A MULTI-CRITERIA APPROACH TO DECISION MAKING CONCERNING ENVIRONMENTAL PLANNING ISSUES WITHIN DECENTRALISED GOVERNMENT INSTITUTIONS

Renaire Shelly Huntley

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ABSTRACT

Environmental planning decisions are typical examples of complex problems involving numerous interacting criteria and often conflicting technical, societal, environmental and political objectives.

Because governments possess the overall responsibility for environmental politics and management, decision makers within government organisations need to be capacitated with value-based, multi-criteria and holistic decision making methods to address the increasing scale, complexity and uncertainty associated with development proposals, public activism aimed at improving environmental quality, and equity in ensuring the process of governance. This research therefore aimed to derive multi-criteria decision making (MCDM) models that would aid practitioners and decision makers in the field of environmental and development planning, in formulating and executing rational, transparent, equitable, valid and sustainable decisions.

The dissertation introduces environmental decision-making and discusses the complexities in decision-making. It presents an overview of the political and legislative frameworks governing environmental and planning decision-making and the problems managers experienced in practical environmental decision-making. Decision frameworks for sustainable development and risk assessment were employed to derive the MCDM models. The research employed Soft Systems Methodology (SSM) (an interpretivist and complementary approach) to identify the decision problem. Following the holistic enquiry into the decision problem, a structuring of the decision problem was undertaken. The problem was structured in a hierarchical manner due to the stability, flexibility, and coherence of hierarchies. This enabled the decision problem to be viewed within its larger environmental, social, organizational and political context. The Analytical Hierarchy Process (AHP), a MCDM method for ranking and synthesising criteria in a systematic manner, was then employed in a problem solving and conflict resolution context.

The dissertation reports on the results of the conceptual, practical and operational validation phases of the two MCDM models derived in this research: sustainable development and risk

models. The models were implemented in three real-world decision problems to test their relevance, applicability and usefulness and were critically appraised by the decision-makers who participated in the practical validation of the models.

The outcome of the validation processes revealed that the research was successful in developing effective and simple MCDM models that aided in the complexities of environmental decision-making. They were especially commended for their holistic, integrative, equitable and transparent approach in dealing with decision problems. With the aid of the models, decision-makers were able to integrate the science of environmental analysis with the politics of resource management.

PREFACE

The work in this dissertation was conducted to provide multi-criteria decision support models to relevant decision makers in the field of environmental and planning management. It forms part of a larger national Decision Support System for environmental management, the South African Integrated Spatial Information System (SA-ISIS 2000), which will be made accessible to decision makers on the World Wide Web (WWW). This work is not duplicated with other work of this nature in South Africa, though research on other aspects of multi-criteria decision modeling is carried out at the University of Cape Town, South Africa.

The practical work discussed in this dissertation was conducted from August 1999 to October 1999 under the supervision of Professors: D. Petkov, a lecturer in the School of Mathematics, Statistics and Information Technology, University of Natal; and D. Archer, an independent lecturer at the University of Natal, Pietermaritzburg.

These studies represent original work done by the author and have not otherwise been submitted in any form for any degree or diploma to any University. Where use has been made of the work of others, it has been duly acknowledged in the text.

This dissertation is dedicated to the memory of my sister, Sandra, who provided me with much inspiration and guidance during my year of full-time study.

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LIST OF ABBREVIATIONS AND ACCRONYMS

AHP:	Analytical Hierarchy Process
CATWOE:	Mnemonic developed in soft systems methodology to assist in the development of root definitions (core essence of a decision problem).
CBOs:	Community based organisations
CSIR:	Centre for Scientific and Industrial Research
DACST:	Department of Arts, Culture, Science and Technology
DFA:	Development Facilitation Act (No.67 of 1995)
DSS:	Decision Support Systems
EC:	European Community
EC:	Expert Choice software
EIA:	Environmental Impact Assessment
EIS:	Environmental Impact Statement
EMS:	Environmental Management Systems
GDS:	Group Decision Support
GDSS:	Group Decision Support Systems
GIS:	Geographical Information Systems
GDTMC:	Greater Durban Transitional Metropolitan Council
GJTMC:	Greater Johannesburg Transitional Metropolitan Council
ICLEI:	International Council for Local Environment Initiatives
IDP:	Integrated Development Plans
IEM:	Integrated Environmental Management
INR:	Institute of Natural Resources
LA21:	Local Agenda 21
LDP:	Local Development Plans
LDOs:	Land Development Objectives
LGTA:	Local Government Transition Act
LSI:	Local systems intervention
MAUT:	Multi-Attribute Utility Theory
MCDA:	Multi-criteria Decision Aids

MCDM:	Multi-criteria Decision Making
NEMA:	National Environmental Management Act (No. 107 of 1998)
NGOs:	Non-government organisations
PDA:	Planning and Development Act (No.5 of 1998)
RDP:	Reconstruction and Development Programme
SA-ISIS 2000:	The South African Integrated Spatial Information System
SAST:	Strategic Assumptive and Surfacing Testing
SCA:	Sensitive Coastal Area
SMLC:	Southern Metropolitan Local Council
SSM:	Soft Systems Methodology
TLC:	Transitional local council
TMC:	Transitional metropolitan council
TSI:	Total systems intervention
UNCED:	United Nations Conference on Environment and Development
UNGASS:	United Nations General Assembly
WWW:	World Wide Web
Weltanschauung:	Loosely translated into 'World-view'

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CHAPTER 1

INTRODUCTION

The South African landscape, both inland and coastal, is characterised by a myriad of unique, sensitive and valuable features and sites. These resources range from those of aesthetic, cultural, heritage and archaeological value to those of scientific and ecological importance. The true value of these assets to the local, national and global community cannot be wholly quantified with the techniques and tools currently available.

South Africa is also home to millions of poor people who currently exist below the breadline. Their many basic needs include employment, housing and security, food, education and access to potable water supplies, sanitation facilities, electricity and other essential infrastructure. This has prompted many entrepreneurs to propose physical development initiatives that could aid in the alleviation of poverty by creating employment opportunities and infrastructure to the local communities. A large proportion of these development projects are tourism related and are targeted at the country's valuable natural resource base, that being, sensitive coastal and inland areas. In addition, a plethora of other development projects also need to be considered.

The challenge for South Africa lies in redressing past imbalances created by apartheid and in providing development opportunities, without compromising the need to conserve and protect valuable, unique and sensitive areas.

Although government departments are in the process of decentralising, provincial authorities, in consultation with their local counterparts, are charged with the decision-making powers regarding the approval of development proposals. The decisions that need to be made have to balance the need for conserving/protecting the natural environment with that for economic and social development, as well as to resolve the inherent conflicts. Thus, the field of environment and development planning is replete with contradictions.

According to David Fig (1999), "conflicts over natural resources and environmental degradation have dogged South Africa since the beginning of this decade and are likely to intensify since there are few agreed mechanisms for their equitable or rational resolution".

This author observed that recent experiences in South Africa points to the inadequacies of EIAs in resolving environmental conflicts, even though legislation and policies are currently in place for settling conditions under which environmental impact assessments (EIAs) should occur. Thus, although current and newly revised environmental and planning legislation and policies provide decision-makers with statutory frameworks within which to operate, the laws that govern the environment still require operational tools, techniques and programmes if they are to be effective. In addition, the institutional arrangements responsible for making decisions on development proposals should also be effective, since they affect the implementation of resource policies and structure the policy-making processes (Smith, 1984). The driving goal of this research is therefore to aid practitioners in the field of environmental and development planning, in formulating and executing rational, transparent, equitable, valid and sustainable decisions. This can only be achieved when the above-mentioned problems are formally recognised and acknowledged, and included in the research framework.

1.1 Current Environment and Development Challenges Facing Decision Makers

The past two decades have witnessed an increase in concern in the state of the environment and a rapid decline, with special reference to large metropolitan environs, in environmental quality and human health (von Schirnding and Padayachee, 1995). Since the 1980's, the perception of environmental problems has also undergone a transformation. Burstrom and Dalin (1999) support this observation by stating that "there has been a shifting emphasis from the protection of our environment from local and acute to global and chronic effects, generated from an increasing number of subtle and interconnected forces". The Rio Earth Summit in 1992, born out of the need to promote environmentally and socially sustainable development, served to confirm the growing recognition that environmental, human and economic concerns need to be addressed in an integrated manner. To achieve the goal of sustainable development, these concerns should not be viewed as separate issues (von Schirnding and Padayachee, 1995). On the one hand, environmental concerns and politics have assumed a global identity. On the other hand, Burstrom and Dalin (1999) suggest that this period also bears testimony to the "individualisation of environmental problems". Environmental issues have become issues of individuals; e.g. life-styles, morals and ethics.

In common with many other major cities in the world, large metropolitan cities in South Africa are experiencing the effects of massive urbanisation. The rapid rate of urbanisation is one of the factors that are responsible for a large number of environmental, health and social/developmental problems. These problems are exacerbated by numerous factors that include housing shortages and overcrowding, exposure to contaminated water supplies, poor access to adequate sanitation, poor and unattractive living environments, high levels of social problems such as crime and violence, ineffective solid waste removal, and the high levels of unemployment. Most important, however, von Schimding and Padayachee (1995) also identified the lack of co-ordinated environmental management and intersectoral networking as crucial factors responsible for the urban environmental crisis. Burstrom and Dalin (1999) support these authors' findings in their statement: "To achieve the overall objectives of environmental management, there is a need for a more strategic and integrated approach to environmental management, comprising an integration of environmental and development planning and a more far-reaching co-operation between different actors in society". These authors further elaborate that, despite the growing role of other stakeholders in society in striving towards improving environmental quality, public authorities and ultimately governments still possess the overall responsibility for environmental politics and management.

However, current urban health and environment related problems are overwhelming the capacities of local authorities to provide basic environmental services. The lack of standards for a healthy and productive population, in turn, affects the economy. Government bodies are presently faced with a dwindling financial, technical and human resource base. In addition, pressure from lay citizens for the provision of services, coupled with increasing urban environmental and developmental planning problems, further complicates the management of urban environs. Thus, they need to adopt a new role if they are to successfully address these burgeoning environmental concerns. This 'new' function can be described as co-ordinating the different environmental initiatives and actions by CBO's, NGO's and other stakeholders, as well as promoting co-operation between these different actors (Burstrom and Dalin, 1999). According to these authors, "this is a formidable task, and is not easily managed".

1.2 Research Issues and Objectives

The overall aim of this research was to formulate multi-criteria decision models for decision-making on environmental and development planning and management issues within decentralised government institutions. These models would have to provide decision-makers with simple, user-friendly tools and techniques that would assist decision-makers in working towards sustainable development. The models would, therefore, have to be acceptable and accessible to all decision-makers in government institutions. The models should also provide a bridge between the science of environmental analysis and the politics of resource management.

The specific sub-objectives were to:

- Investigate current environment and development decision-making practices within decentralised government institutions.

- Investigate/research the role of soft systems thinking to enable stakeholder participation in the decision-making process.

- Identify decision problems, with regard to environmental and planning issues, by applying soft systems methodology.

- Research the Analytical Hierarchical Process (AHP), a field of decision-making.

- Explore the potential differences in the assessment and evaluation of development proposals for sensitive coastal areas as compared to sensitive inland areas.

- Develop appropriate Multi-criteria Decision-making (MCDM) models for typical environmental and development planning decisions at local and provincial levels of government.

- Validate the MCDM models by applying them to real-world problem situations.

- Investigate the relevance and usefulness of the multi-criteria models as a decision support tool in local and provincial levels of government.

- Determine the acceptance of the MCDM models within government institutions.

1.3 Scope and Delimitations of the Research

This research was confined to decision-making processes at local authority and provincial levels, although the links between these levels and higher powers of decision-making (national government) were examined. Although links with other stakeholders are investigated, time did not permit practical validation processes with all the stakeholders in the decision processes.

This research forms a component of a much larger decision support system project, the South African Integrated Spatial Information System (SA-ISIS 2000), involving a consortium from the Agricultural Research Council, the CSIR, the University of Pretoria and the University of Natal, and is a National Innovation Fund project which is sponsored by the National Department of Arts, Culture, Science and Technology (DACST). The development of the SA-ISIS 2000 system was born out of the recognition that decision-making governing land use and natural resource management has become increasingly complex within the last decade. There is a global trend towards a more holistic, multi-use and multi-value view of the environment in a wider spatial context. The public also plays a more active role in decisions relating to land use and natural resource management with NEMA[1] granting them a strong legal backing. In addition, environmental legislation places much emphasis on measures of accountability, equity and informed decision-making. Thus, decision-makers within government organisations need to be capacitated with a value-based, scientific and holistic decision support system that caters for both single and group decision environments.

The aim of the SA-ISIS 2000 is to provide decision-makers in the field of environmental management with spatially related information and decision support models, accessible through the World Wide Web (WWW) (Petkov, 1999). This system is intended to be used

[1] National Environmental Management Act (No.107 of 1998).

in conjunction with other existing Decision Support Systems such as a GIS. Both the WWW and MCDM are recent technological developments in the field of decision-making and computing (Petkov, 1999).

1.4 Significance of the Research

As described above, the past decade bears testimony to an overwhelming increase in the environment and development challenges facing decision-makers in South Africa who are responsible for equitable, sound and transparent resource management decisions. Thus, within all tiers of government, decision-makers are currently facing daunting and "messy" problems within the arena of environment and development planning. These problems may be semi-structured or unstructured; they may also be non-routine and, frequently, consist of multiple, interlinked problems. Messy problems have characteristics that make it difficult to improve the performance of the decision maker(s) or to provide computer-based decision support aids (Wagner, 1995). According to Wagner (1995), these problems require domain knowledge, innovative thinking and general problem solving skills. In addition, these problems cannot be well identified, defined and understood by quantitative techniques, at least, not in the early phases of the search for a solution. The human-computer interaction provides a more promising method of addressing these messy problems (Wagner, 1995), which places emphasis on the reasoning capabilities of key decision-makers and other relevant stakeholders.

The human-computer interface model for problem solving was adopted in this research. Within the intricate realm of uncertainty and "messiness", the key issues and practices of environment and development planning within decentralised government were investigated. The use of Soft Systems Methodology (SSM), an interpretivist approach for problem identification and decision-making, was employed. SSM not only encourages human participation, but also promotes dialogue within small groups. Hence, it has considerable value in identifying potential problems and accounting for human values and conflict in the decision-making process. Such problems are often comprised of multiple criteria and need to be treated from a multi-perspective: thus, the need for MCDM methods.

Map 1: Orientation map of Southern Africa illustrating the location of the Local Authorities and Provincial Departments interviewed.

This study not only attempts to unravel the problem areas and critical parameters in environmental planning decision-making, but also tries to provide a deeper appreciation and insight into the messy and often contentious problems that are part and parcel of environmental planning. The study also provides an initiation into problem solving and conflict resolution with the aid of the AHP (as a decision support method) to assist decision-makers achieve equitable, transparent and objective resource management and environmental planning.

1.5 Research Method

The research methodology followed a six stage process:

I. A literature survey was carried out by the author on environmental decision-making, current environmental and development issues/problems, legislation and policies, Soft Systems Thinking (SST), SSM, MCDM, and the AHP.

The literature survey provided:

- An overview of environmental decision-making
  - The history of environmental decision-making
  - The concept of sustainability
  - Local Agenda 21 as a strategic framework for decision-making
  - Environmental politics and management in South Africa.
- The value and application of SST and SSM in decision-making
- A discussion on Multi-Criteria Decision-making and the role of the AHP in decision-making
- A framework for the research
- A framework for model validation.

II Structured, informal interviews were conducted with managers in the fields of environmental management and planning within local and provincial governments. These provided a preliminary investigation into the problems decision-makers experience in formulating and executing decisions within their respective fields. The local governments included in this research comprised the Pietermaritzburg

Transitional Local Council (TLC), the Durban Metropolitan Council (DMC), and the Greater Johannesburg TMC. The provincial departments comprised the KwaZulu-Natal Department of Local Government & Housing and the KwaZulu-Natal Department of Agriculture & Environmental Affairs. Informal discussions were also held with a representative of the SA-ISIS 2000 project from Cape Town.

III. After gaining an insight into the nature, complexity and diversity of problems decision-makers in the fields of environmental management and planning were experiencing, a framework for the SSM workshops was constructed. Workshops were hosted with the Pietermaritzburg TLC and the KwaZulu-Natal Department of Agriculture & Environmental Affairs to identify the criteria and factors affecting decision-making in the field of environmental planning. This was achieved by conducting a stakeholder analysis, Strategic Assumption and Surfacing Testing (SAST), formulating rich pictures, root definitions and undertaking a CATWOE (refer to list of abbreviations) analysis. These criteria and factors were then used to design and structure the hierarchical multi-criteria decision models.

The outcomes of the stakeholder analysis, SAST, rich pictures, CATWOE analysis, the root definitions, and the structure of the MCDM models derived from the workshops were then presented to all the decision-makers involved in the preliminary investigation phase of the research. This was mainly conducted to achieve a consensus on the structure of the MCDM models. The SSM workshops and feedback sessions also served to conceptually validate the MCDM models.

IV. Once all the decision-makers were satisfied with the structure of the decision problem (in the form of hierarchical MCDM models), a practical validation of the models was achieved by applying them to three case-studies:

1) The Thaba Ya Batswana hotel/conference centre development proposal in the Greater Johannesburg;
2) The low-cost housing development proposal in the Sherwood urban open space area - Durban Metropolitan Area; and
3) The "up-market" tourism development proposal at Threlfal - Kosi Mouth (a sensitive coastal area located along KwaZulu-Natal's east coast.

The results obtained from this phase of the research were fed back to the decision-makers, who participated in this process, for validation and comment.

V. The MCDM models were then operationally validated by decision-makers who participated in the practical validation phase of the research. This was achieved by a reflection on the implementation phase and a critical appraisal of the relevance, usefulness and ease of use of the models.

1.6 Outline of the Dissertation Structure

Chapter 2 provides an overview of environmental decision-making by discussing the complexities in decision-making and by reviewing the legislative frameworks governing environmental and development decision-making. In addition, current decision problems experienced by managers in environmental management and planning departments, in decentralised government institutions, are investigated.

Chapter 3 examines the application and usefulness of SSM in problem identification. In this chapter, the limitations of this methodology are also mentioned, and recommendations to overcome some of these limitations are forwarded.

Chapter 4 explores the field of multi-criteria decision-making as well as the advantages of structuring the decision problem in a hierarchical fashion. In addition, it examines the strengths and utilities of the AHP as a multi-criteria decision method to aid decision-making in the field of environment and development planning.

Chapter 5 illustrates how SSM and the AHP are employed to derive the multi-criteria decision models. SSM is employed to identify all the stakeholders involved in evaluation and assessment of development proposals. In addition, this method is also used to elicit perceptions on the organisational dynamics (that being, culture, politics, etc.) and technical issues that influence the decision-making processes. The AHP is then used to structure and design the multi-criteria models.

Chapter 6 provides the dissertation with the implementation and practical validation of the multi-criteria models. A validation framework was employed to test the relevance, applicability and usefulness of the models.

Chapter 7 reports on the critical appraisal of the models by the decision-makers who participated in the practical validation process. **Chapter 8** follows with a conclusion and recommendations for areas of future application of the multi-criteria decision models.

CHAPTER 2

AN OVERVIEW OF ENVIRONMENTAL DECISION MAKING

Although government authorities (local, regional, provincial and national tiers of government) possess the overall responsibility for implementing environmental policies and management in South Africa, environmental and development planning issues concern everyone and the environment is being taken seriously by more actors in society. This necessitates the need for transparent, integrative and participative decision-making, thereby adding complexity to an already unstructured decision-making process. This chapter is therefore devoted to an exploration of the complexities in current environmental decision-making.

The roles of Local Agenda 21, Environmental Impact Assessments (EIAs), and environmental/planning legislation and policies, in providing local and provincial government officials with global and project specific frameworks for sustainable environmental decision-making, are discussed. Due to the importance of the concept of sustainability in environmental and planning decision-making, this concept is also examined.

In addition to the above, this chapter provides an outline of the problems environmental and planning managers currently experience since government institutions define the conditions under which resources are managed. The factors/processes that prevent the existing institutional arrangements from achieving efficient and effective levels of operation are also explored.

2.1 Introduction to Decision Making and its Complexities

Decision-making is integral to all human activities. The work of heads of states, of politicians, managers, scientists, economists, engineers and lawyers - the work that directs the course of society, its economic prosperity and governmental organisations, is largely the work of making decisions and solving problems. Collectively, society is responsible for making countless conscious and unconscious decisions every day.

In reality, decision-making is seldom a straightforward and well-understood process. Terms such as "groping along" and "muddling through" are frequently encountered in literature when attempts are made at defining decision-making in practice. According to Simon, et. al. (1987), decision-making is the "work of choosing issues that require attention, setting goals, finding or designing suitable courses of action, and evaluating and choosing among alternative actions". The first three activities are generally referred to as problem solving: while the latter two, evaluating and choosing, are usually called decision-making. The health of an economy and the well being of a society requires that this work be performed effectively and efficiently at national, local and individual levels (Simon, et. al., 1987). Radford (1981) provides another definition of decision-making: "The essence of decision-making is in the formulation of alternative courses of action to meet the situation under consideration and in the choice between these alternatives after an evaluation of their effectiveness in achieving the decision-maker's objectives". This definition is quite similar in nature to that of problem solving as defined by Simon, et. al. (1987).

Intellectually, decision-making is the funnelling action of information and knowledge gathered from experience and observation (Saaty, 1994a). This author defines decision-making as the science of transforming and relating data about the world to our value system, to enable us to take the necessary actions to fulfil our needs and aspirations. Values and knowledge are intricately interwoven in and through actions. According to Saaty (1994) "all action signifies an ethic, serves or disserves certain values". The recognition of the importance of reflecting and accounting for human values in decision-making drives the need to find new ways of performing valuations. Peter F. Drucker addressed this question in his article "We need to Measure, not Count" in the Wall Street Journal of April 13, 1993, where he stated:

> ...so far, there are neither the concepts nor the tools for business control - i.e., for economic decision-making. In the past few years, however, we have become increasingly aware of the need for such measurements... It may take many years, decades perhaps, until we have the measurements we need in all these areas. But at least we know that we need new measurements and what they have to be. Slowly, and still groping, we are moving from counting to measuring (Ibid, 1993).

Thus, the need to derive new approaches and techniques in incorporating, and accounting for values in the decision-making arenas has received much recognition. The most rewarding and important challenges facing scientific research lie in the understanding of

how human minds, with and without the aid of hardware and software, solve problems and make decisions effectively, and in improving present problem solving and decision-making capabilities (Simon, et.al., 1987).

The gathering of sufficient information and the development of inventories and databases appear to be one of the most important components in current decision-making practices, from which an appreciation can be gained of the decision situation (Radford, 1981). However, the lack of sufficient time, technical expertise, and human and financial resources' makes it practically impossible to collect all of the information and material that influence and affect a given decision situation. In addition, it may not always be possible to determine what information is needed, even if time and resources are sufficient. Thus, an element of uncertainty enters into the complex equation of decision-making. According to Radford (1981), uncertainty is one of the most pervasive characteristics of the decision situations encountered by modern management. It is also one of the factors causing the greatest difficulty in practical decision-making.

Environmental Decision Making

The concern that several, seemingly endemic, global problems could no longer be divorced from a consideration of a threatened future was recognised almost four decades ago when Rachel Carsen published her epic book "Silent Spring" (Carsen, 1962). This book served as one of the early and most powerful warnings to humanity of the consequences of its actions on the environment. It also contributed to a global change in the perception of environmental problems, hence, environmental decision-making. Since the 1980's, the emphasis has shifted from the local and acute protection of our environment to the global and chronic effects, generated from an increasing number of subtle and interconnected sources (Burstrom and Dalin, 1999). Thus, according to Schulkin and Sarokin (1996), there exists a "fragile growth in the decision-making linked to nature and the use of resources". Sustainable resource management illustrates the delicate balance in the decision-making process between the economic, physical and social environs (Schulkin, and Sarokin, 1996).

For many, growth and development is synonymous with increasing wealth (Daly, 1990). But it is increasingly recognised that, if growth and development continue in an

unregulated and uncontrolled fashion, it would eventually push beyond the optimal scale relative to the biosphere, which would, in fact, make us poorer. "Growth, like anything else, can cost more than its worth at the margin" (Daly, 1990). This recognition gave rise to several milestones in the field of environment and development encouraging decision-makers to formulate alternative resource utilisation and management strategies. Among these milestones were: the 1975 Belgrade Charter, the 1980 *World Conservation Strategy* of the International Union for the Conservation of Nature and Natural Resources, the 1987 Report of the Brundtland Commission, the unprecedented Rio Earth Summit in 1992, and the Habitat Conferences on Human Settlements.

These events influenced South Africa to revisit many outdated legislation and policies that had previously guided its environmental and planning decision-making. It also assisted policy makers to identify the gaps and limitations in current environmental and planning legislation. In order to gain a deeper appreciation of the legislative context of environmental and development decision-making, the next section is dedicated to describing the evolution of environmental decision-making and the emergence of environmental impact assessments (EIAs) in South Africa.

2.2 Evolution of Decision Making in Environmental Planning

Environmental decision-making has undergone a series of transformations to provide managers with increasingly more effective and efficient techniques, methods and tools to manage resources in a more sustainable manner. Traditionally (up until the 1950s), resource management decision-making focussed on a narrow range of 'technical fix' options derived from engineering-based questions, which focussed on the technical feasibility, the financial viability and the legal standing of development projects (Smith, 1993). This type of resource decision-making worked well when the scale of the project was limited, the problem well defined and sufficient information was available. However, this form of decision-making did not account for the wider environmental, health and social costs of developments such as dam construction, location of landfill sites, etc. and did not comprehensively consider the socio-political factors and "ulterior motives" that often influenced the decision-making processes (Smith, 1993).

The increasing complexity, scale and implications of resource development projects led to the introduction of "cost-benefit analysis" in the 1960s which aimed to address the limitations of this form of decision-making (Smith, 1993).

2.2.1 The role of cost-benefit analysis in decision-making

Cost-benefit analysis provides an economic framework for both strategic and operational planning in resource management. According to Simpson (1998), economics could be defined as "the study of which among our unlimited wants we choose to satisfy given our limited resources". This decision-making technique dominated resource management decision-making in the 1960s, because of the apparent ease with which it could be applied to a wide range of situations and the ability to clearly define objectives that could be easily understood (Smith, 1993). It was particularly appealing to decision-makers since it could produce a quantitative measure of 'social utility' with an emphasis on the criterion of economic efficiency (Smith, 1993). Analysing costs versus benefits thus provided decision-makers with a useful way of gathering and analysing data on proposed projects or courses of action, as well as the cheapest method of undertaking a venture (Miller, 1992).

However, cost-benefit analysis presented decision-makers with a few limitations. It is often possible to adopt different assumptions and derive different interpretations of the data, which then, in turn, generates very different conclusions (Simpson, 1998). Simpson (1998) further elaborates that economists are not yet in a position to offer very precise policy advice on, or with respect to, ecological issues, since many factors cannot be measured with economic tools. Cost-benefit analysis is also criticised for its inabilities to account conceptually for the distributional aspects of costs and benefits, and the problems of aggregation (Carley and Bustelo, 1984; cited in Smith, 1993).

According to Simpson (1998), ecological and environmental amenities are responsible for a number of "market failures"; hence, economic prescriptions are not always heeded in environment and development planning decisions. The costs of preserving natural resources are frequently not borne by the same people receiving the benefits (Simpson, 1998). Cost-benefit analysis also suffers from an abundance of misapplication in practice, including "...a failure to consider alternatives; a focus on easily measured, quantifiable benefits and costs; a failure to adhere to key premises, leading to inflated benefit measures

and manipulated accounting; and an inability to account accurately for, and incorporate, such temporal changes as variations in interest rates, adequate discount rates and price levels" (Smith, 1993).

The limitations of cost-benefit analysis prompted a search for, and the development of, alternative techniques that would better address the issues of social accountability and resource allocation. Simple cost-benefit analysis was replaced by more sophisticated variants, using "multiple objectives and discount rates, proxy-pricing mechanisms" and other forms of planning, budgeting and cost-effectiveness analysis (Smith, 1993). However, these sophisticated techniques were still severely criticised on the basis of the inappropriateness of these methods and techniques in attempting to evaluate projects by oversimplifying complex environmental interrelationships and the broader social issues of resource allocation (O'Riordan and Sewel, 1981). Many economists who recognised these difficulties advocated simpler decision rules.

Although cost-benefit analysis was (and still is) a good technique when applied properly and its limitations recognised, the need for an alternative form of decision-making became apparent. This was further reinforced by two interrelated factors: the increasing scale, complexity and uncertainty of development proposals; and public activism aimed at maintaining environmental quality and ensuring equity in the processes of governance (Smith, 1993). These factors led to the birth of environmental impact assessment (EIA) to better address these value-based concepts.

2.2.2 The role of Environmental Impact Assessment

Impact assessment came about as result of a desire for a marked change in both the philosophy and methodology of resource management. EIA is based on the assumption that a systematic, focussed and interdisciplinary use of science may improve the quality of environmental planning and decision-making (Smith, 1993). EIA became a major tool in development planning and, by the end of the 1960s, it was adopted as the dominant framework for environmental decision-making in the USA.

The National Environmental Policy Act (NEPA) in the USA established the requirement for an environmental impact statement (EIS) as the principle means of implementing impact assessment (Smith, 1993). This not only marked a firm commitment to

environmental protection but was also an 'affirmation of faith' in the use of science for planning and decision-making (Sadler, 1986; cited in Smith, 1993). The NEPA EIA model was firmly entrenched in positivist ideals, and placed much emphasis on the collection of scientific data and the production of technical reports. It paved the way for EIAs in other countries.

This early model of EIA, was, however, not without its criticisms. According to O'Riordan (1981), a number of practical difficulties reduced its effectiveness. These included: (1) a general lack of adequate data-bases; (2) inadequate time for a thorough investigation; (3) the lack of any form of social accountability; and (4) the problematic weightings of findings. In addition to these technical limitations, most agencies used EIAs to "rubber stamp" predetermined decisions by only reviewing 'proximate alternatives' rather than fundamental choices (Fairfax and Ingram, 1981; Friesma and Culhane, 1976; Fairfax, 1978). Decision-makers reacted to NEPA's shortcomings by focussing on improving the science of impact analysis (by making impact statements more analytical, readable, and informative). This resulted in decision-makers favouring technical data (project design and economic feasibility) above EIAs.

As was the case with the restructuring of cost-benefit analysis, the 1980s witnessed EIAs becoming more comprehensive and integrative. Social, technological, community and risk assessment were incorporated into the process. Adaptive environmental assessment and management improved the potential of EIAs. The predominant rationale for incorporating all of these processes into impact assessment stemmed from a concern for the "poor level and quality of science within existing impact statements" (Smith, 1993). According to Beanlands and Duinker (1983) (cited in Smith, 1993), "the paucity of good science (pure, applied and/or social) is perceived to be operating within well-defined administrative procedures". These authors further elaborated that the 'result often has been a somewhat confused and frustrating technical review process" (Ibid, 1983). This resulted in a surfeit of proposals to better define, specify and quantify the scientific techniques and methodologies employed in assessment studies.

Beanlands and Duinker (1983) stressed that, before focussing on the scientific basis of EIA, institutional frameworks should be established to overcome the practical limitations of the

application processes of EIA. They confined themselves to a "consideration of the ways by which the adoption of ecological principles, and ecology as a science, would improve the practice of impact assessment within those constraints" (Smith, 1993). Smith (1993), on the one hand, argues that these constraints do not reflect a weakness of science, rather, they reflect the reality that impact assessment has evolved as a continuous political process within development planning. On the other hand, this author does however, acknowledge that by focussing on improving the science of impact assessment, the political processes of resource management that govern how the information is utilised will not be reformed.

Despite the practical limitations and drawbacks of EIA, it is, and still remains, a good framework to aid decision-making at a local (project specific) level. In essence, it provides a systematic process that examines, in advance, the environmental outcomes of development actions. The decision maker can therefore consider EIAs, in conjunction with other relevant documentation, related to the planned activity. Although EIA is not a replacement for decision-making, it is designed to assist in clarifying some of the trade-offs associated with a proposed development action. This should lead to more logical and structured decision-making (Pretorius and Ferreira, 1994). Smith (1993) therefore insists that impact assessment needs to be redefined, since, in its present form, its full potential has not been realised.

In Smith's (1993) opinion, impact assessment can only be an effective decision-making tool when the three basic components to sustainable resource management are integrated: problem identification, resource management, and the goal of sustainability. As a point of departure, problems have to be recognised. Secondly, proposals for policies, strategies and projects to respond to the perceived problems must then be derived through the process of resource management. And thirdly, sustainability should be present as the desired outcome for resource management in the solving of recognised problems (Smith, 1993). Since sustainablility is the driving goal of environmental planning and management, this concept needs to be explored and examined in more detail.

2.2.3 The Concept of Sustainable Development

Environmental and developmental planning and decision-making, both locally and internationally, are currently driven by the goal of sustainability. According to Jonker and

Klaver (1999), sustainability and social accountability are two of the three major "quality driven movements" that have emerged within the last decade (total quality management being the third).

Sustainable development was defined in a general manner by the World Commission on Environment and Development (1987: 43) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". There is a substantial and growing literature on the topic of sustainable development (e.g. Clark and Munn, 1986; Brown et al, 1987; Jacobs and Munro, 1987; Redclift, 1987; Rees, 1988; Turner, 1988; Archibugi and Nijkamp, 1989; Daly, 1990; Dovers, 1990; Pearce and Turner, 1990; Shearman, 1990; Rees, 1990). Much of this literature, however, focuses on the definition and application of sustainability within the field of environmental economics and distinguishes between 'sustainability', 'sustainable development', 'sustainable utilisation' and 'sustainable growth' (Smith, 1993).

As a concept, sustainability implies that there is an inherent contradiction in pursuing development for economic growth that may actually result in human suffering (Shearman, 1990; Redclift, 1987; Sen, 1984).

According to Smith (1993), sustainability should be best viewed as a concept. It is a social goal based on human and social values that requires 'the moral choice of accepting intergenerational equity as an overriding ethic' (Dovers, 1990). The challenge, therefore, is not to become embroiled in defining what sustainability will involve in practice, but rather to develop 'a conceptual framework for addressing issues in sustainability in order to understand and appreciate what would be involved in cultivating and initiating appropriate environmental planning and policy' (Shearman, 1990).

The key aspects of sustainable development relate to the understanding of *environment* (which includes the biophysical, socio-political and human components), *development* (as a process of qualitative and equitable growth), *society* (being the interdependent world community) and *linkages* between poverty, inequality and environmental degradation (Smith, 1993). To achieve sustainable development, 'both technology and social organisations need to be managed and improved to make way for a new era of economic

growth' (World Commission on Environment and Development, 1987: 8). According to Smith (1993), "the key is in how to manage technology and social organisations in resource development to provide for decision-making that will foster sustainability" (Ibid, 1993: 5)

2.3 Local Agenda 21 as a strategic framework for sustainable development

Agenda 21, an action plan and blueprint for sustainable development, was one of the five documents adopted at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992, where decision-makers from 178 nations world-wide met to formulate strategic action plans to achieve sustainable development. The Rio conference served not only to heighten awareness of global environmental threats, but also to open new pathways for communication between governmental and non-governmental organisations working towards a common goal and to increase public awareness (World Bank, 1997). According to Archer (1996), Agenda 21 is not an environmental agenda, but an agenda for integrating and cooperating across the fields of environment and development to achieve a sustainable society. In simple terms, this author states that " in all development decisions made, one should consider balancing the economy, equity and the environment"(Ibid, 1996).

South Africa is firmly committed to implementing Agenda 21's seven key principles. The former Deputy President, Thabo Mbeki (who is now the current State President), reaffirmed South Africa as one of the global partners to sustainable development in his speech at the Nineteenth Special Session of the United Nations General Assembly (UNGASS) in June 1995 (Department of Environmental Affairs and Tourism, 1998a). This assembly is also known as the Earth Summit +5. The former Deputy president stated that "Agenda 21 remains the fundamental programme of action for achieving sustainable development and that the achievement of sustainable development requires the integration of the economic, social and environmental components" (Department of Environmental Affairs and Tourism, 1998a). The former Minister of the Department of Environmental Affairs and Tourism, Minister Pallo Jordan, committed South Africa to the development of a national strategy for sustainable development by the year 2002. This commitment is reflected in the current revisions of the environmental and planning legislation.

Agenda 21 recognises the need for local authorities to play a specific role. This initiative set the objective that "by 1996 most local authorities should have undertaken a consultative process with their populations and achieved a consensus on a 'local Agenda 21' initiative for the community" (Archer, 1996). In response to this mandate, the International Council for Local Environmental Initiatives (ICLEI) established the Local Agenda 21 (LA21) Initiative to assist local governments in creating their LA21s and to aid in advancing professional standards and techniques for integrated environmental planning or "sustainable development planning". In short, the LA21 Initiative outlines the fundamental principles on which local authorities must base future decisions and policies, considering the environmental, health and economic implications of development initiatives. These principles are based on: partnerships, accountability, public participation and transparency in decision-making, equity and justice, a concern for the future, a systematic approach to problem solving, and the recognition that society must learn to live within the Earth's carrying capacity.

The LA21 Initiative and principles were formally adopted by South Africa's three major cities - The Durban Metropolitan area, the Greater Johannesburg Metropolitan area and the Cape Metropolitan area. According to Hindson, et. al. (1996), Durban was the first city in South Africa to respond to LA21. The former Durban City Council formally adopted the LA21 initiative in August 1994, and approved an initiation of the then first State of the Environment and Development study, as the first phase of the programme in November of that year (Hindson, et. al., 1996). This study investigated the state of the environment and development in five systems of the Durban Metropolitan Area - natural, built, economic, social and governance (Hindson, et. al., 1996) to orientate the city towards a sustainable future.

The Cape Metropolitan Council, on the other hand, formally approved the adoption of LA21 as a strategic framework in June 1995 to address some of the region's major environmental and development planning challenges (ICLEI, 1995). The implementation of LA21 in this city initially focussed on the formulation of one or two appropriate Reconstruction and Development Programme (RDP) Forums to increase the awareness of LA21 principles. In addition, this Forum was also tasked with researching ways in which

partnership arrangements could be institutionalised within the new municipal structures and processes (ICLEI, 1995).

The Greater Johannesburg Transitional Metropolitan Council (GJTMC) formally adopted LA21 principles and joined ICLEI in 1995. Together, with ICLEI, this Council was responsible for hosting the first Africa Regional Workshop on Agenda 21 in October 1995. In the same year, the GJTMC formed an Environmental Management Committee to make provision for city politicians, officials and civil society to participate in the decision-making process with respect to the city's environment (ICLEI, 1995). This committee coordinated and drove Johannesburg's LA21 planning process. The start-up phase of LA21 focussed on the following:

- *"the development of a mission statement, and terms of reference for a LA21 project;*
- *the development of structures to co-ordinate the project;*
- *the identification of partners;*
- *the development of support structures and the formalisation and roles and responsibilities of partners;*
- *obtaining formal approval from the GJTMC;*
- *presentation of the project to a wider group of stakeholders for discussion; and*
- *the development of an action plan for the project and securing resources."* (ICLEI, 1995).

Since then (1995), many other municipalities and provincial departments in South Africa have formally adopted the LA21 Initiative. In addition, a number of planning and development programmes that are similar to the LA 21 planning programme developed by ICLEI were developed in South Africa. Of particular importance are the Integrated Development Plans (IDPs) and the Local Development Plans (LDPs) in KwaZulu-Natal, Integrated Water Plans, Transport Plans and Environmental Plans (KwaZulu-Natal Department of Local Government and Housing, 1999). Indeed, because LA21 is not a new programme/project requiring additional resources, the planning process recommended by ICLEI need not be implemented in South Africa due to its similarity to the IDP and LDP processes (KwaZulu-Natal Department of Local Government and Housing, 1999).

According to the ICLEI Report (1995), the varying approaches to LA21 planning in South Africa offer an interesting learning opportunity that is based on a comparison of approaches and outcomes of the various programmes. As illustrated, LA21 requires a new approach to existing planning and development programmes and/or projects. The next section examines, in more detail, the political and legislative approaches to sustainable development.

2.4 ●n environmental management issues in South Africa

Political commitment is a critical determinant of the effectiveness of environmental legislation. Although some legislative acts and aspects of the centralised control system of governance (pre-1994) are still active, they are being complemented with new and improved efforts that attempt to deal with the diffuse and complex environmental problems in South Africa. The country's political commitment to environment issues is reflected in the New Constitution, the revised environmental and planning legislation, as well as the number of environmental posts within the local, provincial and national tiers of government.

Local authorities have been identified as important actors, not least for their proximity to the every-day life of the public citizens and companies. They construct, operate and maintain economic, social and environmental infrastructure, oversee planning process, establish local environmental policies and regulations, and assist in implementing national and provincial policies. As the level of governance closest to the people, they play a vital role in educating, mobilising and responding to the public's needs. The Local Government Transitional Act, No. 209 of 1993 affords local authorities some autonomy in executing their functions, making decisions and establishing institutional structures to facilitate the efficient delivery of services. Although the Local Government Municipal Structures Act (117 of 1998) allows for the establishment of different categories of municipalities, provincial legislation ultimately determines the different types of municipalities to be established in a province.

A municipality possesses the legislative authority to manage issues of public interest related to the geographical area (i.e. territory) or the members of the municipality

(Burstrom and Dalin, 1999). According to these authors, an important aspect of municipalities is their responsibility for promoting welfare and overall societal development within the municipal territory. Politics, in general, and environmental politics in particular, is in the process of being decentralised from a national/provincial level to a local level. In terms of the Constitution[2], several functional areas pertaining to environmental issues have been devolved to provincial and local levels for legislative and administrative control (McEwan, et. al., 1999). In areas relating to environmental and pollution control, both national and provincial governments possess concurrent legislative competence, with national legislation prevailing in case of conflict (McEwan, et. al., 1999).

