowledge will be used as inputs to aid decisions on which project alternative should be implemented. The better suited tool to the requirements of the ‘Plan and Design’ phase, the more easily the Project-Cycle can move to the next phase, being the implementation of the decision.

4.3.2.1 Cost Benefit Analysis

The role of the CBA in the ‘Plan and Design’ phase would be to collect information and generate knowledge. Data is collected by the CBA expert and other specialists relevant to the various impacts. The role of the CBA and its expert would then be to understand the relationship between the projects and the impacts, and transform the data on the impacts into monetary values appropriate for input into the model. The tool then processes all the data together to provide an NPV used to rank the project alternatives. The ranking of the NPVs would be used to aid decisions and is therefore fully suitable to the ‘Plan and Design’ phase.

4.3.2.2 Simple Multi-Attribute Ranking Technique

According to Belton and Stewart (2003:5), “the principle aim [of MCDA tools are] to help decision-makers learn about the problem situation, about their own and others values and judgements, and through organisation, synthesis and appropriate presentation of information to guide them in identifying, often through extensive discussion, a preferred course of action”. The tool therefore plays the same role as CBA in the ‘Plan and Design’ phase as it collects data and generates knowledge. Again, data would be used as inputs into the tool after which it is up to the tool to structure the data in a manner which takes account of multiple, conflicting criteria (Belton & Stewart, 2003). The result of the tools are value scores for project alternatives which can be used for ranking and is therefore also fully suited to the ‘Plan and Design’ phase.

4.3.2.3 Comparison

It is evident that both tools suit the ‘Plan and Design’ phase of the Project-Cycle. The role of both the tools in this phase is to collect data and generation of knowledge in the form of their ranking outputs which would then be used to aid decision-making. Data is collected by other sources, such as specialists, or can be inferred from other tools like the EIA for example, but can still be considered as part of the tool’s process.

Table 4.5: Differences between CBA and SMART in terms of the Phase in the Project Process principle

	CBA	**SMART**
Phase of the Project Process	✓	✓

4.3.3 Stakeholder Engagement

4.3.3.1 Cost Benefit Analysis and Simple Multi-Attribute Ranking Technique: evaluation and comparison

The minimum requirement for a tool to meet the objective of this 'Procedural Principle' is by having a stakeholder engagement process towards the 'Collaboration and Empowerment' end of the IAP2 spectrum that maintains the potential to encompass the 'universal' objectives. Because both tools require a stakeholder engagement mechanism in the form of a workshop, both tools fully meet the objective. It is therefore not necessary to discuss a separate evaluation and comparison for both tools.

As mentioned previously, the PPP is a legal requirement of IEM and is guided by a set of 17 objectives. Both tools require a PPP of their own and it was suggested that this process should be divided into a series of workshops in order to suit the procedure of the tool. Under the 'Philosophical Principle' of 'Intragenerational Equity', it was made evident that both tools have the potential to meet the objective relating to Holistic Decision-Making and Transparency. The remaining objectives, which do not relate to Holistic Decision-Making and Transparency have been referred to as 'universal objectives' and are listed as the following:

1. raising awareness, educating and increasing understanding between stakeholders (a two-way information exchange);
7. commenting on the findings of technical studies;
9. informing and improving decision-making;
11. generating a sense of joint responsibility and ownership for the environment;
14. assisting in the review and monitoring of activities that may negatively affect the environment;

15. contributing to the development of appropriate policy, legislation and regulations; and
16. promoting democracy.

Any workshop has the potential to meet these objectives and depends mainly on the skills and willingness of the practitioner. This implies that the tools hold the potential to achieve these objectives simply by conducting this form of stakeholder engagement mechanism.