The autonomy and decentralisation process is evident in the "one Municipality, one Plan" concept in KwaZulu-Natal where provincial, regional/metropolitan and local development plans were introduced to the province via the Planning and Development Act, No.5 of 1998 (Department of Local Government and Housing, 1999). However, there is still much to do before municipalities are able to manage environmental issues within their municipal territories. The results obtained from Burstrom and Dalin's study (1999) on environmental management and politics in Sweden can be extrapolated to the outcomes of an initial investigation into environmental and planning problems in decentralised government institutions in this research. Both investigations revealed that municipalities lacked human resource and financial capacity to manage many environmental issues, expertise to set objectives and take management decisions, funds and the political commitment to implement decisions and plans to accomplish the objectives (Burstrom and Dalin, 1999).

The following sub-section examines, in more detail, the role of legislation in environmental and planning decision-making.

2.4.1 Legislation governing environmental issues

Legal provisions for environmental protection, planning and regulation establish the context for decision-making in environmental and development planning. These provisions are a product of each nation's distinct political culture (Smith, 1993). According to O'Riordan (1981), as much as law may be viewed as an instigator of reform, it is itself

[2] Act 108 of 1996, Chapters 6 and 7, read with schedules 4 and 5.

shaped by new political perspectives. This statement is supported by McEwan, et. al. (1999) quoting Loots' (1996) observation that environmental legislation in South Africa is no longer distanced from the environmental norms established by the international community.

The Bill of Rights in the Constitution[3] states that each individual has the right to an environment that is not harmful to health or well-being, and to have the environment protected from pollution and degradation. This Bill of Rights is the country's most important legislation. Sub-section (c) of section 24(b) of the Constitution embodies the notion of sustainable development and Integrated Environmental Management by linking the "*ecologically sustainable development and use of natural resources*" to the promotion of "*justifiable economic and social development*". The use of the word "justifiable" indicates that the Constitution requires all economic and social development to be justifiable within the parameters of section 24(b), that is, the protection of the environment for the benefit of both present and future generations (Rutsch & Co., 1995). Thus, according to these authors, the science of EIAs has a constitutional sanction. Sustainable development and LA21 principles, and provisions for these rights, have been made operable in the revised planning and environmental legislation discussed in this section.

Environmental Legislation

According to Rabie (in Fuggle and Rabie, 1992), South African legislation was characterised as being fragmented since provisions were contained in an extremely wide variety of parliamentary Acts, supplemented by provincial ordinances, local by-laws and ministerial regulations. This author also observed that "there has never been, nor likely to be, a single statutory instrument which comprehensively codifies environmental law. It is doubtful whether such an instrument is even feasible." (Fuggle and Rabie, 1992). In addition, there existed a considerable degree of uncertainty as to what constituted environmental law. This was mainly attributed to lack of clarity over: the term "environment", and the legal rules pertaining to the environment, which constitutes environmental law (Rabie, 1992). Although the Environmental Conservation Act 73 of

[3] This refers to section 24 of the Constitution of the Republic of South Africa (Act 108 of 1996)

1989 extended the scope of environmental law, it did not provide clarification over what constituted the "environment". This Act also differed from the European Community (EC) legislation in that it failed to provide common law remedies for individual victims of environmental pollution and reinforced a centralised form of environmental management, since most decisions related to the environment were implemented by government departments through ministerial regulation (McEwan, et. al., 1999).

The National Environmental Management Act (NEMA), No.107 of 1998 was an attempt to comprehensively codify environmental law. Although this Act largely replaces the Environmental Conservation Act 73 of 1989, it is being gradually implemented; thus, many aspects of the old legislation are still operative. NEMA provides for co-operative environmental governance (chapter 3 of NEMA) by establishing principles for holistic, integrated and transparent environmental decision-making. In addition, NEMA has provided for the institutional arrangements for effective service delivery and policy formulation within government bodies in its recommendation for a National Environmental Advisory Forum as well as a Committee for Environmental Co-ordination.

McEwan, et. al. (1999) observed that NEMA contains several noteworthy and unique provisions, with no blind adoption of first-world norms and standards. Of these provisions is Section 2 of the Act, which contains a comprehensive list of universally recognised principles such as: Agenda 21, the polluter pays, and the precautionary principle. In addition, the Act makes allowances for "Duty of Care" and remediation of damage, it provides individuals with a legal standing to enforce environmental laws, and it makes provision for private prosecutions as well as environmental management co-operation agreements (McEwan, et. al., 1999).

However, these authors also identified seven practical limitations in NEMA that may prevent it from achieving its objectives, summarised as follows:

a) *A fragmented policy leading to ineffective legislation;*
b) *Uncoordinated planning at all tiers of government;*
c) *Weakly enforced regulations;*
d) *Institutionalised conflicts of interest between stakeholders regulating environmental impacts and those promoting the extraction of resources;*

e) *Lack of cooperation and coordination between the different interdepartmental functions;*

f) *Limited capacity and resources in government and civil society; and*

g) *Limited public participation.*

Many of the shortcomings listed above can be described as limitations in current environmental management practices, which will be discussed in more detail in the following sub-section. McEwan, et. al. (1999) also recognised seven strategic goals stipulated in NEMA that are intended to overcome the perceived limitations. These include:

a) *An effective institutional framework and legislation;*

b) *Holistic and integrated planning;*

c) *Sustainable use of resources and impact management;*

d) *Partnerships in environmental governance;*

e) *Empowerment and environmental education;*

f) *Improved information management; and*

g) *Increased international cooperation.".*

All of the strategic goals listed above are essential for sustainable development and provide the research with useful criteria in developing multi-criteria decision models.

In South Africa, EIAs are still recognised as the most effective regulatory mechanisms in assessing development proposals at a project-specific level of decision-making. Both NEMA and the Environment Conservation Act 73 of 1989 make provisions for EIAs. In the case of the latter Act, EIAs are required in the case of identified activities and limited development areas. This is evidenced in the EIA checklists[4] provincial and local government bodies have developed to screen development proposals (see Appendix 2). In addition to the Environment Conservation Act 73 of 1989 and NEMA, other environmental legislation relevant to LA21 includes the National Water Act (36 of 1998), the Water Services Act (108 of 1997), the Conservation of Agricultural Resources Act (43 of 1983), the Forest Act (122 of 1984), and the Mountain Catchment Areas Act (63 of 1970) (KwaZulu-Natal Department of Local Government and Housing, 1999).

[4] These checklists have been adapted from the EIA regulations stipulated in the Environmental Conservation Act, No. 73 of 1989 (sections 21, 22 and 26) as well as the environmental policies of the respective institutions.

Environmental policy documents geared towards sustainable development include the Draft White Paper on Integrated Pollution and Waste Management (1998), the White Paper on Water and Sanitation (1994), the White Paper on Environmental Management Policy for South Africa (1997), and the Green Paper on Development and Planning (1999).

With particular reference to coastal/marine environments, the need for adequate legal protection for South Africa's coastline has long been recognised. Regulations to control development initiatives and/or activities within 1000m of the high water mark were effected on 12 December 1986 in terms of the old Environmental Conservation Act (Act 100 of 1982) (Department of Environmental Affairs and Tourism, 1998b). These regulations were withdrawn when the Environmental Conservation Act, Act 73 of 1989 replaced this Act, due to technical and legal problems.

However, the "new" Environmental Conservation Act made provisions for the protection of sensitive areas and areas under intense pressure from development. Mechanisms in this Act have been utilised to control potentially harmful activities in sensitive coastal areas (SCAs). According to the Department of Environmental Affairs and Tourism (1998b), the first regulations of this type were introduced on 31 May 1996 for a SCA along the Garden Route in South Africa's Western Cape Province.

SCA regulations[5] are generally aimed at controlling small-scale activities at individual plot level, that are not controlled by other legislation[6] and which are not subject to some form of environmental assessment. It should be noted that SCA regulations do not apply to activities controlled under the general regulations[7] that require a full EIA prior to the

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[5] These regulations state that "if you are a private land-owner, permission is required from your Local Authority to undertake any of the following activities within SCAs: Disturbance of vegetation; earthworks; dredging; and dune stabilisation"(Department of Environmental Affairs and Tourism, 1998). A Local Authority or Provincial Department who condones such activities would then require a permit from a Provincial Premier and a National Government Department would then have to apply to the Department of Environmental Affairs and Tourism for permission.

[6] SCA regulations specifically exclude activities which are controlled by the Sea Shore Act (21 of 1935), the Minerals Act (50 of 1991), the Forest Act (122 of 1984), the Nature and Environmental Conservation Ordinance (19 of 1974) of the Western Cape Province, and similar ordinances applicable to KwaZulu-Natal, the Eastern Cape and the Northern Cape Provinces.

[7] Promulgated as Notices R1182, R183 and R1184 in Government Gazette 18261 on 5 September 1997.

development. Thus, the Department of Environmental Affairs and Tourism (1998b) stipulated that SCA regulations should not be viewed as punitive measures, but rather as attempts to ensure sustainable development along the coastal zone.

In 1999, a White Paper on Coastal Zone Management (1999) was introduced as an attempt to provide decision-makers with a statutory framework for making decisions that protect the integrity of the coast and promote the sustainable use of its resources.

It may therefore be concluded that the objective of codifying environmental legislation through a single piece of legislation (NEMA) has not been successful, since a plethora of legislation and White Papers pertaining to environmental issues continue to emerge. Thus, Rabie's (1992) statement that "there has never been, nor likely to be, a single statutory instrument which comprehensively codifies environmental law" continues to hold true.

Planning Legislation

South African Common Law of property poses a major limitation to the development of environmental land-use control since it regards land ownership as 'an absolute, abstract and exclusive right that allows an owner to use his property as he deems fit' (Van der Walt, 1992 cited by Kidd, 1997). These rights, however, are restricted to a certain extent by common law, in the interests of neighbouring landowners. An owner is not allowed industrial activities on his land if it is situated in a residential area since it would affect the health and well-being (constitutional rights) of neighbours thereby creating a 'nuisance'. Land use zoning, enforced by the town-planning legislation, determines what human settlement activities are allowed in a demarcated land-use zone.

Town-planning legislation enforces planning at a micro level, with each province drawing up its own town-planning ordinances. The most important functions of town-planning legislation are subdivision control and zoning (Kidd, 1997). Subdivision control is aimed at controlling the process of urbanisation in such a way that the objectives of public welfare[8], efficiency[9] and amenity[10] are achieved. Zoning refers to the process whereby a

[8] Welfare refers to the promotion of health, safety, order, convenience, and general welfare.

[9] Efficiency refers to efficient infrastructure and communications.

[10] Amenity includes everything that stimulates all the senses in a pleasant manner.

town is divided into a variety of coordinated and regulated land-use zones which determine the nature of activities to be carried out, e.g. of zones include industrial, residential, education, agricultural, open, etc. The limitation of this type of planning is that it's conducted on a micro scale allowing for an uncoordinated, fragmented and disjointed approach to planning.

The Physical Planning Act (125 of 1991) allows for a more coordinated approach to land-use planning on a meso scale (regional and national) with the objective of promoting the orderly physical development of the area to which that policy plan relates to the benefits of all its inhabitants. The hierarchical structure of the different policy plans is depicted in figure 2.1.

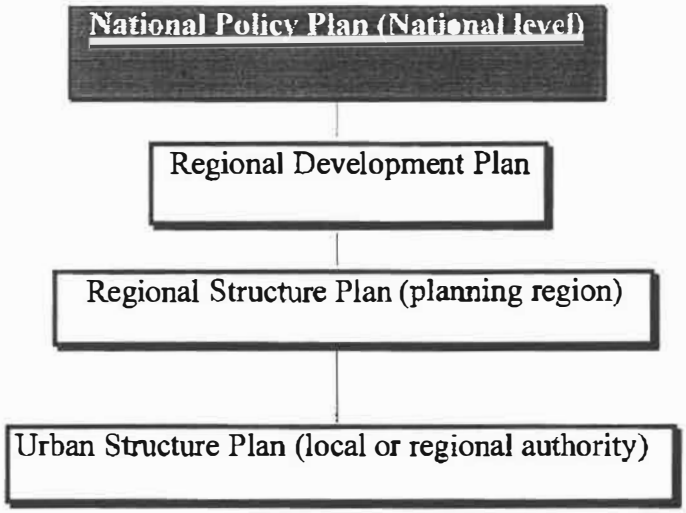


Figure 2.1: Hierarchy of policy plans with their areas of applicability

The significance of this Act is that it created a framework within which most of the present town-planning schemes can continue operating. This hierarchical framework allows for the urban structure plan to provide a broad basis for uniformity, consistency and coordination to land-use planning (Kidd, 1997). The legal effect of both regional and urban structure plans is that provision in either existing or new town-planning schemes for zoning of land, for a purpose not in keeping with a plan, is prohibited.

There are also other important Acts that impact on land-use and land planning. The legacy of racial segregation in the former apartheid system, as a land-use planning policy, gave rise to the Abolition of Racially Based Land Measures Act 108 of 1991. The main aim of this Act was to abolish the fragmentation of racially based land-use planning (Kidd, 1997).

In most cases, land-use based on racial segregation has resulted in damage to natural resources, since communities discriminated against suffered from overcrowding and were compelled to make use of available resources, e.g. burning of fossil fuels for survival.

The Development Facilitation Act (DFA) 67 of 1995 set out to transform the current legislative incoherence (Kidd, 1997) into an integrated, efficient and equitable planning and development system that balanced public interest and private property rights. This Act sought to facilitate the development of land, in the context of land reform, to benefit previously marginalised communities. The EIA procedure is provided for in regulations issued under the DFA. The main aim of this Act was to facilitate the development of land and in doing so establish general principles governing sustainable and integrated land development. One of the mechanisms the DFA employed to achieve this aim was in its requirement for all Municipalities to formulate Land Development Objectives (LDOs). The formulation of LDOs required an integration of the physical, social, economic and institutional components of land development for the respective Planning Authorities to address issues pertaining to spatially distorted settlement patterns and the optimum use of existing infrastructure (KwaZulu-Natal Department of Local Government and Housing, 1999). Thus, the promotion of sustained protection of the environment was established as a factor to be accounted for during this process.

The Local Government Transition Act (LGTA), Second Amendment (No. 97 of 1996) required Municipalities to draft Integrated Development Plans (IDPs) to promote planning for a range of issues and sectors with all the stakeholders (including the community and tiers of government other than the respective municipality (KwaZulu-Natal Department of Local Government and Housing, 1999). According to this document, municipalities are required to formulate, implement, monitor and coordinate an IDP and account for issues pertaining to land use planning, transport planning, infrastructure planning and promote integrated economic development. Other legislation includes the KwaZulu-Natal Planning and Development Act (No.5 of 1998), which rationalises and consolidates laws governing planning and development in this province to ensure rational development through the Development Planning process; and the Municipal Systems Bill (1999), which is to replace the LGTA and give effect to the Constitutional provision for basic development rights (KwaZulu-Natal Department of Local Government and Housing, 1999).

Thus, land use planning and development legislation serves to guide decisions on land use in a manner that allows environmental resources to be of beneficial use, whilst, at the same time, conserving those resources for the future. Planning must therefore be based on an understanding of both the natural environment and the proposed land use.

2.4.2 Some Practical Aspects of Environmental Management

The concept of "integrated environmental management" within government departments is fairly new to South Africa and can best be described as being in an infancy stage. The fragmented nature of environmental legislation described above is a reflection of the fragmented institutional arrangements in place for managing various components of the environment. Environmental issues are currently distributed among health, planning, environmental management, and various other departments.

At a local level, the environmental challenge has in large been separated from the mainstream work of the municipalities (Burstrom and Dalin, 1999). However, with the reintroduction of international influences and the new/revised environmental and planning legislation, a growing number of South African municipalities are beginning to explore and integrate environmental issues into their municipal strategies. Decision-makers at both local and provincial levels of government have recognised that a need exists for a more strategic, holistic and integrated approach to achieve the overall objectives of environmental management. This approach requires an integration of environmental and planning as well as more co-operation between the various departments within government institutions.

To investigate the environmental and development concerns of managers in decentralised government institutions, structured interviews were held with key decision-makers in this field (see Appendix 1 for the questions posed to the decision-makers). The following outcomes were based on the perceptions of decision-makers within the KwaZulu-Natal Department of Local Government and Housing, the KwaZulu-Natal Department of Agriculture and Environmental Affairs, the Durban Metropolitan Council, the Greater Johannesburg City Council and the Pietermaritzburg Transitional Local Council.

Environmental decision-making was, at large, found to operate strictly within the existing environmental and development legislative frameworks. Although this provides decision-makers with a firm grasp of the principles and statutory criteria, difficulties in decision-making arise when the legislation overlaps (as in the case with NEMA and the Environmental Conservation Act, No.73 of 1989), and when a plethora of environmentally related Acts have to be taken into account. This serves to further complicate the decision process, thus, hampering the efficiency of the approval process.

To overcome this problem, government organisations have developed an EIA framework, EIA checklists to screen development proposals, and environmental management policies. According to the decision-makers interviewed, the practical limitations of these frameworks and the revised planning and environmental legislation include:

- *"A strong reliance on consultants, who make use of their own frameworks."*
- *"Financial and human resource constraints."*
- *"Too much diversity of opinion."*
- *"A strategic approach does not provide for enforcement control."*
- *"LA21 principles lie on the outskirts of the IDP process and are not embodied within the process due to the highly sectoral nature of departments within the municipality. Thus, the integration of joint objectives has not yet been achieved."*
- *"Although the PDA makes allowances for the declaration of special case areas, the regulations to execute this function are not yet in place."*
- *"The IDP has no formal status within the TLC, hence, it has become a 'white elephant'."*
- *"The LDP is not in place yet."*
- *"Although Council has been informed of LA21, it has not been operationalised. Leaflets were developed without any context."*
- *"Environmental policies do not reflect the values and needs of society."*

The concerns listed above mainly illustrate the lack of continuity between strategic and operational planning, and the effects of a fragmented institutional arrangement. Although the new legislation provides environmental managers and decision-makers with many exciting opportunities for an integrated and holistic approach to environmental

management, its full potential has not yet been realised within government. This could be attributed to:

- The PDA and NEMA not yet being operational: - no regulations and by-laws to these Acts have, as yet, been developed. Thus, the principles and processes advocated Agenda 21 were not being implemented at a local level. A lack of understanding of the LA21 goals and objectives by politicians and a number of officials in other departments within municipalities has contributed to the slow implementation of sustainable development and LA21 principles in local government.

- The sectoral/silo approach to environmental decision-making and problem solving within local government:- this has resulted in a lack of cooperation and coordination between the different departments within municipalities. However, the degree of non-cooperative action on environmental problems differs between municipalities. When it does occur, it is quite often restricted to single issue cooperation at the administrative level (e.g. between the planning administration and the environmental administration). The ultimate aim of this cooperation has, however, rarely been used to solve the environmental problems but mainly to ensure that environmental issues are not overseen when considering physical development initiatives. In order to overcome this sectionalisation in decision-making, some municipalities and provincial departments have aggregated functions into one cluster department, e.g., the Provincial Departments of Agriculture and Environmental Affairs have combined to form one provincial department. It should be noted that although many decision-makers listed compartmentalisation of functions as one of their main concerns, all of the local authorities interviewed indicated that a high level of cooperation and communication exists between them and their provincial counterparts.

- The lack of interdepartmental coordination and communication:- at a strategic level, the lack of co-operation in one of the municipalities interviewed, resulted in each department (environmental, planning, local economic development, urbanisation, etc) formulating their own strategies. The strategies from each of the departments

were then merged to produce the IDP for that particular municipality. This IDP did not reflect any of the LA21 and sustainable development principles because of the sectoral approach adopted in the compilation of this report. Thus, the shortcomings of the planning legislation in incorporating LA21 principles were highlighted in this case.

- The scarcity of financial and human resources within local government:- this limited the ability of decision-makers within local and provincial government departments to execute certain critical functions in environmental management.

- The extensive use of consultants: by employing consultants, co-operation across the various sectors within the government departments was not achieved, hence, integrated and holistic environmental management remained an ideal. In addition, consultants employed their own frameworks that did not necessarily reflect the interests and environmental policies of the local authorities.

- The influence of politicians:- the investigation also revealed that decision-making in local authorities is, in essence, a political process. Politicians were perceived to possess the overall decision powers with regard to the approval of development projects that often excluded the opinions of other stakeholders in the decision process. Politicians were also perceived as being biased towards approving development projects since they needed to do as much as possible for their constituents during their terms of office, in order to be re-elected into office. In addition, their short term of office does not allow them to gain a full appreciation and understanding of the issues involved in sustainable development planning. More than one environmental manager summarised environmental decision-making as being adhoc due to the sectoral nature of the organisational culture as well as the political influences on the decision-making processes.

The practical environmental and planning concerns identified above are in agreement with McEwan, et. al.'s (1999) perceived shortcomings of NEMA. Environmental decision-making, at a local level, still relies heavily on the Environmental Conservation Act (No.73 of 1989) and the EIA regulations in Sections 21, 22 and 26, of this Act.

2.5 Concluding Remarks on Environmental Decision Making

The history of environmental decision-making illustrates that practitioners in the field of environment and development are constantly searching for new and improved methods and tools to aid in decision-making in this field due to the increasing complexity of environmental problems. This search resulted in the formulation of EIAs, the most effective tools to date, as they provide decision-makers with a practical framework to gage and assess development proposals. The importance of this tool is seen in its incorporation in the Environmental Conservation Act (No. 73 of 1989), NEMA and the PDA. However, Smith (1993) observed that EIAs have not achieved their full potential as sustainable development instruments since the EIA process has not yet integrated the science of environmental analysis with the politics of resource management.

Environmental decision-making in practice relies quite strongly on the legislative frameworks provided by NEMA, the PDA and DFA, even though these Acts have not been fully effected as yet. Much emphasis is placed on NEMA since it introduces legislation to the country that compliments similar environmental legislation found in the international arena. Legislation provides environmental planning with mechanisms to implement sustainable development, since sustainable development and LA21 principles are firmly entrenched in the above Acts. However, these Acts are only enabling or framework Acts. Regulations and by-laws for these Acts are still in the formulation phase and it remains to be seen if they will assist the decision-making process.

Practical environmental decision-making continues to be haphazard and fragmented due to the sectoral/silo approach to environmental management, as well as the political and economic influences on the decision environment. The need for co-ordination and organisational co-operation appears to be the most urgent concern in environmental management.

It is evident that the South African government is committed to an action-based programme of sustainable development in order to establish an equitable balance between reasonable needs of man and the effective protection and conservation of the environment. The greatest single challenge in the application of the unique South African environmental

policy (NEMA) is to reconcile the ideals, expectations and aspirations of the developed and developing components of the South African community. In addition, sustainable development can only be achieved when decision-making integrates the science of environmental analysis with the politics of resource management.

If this goal is to be achieved, a more sophisticated technique is required to gain a deeper appreciation of the decision problems experienced in this field. The following chapter investigates the role of Soft Systems Methodology (SSM) in providing a structured and focussed investigation into decision problems.

CHAPTER 3

THE ROLE OF SOFT SYSTEMS METHODOLOGY IN DECISION MAKING

Research into quantitative decision-making has made considerable progress in recent years. Decision-makers have moved from studying decision theory, based on single criterion decisions, to a decision support science, focussing on the study of more realistic situations involving several decision-makers. Complexity has been added to the process (Ho and Sculli, 1995), allowing for choices based on multiple, and often conflicting, criteria (Banville, et. al., 1998). This has culminated in the development of about six Multi-Criteria Decision Making (MCDM) methods that are in use to address multi-criteria problem solving. However, according to Banville, et. al. (1998), the penetration of these MCDM methods in practice, is quite limited. These authors attribute this limitation to several factors: their inability to clarify and assist in the problem formulation phase; the decision-maker's limited 'freedom of speech'; and the dominant technical aspects of their application.

Banville, et. al. (1998) also stress the importance of understanding, and including, the socio-political context in which a multi-criteria approach occurs to enable MCDM aids to be used in *pluralist*, *unitary*, *simple* and *complex* situations (these terms are explored in greater detail in this chapter). Hence the need for a structured and value-based enquiry into typical environmental and development planning decisions prior to the development of MCDM models to aid in this form of decision-making. To identify problems/issues, incorporate the socio-political context of the decision problem and better involve decision-makers in the decision-making process, MCDM methods can be supplemented with systems thinking and problem solving. The value of these methodologies are explored in greater detail in this chapter, as a basis for evaluating the most suitable methodologies to holistically assess and identify the problems and issues in environmental decision-making.

Soft Systems Methodology (SSM), is an iterative systemic process that allows for a structured, organised, and holistic approach for problem identification and decision-making. Although systems engineering focuses on achieving objectives, SSM is a

learning system. In this chapter, a short description of how this method encourages systemic problem solving is given. Following this, the distinctions between SSM and the "hard"sciences are clarified. The nature of SSM is presented by discussing the history, techniques and processes entailed in SSM. The limitations of SSM are discussed in specific relation to this research, and the manner by which these limitations were overcome is outlined.

3.1 SSM as a process to encourage systemic problem solving

The process of SSM provides for a structured, organised and logic-driven stream of enquiry into a complex problem situation to enable decision-makers obtain a rich appreciation of the problem and to clearly identify the constraints and problems in the situation.

	Unitary	**Pluralist**	**Coercive**
Mechanical	Mechanical-unitary	Mechanical-pluralist	Mechanical-coercive
Systemic	Systemic-unitary	Systemic-pluralist	Systemic-coercive

Figure3.1 Six decision problem-contexts (Source: Jackson and Keys, 1984)

Jackson and Keys (1984) classify problem situations along two dimensions: "according to the nature of the 'systems' of concern and the relationship between the 'relevant' participants". According to these authors, systems stretch from the 'mechanical' (relatively simple) to the 'systemic' (complex). The relationships between participants in the process can be of a 'unitary' nature (reach a consensus), they can display differences of opinion (pluralists) or they can be 'coercive', where they exhibit polarised viewpoints but are bound together by a common goal or system, e.g., power. Figure 3.1 illustrates these relationships in a matrix form. SSM is made possible by setting the perceived situation (real-world scenario) against a number of purposeful

'holons' or 'human activity systems' (Checkland, 1988). These purposeful holons are defined and modelled in such a manner that they provide a set of critical questions relevant to "uncovering" and investigating the problem situation in a structured and coherent fashion (Checkland and Tsouvalis, 1997). Answering these questions provides a clearer and deeper understanding of the situation, which eventually results in a structured method of action-based problem solving. This may take the form of a structured debate or discussion. SSM can be summarised as follows:

> **SSM is a methodology that aims to bring about improvement in areas of social concern by activating in the people involved in the situation a learning cycle which is ideally never-ending. The learning takes place through the iterative process of using systems concepts to reflect upon and debate perceptions of the real world, taking action in the real world, and again reflecting on the happenings using systems concepts. The reflection and debate is structured by a number of systematic models. These are conceived as holistic ideal types of certain aspects of the problem situation rather than as accounts of it. It is taken as given that no objective and complete account of a problem situation can be provided.(von Bulow, 1989).**

3.2 The Hard/ Soft Distinction in Real-World Problem Solving

According to Saaty (1994d), there appears to be a dichotomy between hard and soft data in relating the 'mind to the mind' and 'nature to the mind'. This distinction is analogous to the difference between tactical and strategic thinking where the former applies directly to the manipulation of the real world and the latter to the manipulation of thought to adjust it to the real world (Saaty, 1994d). This author further elaborates that hard data have to be transformed into data that are meaningful, and can thus be combined with other qualitative information needed to structure a decision problem. Thus, hard data must assume the same form as soft data to enable the decision maker to combine and manipulate them to serve the goals and values inherent in the problem situation. However, although both hard and soft data relate to the understanding of how to deal with the real world to satisfy our needs, they do not represent the real "truth" of the world but only an interpretation of it to conform to our own standards and values.

The process of SSM can be viewed as a formalised and structured version of the process of purposeful thinking that is undertaken on a daily basis (Checkland and Tsouvalis,

1997). SSM does not discriminate between the most relevant of possible 'relevant systems' as is the case with hard systems thinking. 'Relevance' is determined by the problem solving process, as decision-makers gradually better understand the problem situation by passing through the various stages of SSM (Checkland and Tsouvalis, 1997). The distinction between the 'hard' and 'soft' approaches to problem solving can be made on the basis of the nature of the problem under investigation and the presence or absence of human beings within the systems examined (Checkland, 1995). Waring (1989) sheds further clarification on this distinction by stating that 'human activity systems' exist in the real world, and that when they illustrate crisis, conflict or unease in relationships among human beings, it is inappropriate to use a 'hard' approach. Patching (1990), cited in Checkland (1995), supports this by suggesting that "hard systems analysis addresses those parts of an enterprise that have a tangible form...Soft systems thinking, however, considers the systems that could be envisaged throughout, and, in particular, those that involve human activity". This is further supported by Jackson (1988) who observed that "SSM treats human elements as active subjects and encourages the participation of all relevant organisational strata". SSM does not seek to solve problems, rather, to assist in the process of continuous learning in organisations thereby keeping options open (Jackson, 1988).

The most fundamental distinction between these two approaches is that 'hard' systems assumes that the world is systematic compared to SSM, which makes no assumptions about the nature of the world other than its complex nature, and that the *process of enquiry* can be organised as a system of learning (Checkland, 1995).

3.3 The Nature of SSM

SSM makes use of some basic systems ideas in the form of 'root definitions' and 'conceptual models'. In its early representations, these two stages were either explicitly (in the seven-stage model depicted in figure 3.2) or implicitly (two-streams model depicted in figure 3.3) divided from the rest of the stages (by a line) to signify the purposeful holons that would be used to question the real-world scenario (Checkland and Tsouvalis, 1997)[11].

[11] The authors have acknowledged that this line should be removed since it can be misinterpreted as dualism and that the modelling process tends to be problematic.

Checkland and Wilson (1980) identified two distinctly different types of root definitions, namely, primary task and issue based. The former root definition is structured and closely resembles the kind of systems' defined by hard systems methods compared to the latter which does not define a task that has been 'institutionalised in an organisational department or section, or an organisation as a whole'. Root definitions can be represented pictorially in the form of rich pictures [12]. The rationale behind this is that 'human affairs reveal a rich moving pageant of relationships, and pictures are a better means for recording relationships and connections than is linear prose (Checkland and Scholes, 1990). According to Checkland and Tsouvalis (1997), the core element of a root definition is in its transformation process in which a defined input is transformed into an output. These authors do, however, caution against confusing the element to be transformed with the resources needed to execute the transformation. They also advise against the use of verbs as inputs and outputs, but rather recommend the use of entities.

As depicted in figure 3.2, rich pictures are normally employed to analyse the problem situation in the first and second stages of the original seven-stage SSM model. According to this model, root definitions of systems relevant to improving the problem situation are constructed in the third stage. Each of these embodies a particular Weltanschauung –W (image of the world or world view). This leads to the fourth stage where conceptual models of the various root definitions are built. According to Jackson (1988), these models present "accentuated, one-sided views of possible, relevant human-activity systems". In the following stage, the conceptual models are then compared to the rich pictures (representations of the real world). It is envisioned that this comparison functions in helping to structure the debate about possible changes of the problem situation. Jackson (1988) finds that this "methodology facilitates a social process in which the 'W's' are held up for examination and their implications are discussed". According to this author, the sixth stage bears testimony to a common understanding of desirable and feasible changes among the participants in this process. In the final stage, the analyst assists in determining what action is needed to implement changes. Jackson (1988) concludes that the "methodological cycle does not see a 'solution' to the original problem but merely the

[12] The authors have acknowledged that the policy in SSM is to use rich pictures to represent the problem situation.

emergence of another, different problem-situation. Problem-solving in human activity systems is, for Checkland, a never-ending process of learning".

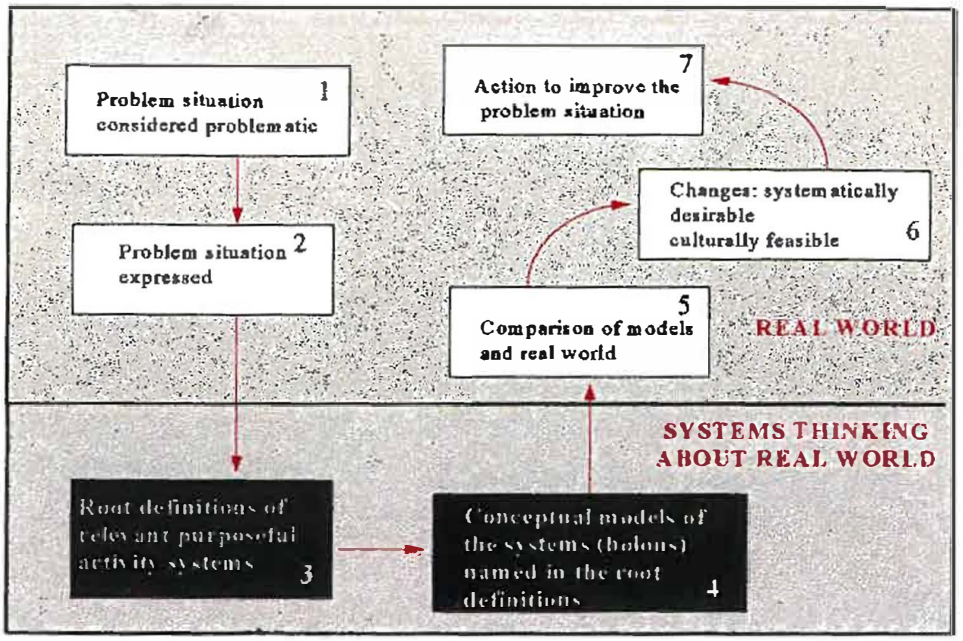


Figure 3.2 The original 'seven-stage model' of SSM (Checkland and Scholes, 1990)

As was the case for cost-benefit analysis and environmental impact assessment, SSM also underwent a series of changes from the original seven-stage model to evolve into a more sophisticated and representative model of the real-world (see figure 3.3). This development occurred over a 20-year period where action research in real-world problem situations was undertaken with an intention to determine whether the methodology used in 'hard' systems could be applied to "messy" problem situations (Hall, 1962; Jenkins and Youle, 1971). This gave birth to the idea of treating a structured set of activities that are connected together so that the entity would make up a purposeful whole.

According to Checkland (1991), research in SSM aimed to improve a situation perceived as problematic and, "through a reflection using a declared framework, more general learning which may be transferred to other situations" (Ibid, 1995). In developing a model depicting a real-world scenario, it was realised that purposeful action usually accommodates different Weltanschauungs. This realisation shaped SSM (Checkland, 1995). The mnemonic CATWOE was developed to expand the idea of the transformation process (T) and

Weltanschauung (W), after Smyth and Checkland (1976) analysed root definitions from past studies, to ensure that root definitions are well developed.

Conceptual models (of purposeful activity) are then constructed and used to structure and encourage debate among decision-makers, after finding out about a problem situation (Checkland and Scholes, 1990). According to Checkland (1995) the structuring is achieved through iterative cycles of the SSM process and debate is encouraged to find a compromise (not necessarily in the form of consensus) which stimulates the problem solving component of the process. Debating therefore serves not only as an aid in assisting decision-makers to clarify the problem situation, but also encourages decision-makers to formulate alternative choices of relevant human activity systems.

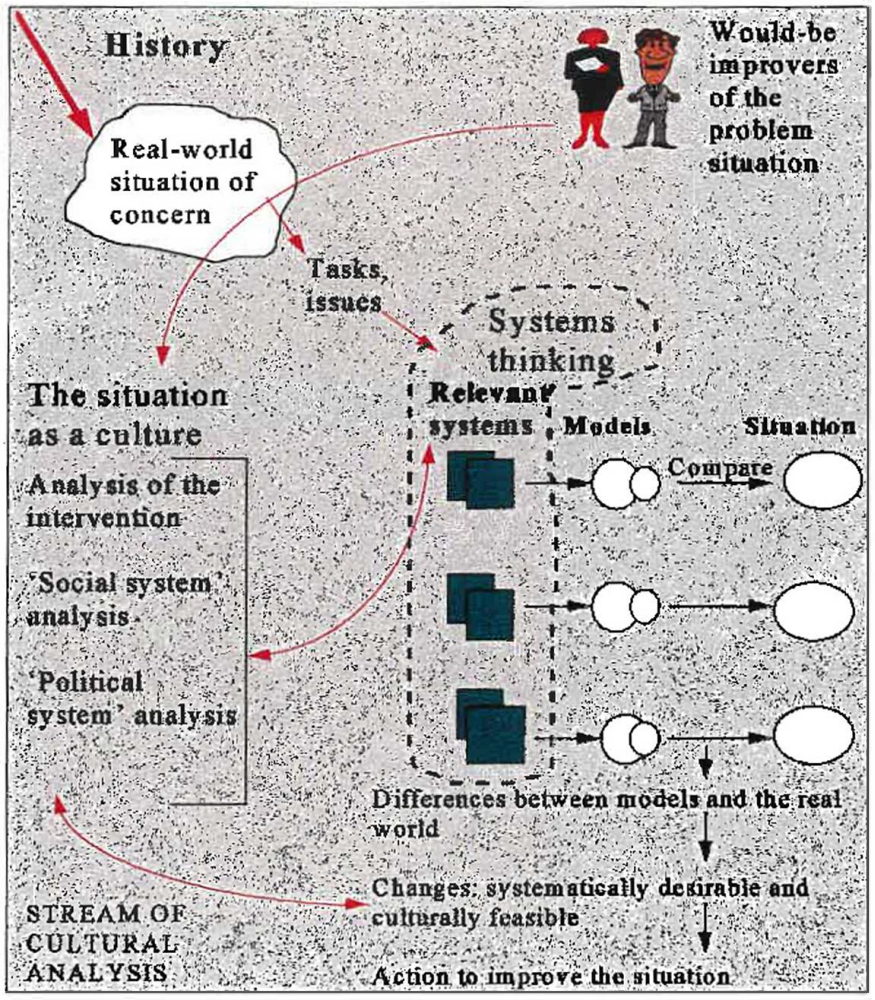


Figure 3.3 The 'two-strands model' of SSM illustrating a logic-based stream of analysis (after Checkland, 1988)

Systems thinking is broader in thinking and besides SSM, it also incorporates stakeholder analysis, strategic assumption and surfacing testing (SAST) and an enquiry into the organisational, political and technical issues that influence the decision problem. Stakeholder analysis involves the identification of key stakeholders on whom the success or failure of the preferred decision depends. These include people who are affected by the decision problem; people who have an interest in it; those who care about it; people who can affect of it; and those who can affect the adoption, execution, or implementation of the decision problem.

The stakeholder analysis is usually followed by strategic assumptive surface testing. Jackson (1988) observed that SAST is designed for use with complex systems of highly independent problems where problem formulation and structuring assume greater importance than problem solving, using conventional techniques. This technique is based on 'adversarial', 'participative', 'integrative', and 'managerial mind-supporting' principles (Jackson, 1988). It is used to elicit the assumptions on which the opposing viewpoints are based. This is accompanied by conducting an assumption specification, where lists of assumptions are made for each of the individual stakeholders established. Flood (1995) advises on:

- Constructing five key assumptions to get started;
- Establishing an assumption rating where stakeholders plot the assumptions on a chart to test their validity;
- Undertaking an investigative debate. In this process, the stakeholders are brought together to present their analysis and, once this process has been completed, to defend their assumptions; and
- Concluding with a synthesis of the assumptions and alternatives identified by the stakeholders. This part of the decision-making process is to reach a compromise between stakeholders on their alternatives and assumptions of the decision problem. It involves the formulation of a list of agreed assumptions. This is a process of negotiation and further modification. According to Flood (1995), issues to account for during this negotiation process include:

  - "*Has the process sufficiently taken into account the issue of whose interests are being served and why?*

- *Is there a genuine synthesis or are there still many pints of disagreement?*
- *Is the synthetic alternative about organisational design?*
- *How can the alternative be implemented?*".

SSM as a tool to analyse organisational culture

The revised version of SSM (figure 3.3) also caters for a cultural analysis of the problem situation to identify the characteristics of the organisational culture that might influence the decision-making process. Organisations have become the most powerful institutions on earth, with the resultant perception that "if something is not organised, it ceases to exist" (Jonker and Klaver, 1999). These authors further substantiate this concept by stating that organisations have become the most powerful 'tools' to create comfort, well-being, roads, safety and health. This perception has become so strong that it could be called the 'mechanisation' of the world-view (Jonker and Klaver, 1999).

However, in the field of environment and development planning, these organisations are made up of individuals with different cultures associated with different professions. Cultural differences and the different discourses developed within different professions have been found to be a major obstacle for cross-competence co-operation on environmental problems in decentralised government institutions (Asplund et al., 1997) as cited in Burstrom and Dalin (1999). This has much in common with the findings about corporate culture and language as barriers for implementing environmental and sustainable strategies in organisations (e.g. Halme, 1994; Post and Altman, 1991) as cited in Burstrom and Dalin (1999).

In addition to differing cultures, organisations and individuals that are involved in decision-making operate in an environment and react to stimuli that influence them in that environment (Radford, 1981). An organisation possesses both an internal and external environment. The internal environment consists of all its component parts as well as the social, technological and natural elements that make up the fabric of the organisation. A particular decision may exist wholly within either the external or internal environment of an organisation, or it may traverse both of these environs. The portions of external and internal environments that are associated with a particular decision situation form the environment of that decision situation (Radford, 1981). Thus, it is essential to analyse the

'stream' of organisational culture that impacts on the decision-making process in order to gain a deeper understanding of the problem situation and to generate substantial and successful solutions that can bridge cultural and language gaps common to the field of environmental planning.

SSM is thus a useful method for enquiry as it provides decision-makers with a sophisticated interpretivist tool for structured and organised enquiry into "messy" problems and also accounts for human values in the decision-making process. SSM encourages human participation and derives its strength by incorporating values into the decision process thereby enabling decision-makers to have more control over the decision situations they face. This method therefore encourages value-focussed thinking to enable decision-makers to better understand and appreciate the problem situation. Not only is this process based on action, but also encompasses problem identification and the formulation of alternatives in its methodology.