Table 4.6: Differences between CBA and SMART in terms of the Stakeholder Engagement principle

	CBA	**SMART**
Stakeholder Engagement	✓	✓

4.3.4 Transferability of Information

Transferability of information in this context is with regards to the flow of information from the project-level into the broader strategic-level. This is in accordance with the idea to apply a combination of IEM tools intended to complement and supplement each other. The EIAMS report (DEA, 2014a) refers to this combination as a "Progression of Tools". The flow of information is to be used as the connecting factor in the Progression of Tools. There are seen to be two information sets associated with CBA and SMART which may be of relevance to the strategic context. The first information set relates to the outputs of the tools, and the second information set relates to the data collected for the tool and the manner in which it is processed. The aim is to evaluate and compare the value of these information sets associated with each tool when intending to integrate them into more strategic IEM tools.

4.3.4.1 Cost Benefit Analysis

The CBA's output takes the form of an NPV. The NPV has been calculated from the real market setting and is not dependent on the characteristics of other project alternatives. Under most circumstances, because the NPV of a project alternative is calculated independent other projects alternatives in the proposed set, it is able to be compared with the NPVs of projects outside of the study. The NPVs of projects could therefore be useful in the strategic context, for example, if there was ever a need to evaluate the net worth of projects within a certain area or among areas. It would be particularly useful if the NPV could be determined for all projects in this sense.

The data collected for the CBA and the manner in which it is processed could also be useful in the strategic context. Impact-type assessment is reactive by nature, and the information that is relevant after a project is implemented is that which relates directly to the chosen project alternative. Information on the other project alternatives will more than likely be irrelevant unless there are close similarities with a different project context that allows for adaption. In some instances of the CBA, the tool requires the valuation of an entire ecosystem good or service in order to infer the value of an impact on that good or service. The values of the impacts are then compared among the alternatives. If the implemented alternative does not completely degrade the ecosystem good or service, then either the full value or the partial value of the ecosystem good or service still exists and the information on this could be useable in a strategic context. For example, in order to internalise the impacts on a small forest, the entire value of the forest must be determined. The impact cost of an alternative is then determined by how much of value is taken away from the forest. The remaining value of the forest is then still known and can be used in a strategic context.

4.3.4.2 Simple Multi-Attribute Ranking Technique

Neither of the two information sets in the SMART tool are able to be brought into the strategic level. The tool therefore does not achieve well in the objectives of this principle. The outputs and value scores of the model are all calculated relatively according to the values of the project alternatives in the proposed set. Due to the relativity, when this information is taken outside the decision context, it becomes obsolete.

4.3.4.3 Comparison

CBA scores higher than SMART on both the objectives of this principle, and is therefore more suitable in a ‘Progression of Tools’. It should be noted that the information that is used as inputs into both tools, e.g. EIA, specialist reports, stakeholder engagement information, etc., has the potential to be useful in the strategic context. What also has the potential to be useful is the qualitative information derived from the processes of the tools. Both tools are reliant on the elicitation of preferences held by the affected stakeholders. This information could be useful given the fact that sustainable development is a value-laden concept.

Table 4.7: Differences between CBA and SMART in terms of the Transferability of Information principle

	CBA	SMART
Transferability of Information: Output	✓	X
Transferability of Information: Collected and processed data	✓	X

Chapter 5: Concluding remarks, conclusion and limitations to the research

5.1 Introduction

Chapter 4 suggested various conclusions, recommendations and limitations that were made in terms of each sustainability-thinking principle. Many of these suggestions were directed at a variety of themes and issues which maintain different levels of importance and were often seen to reoccur across many of the principles. The aim of this chapter is to streamline the suggestions made in chapter 4 to provide a clear and coherent basis upon which a conclusion can be made.

The chapter begins by making concluding remarks on chapter 4 'Evaluations and Comparison'. A conclusion will then be drawn which suggests SMART as the tool better aligned with sustainability-thinking according to the set of objectives used in this study. It was determined that the advantages of SMART mainly drew from balancing accuracy and technicality with simplicity and transparency, as well as the ability to integrate qualitative information. Finally, the limitations to the research will be discussed.