3.4 Limitations of SSM

SSM does, however, have some limitations. SSM is largely based on a systems approach to deal with complex and "messy" problems. In general, the systems approaches exhibit holistic, reductionist and dynamic features (Liao, 1998). One of the criticisms of this approach, according to Mingers (1992), is that conceptual modelling in SSM provides for a reductionist approach to problem solving. This author further elaborates that, in developing a conceptual model, very little attention is given to how activities relate with each other, thus, not paying attention to the dynamic features of the problem situation. In addition to this, conceptual modelling pays little attention to interactions with the environment and the wider systems, that is, seeing it within a holistic context. According to Liao (1998), a reductionist approach is biased since it pays attention only to the reduction of complex problems. To overcome the reductionism of conceptual models in SSM, hierarchical multi-criteria models were developed in place of the conceptual models, as defined by Checkland and Scholes (1990).

The justification for replacing the original SSM conceptual models with conceptual hierarchical multi-criteria models is based on Liao's (1998) observation that, in complex

decision-making, a number of inter-related decision-making tasks need to be addressed simultaneously in order to obtain an overall objective. Koestler (1967) argues that many complex structures exhibit some degree of coherence, stability and hierarchical structure. Thus, a method used to investigate "messy" and complex problems should have the ability to simulate its hierarchical nature.

A multi-criteria approach is therefore needed to overcome the reductionism of the conceptual models in SSM. The multi-criteria hierarchical representation of the real-world allows the decision problem to be viewed within a larger environmental, organisational and political context. The inter-relationships between the various criteria that affect the decision problem are also better represented by hierarchical multi-criteria models. According to Liao (1998), both a systems approach and a hierarchical approach have long been used in dealing with complicated decision-making problems.

Another important criticism of SSM is its ability to bring about change. Mingers (1992) observed that one of the problems identified by SSM users was its problem in reaching a compromise and accounting for the existing power structures in an organisation. According to this author, existing power holders are not obligated to take other viewpoints into account. One way of getting around this limitation is to employ the Analytical Hierarchy Process (AHP). This technique incorporates the opinions and views of all the stakeholders by a process of logical synthesis in a group decision environment.

In addition to the above criticisms, the ability of a rich picture to incorporate all the Weltanschauungs of the stakeholders in the decision process, was also questioned.

3.5 Conclusion to the Use of SSM in Decision Making

In this chapter and in regard to the research project, the value of the holistic and people-centred approach of SSM for problem identification and solving was clearly demonstrated. Stakeholders may be identified in a structured, logical and organised manner. In addition, the opinions and Weltanschauungs of all the stakeholders can be creatively explored and included in the problem identification phase. SSM also allows for the creative identification of the organisational and political issues that affect the decision-making

processes. This can provide the research with a very important tool to investigate the cultural and political dynamics that influence decision-making in the field of environment and development.

Results obtained from the preliminary investigation into problem identification in decentralised government institutions illustrated that non-cooperation and sectionalisation of decision-making severely hampered the decision-making processes. Through structured debate and discussion, SSM and SAST techniques allow for an integrative, holistic and participative approach to problem identification. These methods can therefore assist the research project in gaining a deeper understanding and appreciation of the issues/problems, within their socio-political contexts, that decision-makers in the field of environmental and development planning are currently experiencing.

This chapter also identified the limitations of conceptual models in SSM. Another expressed concern is the inability of SSM to influence the political powers. To overcome these limitations, it was proposed that in this research project hierarchical multi-criteria models be developed which would better reflect the relationships between the various factors that influence the decision process and formally incorporate the political dimensions influencing and affecting the decision problem.

The following chapter deals with the role of the AHP, a multi-criteria approach to decision-making, in problem solving. A combination of SSM and the AHP allows holism and reductionism to be considered simultaneously, thereby strengthening the conceptual multi-criteria decision models proposed in this research.

CHAPTER 4

MULTI-CRITERIA DECISION MAKING AND THE ANALYTICAL HIERARCHY PROCESS

Although an overwhelming amount of knowledge on decision-making and problem solving, derived largely from quantitative techniques and methodologies, has already been put to use in a wide variety of applications (such as the assessment of health and environmental risks and impacts, inventory tools and methods for industry, and procedures for modelling energy and environmental systems); there exists an ever increasing need for decision-making to successfully address the environmental, social and health concerns of the 21st century. These concerns include, among others, problems associated with such issues as: burgeoning populations and overcrowding, an increasingly complex technological world, economic development, education and health, redressing past inequalities and controlling crime. More importantly, there exists an increasing need for valid methodologies to aid decision-makers in making objective decisions governing subjective factors, and to derive fair, transparent and equitable ways of trading-off and balancing tangible with intangible factors. These concerns have led to the emergence of new and exciting multi-criteria theories and methodologies as tools to aid in the decision-making processes.

In this chapter, the strengths and limitations of multi-criteria approaches to decision-making are explored. Special attention is paid to the AHP, a multi-objective multi-criteria decision-making method. The nature of the AHP is investigated and its numerous attributes and utilities are discussed. The strengths of the AHP illustrate how this method can overcome many of the limitations inherent in most multi-criteria decision aids. The AHP's measurement scales are explored as well as its unique attribute, a measure of the consistency of the judgements entered. Areas of application of the AHP are also discussed, with particular reference to the research project.

4.1 The Need for Multi-criteria Approaches to Decision Making

The research into quantitative decision-making has made significant progress within recent years (Banville, et. al., 1998). According to these authors, this stemmed from a transition

in decision theory based on single criterion decisions to a decision support science which has, as its focus, more realistic situations involving several decision-makers, which makes the process much more complex. Thus, choices are often based on multiple, and often conflicting criteria. The breakdown of traditional approaches to the study of single criterion decisions (undertaken by one person in one place and time) provided the motivation for multi-criteria approaches to decision-making (Banville, et. al, 1998).

Although an individual decision-making problem normally includes only one specific decision-making task, multiple criteria and multiple alternatives have to be considered (Liao, 1988). This author observed that a number of interrelated decision-making tasks need to be addressed simultaneously, in complex decision-making, to reach an overall objective. "Complex decision-making can therefore be structured as an integrated decision-making process which involves at least: (a) identifying multiple tasks and chain effects, (b) assessing environmental influences and determining multiple criteria, and (c) evaluating multiple alternatives" (Liao, 1998). Thus, the development of Multi-criteria Decision-making (MCDM) aids originated from a recognition of the multi-criteria nature of managerial decision tasks as well as the increasing power and accessibility of computers (Kotteman and Davis, 1990).

4.2 Goals of Formal MCDM Techniques

MCDM is a human, managerial task that cannot be automated by tools, techniques or algorithms (Stewart, 1992). Its aim is to guide the decision maker in determining the course of action that best achieves the long-term goals, by providing the decision maker with some measure of consistency during the decision maker's search for solutions to a problem situation (Stewart, 1992). This methods may be used within two contexts namely, (1) when the decision maker (who can be represented by a single individual or an essentially homogenous group) undertakes a decision that does not require justification to other parties; and (2) when the decision maker (individual or group) has to make decisions on behalf of a much larger group or community (e.g. in government organisations).

In the former scenario, the methods can be relatively informal whereas, in the latter case, the rationale for choices has to be clearly documented and the decisions justified. This

necessitates the need for a more formal method of analysis, even when these may be less efficient and/or may impose structures (e.g. rationality), which may not be strictly justifiable (Stewart, 1992).

Thus, Stewart (1992) argues that the context of the particular decision situation needs to be considered before selecting a particular MCDM method. According to this author, a distinction between methods in this context is that between 'prior' and 'progressive/interactive' articulation of preferences. Methods of prior articulation of preferences require the decision maker to specify value judgements in isolation from the particular choices available which are then translated into a particular choice/s consistent with these preferences (Stewart, 1992). This approach suits contexts where justification and rationale are prerequisites. Progressive or interactive articulation of preference methods explore the decision problem systematically, with no need for the decision maker to specify prior preferences. Although this method is more efficient and demands less 'sweeping assumptions' regarding preference structures, it is however vulnerable to manipulation by skilled users and is therefore not very defensible when solutions need to be justified or rationalised (Stewart, 1992).

4.3 Practical Limitations of MCDM Aids

Theoretically, multiple criteria decision aids (MCDA) represent progress in overcoming the single criterion barrier that often portrays the field of decision support incorrectly. As previously mentioned, their penetration is often quite limited (Banville, et. al. 1988). Kotteman and Davis (1990) further elaborate on the practical difficulties of using MCDAs. According to these authors, MCDAs often assist decision-makers in formulating an exhaustive list of objectives and alternatives. Although such a broadening of the scope of the decision problem/s may be deemed desirable at the onset, it is also possible that decision-makers' "subjective impressions of decision quality" may be adversely affected due to increases in decisional conflict (Kotteman and Davis, 1990). Thus, despite the aid's positive influence on actual quality decisions, these negative impressions may well arise.

4.4 The Hierarchical Approach

Quite often, a decision problem consists of a plethora of inter-related factors and attributes. In such cases, the number of factors and their mutual relations increases beyond the ability of the decision maker to comprehend distinct pieces of information (Saaty and Vargas, 1994). Decision-makers are able to structure a complex decision problem with the aid of the hierarchical approach thereby making decision elements and their relationships more visible (Liao, 1998). According to Saaty and Vargas (1994), a hierarchy is a particular type of system, which is based on the assumption that the elements influencing the decision problem can be grouped into disjoint sets. The elements of one group (level) influences only the elements of one other group, and are themselves affected by the elements of only one other group. The elements in each hierarchical level are assumed to be independent (Saaty and Vargas, 1994). These authors observed that the main aim of a hierarchy is to understand the goal (the highest level in a hierarchy) based on the interactions of the various levels, rather than directly from the elements of the levels. Hierarchical representations of a decision problem have several advantages (Saaty and Vargas, 1994):

- *They can be used to describe how changes in the priority of higher levels affect the priority of criteria in the lower levels.*
- *They provide a large amount of information on the structure and function of the system in the lower levels. An overview of the actors and their objectives are provided for in the upper levels.*
- *Natural systems constructed as a hierarchy evolve more efficiently than those assembled as a whole.*
- *These systems are stable and flexible: Stable because small changes in the decision have small effects on the outcome, and flexible because any additional criteria added to a well-structured hierarchy does not affect its performance.*

Most decision problems involve a number of variables, and, where needed, appropriate weights can be attributed to all the variables deemed important, thereby enabling each alternative to be evaluated in terms of these variables. In many other instances, it may be difficult to determine accurately various factor weights and to quantify a decision maker's preference for alternatives (Liao, 1988). Saaty and Vargas (1994) observed that, when

making decisions, people usually provide subjective judgements based on "gut" feelings and intuition, rather than on well-structured, logical reasoning. This typifies a managerial decision-making environment.

4.4.1 Analytical Hierarchy Process (AHP)

The search for environmental quality is a global phenomenon that drives all forms of decision-making and has thus become an organisational, political and societal issue. According to Jonker and Klaver (1999), quality decision-making is brought about by a systematic and structured approach and is guided by principles, methods and tools. "The backbone of almost any quality system is a scheme based on agreed norms and values" (Jonker and Klaver, 1999). Values are fundamental and integral to our very existence and should therefore be the engine in our decision-making processes. In spite of this, decision-making usually focuses on the choice among alternatives (Keeney, 1996).

In practice, decision problems tend to be thrust upon us by actions of others and/or circumstances, both of which serve to initiate the problem-solving phase of the decision-making process. Decision-makers tend to concentrate immediately on the alternatives and only afterwards address the objectives or criteria to evaluate the alternatives thereby practising crisis management or reactive decision-making (Keeney, 1996). According to Keeney (1996), alternative-focussed thinking is backward because it puts identifying alternatives before articulating values, the essential ingredient that enables decision-makers to have more control over the decision situations they face. This author further elaborates that value-focussed thinking provides a mechanism to channel a critical resource - hard thinking - to enable better decisions by stating that "better decisions come about both because of insights provided by the thinking and because of the specific procedures that view decisions through 'value-focussed' glasses".

Keeney (1996) therefore encourages "a shift to this way of thinking about decisions can significantly improve decision-making because values guide not only the creation of better alternatives but the *identification of better decision situations*. These better decision situations...should be thought of as *decision opportunities*, rather than as decision problems". Because AHP encourages decision-makers to concentrate on the objectives,

and not the alternatives, of a decision problem, it could be described as a value-focussed decision aid.

AHP - designed, developed and promulgated by Thomas Saaty - arose out of a need to consider not only all the essential information and hard data but also the goals and criteria which impact on the decision (Saaty, 1994d). With reference to decision-making on key environmental planning issues within government institutions, managers are often forced to cope with limited resources. An ordering of priorities is needed, that is, a consensus that one objective outweighs another during the near future. Thus, the need exists to recognise the trade-offs that will best serve the greatest common interest. Saaty (1994d) described AHP as "a framework of logic and problem-solving that spans the spectrum from instant awareness to fully integrated consciousness by organising perceptions, feelings, judgments and memories into a hierarchy of forces that influence decision results". It allows decision-makers to consider both quantitative and qualitative criteria, as well as various alternatives.

AHP is therefore, in essence, a general theory of measurement (Saaty, 1996). According to this author, it is used to derive ratio scales from both discrete and continuous paired comparisons in multilevel hierarchic structures. This author further elaborates that the paired comparisons may be derived from actual measurements or from a fundamental nine-point scale (expressed in dominance units) that reflects the relative strength of preferences or feelings. The scale for comparisons among pairs of elements/criteria in a level consists of verbal judgements ranging from equal to extreme (equal, moderately more, strongly more, very strongly more, extremely more). Absolute numerical judgements correspond with the verbal judgements (1, 3, 5, 7, and 9) and include compromises between these values (2, 4, 6, and 8). Research and experience have shown that the nine-point scale offers reasonably good discrimination. Saaty in (Saaty and Vargas, 1994) has proven that when the number of elements to be compared is reasonably small (between seven and nine), the derived priorities derived from these comparisons are very stable, even when small changes in the numerical judgements are made. Small can be as large as a whole or unit or two in either direction (Saaty and Vargas, 1994).

Expert Choice, the software package for the personal computer that implements the AHP as it was conceived by Saaty (Saaty and Vargas, 1994), allows the user to conduct a sensitivity

analyses to test the effect of the uncertainty of the criteria on the choice of a best alternative.

AHP has also been demonstrated to articulate the fundamental mental processes by which overall judgements are arrived at in situations that involve goals and criteria (Saaty and Vargas, 1994). It is a multi-objective multi-criteria decision-making approach that makes use of pairwise comparisons to arrive at a scale of preferences between sets of alternatives. It is a theory based on four axioms: the reciprocal relation for making comparisons (if A is 5 times more preferable than B, then B is 1/5 as preferred a A); homogenous comparison groups (that differ by no more than one order of magnitude); inner and outer dependence (whereby the elements of a hierarchy in a level may depend on each other [inner] and also on the elements in another level [outer]); and expectations (which must be represented explicitly in the structure to determine whether they would be satisfied) (Saaty, 1994a). In addition to the axioms, AHP is also based on applicable mathematics.

It must be acknowledged that this is in contravention of the Multi-attribute Utility Theory (MAUT), an older theory, where alternatives are ranked one at a time subject to strong axioms about lottery comparisons, transitivity preferences, and rationality as defined by the experts (Saaty, 1994d). Utility theory is concerned with representing an individual's relative preferences among the elements of a set, by using real numbers (Saaty and Vargas, 1996). These authors observed that an ordinal utility function lists the rank order of the elements, compared to cardinal utility that includes information on the strength of preferences. In addition, there are also ordered metric ranking and multidimensional utility theories (Saaty and Vargas, 1996). AHP, the new theory, questions all of these.

However, a discussion on the criticisms towards AHP is out of the scope of this mini-dissertation for space reasons. Further details can be found in Dyer (1990), Saaty (1990), Donegan (1997), and Salo and Hamalainen (1997). AHP was chosen for decision modelling in this research due to its applicability in this area of research, its wide practitioner acceptance and popularity in many other fields.

Cognitive psychologists have recognised that two kinds of comparisons exist - **relative and absolute** (Saaty, 1996). In the latter, alternatives are compared with a standard in one's

memory based on prior experience. In the former, alternatives are compared with pairs according to a common attribute (Saaty, 1996). AHP is both a descriptive and normative theory of measurement (Saaty, 1996) since the pairwise comparisons render it a descriptive theory, whereas, absolute comparisons makes it a normative theory. Relative and absolute measurements differ in that the alternatives' local priorities in relative measurement are normalised so that they add up to one (Salo and Hamalainen, 1997). These authors also observed that in absolute measurement, the alternatives' local priorities are not normalised. These measurements are discussed in more detail below.

4.4.2 Relative Measurement - The descriptive mode

The AHP is based on the ability of decision-makers to use both information and experience to estimate relative magnitudes through paired comparisons (Saaty, 1994d). These comparisons are used to formulate ratio scales (relative measurement scales) on a variety of both tangible and intangible decision criteria. Thus, AHP cannot only compare alternatives, one at a time in the context of priorities, but it can also use relative comparisons, which is essential when the decision maker(s) cannot draw on previous experience to create scales to judge alternatives one at a time. Relative, or paired, comparisons are convenient for scaling intangible factors side by side with tangible ones and for dealing with different types of dependence in a coherent way. They are also useful in explaining paradoxes on rank preservation and reversal encountered by the older MAUT theory (Saaty, 1994d). These characteristics of AHP make it particularly appealing for the analysis of impacts in environmental concerns.

4.4.3 Absolute Measurement - The normative mode

Absolute measurement is also referred to as scoring or rating (Saaty, 1996). This measurement ranks the decision alternatives in terms of the criteria, or in terms of the intensities of the criteria; for example: excellent, very good, good, fair, poor (Saaty, 1996). Once the priorities on the criteria (or subcriteria) have been established, pairwise comparisons can be executed between the ratings themselves to establish priorities for them under each criterion (Saaty, 1996). The priority of each criterion is then divided by the largest rated intensity (the ideal intensity). The alternatives are evaluated by identifying for each criterion (subcriterion), the relevant rating which best describes that alternative (Saaty and Vargas, 1994). The weighted (global) priorities of the ratings (one under each criterion

corresponding to the alternative) are added to produce a ratio scale score for that particular alternative (Saaty and Vargas, 1994). The scores of all the alternatives can be normalised, if so desired.

This method is useful when dealing with a large number of alternatives; however, not every large-scale problem needs to employ the absolute mode of comparison (Saaty and Vargas, 1994). Because absolute measurements require standards (often set by society for convenience), relative measurement is advised in cases where no standards have been established. In this case, the alternatives will be compared in pairs to determine the best alternative.

4.4.4 Consistency

Inconsistency is a natural human trait to allow for a change of mind when new facts come to light, and it happens naturally in human affairs (Saaty, 1994). One of the most important attributes of AHP, with the aid of the Expert Choice software package, is its ability to allow for inconsistency during the decision-making process. It also offers a method to improve on the consistency of the judgements. AHP does this by providing an overall measure of consistency of the judgements entered by the decision-makers(s) throughout the evaluation process (Mulye, 1996). According to Mulye (1996), the measure of consistency is calculated from the principle eigenvalue (λ) of the matrix of pairwise comparison. The author also observed that, when the matrix is perfectly consistent, then the principle eigenvalue is equal to the order of that particular matrix. When it is inconsistent, the eigenvalue exceeds n (Mulye, 1996). Thus, the difference between λ and n is a measure of the inconsistency, by taking a ratio of this difference to the average of the corresponding difference of a large number of matrices of randomly generated comparisons. As a rule of thumb, an inconsistency ratio of 10% and less is considered good, and less than 20% is generally considered acceptable (Mulye, 1996). If it exceeds 20%, it is advised to alter some of the comparisons to achieve a greater level of consistency (Mulye, 1996). Mulye (1996) does caution against mistaking consistency for accuracy of the judgements since it is possible for a person to simultaneously be perfectly accurate and inconsistent.

4.5 Areas of Application

AHP has been applied to numerous and diverse fields of decision-making. According to Saaty (1996), AHP is spreading in academic, government and business practice. This author observed that it has been applied extensively in various fields of planning, resource allocation, and in conflict resolution. Its application to a variety of prediction problems in the fields of technological, environmental and social impact assessments has gained momentum over the past decade. According to Saaty and Vargas (1994), some of the types of problems to which AHP has been applied include:

- Setting priorities and generating a set of alternatives;
- Determining requirements, allocating resources
- Making decisions based on costs and benefits;
- Predicting outcomes (Time dependence) - Risk Assessments;
- Measuring the level of performance of a system;
- Designing a computer system and ensuring the stability of the system; and
- Optimising, planning and conflict resolution.

The application of AHP to understanding, analysing and negotiating conflicts has been employed since the early 1970s. Areas of its application include, among many other, the conflicts in Northern Ireland, the Middle East, South Africa, and the Falkland Islands; and the free-trade negotiations between Canada and the United States. The areas of application have grown since AHP's conception, and still continue to grow.

In addition to the above-mentioned areas of application, the AHP can also be used in a group decision-making context. This utility is especially important in areas of environmental and development planning when evaluating development proposals and resolving conflict.

Group Decision-making

According to Saaty and Vargas (1994), group decision-making with the aid of AHP comprises of two alternatives: the group can either meet and debate the issues with the intent of obtaining consensus after discussing each judgement, or, they may write out their personal judgements independently of each other.

In the first case, the process runs smoothly when the group reaches an agreement. Quite often, consensus cannot always be obtained due to individuals in a group disagreeing. In these instances, the different judgements on each question can be combined by taking the geometric mean. Aczel and Saaty (1983) proved that the geometric mean is the only way to preserve the reciprocal property when combining judgements made on paired comparisons. This implies that if two criteria (A and B, assuming A is more important that B) are compared in a pairwise fashion, the judgements are combined by multiplying them, and taking the nth root to obtain the average judgement on A with respect to B. The reciprocal of this result coincides with the nth root of the product of the reciprocals of the judgements comparing B with A (Saaty and Vargas (1994).

Alternatively, when stakeholders in a group decision environment agree on most judgements, but differ on one, each proposed value can be tested with the remaining ones to determine which one yields the greatest consistency (Saaty and Vargas, 1994). The one that is most consistent is then adopted.

In some cases, when no consensus can be obtained, Saaty and Vargas (1994) advise that decision problems be resolved within the context of conflict resolution, using benefits and costs. According to these authors, the geometric mean should only be used as a last resort when consensus cannot be obtained.

In cases where stakeholders are unable or do not wish to meet, each participant can work out his/her prioritisation of the alternatives (on an agreed upon hierarchical structure of the problem). The results can then be averaged arithmetically, or if desired, a separate hierarchy can be used to rate the importance of the participants and the outcome used to weight and combine their individual rankings (Saaty and Vargas, 1994). Finally, if the participants are willing, individual judgements can be elicited from each stakeholder. These judgements can then be combined with the aid of the geometric mean. Illustrated in Appendixes 3 and 4 are the types of questionnaires designed for this purpose.

4.6 Conclusion on MCDM and the AHP

This chapter illustrated that complex decision-making, which typifies the environmental and development decision-making environment, requires a multi-criteria approach to address the interrelated multiple criteria and alternatives in order to gain an overall objective for the decision problem. Thus, complex decision-making can be facilitated with the aid of Multi-criteria Decision-making (MCDM). These aids guide decision-making and provide some measure of consistency during the decision-making process.

The application of MCDM aids in decision-making does, however, have some limitations. The most notable limitations of many MCDM aids are their technical complexities and their inability to holistically capture and formulate the decision problem. Thus, most MCDM aids require the help of technical experts thereby limiting the role of the decision maker(s) during the decision-making process.

Also discussed in this chapter, was the hierarchical approach to decision-making and the role of AHP in overcoming the limitations outlined above. This approach enables decision-makers to structure the decision problem in a rational and systematic manner. The arrangement of decision criteria in a hierarchical structure thus allows for a logical and organised investigation into the problem situation. The main aim of a hierarchy is to encourage decision-makers to focus on the objectives of the problem and not the alternatives, thereby directing decision-making.

AHP is a general theory of measurement that is based on four axioms: the reciprocal relation for making comparisons, homogenous comparison groups, inner and outer dependence, and expectations. It is a relatively simple, systematic procedure for representing the elements of any problem in a hierarchical structure. It organises basic reasoning by breaking down a problem into its smaller constituent parts and has also been demonstrated to articulate the fundamental mental processes by which overall judgements are arrived at in situations that involve goals and criteria. It makes use of both relative and absolute comparisons to compare criteria in a hierarchy. Relative comparisons enable decision-makers to make use of both their experience and information to estimate the

relative magnitudes of the criteria through paired comparisons. Absolute measurements, on the other hand, require already established standards.

AHP therefore leads from simple pairwise comparison judgements to the priorities in a hierarchy. Thus, the AHP encourages value-focussed thinking and derives its strength by enabling "soft" data to be compared with "hard" data. It allows for objective decision-making regarding subjective matter.

By arranging the goals, attributes, issues and stakeholders in a hierarchy, an overall view of the complex relationships inherent in the problem situation can be obtained. A unique attribute of AHP is its ability to allow for inconsistency during the decision-making process. Inconsistency is a natural human trait to allow for a change of mind when new facts come to light. It also offers a method to improve on the consistency of the judgements.

Another attribute of AHP is its ability to allow for group decision-making where all the stakeholders can participate in the decision-making process. This is especially important when equitable, fair and transparent decisions need to be made. Group decision-making also facilitates in conflict resolution since the opinions of all the stakeholders in the decision process can be accounted for in a transparent manner. Thus, unlike most MCDM aids, AHP is relatively easy to understand and use, and engages decision-makers in the decision-making process from problem identification to problem solving.

Because the generation of MCDM models is not a simple and straightforward process, a problem structuring phase is required. This is facilitated through SSM sessions with key decision-makers in the field of environmental and development planning. It is thus appropriate to consider and apply AHP, with the aid of SSM, to structure decision issues/problems within the field of environment and development and identify pertinent socio-political factors that influence and affect the decision problem. The practical application of soft systems thinking and MCDM in the field of environment and development planning is explored in greater detail in the next chapter.

CHAPTER 5
DERIVING CONCEPTUAL MULTI-CRITERIA MODELS FOR ENVIRONMENT AND DEVELOPMENT DECISION MAKING

This chapter is devoted to the application of soft systems thinking techniques (SST) in deriving a conceptual decision framework to aid decision-making in the field of environment and development. Due to the iterative nature of problem identification and solution, Soft Systems Methodology (SSM), an interpretivist approach for problem identification and solving, was employed in the derivation of the framework.

The chapter illustrates and discusses how (with the aid of SST techniques and the results obtained from investigating current environment and development planning legislation and decision-making) two conceptual hierarchical multi-criteria models were constructed in collaboration with selected decision-makers in local and provincial government departments. These models to were designed to assist decision makers in assessing and evaluating development projects in both inland and coastal environs.

5.1 Aim of the Multi-Criteria Decision Making Models and the Derivation of a Decision Framework

As previously described, at all tiers of government and at all levels within government organisations, decision makers face "messy" problems when evaluating and assessing development proposals. Environmental planning decisions are typical examples of complex problems involving numerous interacting factors and often conflicting technical, societal, environmental and political objectives. To derive a successful decision, decision makers have to consider not only the "hard" data but also the "softer" information that can influence and affect the decision. According to Saaty (1994b), certain kinds of data that appear most urgent scientifically may not impact on the goals and objectives of the decision problem as much as other less precisely quantifiable information. This author further elaborates that the best decisions often do not depend on great precision of measurement, because the measurements must eventually be interpreted in terms of goals that are often not very well understood. Thus, how judgements are structured and applied are as essential, if not more so, than having a great deal of data about the problem, but with no effective way

of trading-off the different kinds of information (Saaty, 1994b). Thus, decision-making places much emphasis on value and its priority (Saaty, 1996).

In Saaty's (1996) opinion, the science of decision-making is concerned with the relation between alternative actions or choices that need to be made and our system of values, since our values help us in identifying different properties and measure intensities within each property. This is why hierarchic structures are of essence in this undertaking. This method of decision modelling may facilitate the timeousness of the approval process of development projects by taking into account all perspectives and human values of the relevant stakeholders in the decision process in a relatively short time period (refer to chapter 4 for a more detailed description of group decision support). It also allows for greater transparency in the decision process thereby aiding in the prevention of using Environmental Impact Assessments (EIAs) as a rubber stamp in the approval process of development projects.

Framework for Decision Making

Due to the complex and "messy" nature of environment and development decision problems, a multi-objective, multi-criteria and value-focused approach to investigating decision-making in this field is essential. In this research, the MCDM models were developed within the framework proposed by Smith (1993) that defined a role for resource management procedures and institutions. This framework involved the translation of values and information into directives for sustainability. Within this paradigm, impact assessment was identified as the process for environmental planning that provides the basis for resource management to achieve to sustainability (Smith, 1993). According to Smith (1993), problems in a society, its economy and/or the environment are perceived on the basis of issue tractability, the justification of need, issue attention and the availability of information. He further observed that, once these issues were identified, resource management should then initiated as the problem solving component, by determining what issues require attention, setting goals and finding or designing suitable courses of action. This process is iterative since it influences the perception of the decision problem.

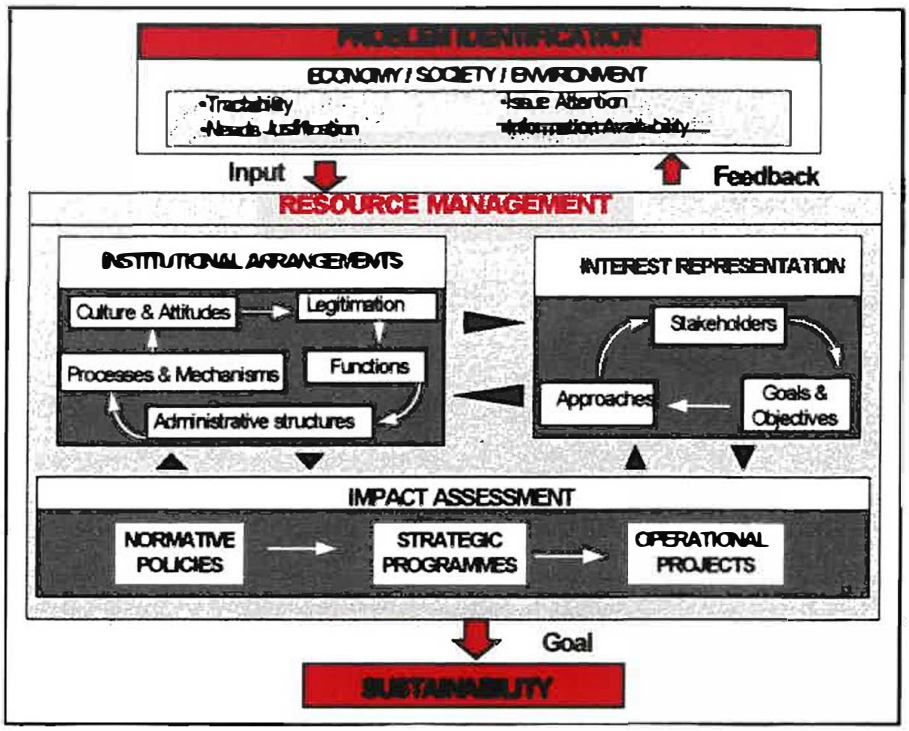


Figure 5.1 An integrative framework for sustainable resource management (adapted from Smith, L. G. (ed), 1993).

In this research, SST (in particular, SSM) techniques were employed to identify the decision problems/issues. These techniques were also used to investigate the institutional, political and organisational issues (in both local and provincial governments) that influence the decision environment. Once the decision problem was identified, the problem was conceptualised and structured in a hierarchical manner. The structure included a stakeholder analysis, key issues affecting the decision problem, the values of the stakeholders and goals they aimed to achieve. Due to the integrative nature of the hierarchical multi-criteria decision models, decision-making geared towards sustainability could therefore be addressed since the models linked problem identification with resource management. Thus, with the overall goal of these MCDM models being sustainable development, the decision-making process will consider not only the objectives, but also the interest representation, institutional arrangements and impact assessment (this refers to environmental, social, health and technological impacts).

5.2 Derivation of the objectives, factors and activities used to construct the decision framework in the form of hierarchical multi-criteria models

Structured interviews and SST workshops were hosted with various key decision makers in the field of environmental planning, within local and provincial government organisations. These events were used to derive the objectives, factors and activities in order to formulate hierarchical decision models, with sustainable development and environmental risk analysis as their driving goals. The structured interviews (refer to Appendix 1) provided the author with background information on the problems decision makers face when assessing development proposals, as well as a practical foundation for structuring the workshops. Workshops were hosted with the KwaZulu-Natal Department of Agriculture and Environmental Affairs and the Pietmaritzburg TLC.

The participants in the KwaZulu-Natal Provincial Department session were presented with a rich picture to initiate the SST session and to provide all of the participants with a common understanding of the problems encountered in environmental planning. The participants were then led through the process of stakeholder and CATWOE analyses (see SSM in chapter 3) as well as an analysis of the political, cultural and technical issues facing decision makers in this field.

For the Pietermaritzburg TLC SST session, a modified version of the SSM proposed by Checkland and Scholes (1990) was used, where the results obtained from the first workshop were presented to these participants for further assessment and comment.

The main focus of both of these workshops was to derive hierarchical models that would aid in the decision-making process when assessing development proposals. The role of the author in this process was to act as a facilitator of the process of learning about the influences of the various factors affecting environment and development planning.

The findings from these workshops were also presented to decision makers in the Greater Johannesburg Southern Metropolitan Local Council (SMLC), the Durban Metropolitan Council (DMC) and the Department of Local Government & Housing for comment.

The outcomes of the feedback sessions proved to be of extreme value to the research since new rich pictures were constructed to portray the Weltanschauung and perceived problem situation, of all the workshop participants, as comprehensively as possible. It also provided the research with an in-depth appreciation of the factors influencing and affecting the approval process of development projects. The findings from the workshops were thus presented, and re-presented, to decision makers until a consensus was obtained. This method illustrated the iterative nature of problem identification.

5.2.1 Stakeholder Analysis

The first task in the SST workshops was a stakeholder analysis. The structured interviews provided the author with an idea of the decision problem, which was used to initiate the stakeholder analysis process. Banville, et. al. (1998) observed that the identification of the stakeholders aids in formulating the problem, through a circulatory effect. This can be attributed to the fact that a problem is not an autonomous reality, but rather a construction stemming from interaction between one or many subjects and the reality upon which the subjects wish to act to modify it to their advantage (Banville, et. al., 1998). Thus, the problem cannot be considered independently from the identification of the problem's owner(s)' and that this identification serves to further pinpoint the problem itself (Banville, et. al., 1998).

Banville, et. al. (1998) also observed that a stakeholder analysis can also be used as a tool to target those who are not the standard stakeholders in the decision process. The key stakeholders in the decision process were collectively identified through a brainstorming session, and, given the experience and expertise of the participants in the workshops, this task was completed with relative ease. Table 5.1 illustrates the stakeholders that were identified.

Table 5.1: Stakeholders identified by all the workshop participants

· Provincial and National government bodies
· Local government and tribal authorities
· Environmental lobby groups
· Ordinary citizens
· Developers
· Technical experts (e.g. engineers)
· Investors
· Politicians
· Future generations

With respect to table 5.1, most of the stakeholders can be identified as standard stakeholders, in terms of Banville et. al. (1998:18), that is, they are both affected by and affect the problem and play a crucial role in the process of environment and development planning. The technical experts can be characterised as "fiduciary stakeholders" as they may participate in the process of formulating the problem and affect the way it is solved but are not personally affected by the solution, at least for the time horizon considered in the problem-solving process. The future generations can be classified as "silent stakeholders" since they have no direct control over the resources or uncertainties deemed relevant for solving the problem. Thus, although they are affected by the outcome of the decision, they have no significant immediate means of affecting the decision or even participating in the decision process.

There were no major differences between the stakeholders identified in each of the workshop sessions. The list in table 5.1 was thus used to confirm the process, the creativity phase, which generates issues to be dealt with using creative thinking. This is explored in more detail in the following sub-section. The creative phase of the workshop involved both divergent and convergent thinking by identifying the roles, functions and interactions between the various stakeholders in the form of rich pictures, root definition and CATWOE analysis.

5.2.2 Rich Pictures, Root Definitions and CATWOE Analysis

Rich pictures creatively encourage divergent thinking. This is extremely valuable in the problem identification phase as it helps people appreciate to the problem situation from

many different angles and consider the viewpoints that others may have on the situation (Flood, 1996). Although rich pictures aim to represent the structure of a complex problem, the processes associated with it and the relationships between the structure and processes, can also be used to represent root definitions (Checkland and Wilson, 1980). The rationale behind this is that "human affairs reveal a rich moving pageant of relationships, and pictures are a better means for recording relationships and connections than is a linear prose" (Checkland and Scholes, 1990). There are no strict guidelines for drawing rich pictures and this can sometimes be an arduous and difficult task. Rich pictures should, ideally, be able to convey more than one Weltanschauung (loosely translated into "world view"), though there are no direct guidelines for that (see Checkland and Scholes, 1990). Due to time restrictions, the author developed a rich picture based on the information obtained from the structured interviews and presented it to the workshop participants for discussion, comment and evaluation.

The initial portrayal of the dynamics involved in the field of environmental planning underwent a series of transformations to better reflect the problem situation as perceived by the stakeholders. The transformed rich pictures presented in figures 5.2 and 5.3 illustrate the different Weltanschauung of the various stakeholders associated with the assessment and evaluation of development proposals.

According to Flood (1996), a rich picture is never finished since it is constantly updated, enhanced and amended as the study progresses, to reflect new aspects learned or discovered about the problem situation. The research took cognisance of this iterative process and, after a series of feedback visits to decision makers at a local authority level, figure 5.2 was produced. This rich picture depicts the vehicle as being a metaphor for a development project with the developers and politicians as the driving forces behind development. The workshop participants also suggested that the local authorities play a more active role in encouraging development by providing the necessary infrastructure and, hence, should ideally be depicted as driving the process (alongside the political powers). International, national and local environmental legislation and policies are perceived as being hurdles in the path of development. Local and provincial government institutions, who are armed with legislation, are tasked with evaluating development proposals and ensuring public participation in this process. These stops and hurdles in the path of physical development

initiatives are institutional frameworks that have been implemented to work towards sustainable development. It should be noted that a suggestion was made to combine the political driving force with the local authority check point as they are part and parcel of decision-making processes at a local level. This perception did, however, conflict with the Weltanschauung of other decision makers who saw politicians as being more active in encouraging development and developers.

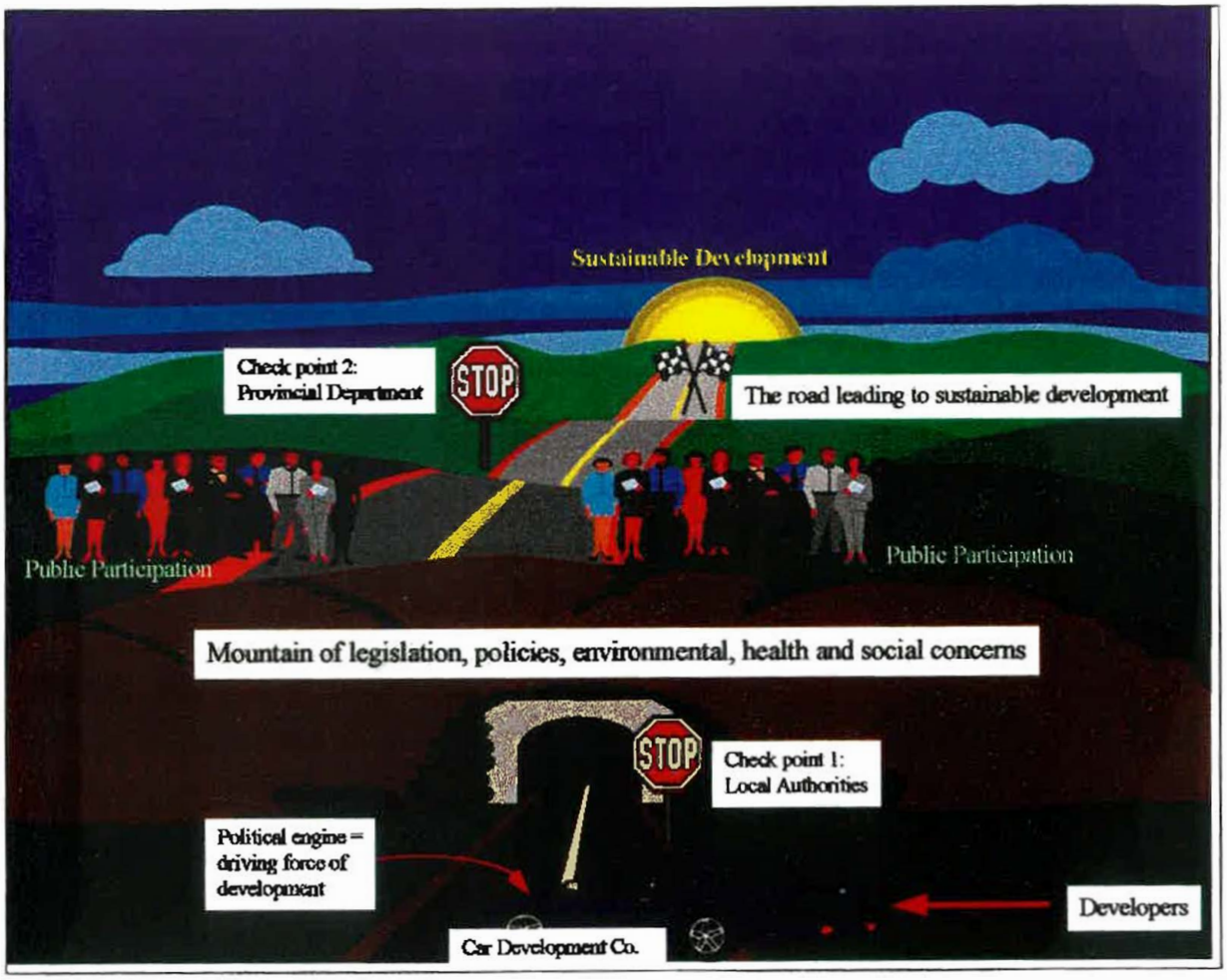


Figure 5.2: A rich picture diagram depicting the main issues associated with the approval process of development proposals as perceived by the Pietermaritzburg TLC workshop participants.

One of the criticisms of rich pictures is that a single picture cannot incorporate the Weltanschauung of all the various stakeholders. The research acknowledged this limitation, hence, a separate rich picture was developed by the provincial team (see figure 5.3).

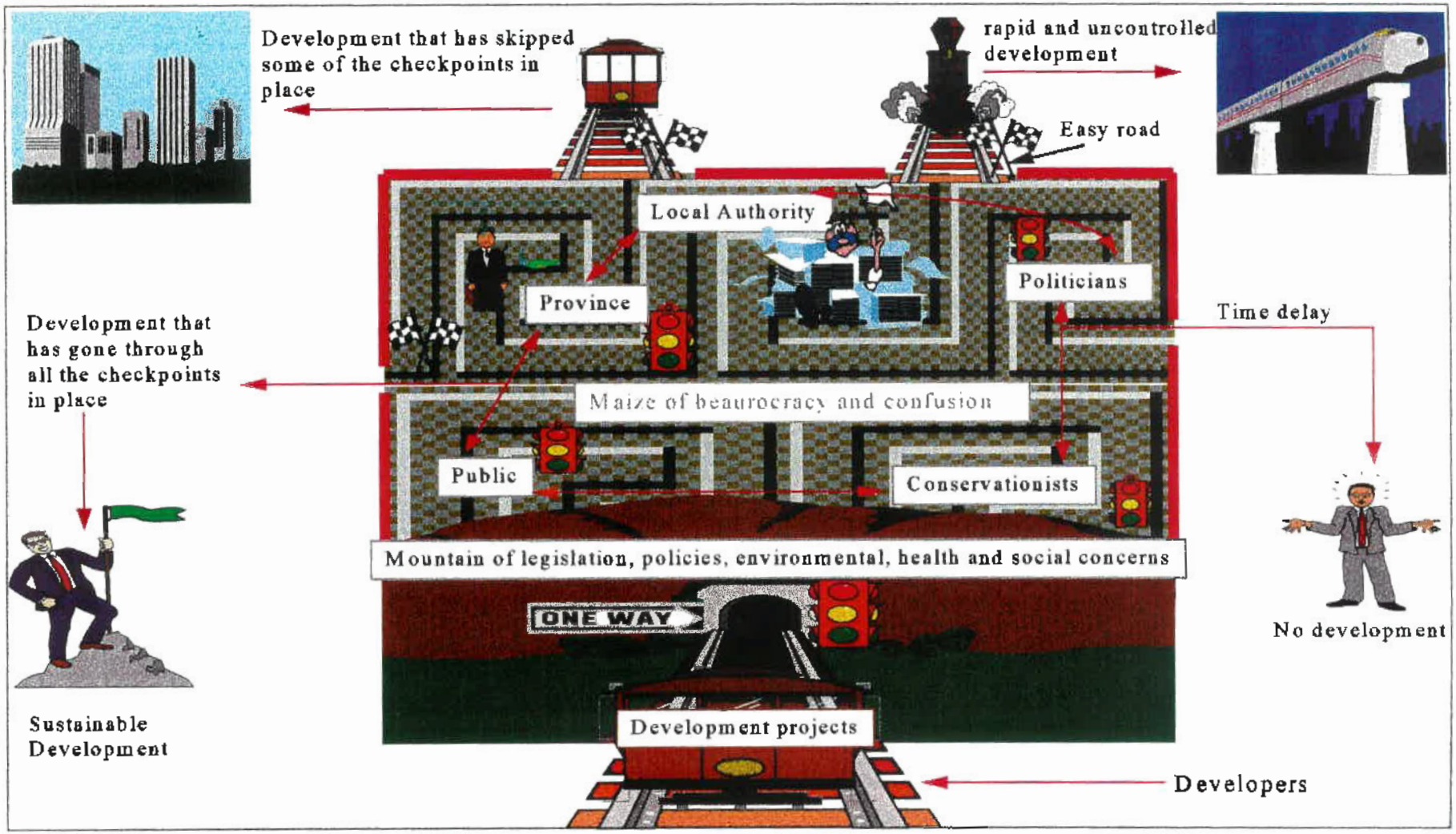


Figure 5.3: A rich picture depicting the issues, conflicts and problems associated with the approval process of development proposals.

The rich picture in figure 5.2 depicts the train as being a metaphor for development projects, which has to enter a dark tunnel of legislative, political, social and environmental concerns. This tunnel leads into a bureaucratic maize comprised of all of the stakeholders in the decision process. Each development proposal has to bypass all of the stakeholders. The workshop participants recognised the confusion and frustration developers suffer during this process, because the process is not linear and they often end up going around in circles. This rich picture also recognises the loop-holes in the system as well as the fact that the rail track to sustainable development is not an easy and well-defined one. The workshop participants also acknowledged that the easy rail track to development often results in rapid and uncontrolled development. This rich picture, compared to the one in figure 5.2, not only identified the interested and affected parties, but also the existing issues, problems and conflicts inherent in this type of decision-making.

Once the issue/problem was identified, the workshop then proceeded to the next step: defining a relevant system within which the problem existed. "A system description identifies all relevant components, including the structural and process relationships in which the problem is embedded" (Flood, 1996). This process involved the use of a technique from SSM with the two groups - the CATWOE analysis (see chapter 3). The CATWOE analysis is used to define the root definition by expressing the core or essence of the perception to be modelled (Checkland and Scholes, 1990:33). This process forms the basis for building an appropriate formal representation or model for studying and manipulating the problem situation of interest (Flood, 1996). The meaning of the CATWOE mnemonic is explained below as per Checkland and Scholes (1990:35):

C	*"customers*	*: the victims or beneficiaries of T*
A	*"actors"*	*: those who would do T*
T	*"transformation process"*	*: the conversion of input to output*
W	*"Weltanschauung"*	*: the world-view which makes this T meaningful in context*
O	*"owner(s)"*	*: those who could stop T*
E	*"environmental*	*: elements outside the system which it takes as given constraints"*

C	Public citizens (tax payers), inhabitants of the local authority area, businesses, civic organisations, developers.
A	Civil servants and relevant stakeholders (politicians, environmental groups e.g. NGOs, CBOs)
T	Sustainable resource management to enable development, economic growth and th provision of jobs, safety and security within ecological limits
W	Ensuring better services and quality of life (employment, stability and basic needs t combat poverty) for the public/community
O	People, agencies, partnerships
E	Available resources; Bio-resource constraints; Perceived need for development; Ignorance and the unresolved position of tribal authorities in local government Problems with communication and empowerment of tribal authorities.

Root definition: To encourage and ensure sustainable development and resource management to improve the quality of life within ecological limits for both present and future generations by delivering a better level of service and operating in a transparent, integrative and partnership approach with all the relevant stakeholders.

Figure 5.4 CATWOE analysis and root definition of the critical issues associated with development planning

The results from the CATWOE analysis assisted in the construction of the root definition for evaluating and assessing development proposals. This root definition reflects the core purpose of the assessment process by identifying the primary tasks and other issue-based tasks in government departments. The above aspects of the analysis introduced the necessary multiple perspective visions on the objectives and difficulties associated with environmental planning.

5.3 Major Issues of Importance to the Process of Evaluating the Factors Associated with Environment and Development Planning

Following the CATWOE analysis, the workshop participants were then asked to generate key issues of concern and importance to each of the stakeholders identified regarding the process of evaluating and assessing physical development initiatives. These issues were

classified according to the perspectives of SSM's mode two (Checkland and Scholes, 1990) and are listed in table 5.2:

- Issues pertaining to the general (technical) side of the process of assessing development proposals, in particular, and environmental planning/management, in general;

- Ideas related to the cultural analysis of environmental planning. These concern:
  - various roles,
  - various norms, and
  - various values of the stakeholders in the decision process

- Ideas related to the political analysis of decision process, revealing vested interests, power relations and processes in which differing interests need to be accommodated.

The rationale behind this analysis is based on Flood's (1996) belief that the organisational dynamics inherent in the methodology should be made transparent. This allows for the surfacing of the possible limitations in the model and also aids in the process of making meaningful choices. According to Flood's (1996) theory of Local Systems Intervention[13] (LSI), organisations are conceived as whole systems that comprise of parts that are continually interacting. This author argues that a need exists to have some understanding of the organisational processes as well as individual and cultural differences and similarities that exist between people that are part and parcel of the decision-making processes. The term "culture" encapsulates processes by which people mediate their relationship to social rules and practices, which provides some framework for continued communication or mutual engagement (Flood, 1996). An appreciation of the political (power) dynamics operating in this process is essential as it provides for a deeper understanding of how power is distributed and how this power may be used to serve certain interests (Flood, 1996).

[13] LSI is a complementarist approach and has evolved out of a postmodern critique of Flood's Total Systems Intervention (TSI) methodology.

Table 5.2: List of issues raised by decision makers in provincial and local government departments.

Technical Issues
1. Need to adhere to international treaties and comply with legislation (e.g. the Constitution, NEMA)
2. A need for effective and efficient service delivery
3. A Need to make the maximum use of available information to make informed decisions
4. To overcome the human and financial resource constraints to assess development applications
5. To formulate mechanisms to educate and empower communities
6. To determine the availability of renewable and non-renewable resources
7. Mechanisms to encourage the conservation of resources need to be developed and implemented
8. Need to ensure a generation of income from rates and taxes
9. Need to provide jobs for the economic and socially uplift communities
10. Government is responsible for the enhancement and maintenance of quality of life of all citizens
11. Developers need to have a competitive edge to be successful
12. Government needs to encourage developers since they contribute to community upliftment and development
13. Need to comply with international standards and regulations (ISO 14000 and 9000)
14. Need to ensure that investors obtain returns on their investments
15. Need to develop marketing strategies to attract investors
Cultural Issues
16. Alleviation of poverty
17. Education and empowerment
18. Need to conserve resources
19. Autocratic decision-making practised by tribal authorities
20. Narrowness of focus of environmental lobby groups (environmental protection at all costs)
21. Enhancement and maintenance of quality of life by ensuring community upliftment and development
22. Developers are perceived to be profit driven and set in their ways
23. Government needs to ensure the preservation of cultural heritage
24. Developers should contribute to community upliftment and development initiatives
25. Government and private companies need to comply with international standards (ISO 14000 and 9000)
Political Issues
26. Need to generate taxes and ensure an increase in GDP by encouraging growth and development
27. Government is committed to the alleviation of poverty
28. Adherence to international treaties and compliance with legislation
29. Achieving political goals and needs
30. Government officials need to be committed to enhanced service delivery
31. Education and empowerment commitments need to be met

Table 5.2 (continued)

32. Political resistance to prioritise environmental management
33. Conservation of resources
34. Public participation should be ensured and their opinions taken into consideration
35. Autocratic decision-making of tribal authorities
36. Survival of conservation bodies
37. Provision and security of jobs
38. Enhancement and maintenance of quality of life
39. Ensure cultural survival
40. Ensure (and contribute to) community upliftment and development
41. Compliance with international standards (ISO 14000 and 9000)
42. Incentives to encourage developers and investors
43. Politicians promote physical development initiatives at all costs within their term of office

Both the CATWOE analysis and "cultural analysis" encouraged convergent thinking. According to Flood (1996), this form of thinking works well with divergent thinking since it converges the issues. It makes sense of the diversity of issues generated by the rich pictures and issue generation phase, since it converges on the core issues that the participants must judge. The items listed in table 5.2 are a combination of all the workshops hosted as well as subsequent meetings with the Provincial Department of Local Government and Housing, the Durban Metropolitan Council and the Greater Johannesburg SMLC.

Table 5.2 illustrates that there is no clear distinction of the issues generated between the three categories. The technical aspects of concern related to the various needs of the stakeholders, which ranged from international and national legislative, policy and statutory compliance to the development of mechanisms to improve service delivery and overcome the human and financial constraints in the field of environmental planning to make the approval process more efficient and effective. Participants also expressed the need to make maximum use of all available information to aid in decision-making, as well as the importance of developing marketing strategies to attract developers and investors. A significant concern was expressed over the fact that political motives for economic growth, job creation and development overshadowed those of the green agenda. However, it was acknowledged that government officials saw development being a main ingredient to the

viability of towns, cities and regions; hence, it should be encouraged within the ecological limits of the area.

Among the many other cultural aspects mentioned are the dogmatic approaches of environmental lobby groups and the autocratic cultural decision-making practised by tribal authorities in KwaZulu-Natal. These factors are often in conflict with democratic decision-making as stipulated in NEMA and the Constitution and practised within government organisations. Another serious issue is the perception that developers are driven solely by profit making reasons and are quite frequently supported by the political powers.

Issues of political concern were identified in both the technical and cultural aspects of the problem situation, implying a political dimension to most of the issues generated. Although government officials are committed to improve service delivery, integrated environmental management (IEM) principles and the promotion of social upliftment and empowerment, they also need to encourage development to increase the rates base for revenue purposes.

It can be noted that issues pertaining to government's compliance with international standards (ISO 14000), the need to actively contribute to the social and economic upliftment of communities, the need to facilitate development initiatives as well as the need for effective and efficient service delivery were listed in all three categories. Due to the complexity and inter-related nature of the aspects identified in table 5.2, these items could not be ranked in order of importance.

The core elements that influence the decision-making processes were then used to construct the multi-criteria decision models illustrated and discussed in the following section. These AHP models aid in the prioritisation of the factors and objectives that influence and affect decisions governing the selection and assessment process of development projects.

5.4 Derivation of the hierarchical conceptual models

The relevant objectives, factors and areas of activity related to the goal of sustainable development, as illustrated in figures 5.5 and 5.6, were derived from a combination of the

EIA legislation[14], environmental and planning legislation (see chapter 2), the Draft White Paper on a National Coastal Management Policy (1999) for South Africa, Agenda 21 principles for sustainable development, as well as the structured interviews and SST workshops with relevant stakeholders and decision makers in government institutions.

As discussed in chapter 4, the hierarchical modelling of the decision problem is useful when dealing with complex phenomena, if both reductionism and holism are considered simultaneously. The AHP enables decision makers to structure a complex decision in the form of a hierarchy. Although the reductionism of the AHP model simplifies the process of comparing the criteria in the models, it derives its durability from taking into account and aggregating the strengths of the judgements holistically through a process of synthesis. The type of AHP modelling can vary depending on the preferences of the decision maker.

The models proposed in this research are not absolute, hence, the inclusion and exclusion of criteria and factors influencing the criteria will vary according to the needs of a particular project. The flexibility of the models in meeting the various issues governing the selection of development objectives, ranging from sensitive coastal environments to conflict resolution, is further investigated in their application in the case-studies discussed in chapter 6. For the application of the decision framework, two conceptual hierarchical models were constructed, namely, for sustainable development and to gauge environmental risks. Both of these models make allowances for the conflict and polarised viewpoints/opinions, which are characteristic of the decision processes in environmental and development planning.

The sustainable development model is depicted in figure 5.5. All development projects are judged from the point of view how it contributes to sustainable development. Four aspects of the problem are incorporated into the sustainable development model: the biophysical, social, economic and political environs that comprise sustainable development. To achieve sustainable development, all of these factors have to be carefully considered and a balance between these items needs to be attained. The decision problem thus involves both tangible (physical environment) and intangible (social) attributes. The AHP is a method that can be used to establish measures in both the physical and social domains (Saaty, 1996) and allows the decision maker(s) to compare tangible with intangible attributes, since this type of

[14] Environmental Conservation Act 73 of 1989

comparison typifies decision-making in reality. This model assists the decision maker(s) in prioritising the social, environmental, economic and political factors when assessing development proposals.

The Environmental Risk Model is described in figure 5.6. It includes five major elements that determine the risks associated with most development initiatives: health risks, physical environmental risks, socio-economic risks, political risks and the risks associated with non-completion of the project. As is the case with the sustainable development model, this model also involves tangible and intangible attributes.

According to Saaty and Vargas (1994), a risk situation differs from cost-benefit analysis as it involves potentially high unacceptable costs that no one expects to pay. These authors observed that a risk analysis should involve different time horizons over which the stability of the system is investigated. It could also involve different geographic locations where the penalty can be minimised (Saaty and Vargas, 1994). Finally, according to Saaty and Vargas (1994), in cases where things go wrong, quick action with appropriate systemic controls, may be followed to minimise the damage. Thus, risk analysis is a complex real-world setting that can be managed with creativity, intelligence, and prior planning.

The risk model proposed in this research will aid decision makers in obtaining a better understanding of the potential risks associated with proposals for development projects.

5.4.1 Detailed description of the criteria for the evaluation of projects from the point of view of Sustainable Development (refer to figure 5.5)

The structure of the model for sustainable development hierarchy consists of four levels: the goal, the objectives which define the goal, the grouping of these objectives and the factors and activities that determine the impacts of a development project on the objectives.

The first level describes the overall goal - promoting development that is sustainable and beneficial to society in both the short, medium and long-term by assessing the potential environmental impacts of proposed development initiatives. The second level describes the criteria used to evaluate the sustainability of proposed projects. Sustainable development depends on the balanced interaction of four major systems - the biophysical (natural)

environment system, the social environment system, the economic system and the political system. These four systems constitute the second level of criteria. The biophysical environment is composed of the biological and physical aspects of the natural environment as illustrated in the third level. The social environment is composed of the built environment, aspects of cultural importance and aspects pertaining to the mental/physical well-being of society, all of which constitutes the third level in the hierarchy.

The fourth level is a representation of the broad factors affecting individual components, described at the third level for the biophysical and social environs, as well as the second level for the economic and political systems. The application of these factors depends on the nature of the particular development initiative decision makers are faced with; hence, all of the criteria may not be applicable to all projects.

The model does not illustrate a possible the fifth level. This level allows for absolute comparisons where the decision maker(s) judge the significance of the proposed project, with respect to each criterion listed in the model (see chapter 4 for more on absolute comparisons using the AHP). Project, site and/or methodological alternatives can be rated using the level of intensities for each factor. The use of a 4 level significance rating scale (weakly significant, moderately significant, significant and very significant) is further explored in the following chapter.

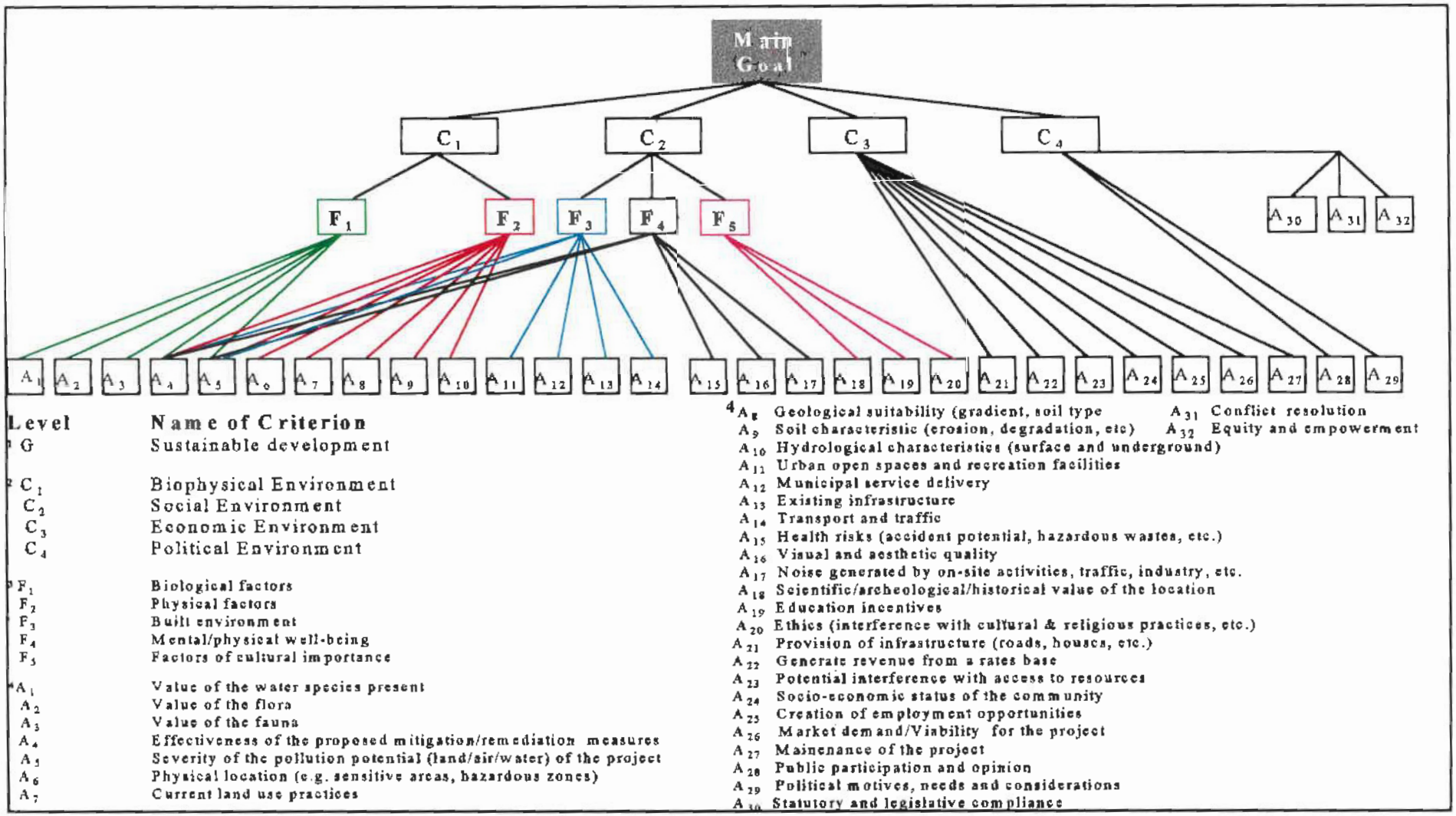


Figure 5.5 A hierarchical representation of the prioritisation of the objectives, factors and activities used to assess the potential environmental impacts of proposed development initiatives

The impacts of proposed projects can be determined by evaluating the following factors:

- Water species: the value and potential impact on the aquatic species present (e.g. the uniqueness and diversity of fish species, coral reefs, etc.).
- Flora: the value and potential impact on the plant species present and/or the removal of large areas of natural vegetation.
- Fauna: the value and potential impact on the animal species present including the increased risk of poaching during and after construction.
- Mitigation/remediation: the effectiveness and detail of the proposed mitigation/remediation measures to minimize the potential negative impacts of the proposed project as specified by the project proponents.
- Pollution: to determine whether the proposed project and related activities could cause significant air, water, radiation (e.g., radon, etc.), urbanisation and land related pollution and impacts.
- Physical location: this refers to sensitive areas such as wetlands, vleis, marsh/swamp areas, or designated coastal zone sensitive areas, nature reserves/conservation areas, mountains, indigenous forests; the 1:100 year floodline for inland development initiatives or the 1:50 year floodline for coastal development initiatives; to assess the significance of the proposed site being located in or near agricultural land or potentially hazardous and nuisance related zones (airports, waste water treatment works, landfill sites, hazardous chemical plants, etc.)
- Current land use practices of the proposed development site refers to the designated zoning of the land as determined by the Town Planning Ordinances of the particular area with respect to residential, agricultural, commercial, etc, land-use zoning. The assessor will determine whether the proposed project is in contravention of current land use practices or not.
- Geological suitability: this refers to the gradient/slope (steeper than 1:5) of the proposed development site and problematic geological/soil conditions such as dolomite and clay.
- Soil characteristics: this refers to the potential for erosion and degradation (acidification, alkalinisation) that could result during and after the construction phase of the development.
- Hydrological characteristics : this refers to the potential impact on both surface and

sub-surface (aquifers, aquiducts, etc) water bodies. This attribute also includes the assessment of the development within 32 cm of the centre line of the stream or river in inland areas (see appendix 2) or above or below the high water mark in coastal areas as well as the significance of any alteration, cut or fill of the natural floodline of any wetland, river, stream or coast during the construction phase.

- The significance of potential impact of the proposed development and/or related activities during construction on both urban open spaces and recreational facilities (natural and built).
- Significance of the impact on municipal service delivery (waste removal, etc) during the construction phase and as a result of the completed project.
- Assess the significance of impacting on the existing infrastructure (water and sanitation pipelines and drains, electricity and telephone lines, roads, etc.).
- Transport and traffic: the potential impact on the volume of traffic as well as existing and future transport routes and modes of transport.
- Significance of health and safety risks associated with on-site construction activities and the proposed development. Health risks include the potential for diseases and illnesses arising from the development initiative, e.g., an increased risk of exposure to radon, malarial infections, air pollution, etc.
- Significance of the impact on visual and aesthetic quality
- Noise generated by on-site activities and by-products of the development project, e.g., traffic, factories, housing settlements, etc.
- Assess whether the proposed site contains national monuments, sites of archeological/historical/scientific/heritage importance.
- Education incentives and community upliftment initiatives of the proposed project.
- Ethics: the significance of interference with cultural and religious practices and beliefs.
- Provision of infrastructure: will the proposed development initiative result in the development of infrastructure in and around the proposed site with respect to roads, schools, houses, clinics, etc.
- The significance of the local authority/municipality to generate revenue/income from the project.
- The significance of the potential interference with physical and financial access to resources that the community depends upon, e.g. forests, coastal resources, food,

etc. during the construction phase and/or as a result of the development initiative.

- The socio-economic status of the surrounding communities, i.e. the assessor needs to have socio-economic and demographic data on the surrounding communities to determine what their basic needs are, and whether they will benefit financially and/or socially from the proposed project.
- The creation of employment opportunities.
- The market demand and/or viability of the proposed project.
- The maintenance of the development project once completed: The success and sustainability of the project will be influenced by the ability (financial and technical) of the project owners (e.g. the community) to maintain the project.
- Public participation and opinion of the proposed project: are the interested and affected communities in support of the project?.
- The political motives, needs and considerations related to the proposed project.
- To assess whether the proposed project complies with regulations, legislation and policies.
- The effectiveness of conflict resolution mechanisms proposed.
- Equity and empowerment : Giving people meaningful control of and decision capabilities in their lives. It has been substantially demonstrated that people are better able to move forward in their lives if they have a meaningful stake in their living situation.

5.4.2 Detailed description of the criteria for the assessment of the risks associated with development projects (refer to figure 5.6)

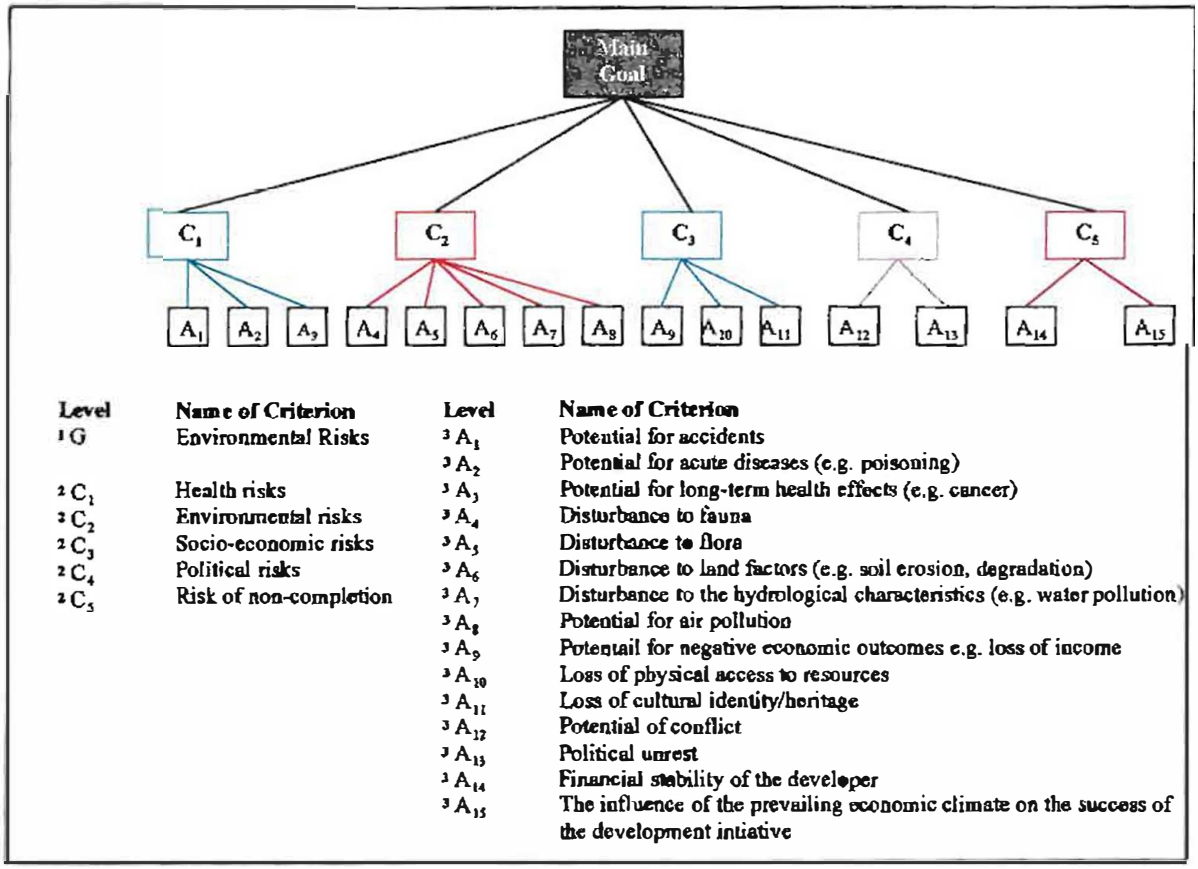
Due to the threat of potential human exposure to pollutants and the associated adverse health implications, a need exists to develop a framework to judge and trade-off the potential environmental risks that may arise during the construction phase and/or as a result of development initiatives. Environmental risk assessment addresses risks to human and ecosystem health and welfare. This involves risk identification, estimation and evaluation (not included in this model).

The first level of the risk model (figure 5.6) describes the overall goal - assessing the level of risk associated with a development proposal. The second level describes the criteria used to evaluate the risks of proposed projects. Health, physical environment, socio-economic,

political and risks associated with non-completion of the proposed project constitute the second level of criteria. Human health and well-being cover a broad range of effects: the potential for accidents and nuisance, mortality and morbidity. In contrast to human health effects (for which individual responses are taken into account), ecosystem effects consider risks at the level of populations and plants. Socio-economic risks relate to loss of income or access to vital resources on which communities depend for their everyday survival. Political risks refer to the potential for conflict, violence and unrest that may have negative implications on the viability of proposed projects.

The third level is a representation of the broad factors affecting individual components described at the second level. The level of risks of proposed development initiatives, stemming from the construction and completion stages of the development project, can be determined by evaluating the following factors:

- Potential for accidents, e.g. chemical leaks, animal attacks, etc.
- Potential for acute diseases, e.g., drinking contaminated water supplies, risk of attracting malaria carrying mosquitoes, etc.
- Potential for long-term health effects, e.g., cancer due to radon/radiation exposure.
- Disturbance to flora.
- Disturbance to fauna.
- Disturbance to the physical characteristics of land factors, e.g., soil contamination, erosion, etc.
- Disturbance to the hydrological balance of the ecosystem.
- The potential for air pollution.
- The level of risk associated with negative economic outcomes, e.g., loss of employment.
- Economic loss associated with loss of physical and financial access to resources.
- The loss of cultural identity/heritage which may result from development activities.
- The potential for political unrest, violence and crime.
- The potential for conflict due to multiple use of resources, e.g., coastal resources.
- The financial stability of the project proponents to ensure that the development initiative will be completed successfully and be operational once completed.
- The prevailing economic climate: the level of risk associated with national and international economic influences on the viability and longevity of the project.



Level	Name of Criterion	Level	Name of Criterion
1 G	Environmental Risks	3 A_1	Potential for accidents
		3 A_2	Potential for acute diseases (e.g. poisoning)
2 C_1	Health risks	3 A_3	Potential for long-term health effects (e.g. cancer)
2 C_2	Environmental risks	3 A_4	Disturbance to fauna
2 C_3	Socio-economic risks	3 A_5	Disturbance to flora
2 C_4	Political risks	3 A_6	Disturbance to land factors (e.g. soil erosion, degradation)
2 C_5	Risk of non-completion	3 A_7	Disturbance to the hydrological characteristics (e.g. water pollution)
		3 A_8	Potential for air pollution
		3 A_9	Potentail for negative economic outcomes e.g. loss of income
		3 A_{10}	Loss of physical access to resources
		3 A_{11}	Loss of cultural identity/heritage
		3 A_{12}	Potential of conflict
		3 A_{13}	Political unrest
		3 A_{14}	Financial stability of the developer
		3 A_{15}	The influence of the prevailing economic climate on the success of the development intiative

Figure 5.6 A hierarchical representation of the prioritisation of the objectives used to assess the potential risks associated with proposed development initiatives

Figure 5.6 does not reflect a possible fourth level that allows the decision maker(s) to judge the levels of risk associated with the proposed project of all of the activities listed above. This allows for absolute measurements (refer to chapter 4) with which project, location and/or methodological alternatives can be rated. The application of this rating scale is further explored in the next chapter.

5.5 Guidelines to the Usage of the Hierarchical Model and the Steps in its Evaluation

According to Saaty (1996), in using AHP to model a problem, one needs a hierarchic or a network structure to represent that problem, as well as pairwise comparisons to establish the relations within the structure. According to the procedure for AHP, the elements in each

level of the hierarchy are compared with the parent or root of the cluster in a pairwise fashion. The software package, Expert Choice, can be used to derive the priorities of the various criteria in the hierarchical model. This software package also allows a sensitivity analysis to be conducted to test the effect of the uncertainty in the criteria on the choice of the best alternative. The scale of comparisons among pairs of elements in a level, as devised by Saaty, consists of verbal judgements and the corresponding absolute numerical judgements (see chapter 4).

The steps in building an AHP model, as described by Saaty (1996), are:

- Structure a problem as a hierarchy or as a network with dependence loops. The overall goal is at the top of this structure with the lower levels consisting of the criteria which guide the decision and the factors that affect them.
- Elicit judgements that reflect ideas, feelings, and emotions.
- Represent those judgements with meaningful values/numbers. This can be achieved by conducting pairwise and absolute comparisons (see chapter 3).
- Synthesize results in the form of local and global priorities.
- Analyse sensitivity to changes in judgement.

The first step in applying AHP requires a detailed analysis of all the relevant facts related to the particular project proposal and the relationship between these factors (Petkov, 1995). The conceptual models proposed in this section can be used to facilitate decision-making concerning both coastal and inland development projects. These models should ideally be used in group decision-making with all of the stakeholders identified in section 5.2.1 for a representative outcome of the values and concerns each stakeholder may have of the particular development initiative.

5.6 Conclusion to the Derivation of the Decision-making Models for Environment and Development

This main objective of this chapter was to develop multi-criteria hierarchical decision models that reflected the needs and concerns of practitioners in the field of environmental and development planning.

This was achieved by using the mode two of SSM developed by Checkland and Scholes (1990), which sought both action to improve a situation perceived as problematic and, through reflection, more general learning which could be applied in other situations. This mode entailed a detailed stakeholder analysis of all the interested and affected parties in the decision process. Rich pictures were formulated to explore the different Weltanschauung of the decision makers' and a CATWOE analysis was conducted to define the root definition, by expressing the essence of the Weltanschauungs' to be modelled. Strategic Assumption and Surfacing Testing (SAST) was also undertaken in this chapter to investigate both the organisational dynamics and the key issues of concern and importance to each of the stakeholders with respect to the process of assessing and evaluating development proposals.

Although the rich pictures encouraged creativity and divergence, convergent thinking among the various decision makers (who participated in this phase of the research) was encouraged with the aid of the CATWOE analysis and SAST to construct meaningful and relevant decision models. With the aid of processes listed above, the criteria to be included in the multi-criteria decision models could be identified.

The two decision models derived from this framework acted as substitutes for the conceptual models as defined by Checkland and Scholes (1990). These conceptual models were structured in a hierarchical manner since reductionism (derived from the AHP) and holism (derived from SSM) was considered simultaneously. The first model had sustainable development and the second model had environmental risk as its main goal. These models therefore provide decision makers with a framework to address development initiatives in a sustainable fashion and to ensure that the environmental, health, social and economic risks are addressed when evaluating development initiatives. The research also established that the conceptual decision models derived in this chapter catered for both inland and coastal sensitive environments.

To determine the relevance, resilience and robustness of the two decision models, they need to be applied and tested in real-world problem situations. This is discussed in the next chapter, where the multi-criteria hierarchical models were practically validated by applying them to three environment and development case studies in KwaZulu-Natal and Gauteng.

CHAPTER 6
IMPLEMENTATION AND PRACTICAL VALIDATION OF THE CONCEPTUAL DECISION MODELS

The conceptual decision models were practically validated by assessing three detailed, large-scale and controversial development proposals in the KwaZulu-Natal and Gauteng provinces. The motive for including both provinces was based on the need to validate and ascertain the applicability and flexibility of these multi-criteria decision models in both inland and coastal environs, as well as their ability to handle polarised viewpoints.

The first case-study, the Thaba Ya Batswana development proposal, considered a proposal for an inland development project in the Klipriviersberg – the Greater Johannesburg's most important natural asset. This case-study was based on an evaluation of the environmental scoping report for the development proposal. Scoping is a critical component of the impact assessment process and involves the identification and prioritisation of potential environmental impacts to ensure that the assessment focuses on the key issues for decision-making. This phase of the EIA process encompasses discussions and consultations with relevant stakeholders in the decision process, including project proponents, decision-makers, local communities, regulatory authorities and outside experts.

The second case-study, the low-cost housing development in the Sherwood urban space open area, examined the decision processes surrounding a highly contentious, low-cost housing scheme in an urban open space in the Durban Metropolitan Area. The maintenance of this urban open space, which is important to the ecology and local economy, had to be weighed against the need to house people from a previously disadvantaged community and formally integrate them into the urban society. This development has been debated for almost a decade due to the intense diversity of interests surrounding the decision problem. Thus, the model's ability to take cognisance of, and incorporate, polarised viewpoints is tested in this case-study. Due to time constraints, both of these local authority case studies were conducted with a single decision maker.

The third case-study, the tourism development proposal near the Kosi mouth, is a group decision-making exercise that was conducted with decision makers in KwaZulu-Natal's Provincial Department of Agriculture and Environmental Affairs. This project proposal centred around the construction of a hotel as an eco-tourism venture in a biophysically and culturally/historically sensitive area - Kosi Bay- located on KwaZulu-Natal's east coast. Decision-making in this case has also been protracted, as this development was proposed approximately eight years ago, and no definite decisions have yet been made.

6.1 Framework for the Practical Validation of the Multi-criteria Models

There appears to be agreement across the various philosophical and academic disciplines that validity is a measure of the "goodness of final product or outcome" and that it involves judgement about the state of the experiment or system (Finlay and Wilson, 1997). Thus, validation is the process by which the validity is determined. In this investigation, it was defined after Finlay and Wilson (1997) as the process of determining the appropriateness of the model to the tasks at hand, as well as the extent to which the hierarchical decision model developed allows for experimentation in real-world situations. Thus, this form of practical validity is much wider than simply model validity.

In Eden's (1992) opinion, the term implementation insinuates that it is separate from other processes of problem solving such as problem construction, problem definition, the definition of alternatives, etc. This author argues that the practicality of possible actions and the formulation of the problems are considered simultaneously, that is, they are not considered in isolation of each other. Processes of problem solving are therefore not staged but cyclical (Friend and Hikling, 1987). Due the cyclical nature of problem solving, some aspects of the cyclical validation framework represented in figure 6.1 were adopted in this research.