5.2 Concluding remarks

This section discusses and interprets the important and recurring themes that were noted in the previous chapter. Where relevant, each remark discusses the underlying issue, the implication of the issue on the comparison of the tools and the issues implication within sustainability-thinking. It must be remembered that these conclusions have been drawn from an analysis based on the *potential* of the tools, as these tools are seen to be flexible and adaptive in accordance with the decision context. In some instances, adaptions to unlock the potential of the tools to meet the sustainability-thinking objectives were suggested, and when uncertain, specialists were consulted to advise on the feasibility of some adaptions. Concluding remarks are as follows:

1) CBA and SMART are able to internalise the multiplicity of environmental management, and have the ability to structure this multiplicity in a manner that allows for rational decision-making.

In a decision context seeking to rank project alternatives with environmental impacts, the EIA has been criticised for its limited ability to structure information in a manner that aids rational decision-making. This led to the search for alternative tools such as CBA and SMART. These two tools are able to handle multiplicity by standardising diverse information's sets using preferences, and then structuring these preferences in an additive algorithm to provide a utility/value score used for ranking.

Although the EIA is limited in the structuring of information, it is well equipped to handle multiplicity by recording the impacts accruing to the three fundamental systems and other development objectives. Because CBA and SMART use the EIA (and other sources) information to inform preferences as inputs into the model, the two tools should not be seen as a replacement of the EIA but rather as the next step in the environmental assessment process.

This concluding remark is made with acknowledgement of the scope of contemporary South African environmental management that is still characterised by a modernistic and reductive approach (Audouin & De Wet, 2010). A transition to better align environmental management tools with sustainability-thinking would be to adopt tools that better account than the current approach for the interdependent and emergent properties inherent in socio-ecological systems. Such tools are applied under the discipline of 'systems thinking', and can be used to "understand the structure of a system, the interconnection between its components, and how changes in an area will affect the whole system and its constituent parts over time" (Maani & Cavana, 2000: 8).

2) CBA and SMART both rely on 'preferences' and are therefore based on the assumption of perfect information.

The preferences used in CBA and SMART rely on various assumptions. When expecting preferences to align with sustainability-thinking, three assumptions entail:

- Stakeholders are rational and aim to maximise their utility/value.

- Utility/value is maximised if stakeholders make decisions according to sustainability-thinking as a contribution towards sustainable development.
- Perfect information is held by stakeholders which informs their preferences.

The underlying logic is that stakeholders aiming to maximise their well-being (utility/value), would prefer options that contribute to sustainable development based on their knowledge (perfect information) of sustainability-thinking. However, given the complexity experienced in environmental management, the assumption of perfect information is unlikely to hold and would misalign preferences with the principles and axioms of sustainability-thinking. This issue limits the ability of both tools to embed the hierarchy of the three fundamental systems and penalise alternatives with uncertain knowledge on their negative impacts. In accordance with the above logic, not aligning with these two aspects of sustainability-thinking would decrease the accuracy and effectiveness of the tools' outputs.

Whilst the tools have the advantage of structuring information, the practice is limited by the assumption of perfect information. To improve upon this limitation, it was suggested that the public participation process would contribute to better aligning information and preferences. Because both tools equally succumb to this limitation, there is no advantage of one tool over the other in this respect. The point of interest is that that the reliance on preferences introduces limitations which should be considered when alternative decision aid tools are compared in the future.

3) Interdependent relationships and emergent properties are an issue for both CBA and SMART.

CBA and SMART fail to integrate interdependent relationships and emergent properties in their models. These aspects are not able to be accounted for in the tools' additive algorithms which requires the division among information sets. By dividing information sets according to themes (ecological, social and economic), the interdependent relationships that exist between the respective systems are lost and so are the derived emergent properties. Whilst the tools are able handle multiplicity, the manner in which this is handled does not fully align with sustainability-thinking. Both tools do however have the potential to account for emergent properties in isolation through the inclusion of secondary impacts and multiplier effects. However, this would only be in obvious, discrete cases whereas system dynamics would be a property of the entire decision context.

Again, both tools succumb to this issue equally and no advantage of one tool over the other can be drawn. Nevertheless, not accounting for these two aspects can be considered a loss of information and in conflict with the Precautionary Principle as argued under the last objective of the 'Uncertainty and Long-Run Impacts' principle. This should also be considered when alternative decision-aid tools are considered and compared in the future.

4) CBA and SMART are well aligned with the 'Uncertainty and Long-Run Impacts' principle, but SMART is better aligned than CBA.

Managing uncertainty is always a prominent and sensitive theme in decision-making, and is especially important in complex contexts such as environmental management where technicality and accuracy is to be balanced with simplicity and transparency. The two tools are well aligned to achieve this balance, as they apply a diverse set of relatively simple mechanisms to reduce uncertainty in the decision context. In addition to this, the tools have the potential to consider some elements of uncertainty that proliferates through time by accounting for long-run impacts using a Life Cycle Approach. If such an approach includes a comparison of impacts over time, it gives rise to the controversial issue of discounting which relates to the principle of 'Intergenerational Equity'. Discounting will be discussed as a separate 'concluding remark'.

SMART proves to have an advantage over CBA on the grounds of greater certainty in scientific information. It was shown that the valuation techniques in CBA do not necessarily provide correct values for environmental impacts and therefore not accounting for the TEV of impacts. SMART in contrast is able to create a variety of quantitative and qualitative criteria targeted at capturing direct, indirect and intrinsic values if required. The advantage of SMART over CBA in this respect is not without acknowledgement of the limitations relating to the assumption of perfect information and strategic biases. Joubert (2002) compared the two tools from a more technical perspective, and argued that SMART was preferred to CBA on the grounds of "general validity and reliability".

Based on her study, it would be safe to conclude that SMART introduces fewer 'gaps of uncertainty'.

It is also reasonable to expect that stakeholders directly affected by the decision context, with the aid of a public participation process or other appropriate augmentations, would provide more accurate preferences than those inferred from surrogate markets. Especially when much of the population in developing countries are not included in the market setting (Joubert *et al*., 1997). Perhaps in the private sector context, characterised by objectives more focused and relatable to the firm, CBA would be more appropriate. This is however not the case in the public context and South African IEM. SMART proves to hold an advantage over CBA in the 'Uncertainty and Long-Run Impacts' principle.

5) A flexible approach towards discounting should be taken, and should not be the primary means to ensure the fair distribution of resources among generations as of the 'Intergenerational Equity' principle.

Intergenerational equity continues to be an ambiguous concept and it is therefore not surprising that this principle was not thoroughly provided for in either of the tools. The discussion explained how particular discounting approaches could be used to better align the tools with the 'Intergenerational Equity' principle.

The desire to discount arises from the combination of a Life Cycle Approach and the need to aggregate measures into a single value for input into the decision model. The economic discipline argues that either the social rate of time preference, or the decreasing marginal utility of future consumption, are grounds for discounting these values. Those opposed to this argument believe that any positive discount rate infringes on the rights of future generations, however if a discount rate is set too low, the rights of present generations are equally infringed upon.

The aspects of analysis which relate to discounting have been left relatively vague. Given the flexibility of both tools and controversy surrounding discounting, the manner in which each tool handles the values of impacts through time was not used as an objective for evaluation and comparison. Instead, it was acknowledged that both tools have the potential to adopt a Life Cycle

Approach, recognise that discounting could be applied to integrate the information of the Life Cycle Approach into the decision model, and recommended that the decision-maker could tailor the discounting approach to their preference which should include concerns for the rights of future generations.

To bypass the moral debate, it was suggested that discounting should be used to better include the concerns of environmental damage and not to be the pivotal instrument to ensure the fair distribution of resources among generations. A potential means to better ensure the fair distribution of resources could be to place more emphasis on the 'Intergenerational Equity' principle in the EIA process by using 'fatal flaws' as a constraint on certain impact levels. This would require that impacts maintain the 'adaptability' and 'transformability' of their receiving system as a minimum standard, to ensure that the system is sustained for future generations.

6) Inclusion of qualitative information in the SMART model proves to be an advantage.