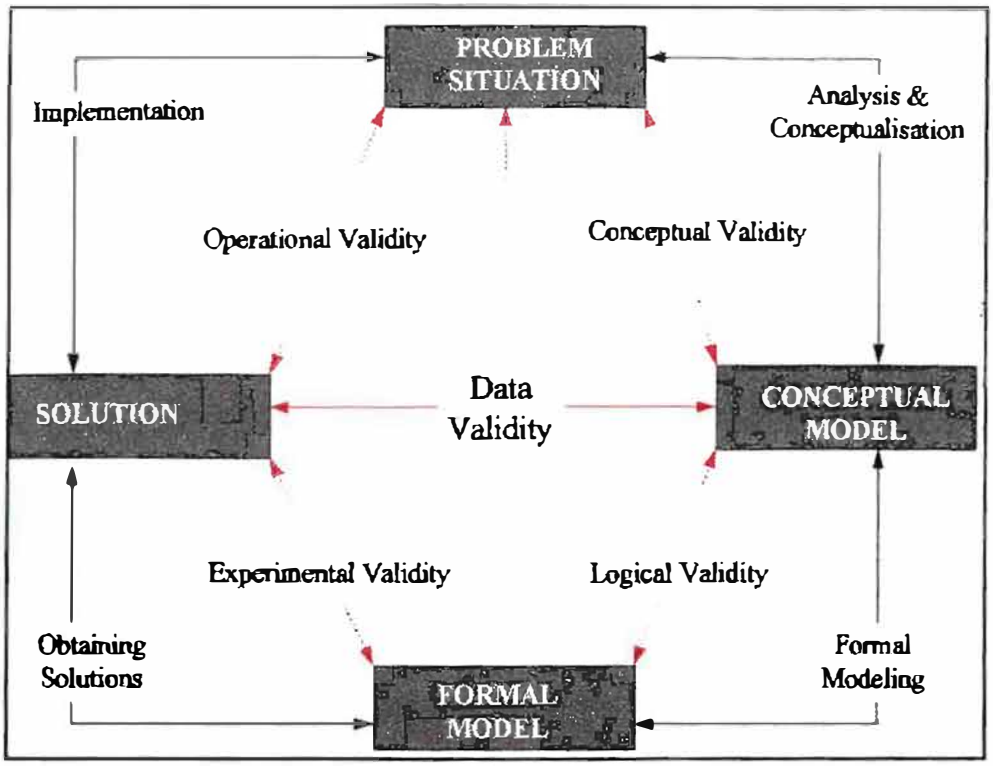


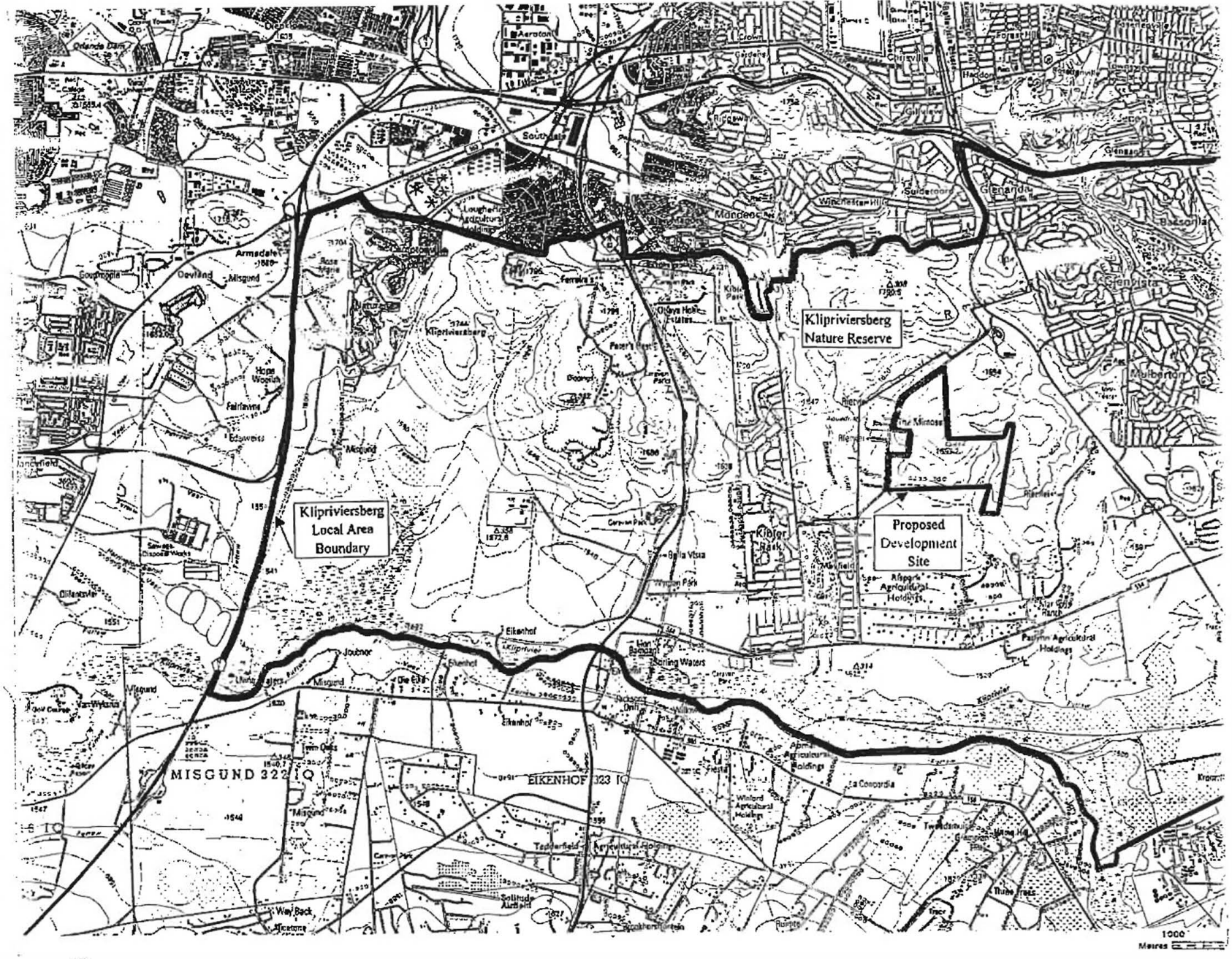
Figure 6.1 A framework for validation (Landry, et. al., 1983)

The framework in figure 6.1 was developed by Landry, et. al. (1983) to provide researchers with a formal methodology to validate Decision Support Systems (DSS). Since this research did not formulate, design nor implement a DSS, not all the validation steps in figure 6.1 were deemed applicable for this research. Thus, the logical and data validation processes of the multi-criteria models were excluded from the validation process.

The previous chapter analysed the decision problem and examined the conceptual validity of the conceptual multi-criteria decision-making (MCDM) models with the aid of SSM. The interactive and iterative nature of this technique made allowances for stakeholders to assess and evaluate the conceptual models. According to Checkland (1995) the conceptual models may be described as 'epistemological devices', which makes conceptual validity a question of how we can tell a 'good' devise from a 'bad' one. There are two aspects to this question: whether these models were competently built and whether the models are relevant or not. The second question (i.e. the question of relevance), will be answered in chapter 7 by the decision makers who participated in the implementation and operational validation of these models. The question of whether the models were competently built was investigated by applying the models within a real-world context, described in this chapter,

with the experimental validation of the MCDM models being substituted with that of a practical nature. Chapter 7 deals with issues pertaining to the operational validation of the MCDM models.

In the following case-study, the results obtained from the practical validation process will be compared to the comments and recommendations derived from any decisions made prior to the application of the sustainable development multi-criteria decision model.



Map 2: The Klipriviersberg area showing the Klipriviersberg Nature Reserve, the boundary of the Klipriviersberg Local Area and the proposed development site (Source: Environmental scoping report for the Thaba Ya Batswana development, Bohlweki Environmental (Pty) Ltd).

6.2 CASE-STUDY 1
THABA YA BATSWANA PROJECT

6.2.1 Introduction

This case study examines AHP's utility in the field of environmental planning by applying the theory, with the aid of multi-criteria modelling, to a sensitive inland environment that was earmarked for development.

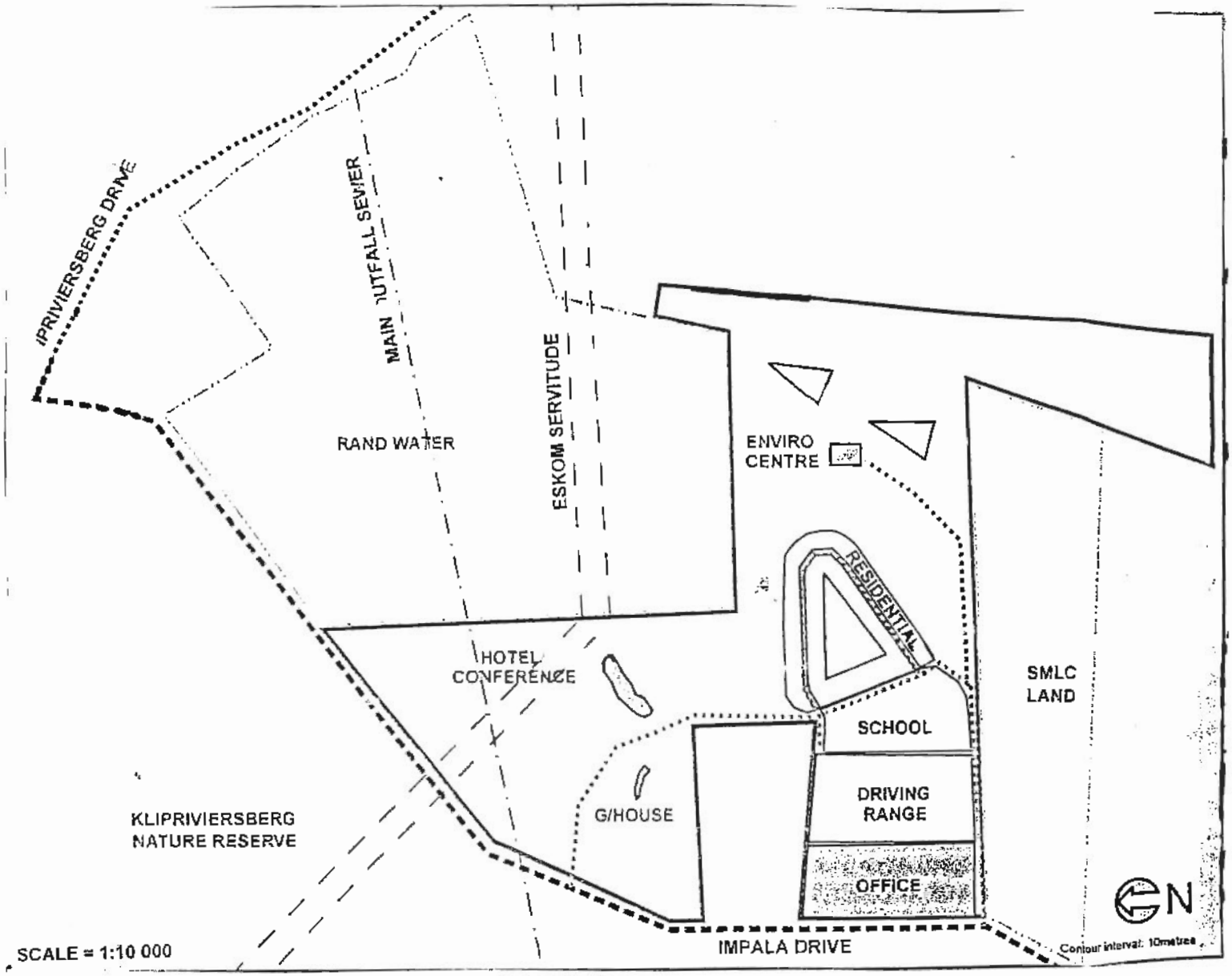
A post factum detailed analysis of the decisions governing the assessment and evaluation of the Thaba Ya Batswana development project was conducted from the point of view of sustainable development with the aid of the multi-criteria decision model proposed in figure 5.5. This development proposal was used as a test bed for the implementation of multi-criteria decision modelling in the selection of the more suitable of two projects for the proposed site of development.

The Thaba Ya Batswana case study makes use of both the AHP's descriptive and normative theories of measurement to determine priority areas of concern as well as to determine which of the two proposed development projects is most suitable for the sensitive site.

6.2.2 Background information on the project proposal that was used to test the implementation of the decision framework proposed in this research in a sensitive inland environment.

Thaba Ya Batswana (Pty) Ltd purchased approximately 132 hectares of undeveloped land on the farm Rietvlei 101 IR, south of Johannesburg, for the establishment of an eco-tourism development project (refer to Map2). This property is adjacent to the Klipriviersberg Nature Reserve. The proposed site for the development is devoid of any buildings and contains features unique to the Greater Johannesburg area which include, among many others, important archeological features, important veld type, a large diversity of birds, and small fauna and game which are increasingly rare in this area, as well as the potential of rare and endangered plant species[15]. The proposed development comprises two phases which will be regarded as project alternatives in the model validation process.

[15] Derived from the comments on the Thaba Ya Batswana eco-tourism environmental scoping report by the Southern Metropolitan Local Council's Executive Officer for Environmental Planning.



Map 3: The proposed site for the Thaba Ya Batswana development (Source: Environmental scoping report for the Thaba Ya Batswana development, Bohlweki Environmental (Pty) Ltd).

The first phase of the development consists of a hotel, with associated conference centre, restaurant and four guest houses. This development forms a single grouping of buildings which spans 1.7% of the total site area to be located on an intermediate plateau. Phase 2 consists of the establishment of a commercial node in a concealed valley on the proposed site located near two residential townships. This development is envisioned to contribute towards the financial viability of the greater Thaba Ya Batswana development and spans approximately 15% of the site. According to the scoping report, the commercial node will include:

- The establishment of a specialist school such as a sports academy;
- The establishment of a golf training centre;
- The establishment of an office park or science and technology centre;
- The establishment of a small, exclusive residential township (30-50 stands); and
- The possible establishment of an environmental educational and experimental centre for water research beside a dam(s) to be built in the non-perennial watercourse on the site.

The project proponent did, however, recognise that the type of commercial developments in phase two would depend on the economic success of phase 1.

It was also envisioned that areas unaffected by the developments in phases 1 and 2 would be used as a conservation and nature area (refer to Map 3). The developer intended to introduce heads of game to this area. In addition, the project proponent envisioned the establishment of hiking and horse trails for recreation and security purposes.

6.2.3 Key issues used to evaluate and assess the project proposal

Decision-making within the Southern Metropolitan Local Council (SMLC) is driven by the need to utilise and manage the Klipriviersberg and the proposed development site in a sustainable manner, thereby allowing for the uniqueness, sensitivity and historical/archeological importance of the proposed development location and the adjacent nature reserve, to meet the needs of both present and future generations. A number of SMLC and Greater Johannesburg documents prioritise the conservation of areas on the site

concerned. These include the SMLC Environment Policy, the SMLC Policy on the Environment Control Zone, the Metropolitan Strategic Development Framework and the Draft Klipriviersberg Policy. In addition, national legislation such as the National Environmental Management Act, No 107 of 1998, the Development Facilitation Act, the Environmental Conservation Act, No 73 of 1989 and policies relating to biodiversity and cultural heritage also emphasise the need to conserve such sensitive areas.

Concerns related to the increasing difficulty in the management of pressures such as fires, alien encroachment and illegal dumping that could arise from the proposed physical development, were also accounted for in the decision process. Decision makers recommended that the landowners find a balance between preserving the physical environment with the economic need of ensuring a financially viable development. The need to relieve poverty, meet basic human needs, create employment opportunities, promote the southern section of the Greater Johannesburg area, and improve the rates base, also influenced the decision process. It was, however, recognised that the proposed development only met some of the afore-mentioned objectives, since the site was deemed more suitable for uses related to the sustainable use of the environment and was less suitable as a platform for pure economic growth and meeting poverty related needs.

Decision makers recognised that correct land use and development coupled with a strong natural and cultural resources management strategy held significant potential for meeting policy objectives in the area and on the site. Thus, phase 1 of the development project was, in principle, largely supported. Other than the proposed enviro centre, phase 2 of the proposal was not supported on the basis of its vagueness, the sensitivity of the areas to be developed and the potential for significant negative impacts.

6.2.4 Application of the Sustainable Development Multi-criteria Decision Model in Assessing the Thaba Ya Batswana Development Proposal

Pairwise Comparisons

The user-friendliness of the AHP lies in its pairwise comparison process by which the local priority vectors are generated (Hamalainen, 1990). Criteria in a level are compared with

each other with respect to their contribution to a single criterion (the parent node) in the adjacent upper level. The decision maker thus focuses on two elements at a time and chooses the one that contributes more favourably to the parent node.

Objectives and attributes. The objectives were based on the need for the local authority to deliver basic environmental, social and economic services without threatening the viability of the natural, built and social systems upon which these services depended. For example, the decision maker was concerned with activities related with the biophysical and social aspects of the decision environment due to the archeological/historical importance and the presence of "Red Data" (flora) and small game species on the proposed site.

The objectives were made operational by assigning them one or more attributes. An attribute directly or indirectly measured the degree of an objective achievement. For example, the objective 'ecosystem maintenance and preservation of biodiversity' was made operational by assigning the attribute 'potential impact of the project on the biological environment' which was further decomposed (see figure 5.5) into a list of activities that defined the attribute.

Making Judgments. Once the structure of the problem was established, the next step was to judge the relative importance of the models' components. First, judgements were made about the relative importance of the objectives of sustainable development in relation to the goal. Table 6.1 illustrates that the biophysical environment was deemed significantly more important than any of the other criteria in this level of the model. The social characteristics of this project were rated as the second most important criterion in the decision process, followed by the economic considerations and gains, and lastly, the political influences on the decision process. Following this, judgments were then made about the relative importance of the factors with regard to the objectives. Finally, the importance of the various attributes/activities was evaluated with respect to the factors and objectives (with reference to the political and economic objectives).

Table 6.1 Pairwise comparisons of the sub-criteria with respect to the main goal, to assess the potential environmental impacts associated with the Thaba Ya Batswana development proposal

Rank	Factor (Overall goal)	Biophysical	Social	Economic	Political	Priority
1	Biophysical	1	3	4	5	0.556
2	Social	1/3	1	2	2	0.214
3	Economic	1/4	½	1	1	0.119
4	Political	1/5	½	1	1	0.112
		Inconsistency = 0.006				

Notes:

1. The priorities at the second level of the hierarchy illustrated in the last column of table 6.1 are both local and global since they refer to the top cluster of the hierarchy. At lower levels of the hierarchy, the type of priorities differ.
2. Following the scale suggested by Saaty, each of the two sub-criteria are compared in a pairwise fashion. For example, the entry in cell (3,2) means that the second sub-criterion, the social environment, is slightly more important than the economic environment, expressing a greater need to conserve the social integrity of the environment above the potential economic gains obtained from the development proposal.

Table 6.2 Priorities for factors that define the criteria (at the third level of the hierarchy)

Rank	Factor (Biophysical)	Biol.	Phys.	Local Priority
1	Biological	1	1	0.278
2	Physical	1	1	0.278
	Inconsistency = 0.000			

Rank	Factor (Social)	Culture	Health	Built	Local Priority
1	Culture	1	1	1/3	0.460
2	Health	1	1	1	0.319
3	Built	3	1	1	0.221
	Inconsistency = 0.130				

Weighting the importance of the factors in the third level. The importance of the biophysical and social factors with respect to each corresponding sub-criterion was ascertained, on a 1-9 scale, through a pairwise comparison matrix (table 6.2). The principle eigenvector revealed the prominence of each social and biophysical activity with respect to the parent node. This vector was multiplied by the adjusted strength of the criteria in the second level to obtain the contribution of each factor to the goal. This table also illustrates that the biological and physical factors of the biophysical environment were regarded as being equally important. However, the cultural factors were deemed much more important than the health and built factors which comprise the social environment. This can be attributed to the cultural/historical significance and importance of the proposed development site.

Weighting the importance of the attributes in the fourth level[16]. The importance of the attributes was assessed by using a pairwise comparison matrix. Each cell value depicted the relative importance between two related attributes (on the 1-9 scale) with the principle eigenvector providing the relative weight of the attributes to each factor. The weights were then adjusted for the importance of the respective factors obtained in the previous step. The results obtained from this process are graphically displayed in figure 6.1. This graphic illustration indicates that the most important activities of the proposed project related to the potential impacts on (1) the flora with respect to the biological aspects of the natural environment; (2) the potential impacts on the cultural/archeological aspects of the site as well as the ethics of condoning the development with respect to the cultural aspects of the site; (3) the aesthetic qualities of the landscape as well as the potential for pollution that may impact on the health of the nearby residents; (4) the importance of the urban open space within the larger spatial context of the highly urbanised Greater Johannesburg area, and (5) the importance of complying with international, national and local policies and legislation.

[16] Refer to table 1(a) in Appendix 5 for a detailed illustration of pairwise comparisons of each of the criteria in the fourth level of the hierarchy.

The local priorities in figure 6.1 illustrate that issues pertaining to the legislative and policy requirements, flora (red data), factors of archeological/cultural/historical importance and the ethics governing the approval of the development project were deemed most important with regard to the political, biological and cultural factors that influence the sustainability of the project. However, the global priorities indicate that the importance of the flora in the area of the proposed development was the most important item that influenced the goal, that being, sustainable development. This was followed by legislative and policy compliance, the mitigation/remediation mechanisms proposed to overcome the negative/undesirable impacts of the proposed development on the physical aspects of the environment as well as the potential pollution related with urbanisation.

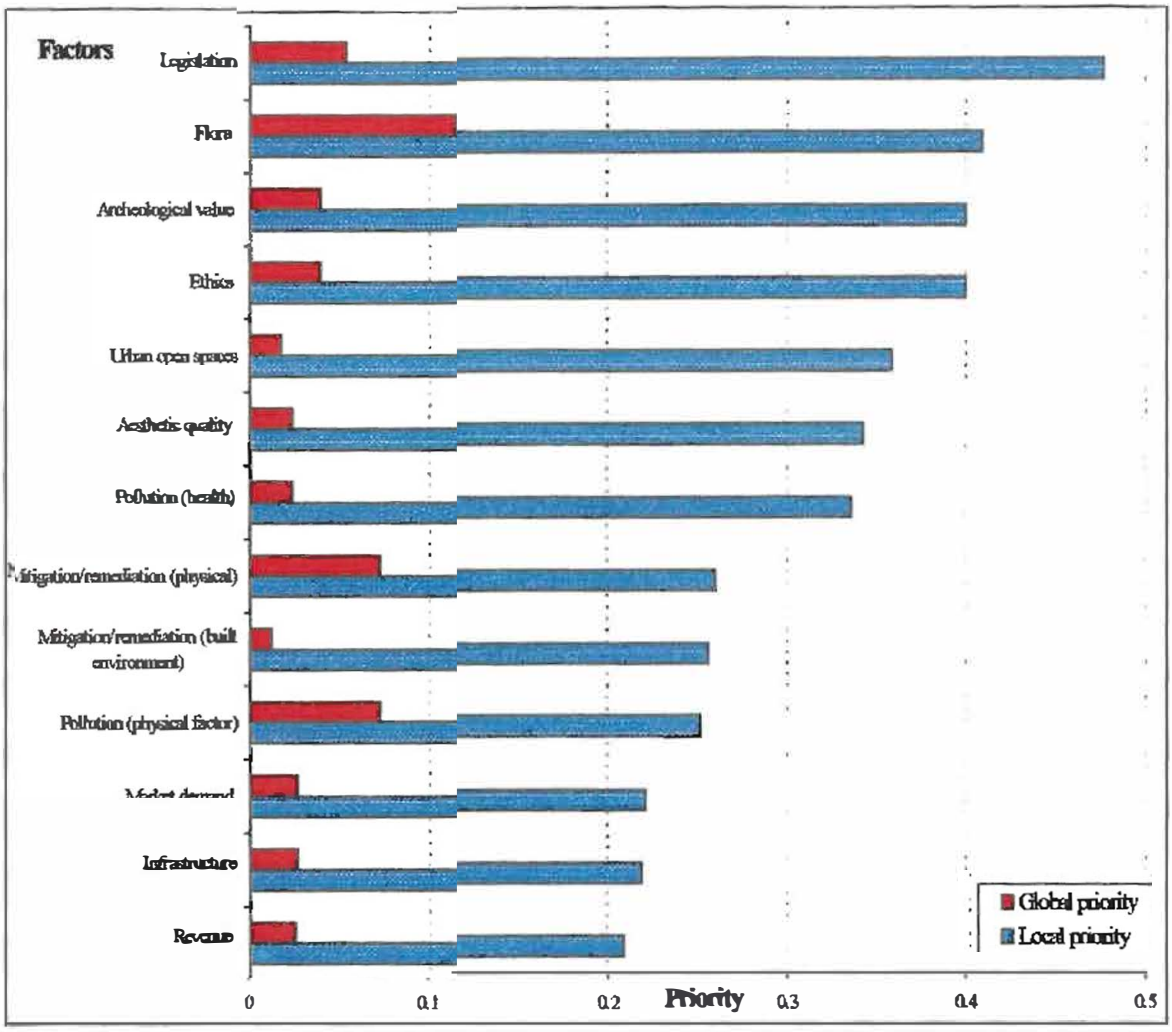


Figure 6.2: Local and global priorities with respect to the various factors influencing and affecting the sustainability of the development project.

Weighting the importance of each alternative[17]. The overall priorities of each alternative were obtained by weighting the priorities of the subcategories, starting at the stop of the hierarchy, by the priority of their parent category. The results obtained from this exercise were then used to further weight the priorities of the criteria which, in turn, were used to weight the priorities of each project alternative at the bottom of the hierarchy and added over all the criteria. The outcome of this process yielded the final priorities for each project alternative. The hotel/conference centre project received a favourable priority weighting of 0.631 compared to the commercial node development project that received an unfavourable weight of 0.369. The overall inconsistency of the exercise was 0.060. The results obtained in this study correlated quite strongly with the decisions taken prior to this exercise, and hence, served to reinforce and strengthen the decision-making process and validate the model.

Table 6.3 Sensitivity analysis of the results obtained from weighting of the importance of each alternative to test the robustness of the decision

Priorities of the categories				**Priorities of the outcomes**	
Biophysical	Social	Economic	Political	Hotel/Conference centre	Commercial node
.556	.214	.119	.112	.646	.354
.995	.002	.001	.001	.650	.350
.004	.995	.001	.001	.673	.327
.000	.005	.995	.000	.570	.430
.000	.000	.005	.995	.655	.345

Table 6.3 indicates how these final priorities would be affected by a change in the relative priorities of the first level categories. The AHP thus provides the decision maker(s) with a facility for altering the intensities of their judgements to accommodate changes in opinions or, in the advent of more information and detail (with special reference to phase 2 of the project), the sensitivity of the judgements can be altered without having to repeat the process. This facility is also extremely useful when an exploration of the different policies

[17] Refer to table 1(b) in Appendix 5 for a detailed illustration of the priorities obtained by weighting the project alternatives in a pairwise fashion.

guiding the evaluation of development proposals is undertaken. Although table 6.3 explores extreme variations in policies and opinions, these variations may not be practical in reality. In this case-study, it is evident that the proposal to develop a hotel/conference centre far outweighs the likelihood that a commercial node would be condoned on this site even when the biophysical and social concerns are accorded very low priorities and higher levels of priority are given to economic and political gains. This illustrates the robustness of the outcome, that is, the selection of the project alternative does not change under different conditions. The sensitivity analysis therefore allows the decision maker(s) to test the effect of the uncertainty in the criteria on the choice of a best alternative.

Absolute Comparisons[18]

Absolute measurement can be applied to the same problem first generating a scale of intensities (table 6.4) under each criterion especially when the number of alternatives at the last level to be considered is greater than seven. Unlike paired comparisons that require observation and an understanding of the alternatives at the time of the decision to enable comparisons, rating the intensities requires prior experience to enable the decision maker(s) to determine the level of significance of the potential impact on each attribute (Saaty, 1994b)

Table 6.4 Rating of the intensities used to determine the significance of the potential impacts caused by the proposed project alternatives

Water species	VS	S	MS	SS	WS	Priority
Very significant	1	2.2	4.1	6.5	9	0.493
Significant		1	1.8	4	6	0.254
Moderately significant			1	2.2	3.3	0.140
Slightly significant				1	1.5	0.068
Weakly significant					1	0.046
Inconsistency = 0.005						

Note: The lower half of the matrix contains the reciprocals of the corresponding entries in the upper half.

Refer to table 1(c) in Appendix 5 for a detailed illustration of the absolute comparisons of each of the criteria in the fifth (hidden) level of the sustainable development hierarchy.

A constant scale of intensities was applied in this project. Each alternative was assigned a scale value that was then weighted by the priority of the attribute, and the results summed for all the attributes. As evidenced in table 6.4, the absolute ranking of the alternatives yielded very similar results as the relative ranking of the same alternatives. The outcome favoured the proposal for a hotel/conference centre development (0.609) but not that of the commercial node (0.391). The AHP does allow for the addition of more alternatives, should the decision expand. This could result in a change in the overall ranking of the two alternatives used in this case-study if the judgments of the other criteria remained constant. The rational for this is that when alternatives are ranked one at a time, their overall weights are determined by the absolute weight of the alternative (a scale with a unit) for each criterion, multiplied by the weight of the corresponding criterion and added over the criteria (Saaty, 1994b). As their absolute weights are not changed, if a new alternative is added, the only way that their overall weights can change is if the weights of the criteria or the number of criteria are changed (Saaty, 1994b).

Although the decision environment in this case-study was guided by the need to relieve poverty, meet basic human needs, create employment opportunities, and promote the southern local authority area of Greater Johannesburg, it was acknowledged that the site of the proposed development initiative was deemed more suitable for uses related to the sustainable use of the environment and was less suitable for pure economic growth (Warner, 1999; pers comm). Thus, correct land use and development coupled with a substantial natural and cultural resources management strategy largely determined the nature of development that was deemed desirable. The importance of the biophysical environment within the larger spatial context of Greater Johannesburg was clearly evident as it received the highest priority (56% of the total) followed by the importance of the social characteristics of the site that were unique to Greater Johannesburg (21% of the total). The potential for rare and endangered plant species largely influenced the decision process with respect to the biological aspects of the natural environment (0.409). The cultural aspects (archeological/historical value and ethics - 80% of the combined total) received the highest priority (0.460) of the social concerns. Other aspects of importance included the aesthetic quality and the potential for pollution related to urbanisation (which jointly comprised 68% of the factors influencing the mental/physical well-being of the social environment), the importance of the urban open space (36% of the total built environment) and compliance

with the SMLC policies, national legislation and international conventions (48% of the total political environment). The market demand for this initiative was perceived as the most important component of the economic environment (0.221).

6.2.5 Conclusion in regard to the Thaba Ya Batswana Development Proposal

In this case-study, the hotel/conference centre received the highest overall priority because it had the highest priority under the biological environment, the cultural and built environment, as well as the political environment. This type of development initiative was deemed as most suitable since it had the lowest negative impacts on the biophysical and social sensitivities of the environment, provided that the mitigation and remediation strategies are firmly in place (the mitigation and remediation strategies were awarded the highest level of importance for the physical aspects of the biophysical environment and the second highest priority for the built environment). Both the pairwise and absolute modes of the rating process supported the approval of the hotel/conference centre facility. The robustness of this decision was further explored and confirmed by conducting a sensitivity analysis of the decision process.

The outcomes of the case-study illustrate that the MCDM model developed in this research is dynamic enough to cater for all the factors that influence the selection process of development projects, yet, simple enough for every day use. Thus, both from a single decision environment to group decisions, the AHP is highly adaptable and gives the decision maker(s) more confidence in the decisions they make. The following case-studies explore the flexibility and holism of the MCDM models in greater detail.

6.3 CASE-STUDY 2

PROPOSED LOW-COST HOUSING DEVELOPMENT IN THE SHERWOOD URBAN OPEN AREA - GREATER DURBAN METROPOLIS

The field of environmental and development planning is fraught with conflict due to the different Weltanschauung and, quite often, opposing personal agendas of the various stakeholders. The selection and approval processes of development initiatives in sensitive environs are particularly volatile and tedious processes due to the different interests of all the parties concerned. The low-cost housing project in an urban open area in Sherwood, a residential suburb in the Durban Metropolitan Area, is a prime example of the conflict found in the field of environmental and development planning. The question to be addressed in this case-study is: should housing be provided for the urban poor on a prime site of vacant land or should this vital "green lung" be maintained for both present and future generations?

This highly contentious project provided the research with an ideal opportunity to examine the utility of AHP in understanding and analysing conflict resolution as well to test the flexibility the multi-criteria models proposed in chapter 5. Conflict analysis and resolution is, in essence, a multi-criteria process for which the AHP was developed (Saaty and Alexander, 1989).

6.3.1 Introduction

The strengths of AHP in conflict resolution are derived mainly from its ability to provide a workable and valid approach for the measurement of intangible criteria. Intangible factors are always present in conflict situations and dealing with them often presents analysts with major problems due to the subjective nature of these problems. Unlike other quantitative techniques, AHP does not convert everything to money, or more generally, to utilities (Saaty and Alexander, 1989). Rather, it allows for "intangibles to be compared according to a preference priority and can be made part of a larger framework that incorporates both the tangible and concrete and the intangible and abstract factors that bear on a problem" (Saaty and Alexander, 1989).

Saaty (1989) observed that "people in conflict are rarely concerned with only maximising their gains; they are often also concerned with the price being paid by opponents in yielding these gains. An element of punishment may enter, particularly if the conflict is of long standing". One approach to dealing with retributive conflict resolution involves the evaluation of party concessions by considering both costs and benefits from each party's perspective (Dyer and Forman, 1992). The evaluations are performed from each side's own value system as well as the perception of their opponent's value system. This approach enables each side to develop a perspective of their needs and how these needs can be satisfied along with those of their opponent (Dyer and Forman, 1992).

The structure of the hierarchies adopted in this research differs to that suggested by Saaty and Alexander (1989) (see figure 6.3) for conflict resolution. This can be attributed to the fact that the primary aim of this research was to develop multi-criteria models that could assist decision makers in understanding, analysing and mediating holistic and integrated environmental planning with conflict resolution as a much desired, but secondary, offshoot from these processes. The preliminary steps suggested by Saaty and Alexander (1989) to understand the nature of a particular conflict include:

1. Stakeholder identification.
2. Identification of the objectives, needs, and desires of each of the stakeholders.
3. Identification of the possible outcomes/"solutions" of the conflict.
4. Assumptions about the way each of the stakeholders' views its objectives.
5. Assumptions about the way in which each of the stakeholders' would view the outcomes and the manner in which these outcomes would meet the objectives.

However, the approach adopted in this case-study was similar to that suggested by Saaty and Alexander (1989) with the exception of items 3 and 5 listed above. Although the structure of the hierarchies differs to that proposed by Saaty and Alexander (1989), the sustainable development and environmental risk MCDM models proposed in this research did reflect the structure of the problem. In addition, the outcomes of synthesis process (using the AHP) of the judgments entered, illustrated the areas for constructive change and highlighted potential areas for compromise. Saaty and Alexander (1989) did, however, acknowledge that the development of a good model and the use of the model in analysing the problem does not equate finding a solution to the problem. It should also be noted that

the manner in which conflict is represented and judgements entered is subject to interpretation since there exists a multiplicity of ways to regard the conflict.

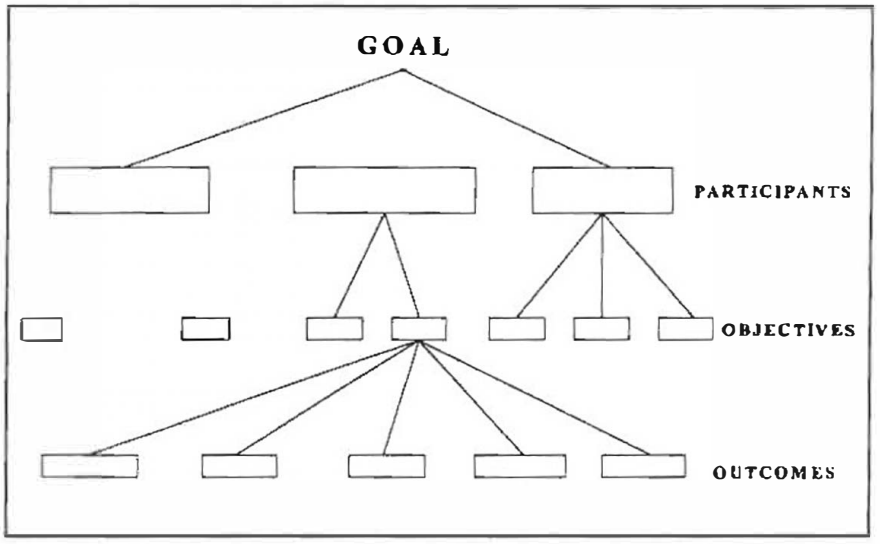


Figure 6.3 Condensed Conflict Hierarchy (Saaty and Alexander, 1989)

6.3.2 Background information on the proposed low-cost housing project that was used to test the flexibility of the proposed multi-criteria decision framework as well as its application in analysing conflict resolution

The conflict surrounding the controversial Sherwood low-cost housing initiative stems from the need to provide housing for a community that was marginalised by the previous apartheid government, in an ecologically sensitive area near the Durban CBD. People in this community are currently housed in unsafe and unhealthy informal structures with no access to water, sanitation and other essential social services. Plans for the Durban Metropolitan Council (hereafter referred to as the DMC) to use this urban open area for a low-cost housing scheme were activated almost a decade ago. After much debate, a compromise decision was recently reached which entailed using a portion of the land for housing development and retaining the remainder of the land as an urban open space.

The decision to cater for the social needs of the urban poor versus the importance of preserving an ecologically important area caused much conflict among the interested and affected parties concerned. Decision makers and stakeholders had to balance the need for redressing the past inequalities, by re-integrating the urban poor back into mainstream society, with the need for retaining the natural integrity of the urban open space. The

Sherwood urban open space area provided an ideal location for the former initiative since this vacant piece of land was located in a residential suburb near the CBD with access to various routes and modes of transport, as well as potable water, electricity, sanitation and other essential infrastructure. However, adjacent to this proposed site for development is an established middle-income residential complex. Residents in this area are strongly opposed to the nature of the development. They are anxious that the proposed housing scheme may result in a devaluation of their properties, as well as attract crime and violence to their neighbourhood. Thus, for this group of people (hereafter referred to as the middle-class community), the costs of developing the urban open area for low-cost housing far outweighed the benefits this project conferred on the urban poor. The inverse applies to the urban poor.

The ecological importance of urban open spaces has long been recognised and acknowledged. There exists a plethora of quantifiable and scientific literature on the long-term health, social, economic and environmental benefits that open spaces confer on urban environs. This has prompted many countries to introduce "greening" programmes into local authority urban management plans as well make allowances for open spaces in urban planning schemes. Thus, decision makers had to weigh the tangible and intangible benefits of the Sherwood urban open space to the Durban Metropolitan Area coupled with the strong opposition of the middle-class community, against the urgent, and high priority need of providing low-cost housing for the urban poor in an easily accessible and prime location. Not surprisingly, this decision took ten years to reach a consensus.

The following section explores the nature of the multi-criteria models used to conduct a post factum analysis of the conflict surrounding the decisions governing the assessment of the Sherwood low-cost housing development proposal. It also illustrates the flexibility of the AHP models in aiding decision-making in the field of environmental and development planning. Due to time constraints, all the stakeholders involved in this case-study were not included in the process. Ideally, this process should be used in an interactive Group Decision Support (GDS) environment, with all of the parties to the conflict who may influence and affect the outcome. Although all perspectives and values attached to this project were fully explored from the perspective of all the stakeholders, judgements were made by a single stakeholder. These were synthesised with the aid of the Expert Choice

software package by Expert Choice Inc. This therefore represents a limitation in the process of conflict resolution. Thus, rather than resolve the conflict surrounding the Sherwood low-cost housing development, the post factum assessment will be used to illustrate how multi-criteria decision modeling, with the aid of the AHP, can be used to obtain a deeper understanding and an objective analysis of intangible issues associated with the project.

6.3.3 The Assessment Models

Table 6.5 A horizontal view of the factors used in the third and fourth levels of the sustainable development hierarchy, that influenced decisions governing the Sherwood low-cost housing project.

SUSTAINABLE DEVELOPMENT MODEL			
GROUPS	**FACTORS**	**GROUPS**	**FACTORS**
F1 Biological factors	A2 Value of flora	F5 Cultural factors	A18 Historical value
	A5 Pollution potential		A19 Education incentives
			A20 Ethics
F2 Physical factors	A5 Pollution potential		
	A6 Physical location	C3 Economic factors	A23 Physical access
	A7 Current land use		A25 Job creation
	A8 Geological suitability		A26 Market demand
	A9 Soil characteristics		A24 Socio-economic status
	A10 Hydrology		A27 Maintenance
			A22 Generate revenue
F3 Built environment factors	A11 Urban open spaces		A21 Provision of infrastructure
	A5 Pollution potential		
	A14 Transport and traffic	C4 Political factors	A28 Public participation
			A31 Conflict resolution
F4 Mental/physical well-being	A15 Health risks		A30 Legislative compliance
	A16 Aesthetic quality		A29 Political motives
	A5 Pollution potential		A 32 Equity & empowerment
	A17 Noise pollution		

Note: Refer to figure 5.5 in chapter 5 for a detailed illustration of the hierarchical model.

Slightly modified versions of both the sustainable development and environmental risk MCDM models proposed in the previous chapter were applied to the decision problem in this case-study. The assessment simultaneously considered factors relevant to the importance of preserving the urban open space as well as those of providing housing. Thus, mirror images of the sustainable development and environmental risk MCDM

models (see tables 6.5 and 6.6) were used to enter judgements from the perspective of both the urban poor and middle-class communities.

Table 6.6 A horizontal view of the factors used in the second and third levels of the risk assessment hierarchy that influenced decisions governing the Sherwood low-cost housing project.

RISK ASSESSMENT MODEL			
GROUPS	**FACTORS**	**GROUPS**	**FACTORS**
C2 Environmental risks	A4 Disturbance to fauna A5 Disturbance to flora A6 Disturbance to land factors A7 Disturbance to hydrology	C4 Political risks	A12 Potential for conflict A13 Political unrest
C3 Socio-economic risks	A9 Potential for negative economic outcomes A10 Loss of physical access		

Note: Refer to figure 5.6 in chapter 5 for a detailed illustration of the hierarchical model.

Tables 6.5 and 6.6 illustrate how the hierarchical models proposed in chapter 5 can be adapted to suit the conditions under investigation, and hence, the flexibility of the AHP. Not all the factors listed in the original models were applicable to this decision problem. Although the modified sustainable development multi-criteria model used in this case study retained all the factors in the second and third levels of the original hierarchy, certain factors in the fourth level were found to be irrelevant to the decision problem, and hence were omitted from the model. These factors comprised of water species, fauna, mitigation and remediation measures, existing infrastructure, and municipal service delivery.

With regard to the environmental risk MCDM model, factors in both the second and third levels of the original hierarchy were omitted. Risks associated with health and non-completion of the project were omitted from this process since the housing project would aid in improving the health conditions of the urban poor and the project did not pose any potential health risks to the middle-class community. The proposed housing project was fully funded by KwaZulu-Natal's provincial housing subsidy scheme. This subsidy was also underwritten by the DMC Housing Fund, hence, the risks associated with non-completion were not applicable in this instance. Risks associated with these factors in the second level of the hierarchy were also omitted. Additional factors that did not apply to the decision problem included the potential for air pollution, as well as losses associated with

cultural heritage/identity of the communities concerned. The next section examines how the AHP models can be used to obtain an objective analysis of intangible issues associated with the project.

6.3.4 Application of the Multi-criteria Decision Models in assessing the conflict surrounding the Sherwood low-cost housing development proposal

The results are presented in parallel for the two communities that represent the conflicting interests of the proposed project. This will aid in the analysis of the tangible and intangible values of the different stakeholders who were represented on the decision-making forum. The relative importance of the attributes was assessed with the aid of a pairwise comparison matrix (see sections 2.1 and 2.2 in appendix 5). Figure 6.4 (a) illustrates the priorities of the main objectives that affected the outcome, sustainable development, in this project as a result of pairwise comparisons. The middle-class community placed significant emphasis on the importance of maintaining the biophysical environment (0.640), followed by the social environment (0.180) and political environment (0.133). Least important to this group were the economic factors (0.047) controlling the decision problem since their losses with regard to property values, safety and security far outweighed any benefits this project could bestow on this community.

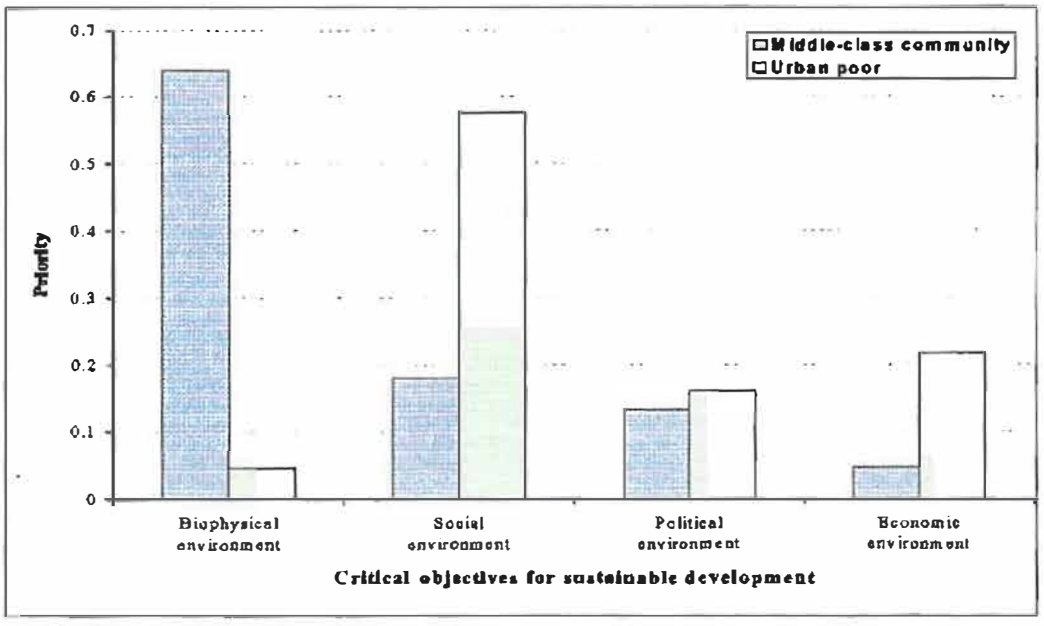


Figure 6.4(a) Local and global priorities of the critical objectives affecting the goal of sustainable development as a result of the pairwise judgements submitted

In contrast to the middle-class community, the urban poor valued the social environment (0.576) highest, followed by the economic benefits (0.217) and political factors (0.161) governing the development proposal. A striking result was the biophysical environment, which was attributed the lowest priority (0.046). This attribute was perceived to be approximately 14 times less important by the urban poor, when compared to the level of importance the middle-class community attached to this factor.

The above results not only confirmed the tension between the two conflicting parties but also laid bear the structure of the conflict by exposing the critical areas of divergence between the two groups. The importance attributed to the biophysical environment appeared to be the main point of contention between the two communities. This was not surprising since the preservation of the biophysical environment nullified any risks associated with the low-cost housing scheme for the middle-class community. This disparity was followed by the values attached to the economic environment. The urban poor attributed almost five times more importance to this item than the middle-class community due their current socio-economic status as well as the high market demand for the housing project (refer to tables 2.2c in appendix 5 for a more detailed analysis).

The social environment was perceived as being a priority criterion for the urban poor (0.576) compared to the middle-class community (0.180), since the provision of housing is largely a social issue. The social factors refer to cultural values, the built environment as well as factors influencing the mental/physical well-being of society. This was not a priority item on the agenda of the middle-class community since most of their basic needs were already met. In the basic needs approach to development, housing, education and health services are among any society's essential requirements for a decent existence. In a quality of life study conducted by Moller and Schlemmer (1980), at least one aspect relating to housing (something which may be described as "residential security") featured among the major concerns of over 50% of the total sample population. According to these authors, non-housing issues in the top rubric referred not only to the basic essentials in life (such as food and shelter), but also to the central values in the urban African community. The study also revealed that health was accorded a high priority status. The results obtained from Moller and Schlemer's 1980 study concur with the pairwise comparisons obtained from this case-study (see figure 6.4(b)).

Figure 6.4(b) illustrates that health and cultural factors were found to be priority social items for the urban poor, with more emphasis being placed on the former criterion. In contrast to this, the middle-class community attributed equal importance to both the built environment and their cultural values. The latter includes their need for residential security. This is hardly surprising since the built environment incorporates items pertaining to the Sherwood urban open space that are strongly associated with the values this community placed on this land. The importance of the urban open space for this group is further reflected in the high value attached to maintaining the biological aspects of the urban open space (0.900).

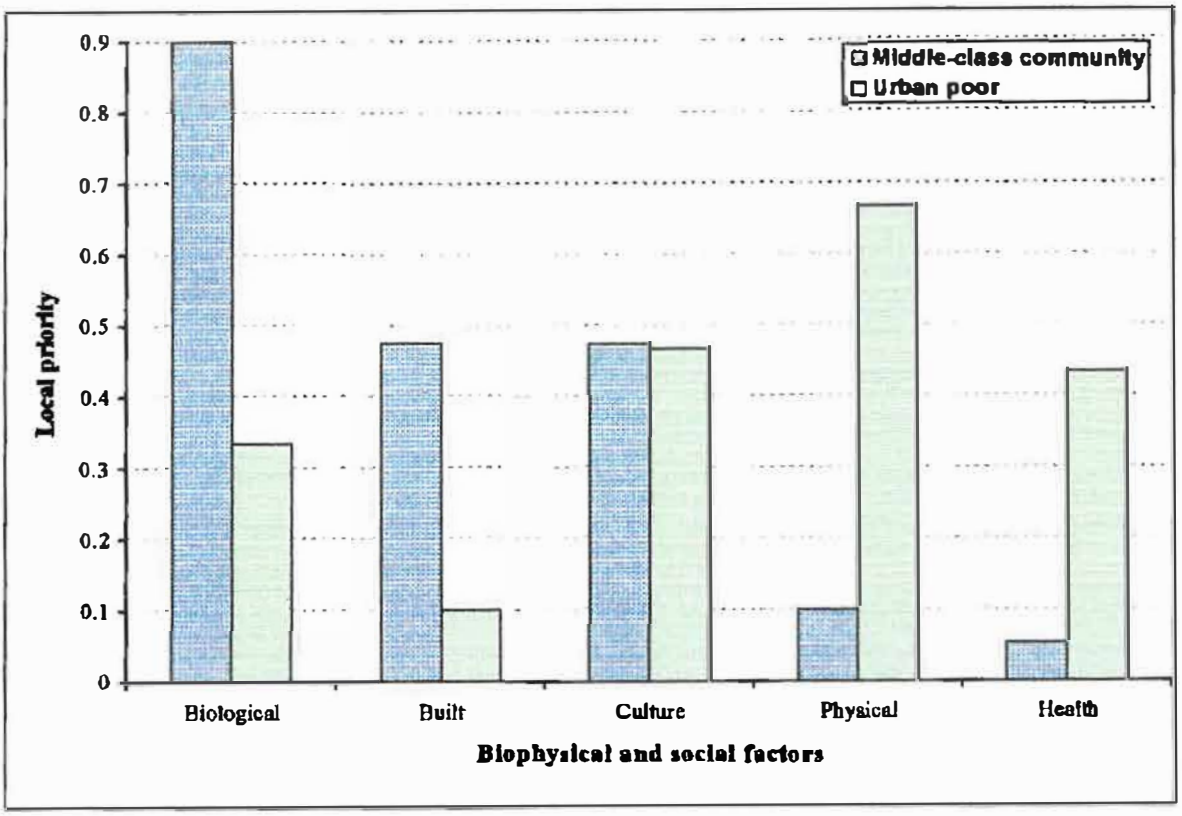


Figure 6.4(b) Local priorities with respect to the biophysical and social factors of the environment

The urban poor valued the physical aspects of the biophysical environment primarily in terms of the prime location of the proposed site for the housing project. The high priority (0.608) attached to the location of both the existing households adjacent to the Sherwood open space as well as the proposed low-cost housing project confirms the models used by Gober (1990). According to these models, the "demand side" of the housing issue is

emphasised from the perspective of the way households choose both housing and location. In practice, such choices are made in the light of residential location (Jooste and Nicolau, 1997). Residential location is determined by three aspects, namely; place, time and form utility. Both the formal housing units and proposed housing units possess a favourable relative location due to the high accessibility (routes, travelling time, costs)to service facilities, thereby conferring a positive/desirable place utility value on both the existing and proposed housing structures.

For purposes of this research, time and form (design) utility of the proposed and existing housing units will not be explored in detail since it does not enrich the process of analysing the nature and structure of the conflict. In addition, the demographic structure of both the urban poor and middle-class communities needs to be established to obtain a rich appreciation of how these variables influence the market demand for housing in the Sherwood area.

Weighting the importance of the attributes in the fourth level[19]

Although figures 6.4(a) and 6.4(b) delineate the structure and nature of the conflict in this decision problem by highlighting critical areas of divergence, figure 6.4(c) illustrates areas of convergence. Thus, despite the fact that the urban poor accorded the biological aspects of the environment a very low priority status (overall global priority rating of 0.007), there was consensus among both study groups that potential negative impact of the housing project on the flora was more important than the pollution which could result from inhabiting the urban open space. Other areas of agreement between the two opposing groups are in the built environment with special reference to the ecological importance of the urban open space. The importance of education as a cultural value was also attributed a high priority by both the urban poor and the middle class communities. In addition, the two conflicting groups recognised the importance of the aesthetic quality to the mental/physical well-being of both current and future residents in Sherwood.

[19]Refer to tables 2.1(c) and 2.3(c) in Appendix 5 for a detailed illustration of pairwise comparisons of each of the criteria in the fourth level of the hierarchy.

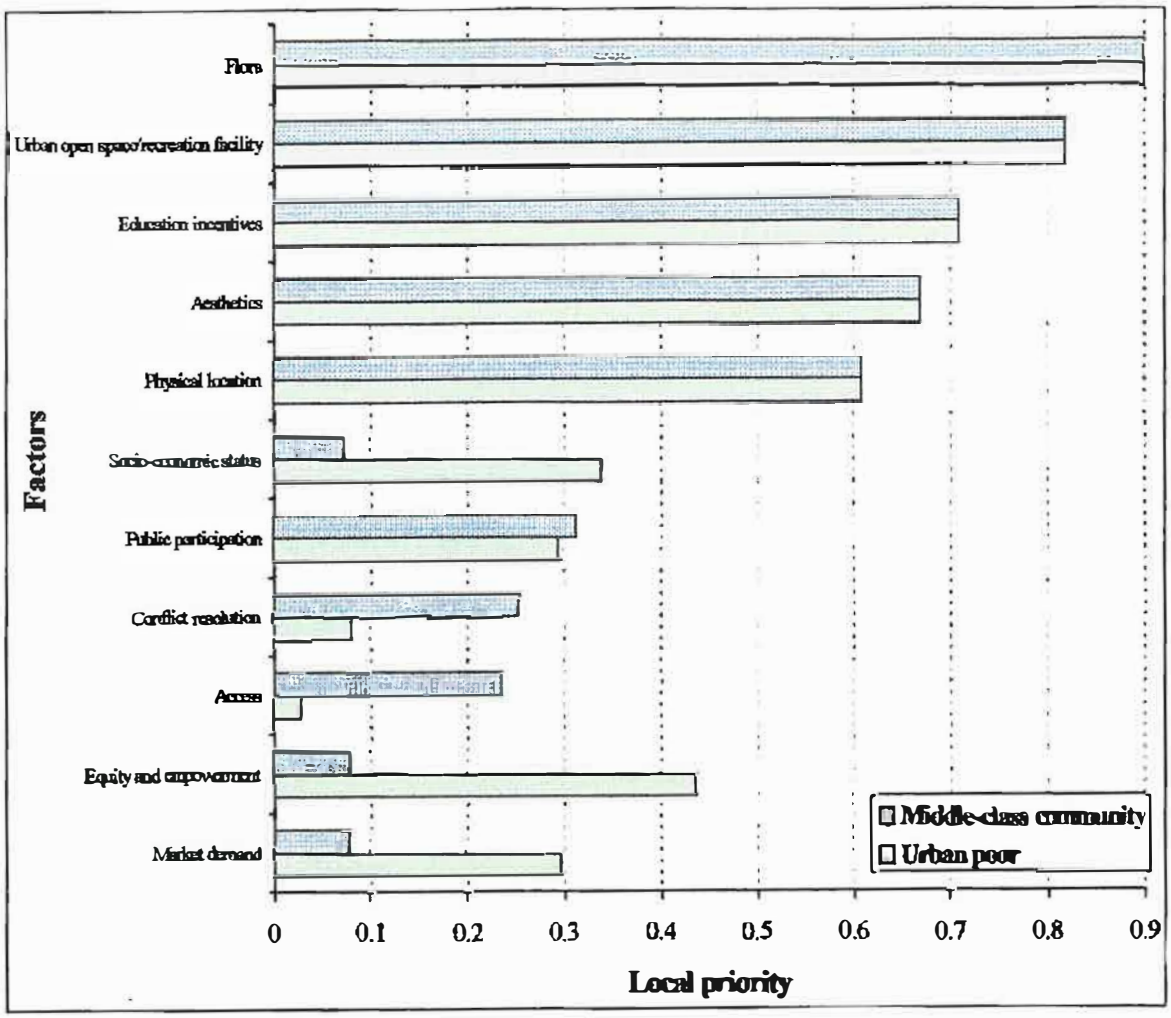


Figure 6.4(c) Local priorities with respect to the attributes in the fourth level of the sustainable development hierarchy

Although the factors in the fourth level (pertaining to the biophysical and social environs) were attributed identical weights by the two opposing groups, areas of divergence, hence conflict, were identified in the economic and political environments. With respect to the economic factors that influenced the goal of sustainable development, the urban poor placed a high priority on the importance of their socio-economic status (0.339) and the demand (0.297) for the housing project. The middle-class community, on the other hand, valued their access to the Sherwood urban open space (0.235) higher than any of the other factors in this category. The low-cost housing scheme presented the latter community with a high economic risk due to the devaluation of their homes as well as the loss of safety and

security. In contrast to this, the project conferred many benefits on the urban poor by addressing their most immediate basic need. Not surprisingly, this group rated equity and empowerment highest (0.436) of all the political factors, compared to the middle-class community, who rated this attribute lowest (0.079).

The question of equity in environmental decision-making has gained recognition and importance in recent years, giving rise to an environmental equity movement (Albrecht, 1995). This can be attributed to the increasing availability of epidemiological and other historical data that reveals how local and international policy decisions in the past appeared to have been based, at least in part, on questions of power and expendability. Current environmental, health and planning legislation stress the importance of consciously incorporating equity and empowerment initiatives into decision-making processes.

The Sherwood low-cost housing project is an effort to redress the past social, health and economic inequalities, which stemmed directly from past apartheid policies, by providing a basic need for a previously marginalised population. Thus, the urban poor placed a high value on equity and empowerment due to their historical injustices. This was followed by the importance of participating in the decision-making processes and policies affecting their livelihood (0.294). Despite the strong political support for the project, the political agendas only accounted for slightly over 11% of the total value placed on the importance of the political/institutional factors that influence and affect sustainable development. Conflict resolution (0.081) was not deemed a priority item for the urban poor.

In contrast to the results obtained for the urban poor, the middle-class community placed the highest value on participating in the decision processes (0.313) to locate the low-cost housing scheme adjacent to their homes. This could be attributed to their fear that their needs (that being, residential security) might not be taken into consideration. This was followed by the need to mediate conflict resolution (0.254) and the importance of complying with environmental legislation and policies governing the Greater Durban Metropolitan area (0.210).

This section illustrated the important trade-offs that often need to be made when striving towards sustainable development. Areas of agreement and divergence between the two

opposing groups were highlighted and analysed. Although this section brought to the fore, the benefits of the proposed housing scheme, an environmental risk analysis of the low-cost housing project was needed to gain a deeper appreciation of the decision problem. The environmental, social and political costs of developing an ecologically important asset to the urban environment will be explored in greater depth in the following section.

Risks associated with the proposed low-cost housing scheme[20]

Risk assessment and analysis is increasingly being incorporated into the decision sciences due to the multidisciplinary nature of the concept of risk (Hamalainen and Karjalainen, 1992). According to these authors, the traditional expert approaches to risk define the overall risk in terms of probabilities and magnitudes of losses, often as the expected value of loss.

Limitations of these methods quite often lie in their inadequacy for expressing individuals' subjective perceptions of risk (Hamalainen and Karjalainen, 1992). These authors further elaborate that research on risk perception has shown that the technical description of risk fails to take into account the way individuals 'feel' about risks. Thus, a single definition of risk cannot exist, as different stakeholders perceive risks in their own unique and different ways. Factors affecting the perception of risk include voluntariness, controllability, familiarity of risks, clarity and equity of benefits, and the potential for catastrophic consequences (Hamalainen and Karjalainen, 1992).

Although no potential for catastrophes exist in this case, many of these characteristics are correlated, as is often the case with the perceived uncontrollability and unfamiliarity of development projects. In this case-study, the biophysical environment, socio-economic and political factors were taken into consideration (see figure 6.5(a)).

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[20] Refer to tables 2.2 and 2.4 in Appendix 5 for a detailed illustration of the pairwise comparisons of each of the criteria in the fifth (hidden) level of the hierarchy.

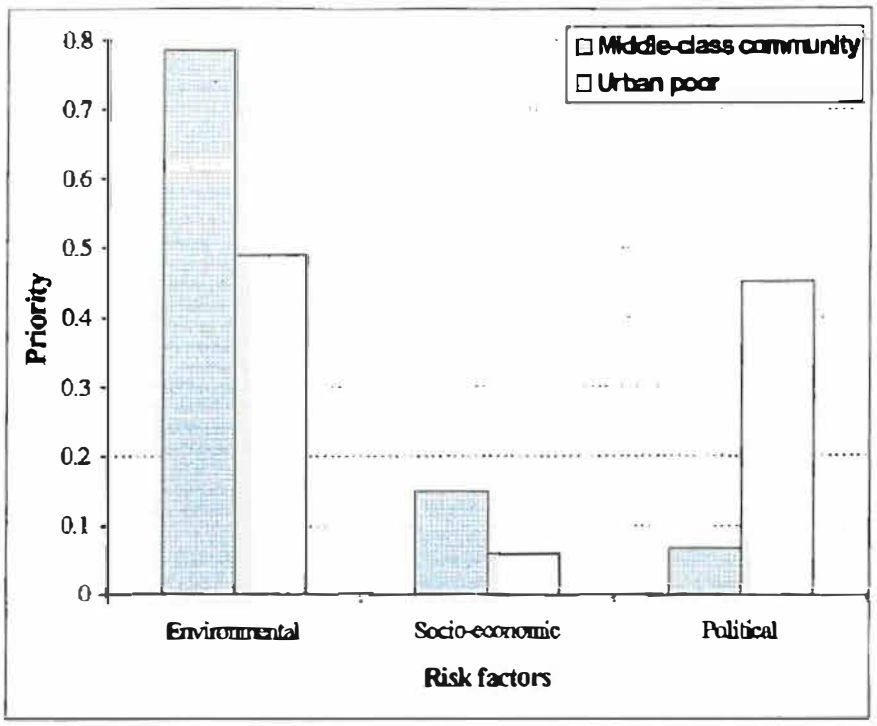


Figure 6.5(a) Local and global priorities with respect to the risks associated with the low-cost housing project

In this project, the environmental risks of developing on an ecologically important asset to the Durban Metropolitan Area were considered clearly higher than those resulting from the socio-economic and political factors. In the long term, both present and future inhabitants in the Durban Metropolitan Area would suffer if this 'green lung' were to be developed. Urban open spaces not only provide habitats for fauna and flora but also provide a number of services to people. These services include absorbing carbon-dioxide from the air, maintaining water quality, controlling storm water as well as providing recreation opportunities to relax and escape the stresses of urban life (Hindson, et. al., 1996). Thus, the risks associated with the destruction of the 'green lung' to the city were areas of concern to both groups, since their health and productivity would be affected in the long run. This, in turn, would affect their economic and social values. The middle-class community placed more emphasis on the socio-economic risks (0.149) compared to the urban poor who attributed a higher priority to the political risks (0.451) associated with the development initiative. The former group based this on their perception of the risks associated with properties being devalued, and crime and violence that could possibly occur. The urban

poor, on the other hand, only stood to benefit economically; hence, the socio-economic risks were given a low priority status (0.059). This community, however, live in constant fear of political unrest and violence (see figure 6.5(b)), and hence, gave the political factor a high priority weighting of 0.451. The perception that formal houses in an established area would confer a greater level of safety and security on this community influenced the weighting of this factor.

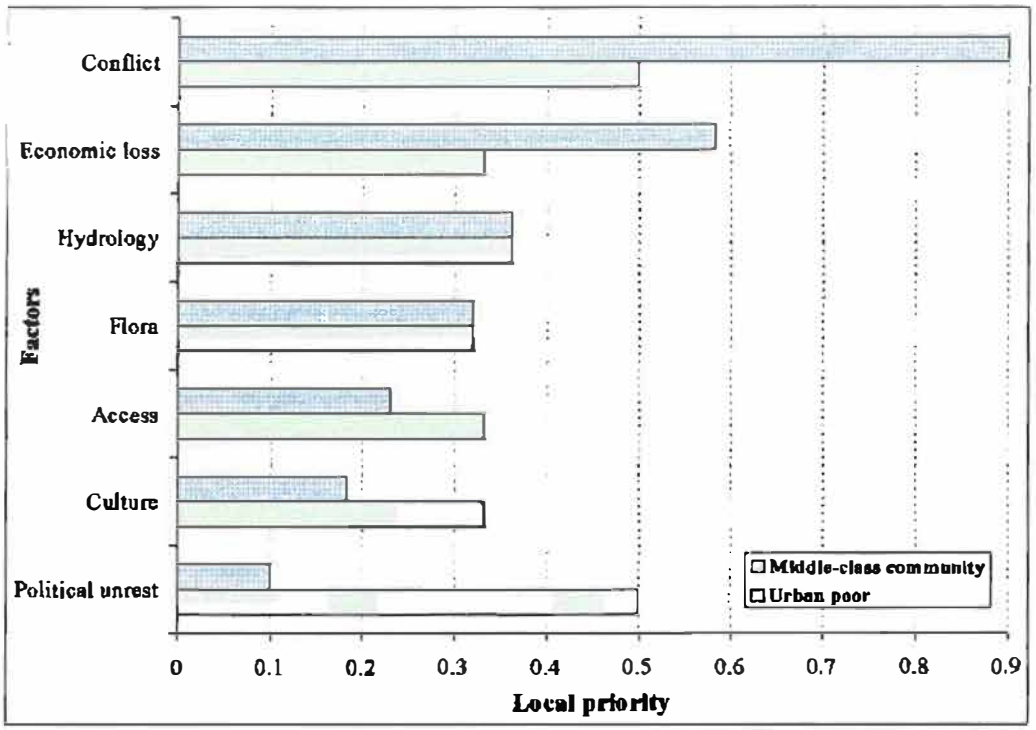


Figure 6.5(b) Local priorities with respect to the attributes in the third level of the risk assessment hierarchy

Within the last decade, the province of KwaZulu-Natal established a notorious reputation for politically motivated crime and violence. Thus, it is not surprising that the greatest concern for the risks associated with the project was perceived to be the conflict of interests between the various stakeholders in this project. The middle-class community attributed 90% of the total political risk to conflict compared to the urban poor who attributed equal importance (50% of the total) to both the conflict and potential for political unrest.

The economic losses were perceived as the most important socio-economic risks (58% of the total) the proposed project would confer on the middle-class community compared to the urban poor who, once again, weighted each of the factors that determined socio-

economic risks equally. In this case, the reason for attributing a weight of equal importance to each of the factors was because the decision-making forum did not perceive the urban poor to suffer any socio-economic risks if the proposed project was condoned.

As was the case for the sustainable development AHP multi-criteria model, areas of mutual agreement between the two opposing groups were based on the perceptions of risk associated with the biophysical environment. The interference with the hydrological balance and plant species found in the Sherwood open space area was an area for concern for both parties. This could be attributed to the importance of urban open spaces to the abatement of air pollution as well as maintaining the hydrological balance in the urban ecosystem.

Absolute Comparisons[21]

The previous sections illustrated and analysed the structure of the decision problem to obtain a deeper understanding of the nature of the conflict. However, it did not provide the decision-making forum with an effective measure to resolve the conflict. To balance the trade-offs between the urgent need and importance to provide low-cost housing in an easily accessible residential area and the need to maintain Durban Metropolitan's urban open space, absolute comparisons of the criteria in the fifth level of the sustainable development hierarchy were conducted. The same process was mimicked for the environmental risk hierarchy to balance the severity of the perceived risks associated with the development project with the potential benefits of the project. This process yielded the final priorities for each of the project alternatives (that being, whether the development should go ahead or not).

The importance of providing low-cost housing received a favourable priority weighting of 0.637 compared to the need to maintain the urban open area, which received a lower priority weighting of 0.334. However, the risks associated with the low-cost housing project were much higher (0.531) than the risks associated with not developing the urban open area (0.469). Thus, the final decision still lies with the decision-making forum. They need to weigh the importance of providing low-cost housing in a prime location within the

[21] Refer to tables 2.5 and 2.6 in Appendix 5 for a detailed illustration of the absolute comparisons of each of the criteria in the fifth (hidden) level of the hierarchy.

Durban Metropolitan Area with the risks associated with providing the housing in the urban open area. The results obtained in this study correlated quite strongly with the decisions taken prior to this exercise. The decision-making forum decided to develop a portion of the urban open space and retain the remainder of the area as a 'green lung' for the urban area. This post factum analysis of the decision problem therefore served to reinforce and strengthen the decision-making process.

6.3.5 Conclusion in regard to the Sherwood Low-cost Housing Development Project

Environmental and development decision-making is governed by the terms: sustainability, holism, integrated, and equitable. This case-study illustrated how, with the aid of the conceptual MCDM models proposed in this research, decision-making can fulfill these needs. The Sherwood low-cost housing project also portrayed the conflict and dilemma inherent in the field of environment and development. Thus, this case-study focused on the manner in which conflict can be better understood, analysed and mediated with the aid of the AHP.

It should, however, be noted that the judgements made both in the pairwise and absolute comparisons were those of the Manager: Environment for the DMC, only one of the stakeholders in the decision process, who reflected an informed opinion of the decision problem. Ideally, they should have been elicited from stakeholders belonging to each of the opposing parties as well as those of "expert" outside observers.

Despite this limitation, several conclusions can be drawn from the previous analysis. It is readily apparent that the urban open space benefited both the urban poor and middle-class communities, even though the needs of these two groups differed. The biophysical environment therefore provided areas of mutual interest in the decision process. The perceived socio-economic and political benefits and risks associated with the development best reflect the critical areas of divergence, hence conflict, in the decision process. In essence, the local authority had to find a balance between their responsibility to redress the past inequalities by providing low-cost housing for a previously marginalised population with the importance of maintaining a "green lung" to the metropolis. Thus, an appropriate solution between the development needs, and the continued existence of the environmental resource, had to be found.

With the aid of the AHP, the costs borne by the proposed project could be compared with the benefits of the low-cost housing development. The outcome of this process revealed that the housing project was deemed a higher priority than the need to conserve the urban open space. However, the risks associated with this project outweighed the risks associated with the non-development alternative. Thus, the final onus was on the decision-making forum to determine whether the risks outweighed the benefits of the low-cost housing project in Sherwood's urban open space area.

Most importantly, this case-study illustrated how the AHP could accommodate both tangibles and intangibles, individual values and shared values in a transparent and equitable manner. In addition, the AHP allowed for conflict-confronting strategies (see Dyer and Forman, 1992) in that it allowed for trade-off of a low value on one dimension against a high value on another. This is essential in the evaluation and selection phase of decision-making (Dyer and Forman, 1992). This case-study also illustrated the rationale of employing the AHP in retributive conflict resolution (Dyer and Forman, 1992) by using a single decision maker to enter judgements from the perspective of both opposing parties. This allowed the decision maker to show more empathy and purpose in defining her opponent's needs which resulted in a greater understanding of how each side's needs could be addressed in the overall solution to the conflict.

The following case-study examines, in more detail, how the AHP can be employed in group decision-making context to structure the problem and to incorporate the conflicting preferences of different interest groups into a formal procedure.

6.4 CASE-STUDY 3

PROPOSED TOURISM DEVELOPMENT AT THRELFALL - KOSI MOUTH

Due to the sensitive nature of the tourism development near the Kosi Mouth, a group decision-making process was adopted in this research. According to DeSanctis and Gallupe (1987), "Group Decision Support Systems aims to improve the process of group decision-making by removing communication barriers, providing techniques by structuring decision analysis, and systematically directing the pattern, timing or content of discussion". The decision-making process in this case-study involved key stakeholders in KwaZulu-Natal's Department of Agriculture and Environmental Affairs since the onus was on them to assess and evaluate the development project. The MCDM technique employed in this case-study was that of a compensatory strategy. This process combined all the available and relevant information to form an overall evaluation with the aid of the AHP. The unaltered conceptual MCDM models developed in this research (see chapter 5) were used. The AHP was used to incorporate the conflicting preferences of the decision-making forum into a formal procedure. The outcome of the AHP, a set of sustainable development and environmental risk coefficients, were then analysed to obtain the best location for the tourism project. The transparency of the method employed, as well as the outcomes of the process, provided a "solution" that minimises the environmental conflicts.

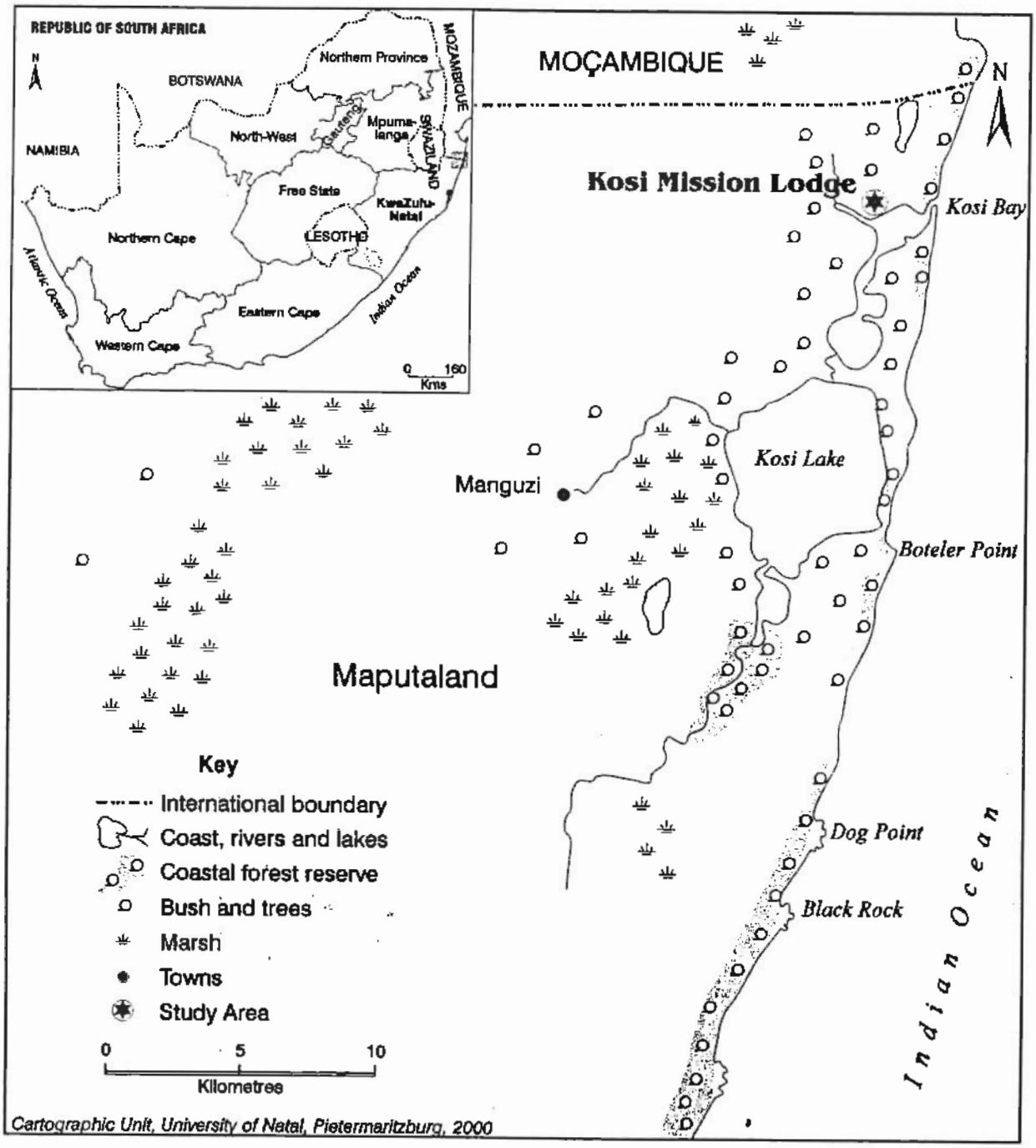
6.4.1 Introduction

The Kosi estuary system is one of 12 internationally recognised wetlands in South Africa. These wetlands are all listed in terms of the international convention on wetlands of international importance, signed in the Iranian town of Ramsar in 1975. This system is also part of a larger area, the Maputaland Centre, which is internationally recognised for its high plant endemism (Totman, et. al., 1995). In addition, Maputaland is home to the Kosi Bay/ Coastal Forest Reserve. According to Totman, et. al. (1995), four features in the vicinity of Kosi Mouth are identified as "unique, valuable and sensitive". Plans to have the fish traps in Enkovukeni (see plate 1, figure1, in appendix 6) proclaimed as a National Heritage Site, and the Threlfall site recognized as the oldest Methodist mission in KwaZulu-Natal, were in the pipeline at the time the environmental scoping investigations were conducted by the Institute of Natural Resources (INR) for the proposed "up-market" tourist resort in this region (Totman, et. al., 1995). Thus, the Kosi Mouth is an extremely sensitive coastal

environment that harbours sites of cultural, heritage and ecological importance and value to both the local communities residing near the river Mouth and the country.

The environment versus development debate in this case-study is further substantiated by the fact that the greater Maputaland area is also home to very poor communities whose daily existences depend on the natural environment. Thus, local economic ventures are required to sustain the region. However, the forced relocations of local communities residing in Kosi Bay in the 1980s, when the apartheid-era government declared this area a Natural Reserve, has had a negative effect on their perceptions of tourism and conservation. According to Moffat and KyewalYanga (1998), after the formation of the reserves, conservation organisations introduced tourism to the reserves without consulting and involving the local communities. The local communities also do not appear to have equitable access to diving concessions (Coastal Policy Green Paper, 1998). Recreational diving, on the other hand, appears to have unlimited access to the reefs. Boats and off-road vehicles also appear to have unregulated access to the coast (Coastal Policy Green Paper, 1998). This, in conjunction with forced removal, reinforced the local communities' perceptions that tourism and conservation was something for "privileged" white South Africans (Moffat and KyewalYanga, 1998).

Despite the local communities' perceptions of tourism, their most urgent priority is to provide for their basic needs (that being, food, shelter and clothing). Creating opportunities for employment therefore appears to be on the agenda of all stakeholders. Tourism appears to be the solution to this problem. Thus, the need to integrate local communities with tourism has been recognised and many programmes are currently underway to redress the past imbalances in resource management and utilisation. The KEN project is one such initiative aimed at capacitating local community with tourism development and management skills in this region. Local communities in Maputaland have since joined forces with relevant government departments and other parastatals in removing exotic plant species from ecological sensitive areas for fuelwood. It is envisioned that tourism in this area will eventually be regulated and controlled by local communities once they have taken ownership of the coast and its resources (Moffat and KyewalYanga, 1998).



Map 4: Location of the proposed tourism development project.

6.4.2 Background information on the project proposal[22]

The study Area

The proposed Threlfall site is located within the Kosi Bay/Coastal Forest Reserve. In the wider spatial context, this site is situated on the north of KwaZulu-Natal's east coast and is approximately 4 kilometres south of the Mocambique border (refer to map 4). The alternative siting of the resort is situated immediately outside the Coastal Forest Reserve at the old trading store. The nearest town, KwaNgwanase, is approximately 15 kilometres inland and southwest of both sites.

The Threlfall site "arguably commands one of the most remarkable views to be found anywhere along the South African coast" (Totman, et. al., 1995). Plates 1 and 2 in Appendix 6 bear testimony to this perception. This site occupies a ridge top position and allows observers a 180° (degree) visual access from the Ponto Do Auro lighthouse in the north to lake Nhlange in the south. However, the view offered by the old trading store site is that of the Coastal Forest, surrounding vegetation and inland landscape.

History

In 1992, the KwaZulu Bureau of National Resources (KBNR) issued a tender call for the development of tourist facilities within designated nodes of proclaimed nature reserves. The rationale behind this decision was to develop facilities that would generate an income for the region. The tender call specified that the Kosi Mouth/ Threlfall development attract "up-market" tourists. Crane (Africa) was selected to develop this site since they were the only developers who found the Threlfall site acceptable. Plate 3 in Appendix 6 is a visual representation of the proposed structures to be erected on this site. Crane proposed that water be supplied from Lake Zilonde and sanitation facilities comprise of septic tanks and soak-away pits for each building. At the time of the environmental scoping evaluation, no infrastructure for potable water, sewage disposal and roads existed. Thus, the project proponents made allowances for providing the nearby Mvutshane community with water and electricity connections. Subsequent to the environmental scoping report, a motorway leading to the Ponta Do Auro border was constructed and many NGOs were in the process

[22] Isivuno (the tourism development organisation of the former KwaZulu Department of Nature Conservation) appointed the Institute of Natural Resources (INR) to conduct an environmental scoping evaluation of the proposed tourism between the months of June and September, 1995. Information in this section was derived from this environmental scoping report.

of providing the local communities with water infrastructure. To cater for refuse disposal, the developers envisioned the municipal dump in KwaNgwanase or a sanitary landfill site, which was yet to be located.

Included in the proposal was a policy of equity, that being, that the community have a stake in the resort. The resort was therefore envisioned to be a joint venture between Crane, the KFC (KwaZulu Finance and Investment Corporation), the local communities and Amanresorts (a Hong Kong based hotel operator). The latter stakeholder is well known for its five star hotels in a number of exotic locations globally, and possesses an international clientele base of over 30 000. The proposal also stipulated that preference be given to local people for employment in the resort.

The Problem

The conflict and tension in this case-study emanated from the different needs and interests of the local communities, the developers and the conservationists. The research was therefore presented with the challenge of providing a framework for decision-making that took into account the polarised viewpoints of all the relevant stakeholders. The importance of such a decision framework was confirmed by the environmental scoping evaluation, where the INR found that the "single most critical issue concerns the need to move away from the present situation of frustration and distrust and build consensus and relationships and trust between key roleplayers. Failure to this may well result in the project not being successfully implemented" (Totman, et. al., 1995). Not surprisingly, no final decision to develop the resort facilities in the Threlfall site has been executed as conservationists and the developers have not yet reached a compromise.

Other areas of contention include issues pertaining to the management and activities in and around the Kosi-Coastal Forest Reserve. In addition to the potential impact of physical development on the pristine natural environment and pollution related to human occupation (litter, sewage disposal, etc.), the aspect of "creeping incrementalism" (this is described by Totman, et. al. (1995) as development that encourages a surge of further development) at Kosi, are valid items of concern. Thus, mitigatory and remediation mechanisms to contain the disturbance to the natural environment are of utmost importance if the development is condoned. It is anticipated that the development would confer a host of significant

economic benefits on the local residents. However, the nature of the proposed resort carries an inherent implication that fully trained and qualified staff is required for the successful operation of such a venture. Thus, the extent and nature of the economic benefits the local communities will actually derive from this initiative were not thoroughly explored in the environmental scoping report. Many informal recreation initiatives (such as boating and fishing) aimed at the tourist market are currently in operation by members of the local communities. The impact of the five star hotel in the Kosi area on local economic initiatives is also a grey issue. However, the scoping investigation identified a range of potential positive and negative social issues associated with the development. Among the negative potential social issues identified are the "ethics of an exclusive private development in publically funded conservation areas, to the possible social ills the development will bring to the local communities" (Totman, et. al., 1995).

The following sub-section examines the application of the AHP in a multi-criteria group decision-making environment to structure the problem as well as analyse and understand the nature of the conflict in this case-study. Ideally, the decision-making forum should include all the stakeholders in the project to resolve the conflict, by reaching a consensus or compromise, and possibly find a solution to the dilemma the development presents to decision makers. Development in a sensitive and unique environment can only be sustainable if all the stakeholders have a shared goal and common vision. Although, the approach adopted in this case-study can be used as an illustrative example of how the relevant stakeholders can work towards, and commit themselves, to a common goal; the scope of this research focussed on decision-making within decentralised government institutions. Thus, the group decision environment in this case was restricted to decision makers within the KwaZulu-Natal Provincial Department of Agriculture and Environment.

6.4.3 Application of the Multi-criteria Decision Models in a Group Decision Environment

According to Eden (1992), some of the success of Group Decision Support Systems (GDSS) comes from their role in encouraging creativity, developing emotional commitment, and attending to the issue of political feasibility. This author attributes the group's commitment to solutions with the aid of a GDSS due to its ability to "manage negotiation and develop coordination and cooperation in relation to the practicalities of

implementation". Increased participation in decision-making also plays a role in this process. If a decision is not politically feasible, it is an ineffective decision since it will not influence the problem the way it was intended to (Eden, 1992). To make a decision in this case, the commitment of stakeholders to the outcomes of the decision process is essential. This is the only way sustainable development can be realised. The conceptual MCDM models employed in this decision problem made allowances for political perspectives to be included in the decision-making process and the group decision context catered for the polarised viewpoints by making allowances for those who were against the development and those who were in favour of the development.