The benefit of formal decision-aid models is to take pressure off the decision-maker's cognitive capacity in decision contexts where large and diverse information sets need to be synthesised. Fundamentally, any omission of information from the model which falls on the responsibility of the decision-maker to synthesise with the model is a diversion away from the aim. This proved to be the case for CBA and its weak ability to include qualitative information in its model, and requires this information to instead be reported on in a separate section of the report. The issue derives from the difficulty of attaching monetary values to impacts which can only be phrased descriptively.

SMART attaches value scores to the scientific measurement of impacts abstractly and is therefore able to value impacts directly or through descriptive scales. This proved to be an advantage for the tool on the principles of 'Integration of Systems', 'Uncertainty and Long-Run Impacts', 'Intragenerational Equity' and 'Robustness'. In accordance with what is outlined in the sustainability-thinking principles, environmental management tools applied in the decision context of this study should be able to integrate qualitative information.

7) CBA is better suited than SMART in a 'Progression of Tools'.

The benefit of a 'Progression of Tools' is to ensure that IEM tools are used correctly and consistently, and fill the gaps based on the strengths and weaknesses of the different tools at different levels (DEA, 2014a). In the case of the 'Transferability of Information' principle, CBA's use of a real-life proxy (price) proved to be an advantage in this respect. The evaluation explained that prices developed irrespective of other project alternatives could be used at a strategic level, in contrast to the values in SMART that are developed relatively and when taken out of the decision context become obsolete. The information from the CBA could be used to inform sustainability strategy at broader programme and policy levels, for example, if there was ever a need to evaluate the net worth of projects within a certain area or among areas. If CBA was to be widely applied, a useful database could be developed.

Sustainability-thinking would probably be most effective at the strategic level, where strategic environmental frameworks and plans are put into place for, *inter alia*, determining sustainability targets (DEA, 2014a). The transferability of information from project-level tools to informing strategic planning and sustainability targets is therefore highly beneficial. Whilst this may be true, because this research is focused at the project level, further studies of the practicality, validity and reliability of using CBA's information at a strategic level would need to be conducted to conclude that this advantage of the tool is able to outweigh the advantages of SMART. Unfortunately, this is beyond the scope of this research. Furthermore, the unit of analysis in this study is sustainability-thinking principles which is predominately a philosophical perspective, whereas the transferability of information in a 'Progression of Tools' is a more practical issue.

8) SMART is better aligned with the 'Intragenerational Equity' principle.

It is widely agreed that MCDA tools such as SMART are advantaged in their ability to include a variety of stakeholders and members of the public (Stewart *et al*., 2003; Herath & Prato, 2006; Joubert *et al*., 1997). In this study, SMART was shown to have an advantage over CBA in all the objectives under the 'Intragenerational Equity' principle. These objectives included Environmental Justice and Stakeholder Engagement which includes Holistic Decision-Making and Transparency. The issues that disadvantaged CBA were; the state of income inequality which results in pro-rich biases, technical processes in the use of shadow pricing methods, as well as limited stakeholder engagement which inflicts transparency issues.

The benefit of adopting the 'Intragenerational Equity' principle in South African IEM is to redistribute the value of developments towards vulnerable and previously disadvantaged groups, and provide for improved and legitimate decision-making in the project process. Although the principle is widely called for in IEM legislation, there is much criticism surrounding its authentic adoption. In the EIAMS report (DEA, 2014a: 76), the "lack of effective public participation and appreciation for public participation as a process that adds value to Integrated Environmental Management" was identified as one of the root causes limiting the success of the current IEM system in achieving sustainability.

Such a movement away from the authenticity of stakeholder engagement, may play to the advantage of more technical and indirect tools such as CBA. This is due to the inherent challenges within a stakeholder engagement process which can be passed onto SMART as limitations. Challenges to stakeholder engagement that also relate to the SMART process may include:

- Political manipulation and misrepresentation – where individuals influence the decision-making process for political or self-interest.
- Political grandstanding – "where individuals or groups dominate the meeting to advance their own positions" (DEAT, 2002: 18).
- Strategic bias and uncompromising stakeholders – where stakeholders either bias their preferences to sway results in their favour, or do not accept results that are not in their favour.
- Internal conflict within stakeholder groups – where stakeholder groups cannot create a shared vision which can be represented.
- Lack of understanding by stakeholders – although SMART is seen as a relatively simple process to follow, some stakeholders may not have the capacity to engage with the process.