Making Judgements

The hierarchical structure of the problem is illustrated in the MCDM models proposed in chapter 5. All the criteria in these models were deemed relevant and applicable to the decision problem. Once this was established, decision makers then made judgements about the relative importance of each criterion, starting with the objectives (in the second level of the hierarchy) in relation to the goal. The conflict in this problem arose mainly from stakeholders who were in favour of the development versus those who opposed the development. In keeping with the compensatory strategy for decision-making, each decision maker entered judgements from the perspectives of both those who condoned the development and those who were opposed to this initiative, with the aid of a questionnaire (see appendix 3). The weighted values of each criterion were then processed with the aid of the Expert Choice software package. The software package calculated the geometric mean (average) of each decision maker's judgements. Aczel and Saaty (1983) demonstrated that the "geometric mean is the uniquely appropriate rule for combining judgements since it preserves the reciprocal property of the judgement matrix".

Weighting the importance of the objectives[23].

The results are presented in parallel for the two opposing viewpoints that represent the conflicting interests in the proposed project (see figure 6.6(a)). These results clearly illustrate that those in favour of the tourism development project placed the highest value on the social environment (0.614). This can be attributed to the perception that this

[23] Refer to tables 3.1(a) and 3.3(a) in Appendix 5 for a detailed illustration of the pairwise comparisons of each of the criteria in the second level of the hierarchy.

initiative will alleviate the poverty in the region by providing the local residents in Maputaland with opportunities for generating an income. It is also envisioned that the development will facilitate the education and empowerment of the residents in this area. The social environment was followed by the importance of the economic environment (0.181). This supports the perception that the physical development has many positive social and economic off-spins for the local residents. The biophysical environment received the lowest priority weighting (0.085). This low value could be attributed to the findings of the environmental scoping report (Totman, et. al., 1995). This report clearly specified that there were "no major environmental issues which would definitely indicate that the development should not proceed" (Totman, et. al., 1995).

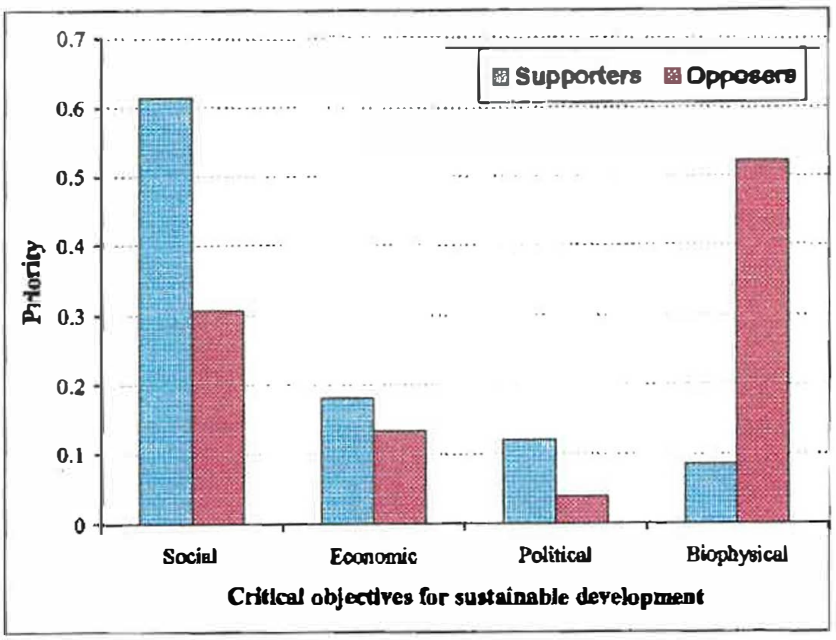


Figure 6.6(a) Local and global priorities of the critical objectives affecting the goal of sustainable development

In sharp contrast to the results obtained for those who supported the development, those who opposed this development valued the importance of the biophysical environment most (0.522). This can be attributed to the ecological, spiritual and cultural importance of this sensitive and unique coastal environment. This was followed by the importance rating of the social environment (0.306) and the economic environment (0.039). The environmental impact of human habitation as well as the negative social impacts originating from the

development and the ethics governing the development of a publicly funded conservation area for an exclusive clientele, influenced the perceptions of these attributes. The lowest priority was attached to the political environment (0.039).

Figure 6.6(a) clearly illustrates the nature and structure of the conflict by highlighting the critical areas of divergence. Although both of the opponents value the social environment, those in support of the resort facilities place a greater emphasis on the social benefits than those opposing the development. The importance of the biophysical environment provides the point of divergence between the two opposing groups. The next section provides a more detailed analysis of the conflict by examining the pairwise comparisons of the criteria in the third and fourth levels of the sustainable development hierarchy.

Weighting the importance of the criteria in the third and fourth levels[24].

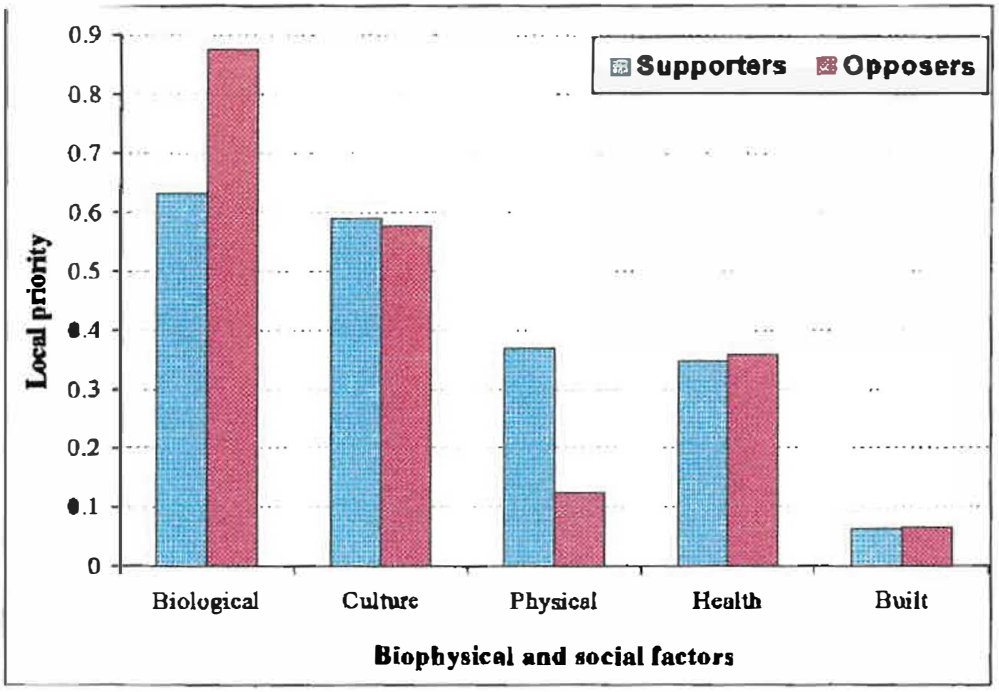


Figure 6.6(b) Local priorities with respect to the biophysical and social factors of the environment

[24] Refer to tables 3.1(b and c) and 3.3(b and c) in Appendix 5 for a detailed illustration of the pairwise comparisons of each of the criteria in the third and fourth levels of the hierarchy.

Biophysical factors

Those in favour of the physical development attached more value to the biological aspects of the biophysical (0.631) than to the physical aspects (0.369). This was mainly attributed to the visual and aesthetic importance of the flora (0.374) in and around the Coastal Forest Reserve. The uniqueness of the vegetation species in this area could also have influenced the high value placed on the biological aspects of the environment since it could act as a feature that would attracts tourists to the Kosi Mouth. The importance of the flora was followed by the need to implement effective mitigatory measures (0.352) to prevent the biophysical environment from pollution and degradation. The uniqueness and diversity of water species were also valued as a feature that attracts tourists (0.120).

Regarding the physical landscape, those in favour of the development rated the mitigatory and remediation mechanisms (0.266) highest. This was followed by the importance of the soil conservation (0.174) and the maintenance of the hydrological balance (0.138). These concerns were reflected in the environmental scoping evaluation conducted by the INR.

This evaluation emphasised the need to give careful consideration to the impacts of sewage and water disposal as well as possible problems of nutrient enrichment in a nutrient poor environment. The scoping report also advised that careful attention be given to soil stabilisation during, and after, on site construction to ameliorate wind blast and erosion due to the concentrated run-off from hard surfaces during torrential summer storms (Totman, et. al., 1995). Thus, although some of the stakeholders favoured the development initiative, they recognised the importance of minimising the impacts of development since the success of the resort depended, to a large extent, on preserving the uniqueness of the landscape.

Similarly to those in favour of the development, those who opposed the development placed the highest value on the biological aspects of the environment (0.875). As with the supporters of the development, this was assigned to the importance of the water (0.374) and vegetation (0.352) species found in this region.

According to Totman, et. al. (1995) the following four features in the vicinity of the Kosi Mouth are identified as unique, sensitive and valuable: Kosi Mouth to Kuguma Rocks, the Khalu Inlet, the streams draining into the Kosi estuary at Enkovugeni, and the mangrove

species at Kosi Mouth. The first area harbours many thousands of fish in transit through the mouth and provides a spawning ground for many important fish species. The Khalu inlet is one of the only nursery areas on Africa's south eastern coast for marine sport fishing species, and the latter contains fish species listed as threatened in the "Red Data Fish Book". The mangrove community is unique and sensitive because it is the only place in this country where five species of mangrove trees grow (Totman, et. al., 1995).

Of the physical factors (which comprised only 12.5% of the total biophysical environment), the opposition party assigned the highest priority to the current land use practices in the Kosi area. This result could be ascribed to the subsistence harvesting of natural resources by residents in the local communities for their daily survival. This group is apprehensive that the development initiative may limit their access to the natural resource base.

Social Factors

Those in support of the development valued the cultural aspects highest (0.589) which was followed by the factors influencing the mental and physical well-being of the potential tourists (0.348). Not surprisingly, the built environment (0.063) obtained the lowest priority weighting in this section. Of the cultural factors, the archeological and historical value (0.739) of the proposed site obtained the highest priority weight. According to Totman, et. al. (1995), the fish traps in Enkovukeni are to be proclaimed as a national heritage site and the remains of the old Threlfall mission is going to be commemorated for its archeological and historical value as the oldest Methodist mission in KwaZulu-Natal. Of the factors influencing the mental/physical well-being of residents in Kosi, the aesthetic and visual quality of the Threlfall site (0.387) was valued the most. This confirms the results obtained for the pairwise comparisons of the biophysical factors. The potential health risks associated with the development, with regards to malaria and the potential for water borne diseases due to sewage contamination, were items of concern for this group (0.234).

The social factors were areas of convergence between the two opposing groups. As in the case of the supporters for the development, the opposing group also valued the cultural aspects most (0.576), followed by the aspects pertaining to the mental and physical health and well-being of the local communities. The built environment obtained the lowest priority rating (0.066). In contrast to the supporting group, the opposition party placed

more emphasis on the ethics of the proposed development initiative (0.458) than on the archeological/historical importance of the Threlfall site (0.419). The health risks (0.528) associated mainly with the potential of tourists being infected with malaria dominated the importance weighting of the mental/physical well-being factors.

Economic Factors

The decision makers in support of the development project valued the creation of employment opportunities by the tourism venture highest (0.341). This was followed by the importance of the local communities' physical access to the natural resources (0.230). In contrast, the opposition party valued the local communities' access to resources the highest (0.258) since their livelihood and survival depended on it. By privatising a portion of the Coastal Forest Reserve, local communities feared that they could be denied access to the natural resources. The socio-economic status of the local communities in Maputaland was also a priority item (0.244).

Political factors

Decision makers in support of the development initiative placed much emphasis on the legislative compliance of the proposed project (0.303). This group also attributed much importance on issues pertaining to equity and empowerment initiatives (0.293) the project conferred on the local community. Due to the diverse interests of the various stakeholders in this project, conflict resolution was also found to be an important item on the agenda (0.245). Until the conflict has been resolved, no decision on the development project can be made. However, the opposition party valued public participation in the decision-making process highest (0.422). This group rated conflict resolution second highest in this category (0.234), followed by the need for equity and empowerment (0.206). Due to the long, drawn-out nature if this decision process, it is not surprising that conflict resolution featured on the agenda of all the decision makers participating in this exercise. It is also evident that the decision process focused intently on the need to redress past historical imbalances, coupled with the importance of educating and empowering local residents in the Kosi area.

Areas of convergence and divergence governing the decision process of the tourism development project were highlighted in this sub-section. Thus, this process revealed both the structure and nature of the conflict. Decision makers were encouraged to compare

tangibles with intangibles to obtain a deeper appreciation of the complexity of the issues facing them. These comparisons were synthesised with the aid of the AHP to produce priority ratings of the criteria. The importance of the biophysical environment appeared to be the main issue of contention to the two opposing groups. In order to gain a better perspective of the potential environmental risks and costs associated with the development project, the procedure conducted in this section was repeated for the decision analysis of environmental risks.

Risks associated with the proposed tourism development[25]

The outcomes of the risk decision analysis revealed that the critical areas of divergence, hence conflict, between those who supported the development and those who were opposed to it, were based on the perceptions of physical environmental risks and the risks associated with the project not being completed (see figure 6.7(a)). The group in favour of the project perceived the risks associated with non-completion (0.443) to be the most important risk factor in the development initiative. This perception is a valid fear since a further delay in making a decision on this proposal could very likely result in the project proponents losing interest in the development initiative and pursuing other, more lucrative, investment opportunities. Not many investors possess the capital of the Hong Kong based Amanresort hotel franchise and Crane was the only development company who found the old Threlfall school site acceptable. The tender process revealed that other developers were interested in developing within the immediate vicinity of the Kosi Mouth. Not surprisingly, this perception was followed by that of the economic risks (0.213) associated with non-completion and the potential environmental risks (0.166) if the development were to be condoned.

[25] Refer to tables 3.2 and 3.4 in Appendix 5 for a detailed illustration of the pairwise comparisons of each of the criteria in the risk assessment hierarchy.

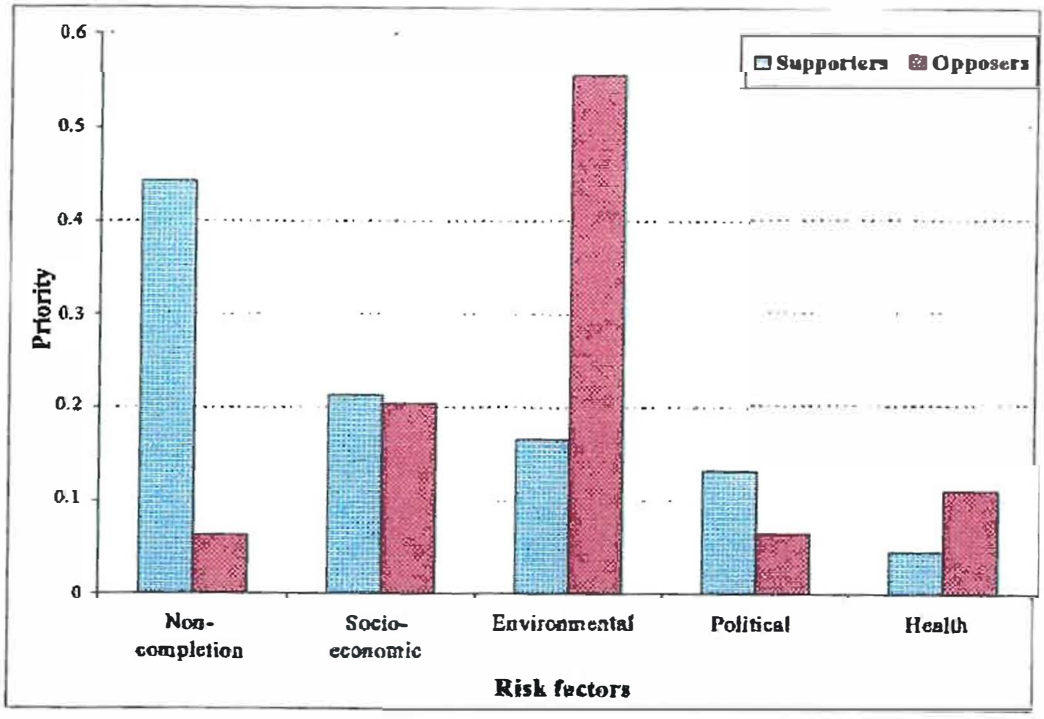


Figure 6.7(a) Local and global priorities with respect to the risk factors associated with the tourism development

The group opposing the development venture perceived the risks associated with the biophysical environment to be the greatest risk factors associated with the tourism development (0.557). These were followed by the socio-economic risks (0.204) that could be attributed mainly to the potential adverse social impacts of the project. Health risks, pertaining mainly to malarial infections, were also deemed important by this group (0.111). The supporters of the project, however, rated the risks associated with health lowest (0.046). The political risks, on the other hand, were perceived to be the lowest items of concern for the objectors to the development initiative (0.046).

Figure 6.7(b) illustrates that the supporters of the project perceived the risk of non-completion to be a priority risk factor because of the instability of the prevailing economic climate (0.825). The opposing group agreed with this perception and rated this aspect highest in the non-completion category (0.797).

However, this group attributed their perception of physical environmental risks mainly to the potential for disturbance to the flora in the Coastal Forest Reserve (0.316), the cattle and

the criteria in the risk assessment hierarchy.

livestock in the area (0.239) and the potential for land pollution (0.190). Supporters of the development perceived the latter factor to be the most important environmental risk factor (0.412), followed by the upset in the hydrological balance (0.214) and the potential disturbance to indigenous flora (0.178).

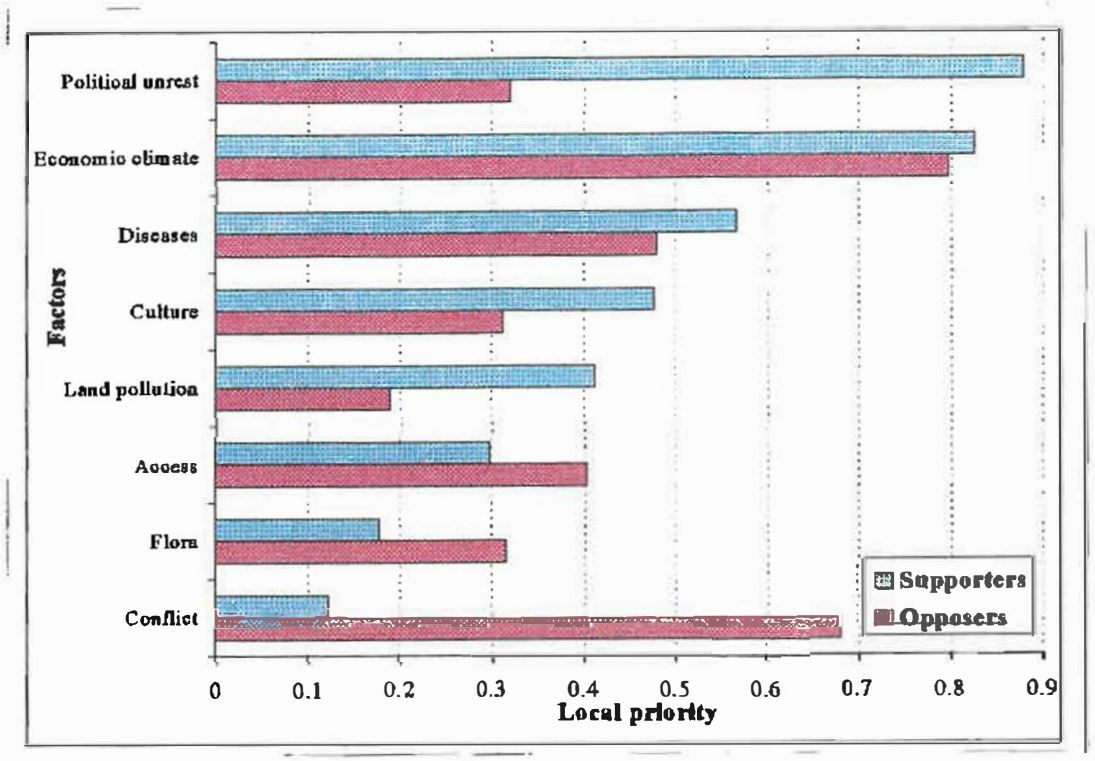


Figure 6.7(b) Local priorities with respect to the critical factors influencing the risks associated with the tourism development

Although both groups perceived the socio-economic risks to be associated with loss of access to the natural resource base and the potential negative impacts on areas of cultural importance to the local communities, the order of importance differed. The supporters perceived cultural risks to be more significant (0.477) compared to the opposition party, who perceived the loss of access to resources to have a greater negative impact on the local communities (0.402).

The supporters of the project also perceived the risks associated with political unrest (0.878) to be a high priority risk factor associated with the political risks of the project. It

should be noted that political risks only comprise approximately 13% of the total risks associated with the project. The opposition party, on the other hand, attributed the highest area of concern to the risks associated with conflicts of interest between the stakeholders in this project (0.680) even though this risk criterion only accounted for approximately 7% of the total risks associated with the development.

The results obtained from the analysis of the risk factors reinforced the concerns expressed by the decision makers in the sustainable development MCDM model. Thus, this process provided the decision makers with a detailed structure and analysis of the conflict inherent in environment and development problems, that is, the need for economic growth has to be carefully weighed against the need to conserve ecologically and culturally sensitive environs.

Absolute Comparisons[26]

To reach a consensus between the two polarised viewpoints and to resolve the conservation versus development debate, absolute comparisons of the intensity ratings in the sustainable development and environmental risk MCDM hierarchies were conducted. In this exercise, an alternative site (the old trading store) for the development initiative was identified. The old trading store is located inland, adjacent to the Kosi-Coastal Forest Reserve. With the aid of the sustainable development hierarchy, decision makers rated the level of significance of each of the criteria used in the multi-criteria model in relation to their impact on the overall goal. The same exercise was conducted for the levels of perceived risks associated with the development proposal. The outcome of this exercise revealed that both the groups in favour and against the tourist development initiative rated the Threlfall site higher than that of the old trading store. Thus, consensus between the two opposing groups was achieved with regards to a common goal, that being, the best location for the resort. However, those who supported the development initiative perceived the risks associated with developing the Threlfall site higher (0.509) than those associated with the old trading store site (0.491). In contrast, those against the development attributed a higher risk to the old trading store location (0.503) than the Threlfall site (0.497). Thus, there appeared to be an overall preference for the development to be located in the Threlfall site.

[26] Refer to tables 3.5 and 3.6 in Appendix 5 for a detailed illustration of the absolute comparisons of each of the intensities in both the sustainable development and risk assessment hierarchies.

6.4.4 Conclusion in regard to the Tourism Development near the Kosi Mouth

The group decision-making process revealed a shift in emotional attitude as well as a cognitive shift to the problem situation, mainly on the part of the decision makers who were opposed to the development initiative. This cognitive shift resulted in a consensus being achieved. Once the structure of the problem was unfolded, the decision makers could focus on the goals and objectives of the decision problem rather than the alternatives. This eliminated the need for participants to resort to common simplistic decision strategies. Because the analysis was structured, discussion continued until all the available and important information was considered and a consensus choice of the alternative (the Threlfall site) most likely to achieve the stated objective was achieved. In addition, the approach adopted in this case-study encouraged the opposing parties to have more empathy with the values of their opponents by enabling them to develop a perspective of their needs and how these needs can be satisfied along with those of their opponents. Eden (1992) argues that the "procedural rationality will influence the emotional attitudes, and substantial rationality will influence shifts in cognition; however, each supports the other".

The transparency provided by the AHP facilitated the negotiation since it made allowances for a transparent analysis of the problem situation. The AHP accommodated both individual and shared values in the group decision environment. Eden (1992) expresses the strengths of the AHP models in conflict resolution and mediation in his statement: "Modelling offers a form of synthesis and a new way of seeing the same data, because its meaning is changed by the change in context and linkage between the data - *new knowledge is created*." Thus, the decision modelling employed in this case-study encouraged synthesis in a positive light.

Although much concern for the potential negative impacts of the development was expressed, the decision-making forum was able to attain a consensus that the Trelfall site was more suited to the development than the old trading store. However, it should be noted that this process is not a substitute for decision-making - it facilitates decision-making. The decision-making forum is still ultimately responsible for making a final decision. The multi-criteria group decision-making (MCGDM) process provided decision makers with more clarity and understanding of the complexity of the issues involved in the process. Thus, despite Trelfall being identified as the best location for the development, the stakeholders

still need to determine whether the project is feasible and whether it is worth risking the biophysical and social environments for the potential benefits the project may (hopefully) confer on the community, the province and the country.

6.5 Concluding Remarks on the Implementation and Practical Validation of the Conceptual Decision Models

The three case-studies in this chapter examined, in great detail, the utility, flexibility and applicability of the conceptual MCDM models, with the aid of the AHP, in sensitive coastal and inland environs. Each of the three case-studies examined unique attributes of the MCDM models proposed in this research. The first case-study, the Thaba Ya Batswana development proposal, examined the application of the sustainable development model in environmental planning and evaluation. It allowed for a comprehensive and holistic assessment and evaluation of environmental scoping reports. The low-cost housing development proposal in the Greater Durban metropolis examined the applicability of both conceptual MCDM models in understanding, analysing and mediating conflict resolution. The third case-study, the tourism development project near the Kosi Mouth, looked at the advantages of using multi-criteria decision modeling within the context of group decision-making.

Each of these case-studies illustrated how the multi-criteria decision models aided in environmental decision-making, thus substantiating the technical question of accuracy, that is, the models were accurately constructed to represent the problems decision makers are faced with in a real-world environment and development context. This was confirmed by the results obtained from the implementation of the models. Decision makers were provided with a greater insight into understanding the nature of the decision problem and the ability to focus on the objectives of the decision problem and not on the alternatives.

The hierarchical constructs of the decision problems, that provided the problems with structure, were also illustrated in this chapter. This facilitated the understanding and analysis of the complex, and often conflicting issues, inherent in environment and development decision-making.

The success of the AHP as a compensatory strategy aid in decision-making was also explored. The approach adopted in this research enabled decision makers to have more empathy and understanding of other viewpoints and perceptions regarding the decision problem. This process facilitated the ability of decision makers to reach a compromise or consensus in decision processes fraught with conflict, thus, enabling transparent and equitable decisions to be made.

This practical validation has therefore illustrated that the goal of developing generic multi-criteria decision models that can be applied to most development problems in the field of environmental planning, was achieved. The conceptual MCDM models were practically validated by their application in real-world problem situations.

It remains to investigate the decision makers' perceptions of the relevance, importance and applicability of the MCDM models in environmental planning within decentralised government institutions, which is discussed in chapter 7. This exercise not only provided this research with the opportunity to improve on the proposed models, but it also enriches the larger SA-ISIS 2000 project, since it allows the acceptance of multi-criteria decision modeling in the field of environmental planning to be gauged.

CHAPTER 7

A REFLECTION AND APPRAISAL OF THE MULTI-CRITERIA DECISION MODELS

An appraisal of the multi-criteria decision-making (MCDM) models developed in this research, forms a component of the validation framework used to assess the appropriateness and relevance of these models as decision aids in environmental planning. This chapter investigates the value of the MCDMs to the decision makers who participated in this process. Value, in this case, pertains to the worth, meaningfulness and usefulness of the multi-criteria models.

7.1 Introduction

According to Landry et. al. (1983), operational validity is the method used to determine the success of the implementation of the models in a decision environment (refer to chapter 6 for a representation of the validation framework). "For a system to have operational validity it would have to be of value to the client in tackling the problem situation for which the system was built" (Finlay and Wilson, 1997). Eden (1992) further elaborates that issues of implementation are as significantly related to attitudes, power, and managerial prerogative as they are to an appropriate consideration of the interaction between individuals and outcomes.

Operational validity is an important step in the validation cycle since it encourages the "right" things to be done "right" (see Ackoff, 1995 for his justification of "'Whole-ing' the Parts and Righting the Wrongs"). By 'whole-ing', this author implies that parts of the whole system must be manipulated with the primary focus being on its effect on the performance on the whole, and not on the parts. According to this author, to do the wrong things right is to do it efficiently but not effectively. Effectiveness can only be achieved when the right things are done correctly. The previous chapter confirmed that the 'right things were done'. The next section investigates whether they were done correctly, that is, are the multi-criteria models acceptable to decision makers within decentralised government institutions?

7.2 Appraisal of the Framework for the Evaluation of Factors Influencing Environmental Planning and Management at a Local Authority and Provincial Level

Various value-based features of the MCDM models were investigated. The features ranged from the models' usefulness and ease of use to their flexibility in different problem situations. Methods of improving on the model design and user satisfaction were also investigated (see Appendix 4). Although decision makers were given the option of evaluating the two models separately, they preferred to assess the models simultaneously, since the values they attached to the models did not differ substantially. The following sub-sections provide a summary of the findings. Each question is presented in italics, followed by the opinions of the decision makers in the field of environmental planning at both local and provincial levels of government.

7.2.1 Usefulness of the models

The first and third questions (see Appendix 4) dealt with the issue of the usefulness of the models as decision aids in the field of environmental planning. The values explored were related to the acceptance of the models, their relevance and applicability to every-day decision problems, as well as the perceived importance of the models in assisting decision makers to make sound, scientifically acceptable, transparent and equitable decisions.

1. *How relevant are the models for decision-making in this field? Please describe the models' flexibility to their application in different problem situations.*

The analysis of the statements (not included in the Appendix section) showed considerable personal commitment to the use of the models as decision support aids. This was substantiated by the responses of the decision makers to these questions, which indicated that they all found the MCDM models very relevant and useful in dealing with both simple and complex problem situations. The application of the models in conflict resolution and analysis was also applauded. Some sample comments were:

- *"Very relevant - it crystalises complex arguments into clear alternatives"*
- *"Appears to be useful even with complex cases"*

- *"Very relevant and interactive"*
- *"Can definitely see the potential with special reference to group decision-making"*
- *"Very relevant for the multidisciplinary approach required for Integrated Environmental Management (IEM) - I can see the light!!"*

However, one of the respondents did express some concern in the application of the models to simple, less complex problem situations. This respondent was not sure whether it would be more difficult or easier than its application to complex problem solving. This could possibly be attributed to the decision maker's involvement in complex problem solving. The research did, however, make allowances for a relatively simple problem situation - the Thaba Ya Batswana development proposal, to illustrate the application of the models in simple problem analysis and solving.

Because decision makers are held accountable for the decisions they make, they quite often need to have the decision-making process documented to justify their decisions/actions. The Analytical Hierarchy Process (AHP) is useful in this case as it makes allowances for transparent and equitable decision-making. Decision makers recognized, and readily welcomed, this attribute. With the aid of the MCDMs, the decision process was guaranteed to be holistic with all the relevant and essential factors being given their due consideration. Thus, in both single and group decision environments, the transparency and equatability of the decision processes could be proved with the aid of the AHP.

7.2.2 The models' ease of use

In order to apply the models widely in every-day decisions, they need to be simple enough to be used by a host of decision makers within government departments in the country. Thus, decision makers should not feel intimidated by the structure and design of the models. The participants in this process based their perceptions on the questionnaires used in the implementation and practical validation stage (see Appendix 3). To gauge the user-friendliness of the models, decision makers were asked:

2. *How easy is it to use (that is, does it require any specialised training)?*

The responses to this question varied from being very easy to use to requiring some form of basic training in using the models. Some of the participants recommended that a non-technical "step-by-step" instruction manual accompany the models as well as clear definitions of each of the criteria. They substantiated this by stating that this method of decision-making is a new concept and the terminology employed may not be familiar to all decision makers. Some sample comments were:

- *"It does not require any specialised training but a list of definitions of each factor will be helpful"*
- *"Very easy to use"*
- *"It requires a lot of knowledge as it is information based"*
- *"It could be cumbersome in a way"*
- *"It requires lots of thinking (which is good anyway in the decision-making process)"*
- *"Training moderately preferred"*

It was recognised that the AHP is based on the ability of the decision makers to use both the information at hand as well as their experience in the field of environmental planning/management to estimate the relative importance of each criterion through paired comparisons. These perceptions of the AHP are confirmed by Saaty (1994d) who stated "the AHP is a framework of logic and problem-solving that spans the spectrum from instant awareness to fully integrated consciousness by organising perceptions, feelings, judgements and memories into a hierarchy of forces that influences decision results".

The processes of pairwise comparisons were perceived to be lengthy and cumbersome due to the number of criteria contained in the sustainable development hierarchical model. However, the structure and design of the model was perceived to be one of its strengths in that it encouraged the decision makers to view the decision problem in a holistic and integrated manner (see the next section). The ability of AHP to compare tangibles with intangibles was also commended since it was thought provoking and encouraged decision makers to consider both quantitative and qualitative criteria as well as various alternatives.

7.2.3 Useful features of the models

In order to determine which features of the MCDM models the decision makers perceived to be of greatest value, they were asked to list aspects of the models' that appealed most to them. This question was formulated to elicit the strengths of the models as perceived by the users:

3. *Please list/describe the features of this model that you find particularly useful.*

Various well-established strengths of multi-criteria decision modeling and the AHP were acknowledged and appreciated in this sub-section. An item that appealed most to the decision makers involved the ability of the MCDM models, with the aid of the AHP, to structure complex problems into a logical and rational framework, which gives the decision maker the ability to understand each part of the problem within its appropriate context. Also recognised was the ability of the MCDM models, and the AHP, to provide an objective analysis of subjective factors as well as to compare multiple factors that influence the decision problem.

The holistic nature of the multi-criteria models received favourable attention since the field of environmental management and planning requires an integrated and holistic approach to problem solving. Thus, once again, the comments were very instructive:

- *"Concept of holistic thinking"*
- *"Objectivity"*
- *"The pairwise comparison feature. It tends to highlight interactions between the factors that might exist"*
- *"Its ability to compare multiple factors"*
- *"The streamlining of complex arguments into more clearly defined positions. It basically re-inforces what is already known"*

It therefore hardly surprising that all the decision makers who participated in this exercise rated their level of satisfaction with the multi-criteria models as "very satisfied" since it fulfilled most of their needs. The models provided the decision makers with a relatively simple set of tools to analyse, understand and clarify the complexity of the decisions most

of them are faced with. Of notable importance is the fact that one of the decision makers acknowledged that the model takes into account factors that are shown to influence the decision problem, but are not always included in current decision-making because they are not considered important at that particular point in time or because they get "lost" in the maize of information that is used to make decisions.

In addition, decision makers appeared to attribute a higher priority value to "hard", quantifiable and scientifically valid data/information than the "softer", more subjective information, because no techniques to measure subjective factors existed until now.

7.2.4 Areas for improvement

In order to construct a sound, scientifically acceptable and user-friendly model, the perceived weaknesses of the model need to be identified and corrected. In addition, areas requiring a greater degree of clarification need to be identified. It should be noted that not all the participants in the operational validation exercise responded to the following question:

4. *If applicable, please suggest methods of improving on this model.*

Of those who responded, the following valid suggestions were made:

- *"Because the final decision rests with the decision maker, guidance on how to factor the output of the model into the decision process may be required (that is, stressing it is not a decision in and off itself)"*
- *"Instructions to be more 'simplistic' to cater for different viewpoints"*

The above-mentioned issues will be dealt with in the tutorial/manual that will accompany the MCDM models, which is the subject of a separate SA-ISIS 2000 project. Of importance is the comment that decision makers should be aware that the models to not provide the "answers" to the decision problem. They only act as tools and techniques to facilitate the decision process by assisting decision makers in understanding the nature and structure of the problem as well as helping them to focus on the objectives of the problem and not the alternatives.

Another important critique of the models that was raised by one of the decision makers during the implementation session was that of the reductionist approach of the AHP on which the models were based. For the "hard" sciences, the learning system is characterised by three R's: reductionism, repeatability and refutation (Checkland, 1976). "We may reduce the complexity of the variety of the real world in experiments whose results are validated by their repeatability, and we may build knowledge by the refutation of hypotheses" (Checkland, 1976). This author therefore argues that the single most important characteristic of science is the reductionism of its approach. This provides the point of divergence between the methodological approach used in this research to derive the models and that of the classical sciences.

Soft Systems Thinking (SST), and in particular Soft Systems Methodology (SSM), were the methodological approaches adopted in this research. These approaches are derived from systems based approaches (see chapter 3). The research recognised the limitations of reductionism in deriving and constructing the MCDM models, hence, employed a systems-based approach. According to Checkland (1976), the systems movement is identified by a conscious use of the term "system" and by the holistic thinking implied in this concept. This author further elaborates that the movement's holism is best understood with reference to its opposite: reductionism. Thus, various Weltanschauung were investigated in the derivation of the models. In addition, SSM provided the research with a more open analysis of the situation within which the problem is perceived and not of "the problem". Not surprisingly, the models made allowances for a variety of Weltanschauung to be included in the problem structuring and analysis phases of problem solving (refer to chapter 6 for the practical illustration of the incorporation of the views of various stakeholders in the decision-making process).

According to Checkland (1976), the systems approach searches for relations between "emergent properties and the wholes of which they are characteristic". Thus, a combination of reductionism and holism were used in this research. The reductionism of the AHP (see chapter 4) was coupled with the holism of SSM. SSM was used to derive models and the AHP was used to structure and analyse the problem situation. Checkland justifies the advantages of using both reductionism and holism in this statement:

"We perceive a complex world outside ourselves and if we are to understand it we must reduce its variety; for that we need tools of analysis such as science has provided. But the world is a whole - everything is connected to everything else - and to restore the whole we need means of integration such as systems thinking may provide" (Checkland, 1976).

It is hardly surprising that one of the respondents recognised the "interactive" nature of the models; that is, they are not based on mathematical models only but are also based on the decision maker(s) value systems, their knowledge and experience. Thus, the decision maker does not enter a value and hope the model will produce the desired outcome. The decision makers are engaged in this process from conception to solution and are ultimately responsible for making the final decision after much consideration regarding each of the criteria that bear on the problem. The reductionism and holism are the strengths of the models.

7.3 Conclusion to the Reflection and Appraisal of the MCDM Models

This chapter provided an overview of the acceptability of the proposed decision frameworks in both local and provincial government departments.

On the whole, the MCDM models, as decision support aids, were met with great enthusiasm and excitement. This not only has positive ramifications for this research but also for that of the larger SA-ISIS 2000 project. The models were perceived to be extremely useful and user-friendly to all the decision makers who participated in the appraisal process. They were especially commended for their holistic and transparent approach in dealing with decision problems in the field of environment and development planning. Thus, it was not surprising that users could see their potential in handing complex planning and development issues in the field of Integrated Environmental Management.

Decision makers also appreciated the logic-based and interactive nature of the AHP since they were constantly engaged in the decision process, from conception to finding solutions to the problem. The fact that the AHP also provided a logical structure and synthesis to "messy" problems appealed to decision makers.

However, some limitations of the practical implementation of the decision framework were identified. The factors/criteria required more definition and the process was perceived as tedious due to the time it took to complete the sustainable development questionnaire (see Appendix 3). Participants in the implementation process recommended that a simple "step-by-step" user instruction manual/tutorial accompany the multi-criteria models to familiarise users with the techniques employed in this method of decision-making.

In addition, decision makers felt that the manual/tutorial should specify that the MCDM models are decision aids that facilitate the decision process by providing structure to complex and/or messy problems, and that decision makers are still ultimately responsible for making the decision. With the aid of the AHP, decision makers are able to better understand the nature of the problem they are faced with as well as focus on the objectives of the decision problem and not on the alternatives.

Thus, the appraisal of the proposed decision framework illustrated that the strengths of both multi-criteria modeling and the AHP were recognised by the decision makers who were involved in the practical implementation of the multi-criteria models. After reflecting on the appraisal of decision framework, it can be concluded that the research was valuable and successful in developing effective and efficient MCDM models to aid in the complexities of environmental decision-making.

CHAPTER 8
CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

The aim of this research was to derive multi-criteria decision making (MCDM) models to facilitate decision-making in the field of environment and development planning. The research was restricted to local and provincial government departments since they are chiefly responsible for assessing and evaluating development proposals in South Africa. Thus, in addition to deriving decision models, their applicability, usefulness and relevance to environment and development planning decision-making had to be tested to determine whether they achieved the objective of facilitating and aiding decision-making.

In order to place the research on decision-making in context with environment and development planning, an overview of environmental decision-making was conducted. Based on the outcomes of the problem identification phase, and the conceptual, practical and operational validation phases of the MCDM models derived in this research, the following conclusions were drawn:

1. The investigation of the role of environmental politics in decision-making illustrated that the South African Constitution (108 of 1996) provided policy makers with a strong foundation on which to develop legislation for environmental decision-making. The country's political commitment to environmental quality and sustainable development is reflected in its Constitution, the revised environmental and planning legislation and the number of environmental posts within the local, provincial and national tiers of government.

2. The research recognised that government authorities still posses the overall responsibility for environmental politics and management in South Africa. Environmental decision-making is in the process of being decentralised from a national and provincial level to a local level since local authorities are the level of governance closest to the people and play a vital role in responding to the public's needs. In terms of the constitution, several functional areas pertaining to

environmental issues were devolved to provincial and local levels for legislative and administrative control.

3. Practical environmental decision-making was found to operated within the legislative frameworks provided by the Environmental Conservation Act (No. 73 of 1989), the National Environmental Management Act (NEMA) (No. 107 of 1998), the Planning and Development Act (No. 5 of 1998), the Development Facilitation Act (No. 67 of 1995) and other Acts and regulations pertaining to the environment (e.g., the National Water Act (36 of 1989), Mountain Areas Catchment Act (63 of 1970), etc.). Difficulties in practical decision-making arose when environmental legislation, such as the "outgoing" Environmental Conservation Act (No. 73 of 1989) and the "incoming" NEMA, overlapped and when a plethora of other environmentally related Acts had to be considered.