If stakeholder engagement is disregarded in the environmental decision-making process, CBA is still able to incorporate redistributive mechanisms such as attaching 'income weights' to costs and benefits. In this instance, having less of a reliance on stakeholder input may prove to be an advantage for CBA in terms of avoiding the above challenges and ensuring a smooth progression through the project process.

Although stakeholder engagement presents many challenges, it is generally accepted as a critical element for sustainable environmental decision-making. A study by Bulman (2011) recorded a 99% preference for the inclusion of a stakeholder engagement element in the decision process. Respondents to the survey included; members of the public, decision-making authorities, Environmental Assessment Practitioners, Specialist Assessment Practitioners, among others. Stakeholder engagement is highly called for in South African IEM and sustainability-thinking which gives an advantage to SMART in this area.

5.3 Conclusion

This study was applied in the context of South African IEM and its relevant policy and legislative framework. Research was conducted in response to the inappropriate application of IEM tools and instruments which fail to adequately inform development decisions in accordance with South African IEM principles. The decision context is at the project-level which involves the selection of the most appropriate project alternative from a set of alternatives according to specified development objectives. Furthermore, the project alternatives would be typically characterised as ones which render environmental impacts.

The goal of the study was to add to the body of knowledge on appropriate tool selection for environmental managers. More specifically, the aim was to compare the two decision aid tools CBA and SMART in terms of sustainability-thinking principles. The comparison of the tools from this perspective is important given that the overall goal of South African IEM is sustainable development. Sustainable development is a highly value-laden concept, therefore the study sought to elicit sustainability-thinking principles from the body of IEM policy and legislation. This was carried out through content analysis from which two categories of principles were determined, ‘Philosophical Principles’ and ‘Procedural Principles’. Principles were transformed into a framework of objectives according to which the theoretical underpinnings and procedure of the tools were evaluated against. Theoretical underpinnings and procedure was deduced from each tool's respective 'guidelines' according to which they should be implemented. This renders the study purely theoretical, as the conclusions were not tested against real-life case studies. Whichever tool better aligned with the framework of objectives was concluded to be more aligned with South African IEM sustainability-thinking on a theoretical level.

From the evaluation and comparison (see chapter 4), SMART was seen to have two significant, overarching advantages over CBA. The first advantage was that SMART has a relatively better ability to balance technicality and accuracy with simplicity and transparency in its process and model. Technicality and accuracy relates to the 'Uncertainty and Long-Run Impacts' principle, which continues to be a challenging theme in decision-making. Although both tools were commended for their simple and diverse mechanisms aimed at handling uncertainty in the decision context, it was determined that if SMART were to emphasise a Life Cycle Approach where necessary, the tool would equally cover temporal concerns surrounding long-run impacts whilst having fewer gaps of uncertainty in its theory and procedure relative to CBA. Gaps of uncertainty are introduced into CBA through its surrogate price and market valuation techniques. Where the SMART tool may fall in the accuracy and certainty of its outputs relative to CBA, it makes up in the transparency of the tool. It is irrefutable that SMART is a more simplistic, inclusive and transparent tool, better aligning it with the 'Intragenerational Equity' principle. If information is better trusted, then it is more likely to have the desired effect on decisions and behaviour which ultimately improves the IEM process.

The second advantage that SMART has over CBA is its ability to integrate qualitative information into its model, thereby making it synthesizable with quantitative information to produce a more encompassing outcome. The importance of qualitative information was relevant to the 'Integration of Systems', 'Uncertainty and Long Run Impacts' and 'Intragenerational Equity', as it provided for a more complete body of information in a sense of instrumental and intrinsic values. It was also relevant to the 'Procedural Principle' of 'Robustness' as the inclusion of a Transdisciplinary Approach requires engagement with more qualitative and value-based questions. As mentioned in the concluding remarks, the benefit of formal decision-aid models is to take pressure off the decision-maker's cognitive capacity. It is a diversion away from the aim where CBA omits information from the model and places it in the responsibility of the decision-maker to synthesize it with the model.

Although SMART was seen to be better aligned with sustainability-thinking than CBA on a theoretical level, certain aspects of the tool does not allow it to align with the philosophy completely. Such aspects relate to the tool's inability to sufficiently account for interdependent relationships and emergent properties, intergenerational equity concerns, as well as not being able to be integrated within a 'Progression of Tools' on a more procedural level. This was no surprise as the tool was not originally conceptualised to be applied solely in the context of sustainability-thinking. The author does however believe that the application of tools better aligned with the framework of principles in this study in the relevant decision context, will be a step in the right direction towards better integrating sustainability-thinking into environmental assessment and management.

5.4 Limitations to the research

The two most important limitations to the study relate to biases arising from interpretation in the content analysis (chapter 2), and the lack of empirical evidence to prove the validity and plausibility of theoretical claims and hypothetical adaptions made in the evaluation and comparison (chapter 4) of the tools. This section will discuss each limitation separately, explain why the limitations arose, and discuss attempts to mitigate the implications of the limitation.

The interpretations of the policy and legislation during the content analysis used to outline the sustainability-thinking principles, may differ from one researcher to the next. This may have implications on the content of the principles, how they are structured, and the scope of principles which make up 'South Africa's IEM sustainability-thinking ethic'. With regards to which principles were included as those related to sustainability-thinking, the author consulted the various subsections of guidelines and legislation outlining relevant environmental management principles. Often the principles listed next to one another were relatable and could be easily structured into a hierarchical order (see figure 2.1). An example of this is the 'Intragenerational Equity' principle, which is made up of Environmental Justice and Stakeholder Engagement, of which Stakeholder Engagement is made up of Holistic Decision-Making and Transparency. These were all stated as separate principles in the guidelines and legislation. As for the content of each principle, a variety of guideline, legislative and policy clauses were cross-referenced to outline what was believed to be the most fundamental aspects relating to each principle. The author believes what is more important here is which clauses were used to formulate the content of the principle and not how the clauses would be strictly interpreted in a court of law. In many instances, clauses, concepts and definition were ill-aligned and sometimes even contradictory. Through cross-referencing according to the hierarchy of legislation and guidelines a consistent idea of the principle could be established.

With regards to the evaluation and comparison of the tools, the analysis was based on each tools' respective 'guidelines', and therefore on a purely theoretical level. In addition to this, hypothetical adaptions were made to the tools to theoretically extend their potential to align with sustainability-thinking. The plausibility of theoretical claims and hypothetical adaptions were not tested empirically. From a practical perspective, one may be sceptical of the conclusions drawn in this study. SMART may be theoretically better aligned with sustainability-thinking with the suggested adaptions, but may deviate from this alignment when implemented in reality. What could deviate the tool is its inherent limitations, or that the suggested adaptions are not applicable and theoretically consistent. It would therefore be unfair to outright conclude that SMART is a better aligned tool with sustainability-thinking without a solid empirical backing.

To test the theory in practice, the best method would be to apply each tool to the same decision problem and analyse how the sustainability-principles manifest. This was originally an objective for this study, but the author experienced various challenges when searching for a suitable case study. Even if the tools were applied in the same decision problem, the characteristics of different decision contexts are highly variable, and the full potential of each tool would not be fully illustrated in a single experiment. A series of these experiments would therefore need to be conducted to provide a solid conclusion. Alternatively, one could compare how sustainability-thinking principles manifested in case studies involving each tool separately. However, the fairness of the analysis would be doubted without consistency. To bypass these challenges, the 'guidelines' of the tools were consulted, as they are seen to be the most consistent point of departure. Where empirical evidence would have been beneficial, illustrative examples were drawn from the ‘guidelines’ as an attempt for credibility. To provide a more wholesome conclusion in the future, a valuable study would be to conduct the suggested empirical research.

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