4. With reference to conclusion (3) above, the investigation into environmental legislation indicated that it was still fragmented and diffuse, even after the introduction of NEMA. Thus, NEMA has not appeared to have been successful in its objective to codify environmental legislation since a plethora of legislation and White Papers pertaining to environmental issues continue to emerge.

5. The research revealed that decision makers placed much emphasis on NEMA because it complimented international environmental legislation and provided a strong context for environmental decision-making as it incorporated sustainable development and Agenda 21 principles. However, because NEMA, the PDA and DFA are being phased in over time, it remains to be seen whether these Acts will achieve sustainable environmental decision-making.

6. Environmental Impact Assessments (EIAs) were found to be the most effective regulatory mechanisms in assessing development proposals. However, the research established that the full potential of EIAs in balancing the trade-offs associated with proposed development actions have not yet been realised. Thus, environmental conflicts continue to ensue.

7. The most critical concern highlighted by environmental and planning managers was the sectoral/silo and fragmented approach to environmental management within local government departments that defeats the aim of sustainable development. In contrast, there appeared to be much co-operation and communication between the provincial and local levels of government. It should be noted that NEMA recognised the importance of effective institutional arrangements to achieve sustainable development.

8. The research identified the lack of cooperation and communication as the main areas of concern, with regard to the institutional arrangements, in practical environmental decision-making. For successful cooperation on environmental issues, the different actors must be able to communicate the issues among each other, since communication is a key aspect of cooperation. The lack of communication and cooperation is closely related to the differing cultures, associated with the different professions, within government organisations. Research in the field of environmental culture within companies has shown that Environmental Management Systems (EMS) are potential tools for developing an environmental corporate culture.

9. Soft Systems Thinking (SST), and in particular, Soft Systems Methodology (SSM) were selected as the methodologies to investigate problems in practical environmental and planning decision-making as they provided for a structured, organised and holistic approach for problem identification. The investigation of SSM revealed how stakeholders could be identified and their opinions and Weltanschauungs creatively explored and included in the problem identification phase of the research. SSM also allowed for the creative identification of the cultural, organisational and political issues that affect the decision-making processes.

10. The limitations of SSM identified included the reductionism of SSM's conceptual models and the inability of this methodology to effect change. To overcome some of these limitations, the Analytical Hierarchy Process (AHP), a multi-criteria decision-making (MCDM) method, was investigated.

11. The investigation revealed that a multi-criteria approach was required to comprehensively address the interrelated multiple (and often conflicting) criteria, the objectives and numerous alternatives inherent in this type of decision-making. The AHP was found to be the most suited MCDM method since it is a relatively simple and systematic procedure for representing the elements of a decision problem in a hierarchical structure.

12. Two conceptual multi-criteria decision models were derived from the SSM workshops and replaced the original SSM conceptual models (as defined by Checkland and Scholes (1990)). The first model had sustainable development as its goal and the second had environmental risk as its main goal. These models provided decision makers with frameworks to address development initiatives in a sustainable fashion, as well as to ensure that the environmental, health, social and economic risks were considered and addressed when evaluating development initiatives.

13. The hierarchical structure of the decision problem made the decision elements and their relationships more visible. This structure also enabled decision makers to better understand the goal (the highest level of the hierarchy) based on the interactions of the various levels of the hierarchy.

14. The MCDM models had both reductionist (derived from the AHP) and holistic (derived from SST and SSM) features. The research also established that these MCDM models catered for the assessment and evaluation of development projects in both sensitive inland and coastal environs.

15. To test the robustness, relevance, and validity of the models, they were applied to three real-world decision problems (case-studies). Each of these case-studies tested attributes and utilities of the AHP in the fields of environment and development, that being: planning, conflict resolution and group decision-making. Post factum decision analyses illustrated how the MCDM models aided in environmental and planning decision-making.

16. Results obtained from the implementation and practical validation phase of the research revealed that decision makers were provided with a greater insight in understanding the nature of their decision problem(s). Also illustrated in this research was the ability of the multi-criteria models to analyse and mediate conflict resolution, and to promote transparent decision-making. Thus, the research answered the technical question of how adequate the models were structured to represent the problems decision makers were faced with.

17. With reference to the above conclusion, it should be noted that the results also highlighted the limitation of employing a single (albeit informed) decision maker to enter judgements for all the stakeholders in the decision process, when assessing and evaluating development proposals. The advantages of including all stakeholders in a group decision-making context were also mentioned. Some of these advantages include: retributive conflict resolution and mediation; fair, transparent and equitable decision-making; and increasing the levels of cooperation and communication between the various departments within government organisation.

18. On the whole, the MCDM models as decision support aids were met with great enthusiasm and excitement. The models were perceived to be extremely useful and user-friendly to all the decision makers who participated in the appraisal process. They were especially commended for their holistic, equitable and transparent approach in dealing with decision problems in the field of environment and development planning. The users could see their potential in handing complex planning and development issues in the field of Integrated Environmental Management.

19. The research also indicated that decision makers who participated in the implementation phase requested a simple "step-by-step" user instruction manual/tutorial to accompany the MCDM models in order to familiarise users with the techniques employed in this method of decision-making. In addition, decision makers requested that the manual/tutorial specify that the MCDM models are decision aids that only facilitate the decision process by providing structure to

complex and/or messy problems, and that decision makers were still ultimately responsible for making the final decision.

20. From the results and discussion presented in the dissertation, it can be concluded that the research accomplished its aim. Adequate, relevant and useful multi-criteria decision models were derived in this research with the aid of both reductionist and holistic methods and techniques. These models have been shown to facilitate the complex, "messy" and often contentious decision-making processes in the field of environment and development planning. Decision makers were able to better understand the nature of the problem they were faced with, as well as to focus on the objectives of the decision problem and not on the alternatives.

21. The research illustrated that, with the aid of the MCDM models, decision-making can integrate the science of environmental analysis with the politics of resource management. Decision makers are therefore provided with tools and techniques to balance the trade-offs between development and conservation in sensitive coastal and inland areas, in an equitable, fair, objective and transparent manner.

22. The research does, however, acknowledge that sustainable development is a dynamic, complex and formidable task and presents a major challenge to government institutions. It requires much more than just implementing legislation, policies and decision support systems (DSS) to achieve sustainable development. Sustainable development is deeply rooted in both individual and organisational cultures, attitudes and perceptions that are, in turn, reflected in the decisions they make.

8.2 Recommendations

In the light of the conclusions listed above, the following recommendations are be made to assist decision makers work towards sustainable development:-

1. That the MCDM models developed in this research be incorporated in the Environmental Management Systems government institutions currently have in place to promote dialogue and interaction between departments. It is envisioned

that this will aid government organisations in better addressing environment and development planning issues in an integrated, comprehensive and holistic manner.

2. That, with regard to conclusion (4), the provisions contained in White Papers dealing with environmental issues that have emerged subsequent to the promulgation of NEMA (such as the Draft White Paper for Sustainable Coastal Development in South Africa) be incorporated into NEMA so as to avoid fragmentation of legislation, in view of the fact that this research indicates that the MCDM models applied herein transcend such fragmentation and provide decision makers with tools for integrated and holistic environmental decision-making.

3. That group decision-making, with all the relevant stakeholders in the decision-making process, be conducted when assessing and evaluating upcoming development proposals.

4. That, with reference to (3) above, the MCDM models developed in this research be further validated by a broader range of stakeholders and decision makers.

5. That the MCDM models be employed to mediate and resolve both current and future environmental conflicts.

6. That, when using the MCDM models, decision makers test the robustness of the results obtained from the decision-making process by employing a sensitivity analysis (as illustrated in table 6.3 of chapter 6) and that such analysis be performed on upcoming development proposals.

7. That in the face of uncertainty, decision makers adopt the precautionary principle which asserts that where uncertainty and doubt make it impossible to be sure about a correct decision, any errors should favour the long-term sustainability of the environment.

8. That it be noted, that the MCDM component of the overall SA-ISIS 2000 (South African Integrated Spatial Information System) project is currently being prepared for use on the World Wide Web (WWW).

9. That with regard to (8) above, the MCDM models be accompanied with a simple, user-friendly tutorial/manual to introduce decision makers to the concepts of MCDM.

10. That the designer of the WWW site be requested to provide decision makers with a facility on the WWW to structure other decision problems (e.g., the restructuring of the magisterial boundaries within provinces) so as to assist in promoting a wider application of MCDM techniques and methods within public authorities.

11. That the abstract of this dissertation be circulated to all relevant decision makers in local, provincial and national levels of government (including Regional Services Councils) and other stakeholders, together with an advise that the MCDM models will be made available on the WWW.

12. That the MCDM models be linked with the spatial information contained in GIS databases to facilitate informed, scientific and transparent decision-making in the field of environment and development planning, as many of the Metropolitan Councils and Provincial Departments in South Africa rely quite heavily on Geographical Information Systems (GIS) as decision support systems (DSS) to aid in environmental and planning decision-making.

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APPENDIX 1

INTERVIEWER GUIDE FOR THE INFORMAL INTERVIEWS WITH RELEVANT DECISION MAKERS

INTERVIEWER GUIDE

SECTION 1: PERSONAL DETAILS

Name_____ Organisation_____

Department_____ Date___/___/99

SECTION 2: ENVIRONMENT AND DEVELOPMENT PLANNING DECISION MAKING PROCESSES

1. The Decision Making Process:

1.1 Apart from the EIA regulations (sections 21, 22 and 26) stipulated in the Environmental Conservation Act of 1989, what are the actual processes entailed in the approval of development plans?

_____

_____

_____

_____

1.2 Within what strategic framework/s does this decision making process operate (e.g. LA21, IDP, PDA, LDP, NEMA, etc)?

_____

_____

_____

1.2.1 In your opinion, what are the practical limitations of these frameworks?

_____

_____

_____

1.3 Please define the role of this TLC/TMC/Provincial department in the approval process.

1.4 What criteria do you use when assessing development initiatives (e.g. economics, health, physical environment, etc)?

1.4.1 Is it possible to rank the criteria in order of importance?

Yes	No

1.4.2 If yes, please rank the criteria (starting with most important).

1.5 Please motivate your selection of criteria.

Criterion (a):

Motivation(a)

Criterion (b):

Motivation(b)

Criterion (c):_____

Motivation(c)_____

_____

_____

Criterion (d):_____

Motivation(d)_____

_____

_____

Criterion (e):_____

Motivation(e)_____

_____

_____

1.6 Does this process provide you, the decision maker, with all the relevant information you need to make a well informed decision?

Yes	No

1.6.1 Please motivate your answer.

_____

_____

_____

_____

_____

1.7 In your opinion, are there any difficulties inherent in the type of decision making you practice?

Yes	No

1.7.1 If yes, please specify.

1.7.2 Please suggest ways to improve on this type of decision making process.

SECTION 3: STAKEHOLDER IDENTIFICATION

1.1 Who are the stakeholders in the decision making processes regarding the assessment and evaluation of development plans/proposals?

1.2 What are the roles of each of these stakeholders listed above?

1.3 What provisions/mechanisms are in place to ensure the participation of city politicians, officials and civil society in the decision making process (e.g. an Environmental Management Committee)?

Thank you for your time and contribution!

APPENDIX 2

EIA/IEM CHECKLISTS USED TO SCREEN DEVELOPMENT PROPOSALS

ENVIRONMENTAL CHECKLIST TO BE COMPLETED IN GREATER JOHANNESBURG FOR ALL:

- **Amendments of the Town Planning Scheme;**
- **Establishment of townships/extension of boundaries;**
- **Subdivisions of property indicated on Plan 1, Environment and Conservation Areas; and**
- **SDP's and or building plans falling within the area indicated on Plan 1.**

Notes:

In order to comply with National, Provincial and Local Authority environmental legislation and policies, the attached Environmental Checklist must be attached with development control applications as specified above. Where indicated on the Environmental Checklist, the relevant environmental issues must be properly investigated and described by a qualified professional. Failure to complete the Environmental Checklist, will result in the development control application not being accepted .

Please circle the correct answer below.

1. Are Regulations 1182 and 1183 (ie the so called EIA Regulations applicable to any aspect of the application)
   Yes No
2. If "yes", has any application been submitted to the Dept of Agriculture, Conservation and Environment (DACE).
   Yes No
3. If "yes" please provide a copy of the application and if "no", please state date by when application will be made. Proposed date to submit application to comply with the Regulations. YY..... M ... D ....
4. If R1182 and R1183 are applicable and any reports have been submitted to DACE or a Record of Decision has been granted by DACE, a copy must be provided with this application.
5. Please complete the attached Environmental Checklist.
   5.1 Any environmental issue in the left hand column of the table, which is relevant to the site, must be circled on this checklist.
   5.2 The information listed under "Content of Report" will be provided in all development control applications under a section headed "Environmental Issues." Clearly where the relevant information may appear in a report required in terms of R1182 or R1183, reference can be made to the specific numbered section of the said report.
6. I hereby accept full responsibility for the accuracy of the information contained in the Environment Checklist and Chapter headed "Environmental Issues."
   Name Signature Date

ENVIRONMENTAL ISSUE	CONTENT OF REPORT
1. <u>If the Application involves land use changes or subdivisions (subdivisions in area shown on Plan 1) which:</u>	
• Contain or abut wetlands, rivers & streams, including the 1:100 year floodline or within 32m of the centre line of the stream or river	• describe, quantify and map the value of the circled issues • describe and quantify the anticipated impacts of the proposal on the circled issue • describe and quantify the proposed mitigation measures
• Contain or abut national monuments, archaeological sites or heritage sites	• describe, quantify and map the value of the circled issues • describe and quantify the anticipated impacts of the proposal on the circled issue • describe and quantify the proposed mitigation measures
• Abut or incorporate koppies, ridges or steep slopes (steeper than 1:5)	• describe, quantify and map the value of the circled issues • describe and quantify the anticipated impacts of the proposal on the circled issue • describe and quantify the proposed mitigation measures

• Is located in the Environment Control Zone. Refer to the "B Series Zoning Sheets"	• describe, quantify and map the value of the circled issues • describe and quantify the anticipated impacts of the proposal on the circled issue • describe and quantify the proposed mitigation measures
• Located in or abuts nature reserves/conservation areas	• describe, quantify and map the value of the circled issues • describe and quantify the anticipated impacts of the proposal on the circled issue • describe and quantify the proposed mitigation measures
• Located in or abuts agricultural land	• describe, quantify and map the value of the circled issues • describe and quantify the anticipated impacts of the proposal on the circled issue • describe and quantify the proposed mitigation measures
• Is located above an aquifer	• describe, quantify and map the value of the circled issues • describe and quantify the anticipated impacts of the proposal on the circled issue • describe and quantify the proposed mitigation measures

• Is for an SDP or building plan located in the area indicated on the attached Plan 1	• describe, quantify and map the value of any of the above site characteristics • describe and quantify the anticipated impacts of the proposal on the circled issue • describe and quantify the proposed mitigation measures
2. <u>If the application includes activities which may cause significant:</u>	
• Air, noise, water and radon/radiation related pollution and impacts	• describe, quantify and map the anticipated impacts and the proposed mitigation measures
• Generation of hazardous waste	• describe, quantify and map the anticipated impacts and the proposed mitigation measures
• Potential pollution problems due to hazardous or problematic geological /soil conditions, ie dolomite, clay, etc	• describe, quantify and map the anticipated impacts and the proposed mitigation measures
• Visual intrusion in a sensitive natural environment	• describe, quantify and map the anticipated impacts and the proposed mitigation measures
3. <u>If the Application contains activities which during construction may:</u>	
• Require significant blasting thereby cracking abutting buildings	• describe, quantify and map the anticipated impacts and the proposed mitigation measures

• Require significant site levelling or cut and fill (more than 2m vertical)	• describe, quantify and map the anticipated impacts and the proposed mitigation measures
• Require any alteration/cut/fill of the natural floodline of any wetland, river, stream	• describe, quantify and map the anticipated impacts and the proposed mitigation measures
• Cause degradation of important species or ecosystems and/or removal of large areas of natural vegetation	• describe, quantify and map the anticipated impacts and the proposed mitigation measures

4. <u>If the Application contains new activities which may be impacted upon by on-site or abutting negative impacts such as:</u>

• Noise from traffic and industry or any other noise disturbing activities	• describe, quantify and map the anticipated impacts and the proposed mitigation measures
• Air borne pollution	• describe, quantify and map the anticipated impacts and the proposed mitigation measures
• Water pollution from adjoining activities	• describe, quantify and map the anticipated impacts and the proposed mitigation measures
• Odours	• describe, quantify and map the anticipated impacts and the proposed mitigation measures
• Radon	• describe, quantify and map the anticipated impacts and the proposed mitigation measures

• Potentially hazardous & nuisance related zones (airports, waste water treatment works, landfill sites, hazardous chemical plant, etc)	• describe, quantify and map the anticipated impacts and the proposed mitigation measures
• Areas of geological / soil problems or hazards (such as dolomite, clay, etc)	• describe, quantify and map the anticipated impacts and the proposed mitigation measures

5. Petrol Filling Stations

The applicant must comply with Regulation R1183 Schedule 1,1c

In addition to the requirements of the Regulations, the issues in the right column must be addressed:

Proposals to place petrol filling stations or any underground petroleum storage tanks should be avoided within the 1:100 year flood line or where geotechnical and / or geo-hydrological reports indicate high risk to the environment.	• provide a vicinity plan indicating location of any surface water within 1 km of the site. • the geotechnical evaluation must indicate the presence of clay, acidic soils, sinkholes or dolomite formations on the site and neighbouring premises • the geotechnical evaluation must indicate the likelihood of stray electrical currents (i.e. is the site close to electrical railway lines, substations, etc.) or galvanic action that will require cathodic protection of metallic installations • describe the expected soil movements on the site

under load and wet as well as dry climatic conditions must be indicated (i.e. 1:50 Year rainy seasons and drought periods)

- quantify the expected maximum level of ground water under wet climatic conditions. (i.e. 1:50 Year rainy seasons.)
- map the zoning of the neighbouring properties, and state whether they are used or zoned for agricultural purposes
- state whether neighbouring properties use ground water from wells / boreholes?(Gardening, agricultural, livestock watering, domestic etc.)
- establish the level of reliance of neighbouring properties on ground water resources
- indicate the location of wells / boreholes on the site and on neighbouring properties on a scaled diagram.
- Indicate if the neighbouring premises are provided with potable water from the local authority

NOTE: - The radius of evaluation of " neighbouring properties " must be determined from the porosity of the soils on the site, underground aquifers etc and the likelihood of contamination of ground water feeding the well / borehole under consideration

Where no detailed geotechnical or hydrological information on the area is available, expert investigations should be undertaken so that appropriate installation and operating conditions may be specified to minimise or eliminate environmental risks.

A competent geotechnical engineer or other suitably qualified person should perform an Installation Risk Assessment for potential leakage of petroleum from storage tanks and piping to the environment.

The Installation Risk Assessment should indicate if there will be a need for extraordinary

- specifications for petroleum storage tanks and related piping
- installation procedures/precautionary measures
- measures to contain leakage's, failure of the petroleum storage system

APPENDIX 3

SUSTAINABLE DEVELOPMENT AND RISK ASSESSMENT QUESTIONNAIRES USED TO IMPLEMENT THE MULTI-CRITERIA MODELS

SUSTAINABLE DEVELOPMENT
PRIORITISATION OF THE CRITERIA

For each comparison, evaluate the relative importance of the options by placing a number next to the preferred option.

Example 1: If BIOPHYSICAL is **strongly preferred** or **strongly more important** than POLITICAL, then:

___5___BIOPHYSICAL as compared to POLITICAL_____

Example 2: If POLITICAL is strongly preferred or strongly more important than BIOPHYSICAL, then:

_____BIOPHYSICAL as compared to POLITICAL___5___

_____	BIOPHYSICAL as compared to SOCIAL	_____
_____	BIOPHYSICAL as compared to ECONOMIC	_____
_____	BIOPHYSICAL as compared to POLITICAL	_____
_____	SOCIAL as compared to ECONOMIC	_____
_____	SOCIAL as compared to POLITICAL	_____
_____	ECONOMIC as compared to POLITICAL	_____

Each evaluator is requested to provide judgements concerning the relative importance of the various criteria. Please use the standard AHP scale, where 1 means equally preferred, 3 means moderately preferred, 5 means strongly preferred, 7 means very strongly preferred, and 9 means extremely strongly preferred. 2, 4, 6 and 8 are intermediate values.

SUSTAINABLE DEVELOPMENT
PRIORITISATION OF THE CRITERIA

For each comparison, evaluate the relative importance of the options by placing a number next to the preferred option.

Example 1: If BIOPHYSICAL is **strongly preferred** or **strongly more important** than POLITICAL, then:
___5____BIOPHYSICAL as compared to POLITICAL_____

Example 2: If POLITICAL is strongly preferred or strongly more important than BIOPHYSICAL, then:
_____BIOPHYSICAL as compared to POLITICAL____5____

____ BIOLOGICAL FACTORS as compared to PHYSICAL FACTORS ____

____ BUILT ENV. as compared to MENTAL/PHYSICAL WELL-BEING ____
____ BUILT ENV. as compared to CULTURAL ENV. ____
____ MENTAL/PHYSICAL WELL-BEING as compared to CULTURAL ENV.____

____ WATER SPECIES as compared to PLANT SPECIES ____
____ WATER SPECIES as compared to ANIMAL SPECIES ____
____ WATER SPECIES as compared to MITIGATION/REMEDIATION ____
____ WATER SPECIES as compared to POLLUTION ____
____ PLANT SPECIES as compared to ANIMAL SPECIES ____
____ PLANT SPECIES as compared to MITIGATION/REMEDIATION ____
____ PLANT SPECIES as compared to POLLUTION ____
____ ANIMAL SPECIES as compared to MITIGATION/REMEDIATION ____
____ ANIMAL SPECIES as compared to POLLUTION ____
____ MITIGATION/REMEDIATION as compared to POLLUTION ____

Each evaluator is requested to provide judgements concerning the relative importance of the various criteria. Please use the standard AHP scale, where 1 means equally preferred, 3 means moderately preferred, 5 means strongly preferred, 7 means very strongly preferred, and 9 means extremely strongly preferred. 2, 4, 6 and 8 are intermediate values.

SUSTAINABLE DEVELOPMENT
PRIORITISATION OF THE CRITERIA

For each comparison, evaluate the relative importance of the options by placing a number next to the preferred option.

Example 1: If BIOPHYSICAL is **strongly preferred** or **strongly more important** than POLITICAL, then:

___5____BIOPHYSICAL as compared to POLITICAL_____

Example 2: If POLITICAL is strongly preferred or strongly more important than BIOPHYSICAL, then:

_____BIOPHYSICAL as compared to POLITICAL____5____

____ PHYSICAL LOCATION as compared to CURRENT LAND USE ____

____ PHYSICAL LOCATION as compared to GEOLOGICAL SUITABILITY ____

____ PHYSICAL LOCATION as compared to SOIL FACTORS ____

____ PHYSICAL LOCATION as compared to HYDROLOGICAL FACTORS ____

____ PHYSICAL LOCATION as compared to MITIGATION/REMEDIATION____

____ PHYSICAL LOCATION as compared to POLLUTION ____

____ CURRENT LAND USE as compared to GEOLOGICAL SUITABILITY ____

____ CURRENT LAND USE as compared to SOIL FACTORS ____

____ CURRENT LAND USE as compared to HYDROLOGICAL FACTORS ____

____ CURRENT LAND USE as compared to MITIGATION/REMEDIATION ____

____ CURRENT LAND USE as compared to POLLUTION ____

____ GEOLOGICAL SUITABILITY as compared to SOIL FACTORS ____

____ GEOLOGICAL SUITABILITY as compared to HYDROLOGICAL FACTORS

____

____ GEOLOGICAL SUITABILITY as compared to MITIGATION/REMEDIATION

____

____ GEOLOGICAL SUITABILITY as compared to POLLUTION ____

____ SOIL FACTORS as compared to HYDROLOGICAL FACTORS ____

____ SOIL FACTORS as compared to MITIGATION/REMEDIATION ____

SUSTAINABLE DEVELOPMENT
PRIORITISATION OF THE CRITERIA

____ SOIL FACTORS as compared to POLLUTION ____

____ HYDROLOGICAL FACTORS as compared to MITIGATION / REMEDIATION ____

____ HYDROLOGICAL FACTORS as compared to POLLUTION ____

____ MITIGATION / REMEDIATION as compared to POLLUTION ____

Each evaluator is requested to provide judgements concerning the relative importance of the various criteria. Please use the standard AHP scale, where 1 means equally preferred, 3 means moderately preferred, 5 means strongly preferred, 7 means very strongly preferred, and 9 means extremely strongly preferred. 2, 4, 6 and 8 are intermediate values.

SUSTAINABLE DEVELOPMENT
PRIORITISATION OF THE CRITERIA

For each comparison, evaluate the relative importance of the options by placing a number next to the preferred option.

Example 1: If BIOPHYSICAL is **strongly preferred** or **strongly more important** than POLITICAL, then:

___5___BIOPHYSICAL as compared to POLITICAL_____

Example 2: If POLITICAL is strongly preferred or strongly more important than BIOPHYSICAL, then:

_____BIOPHYSICAL as compared to POLITICAL____5____

____ HEALTH RISKS as compared to VISUAL/AESTHETIC QUALITY _____

____ HEALTH RISKS as compared to NOISE _____

____ HEALTH RISKS as compared to MITIGATION/REMEDIATION _____

____ HEALTH RISKS as compared to POLLUTION _____

____ VISUAL/AESTHETIC QUALITY as compared to NOISE _____

____ VISUAL/AESTHETIC QUALITY as compared to MITIGATION/REMEDIATION _____

____ VISUAL/AESTHETIC QUALITY as compared to POLLUTION _____

____ NOISE as compared to MITIGATION/REMEDIATION _____

____ NOISE as compared to POLLUTION _____

____ MITIGATION/REMEDIATION as compared to POLLUTION _____

Each evaluator is requested to provide judgements concerning the relative importance of the various criteria. Please use the standard AHP scale, where 1 means equally preferred, 3 means moderately preferred, 5 means strongly preferred, 7 means very strongly preferred, and 9 means extremely strongly preferred. 2, 4, 6 and 8 are intermediate values.

SUSTAINABLE DEVELOPMENT
PRIORITISATION OF THE CRITERIA

For each comparison, evaluate the relative importance of the options by placing a number next to the preferred option.

Example 1: If BIOPHYSICAL is **strongly preferred** or **strongly more important** than POLITICAL, then:
___5___BIOPHYSICAL as compared to POLITICAL_____

Example 2: If POLITICAL is strongly preferred or strongly more important than BIOPHYSICAL, then:
_____BIOPHYSICAL as compared to POLITICAL____5____

____ URBAN OPEN SPACES/REC. FACILITIES as compared to MUNICIPAL SERVICE DELIVERY _____

____ URBAN OPEN SPACES/REC. FACILITIES as compared to EXISTING INFRASTRUCTURE _____

____ URBAN OPEN SPACES/REC. FACILITIES as compared to TRAFFIC AND TRANSPORT _____

____ URBAN OPEN SPACES/REC. FACILITIES as compared to MITIGATION/REMEDIATION _____

____ URBAN OPEN SPACES/REC. FACILITIES as compared to POLLUTION____

____ MUNICIPAL SERVICE DELIVERY as compared to EXISTING INFRASTRUCTURE _____

____ MUNICIPAL SERVICE DELIVERY as compared to TRAFFIC AND TRANSPORT _____

____ MUNICIPAL SERVICE DELIVERY as compared to MITIGATION / REMEDIATION _____

____ MUNICIPAL SERVICE DELIVERY as compared to POLLUTION _____

____ EXISTING INFRASTRUCTURE as compared to TRAFFIC AND TRANSPORT _____

____ EXISTING INFRASTRUCTURE as compared to POLLUTION _____

____ TRAFFIC AND TRANSPORT as compared to MITIGATION/REMEDIATION _____

____ TRAFFIC AND TRANSPORT as compared to POLLUTION _____

____ MITIGATION/REMEDIATION as compared to POLLUTION _____

Each evaluator is requested to provide judgements concerning the relative importance of the various criteria. Please use the standard AHP scale, where 1 means equally preferred, 3 means moderately preferred, 5 means strongly preferred, 7 means very strongly preferred, and 9 means extremely strongly preferred. 2, 4, 6 and 8 are intermediate values.

SUSTAINABLE DEVELOPMENT
PRIORITISATION OF THE CRITERIA

For each comparison, evaluate the relative importance of the options by placing a number next to the preferred option.

Example 1: If BIOPHYSICAL **is strongly preferred or strongly more important** than POLITICAL, then:
___5___BIOPHYSICAL as compared to POLITICAL_____

Example 2: If POLITICAL is strongly preferred or strongly more important than BIOPHYSICAL, then:
_____BIOPHYSICAL as compared to POLITICAL____5____

____	CULTURAL/HISTORICAL VALUE as compared to EDUCATION	_____
____	CULTURAL/HISTORICAL VALUE as compared to ETHICS	_____
____	EDUCATION as compared to ETHICS	_____
____	INFRASTRUCTURE as compared to REVENUE	_____
____	INFRASTRUCTURE as compared to ACCESS TO RESOURCES	_____
____	INFRASTRUCTURE as compared to SOCIO-ECONOMICS	_____
____	INFRASTRUCTURE as compared to JOB CREATION	_____
____	INFRASTRUCTURE as compared to MARKET DEMAND	_____
____	INFRASTRUCTURE as compared to MAINTENANCE	_____
____	REVENUE as compared to ACCESS TO RESOURCES	_____
____	REVENUE as compared to SOCIO-ECONOMICS	_____
____	REVENUE as compared to JOB CREATION	_____
____	REVENUE as compared to MARKET DEMAND	_____
____	REVENUE as compared to MAINTENANCE	_____
____	ACCESS TO RESOURCES as compared to SOCIO-ECONOMICS	_____
____	ACCESS TO RESOURCES as compared to JOB CREATION	_____
____	ACCESS TO RESOURCES as compared to MARKET DEMAND	_____
____	ACCESS TO RESOURCES as compared to MAINTENANCE	_____
____	SOCIO-ECONOMICS as compared to JOB CREATION	_____
____	SOCIO-ECONOMICS as compared to MARKET DEMAND	_____
____	SOCIO-ECONOMICS as compared to MAINTENANCE	_____
____	JOB CREATION as compared to MARKET DEMAND	_____
____	JOB CREATION as compared to MAINTENANCE	_____
____	MARKET DEMAND as compared to MAINTENANCE	_____

Each evaluator is requested to provide judgements concerning the relative importance of the various criteria. Please use the standard AHP scale, where 1 means equally preferred, 3 means moderately preferred, 5 means strongly preferred, 7 means very strongly preferred, and 9 means extremely strongly preferred. 2, 4, 6 and 8 are intermediate values.

SUSTAINABLE DEVELOPMENT
PRIORITISATION OF THE CRITERIA

For each comparison, evaluate the relative importance of the options by placing a number next to the preferred option.

Example 1: If BIOPHYSICAL is **strongly preferred** or **strongly more important** than POLITICAL, then:
___5___BIOPHYSICAL as compared to POLITICAL_____

Example 2: If POLITICAL is strongly preferred or strongly more important than BIOPHYSICAL, then:
_____BIOPHYSICAL as compared to POLITICAL____5____

____ PUBLIC OPINION as compared to EQUITY & EMPOWERMENT ____

____ PUBLIC OPINION as compared to POLITICAL NEEDS ____

____ PUBLIC OPINION as compared to LEGISLATIVE COMPLIANCE ____

____ PUBLIC OPINION as compared to CONFLICT RESOLUTION ____

____ EQUITY & EMPOWERMENT as compared to POLITICAL NEEDS ____

____ EQUITY & EMPOWERMENT as compared to LEGISLATIVE COMPLIANCE ____

____ EQUITY & EMPOWERMENT as compared to CONFLICT RESOLUTION ____

____ POLITICAL NEEDS as compared to LEGISLATIVE COMPLIANCE ____

____ POLITICAL NEEDS as compared to CONFLICT RESOLUTION ____

____ LEGISLATIVE COMPLIANCE as compared to CONFLICT RESOLUTION ____

Each evaluator is requested to provide judgements concerning the relative importance of the various criteria. Please use the standard AHP scale, where 1 means equally preferred, 3 means moderately preferred, 5 means strongly preferred, 7 means very strongly preferred, and 9 means extremely strongly preferred. 2, 4, 6 and 8 are intermediate values.

SUSTAINABLE DEVELOPMENT
PRIORITISATION OF THE CRITERIA

Please tick (_) the following box to specify the alternative as stipulated in the environmental scoping report:

Project
Methodology
Materials

Please specify the project/methodological/material alternative used in this case-study:
Alternative 1: _____

Please tick (_) the following box to indicate the significance of the impact associated with alternative 1:

Criterion	Very significant	significant	Moderately significant	Slightly significant	Weakly significant
Water species					
Plant species					
Animal species					
Mitigation/remediation mechanisms					
Pollution (air/water/land)					
Physical location (sensitive areas)					
Current land use					
Geological suitability					
Hydrological factors					
Soil factors					
Urban open spaces/recreation facilities					
Municipal service delivery					
Existing infrastructure					
Traffic and transport					
Health risks					
Noise					

SUSTAINABLE DEVELOPMENT
PRIORITISATION OF THE CRITERIA

Criterion	Very significant	significant	Moderately significant	Slightly significant	Weakly significant
Visual and aesthetic quality					
Education incentives					
Cultural/scientific/historical/archeological value					
Ethics					
Provision if infrastructure					
Access to resources					
Generate revenue					
Socio-economic conditions					
Market demand					
Maintenance					
Create employment					
Public opinion					
Equity and empowerment					
Political needs/agendas					
Legislative/policy compliance					
Conflict resolution					

SUSTAINABLE DEVELOPMENT
PRIORITISATION OF THE CRITERIA

Please tick (_) the following box to specify the alternative as stipulated in the environmental scoping report:

Project
Methodology
Materials

Please specify the project/methodological/material alternative used in this case-study:
Alternative 2: _____

Please tick (_) the following box to indicate the significance of the impact associated with alternative 2:

Criterion	Very significant	significant	Moderately significant	Slightly significant	Weakly significant
Water species					
Plant species					
Animal species					
Mitigation/remediation mechanisms					
Pollution (air/water/land)					
Physical location (sensitive areas)					
Current land use					
Geological suitability					
Hydrological factors					
Soil factors					
Urban open spaces/recreation facilities					
Municipal service delivery					
Existing infrastructure					
Traffic and transport					
Health risks					
Noise					

SUSTAINABLE DEVELOPMENT
PRIORITISATION OF THE CRITERIA

Criterion	Very significant	significant	Moderately significant	Slightly significant	Weakly significant
Visual and aesthetic quality					
Education incentives					
Cultural/scientific/historical/ archeological value					
Ethics					
Provision if infrastructure					
Access to resources					
Generate revenue					
Socio-economic conditions					
Market demand					
Maintenance					
Create employment					
Public opinion					
Equity and empowerment					
Political needs/agendas					
Legislative/policy compliance					
Conflict resolution					

RISK ASSESSMENT
PRIORITISATION OF THE CRITERIA

For each comparison, evaluate the relative importance of the options by placing a number next to the preferred option.

Example 1: If HEALTH is **strongly preferred** or **strongly more important** than POLITICAL, then:
___5___HEALTH as compared to POLITICAL_____

Example 2: If POLITICAL is strongly preferred or strongly more important than HEALTH, then:
_____HEALTH as compared to POLITICAL___5____

____ HEALTH RISKS as compared to ENVIRONMENTAL RISKS _____

____ HEALTH RISKS as compared to SOCIO-ECONOMIC RISKS _____

____ HEALTH RISKS as compared to POLITICAL RISKS _____

____ HEALTH RISKS as compared to RISK OF NON-COMPLETION _____

____ ENVIRONMENTAL RISKS as compared to SOCIO-ECONOMIC RISKS_____

____ ENVIRONMENTAL RISKS as compared to POLITICAL RISKS _____

____ ENVIRONMENTAL RISKS as compared to RISK OF NON-COMPLETION____

____ SOCIO-ECONOMIC RISKS as compared to POLITICAL RISKS _____

____ SOCIO-ECONOMIC RISKS as compared to RISK OF NON-COMPLETION____

____ POLITICAL RISKS as compared to RISK OF NON-COMPLETION _____

Each evaluator is requested to provide judgements concerning the relative importance of the various criteria. Please use the standard AHP scale, where 1 means equally preferred, 3 means moderately preferred, 5 means strongly preferred, 7 means very strongly preferred, and 9 means extremely strongly preferred. 2, 4, 6 and 8 are intermediate values.

RISK ASSESSMENT
PRIORITISATION OF THE CRITERIA

For each comparison, evaluate the relative importance of the options by placing a number next to the preferred option.

Example 1: If HEALTH is strongly preferred or strongly more important than POLITICAL, then:
__5____HEALTH as compared to POLITICAL_____

Example 2: If POLITICAL is strongly preferred or strongly more important than HEALTH, then:
_____HEALTH as compared to POLITICAL____5____

____ ACCIDENTS as compared to ACUTE DISEASES _____

____ ACCIDENTS as compared to LONG-TERM HEALTH EFFECTS _____

____ ACUTE DISEASES as compared to LONG-TERM HEALTH EFFECTS _____

____ DISTURBANCE TO FAUNA as compared to DISTURBANCE TO FLORA ____

____ DISTURBANCE TO FAUNA as compared to DISTURBANCE TO LAND _____

____ DISTURBANCE TO FAUNA as compared to DISTURBANCE TO HYDROLOGY _____

____ DISTURBANCE TO FAUNA as compared to AIR POLLUTION _____

____ DISTURBANCE TO FLORA as compared to DISTURBANCE TO LAND _____

____ DISTURBANCE TO FLORA as compared to DISTURBANCE TO HYDROLOGY _____

____ DISTURBANCE TO FLORA as compared to AIR POLLUTION _____

____ DISTURBANCE TO LAND as compared to DISTURBANCE TO HYDROLOGY _____

____ DISTURBANCE TO LAND as compared to AIR POLLUTION _____

____ DISTURBANCE TO HYDROLOGY as compared to AIR POLLUTION _____

Each evaluator is requested to provide judgements concerning the relative importance of the various criteria. Please use the standard AHP scale, where 1 means equally preferred, 3 means moderately preferred, 5 means strongly preferred, 7 means very strongly preferred, and 9 means extremely strongly preferred. 2, 4, 6 and 8 are intermediate values.

RISK ASSESSMENT
PRIORITISATION OF THE CRITERIA

For each comparison, evaluate the relative importance of the options by placing a number next to the preferred option.

Example 1: If HEALTH is **strongly preferred** or **strongly more important** than POLITICAL, then:
___5____HEALTH as compared to POLITICAL_____

Example 2: If POLITICAL is strongly preferred or strongly more important than HEALTH, then:
_____HEALTH as compared to POLITICAL____5____

____ NEGATIVE ECONOMIC OUTCOMES as compared to LOSS OF PHYSICAL ACCESS TO RESOURCES _____

____ NEGATIVE ECONOMIC OUTCOMES as compared to LOSS OF CULTURAL HERITAGE _____

_____ LOSS OF PHYSICAL ACCESS TO RESOURCES as compared to LOSS OF CULTURAL HERITAGE _____

____ CONFLICT as compared to POLITICAL UNREST _____

____FINANCIAL STABILITY (developer) as compared to ECONOMIC CLIMATE___

Each evaluator is requested to provide judgements concerning the relative importance of the various criteria. Please use the standard AHP scale, where 1 means equally preferred, 3 means moderately preferred, 5 means strongly preferred, 7 means very strongly preferred, and 9 means extremely strongly preferred. 2, 4, 6 and 8 are intermediate values.

RISK ASSESSMENT
PRIORITISATION OF THE CRITERIA

Please tick (_) the following box to indicate the level of risk associated with the following alternative as stipulated in the environmental scoping report:

Project
Methodology
Materials

Please specify the project/methodological/material alternative used in this case-study:

Alternative 1: _____

Criterion	Very High	High	Moderate	Fair	Weak
Potential for accidents					
Acute diseases					
Long-term health effects					
Disturbance to fauna					
Disturbance to flora					
Disturbance to land factors					
Hydrological disturbances					
Potential for air pollution					
Potential for negative economic results					
Loss of access to resources					
Cultural losses					
Potential for conflict					
Political unrest					
Financial stability of the developer					
Economic climate					

RISK ASSESSMENT
PRIORITISATION OF THE CRITERIA

Please tick (_) the following box to indicate the level of risk associated with the following alternative as stipulated in the environmental scoping report:

Project
Methodology
Materials

Please specify the project/methodological/material alternative used in this case-study:

Alternative 1: _____

Criterion	Very High	High	Moderate	Fair	Weak
Potential for accidents					
Acute diseases					
Long-term health effects					
Disturbance to fauna					
Disturbance to flora					
Disturbance to land factors					
Hydrological disturbances					
Potential for air pollution					
Potential for negative economic results					
Loss of access to resources					
Cultural losses					
Potential for conflict					
Political unrest					
Financial stability of the developer					
Economic climate					

APPENDIX 4

QUESTIONNAIRE USED FOR THE APPRAISAL OF THE MULTI-CRITERIA DECISION MODELS

EVALUATION OF THE MULTI-CRITERIA DECISION MODELS

SECTION 1: PERSONAL DETAILS

Name_____

Organisation_____

Department_____

Date____/__/__ Model_____

SECTION 2: ASSESSMENT

1. How relevant is this model for decisions in this field?

_____

_____

_____

2. How easy is it to use (i.e. does it require any specialised training)?

_____

_____

_____

3. Please describe the model's flexibility with respect to its application in different cases (e.g., development proposals, environmental planning, etc.).

_____

_____

_____

_____

4. Please list/describe the features of this model that you find particularly useful:

5. Please indicate your level of satisfaction with this model by ticking (✓) the appropriate box:

Extremely satisfied
Very satisfied
Satisfied
Moderately satisfied
Unsatisfied
Very unsatisfied
Extremely Unsatisfied

6. If applicable, please suggest methods of improving on this model:

7. Please list any other additional comments you have on this model

APPENDIX 5

DETAILED ANALYSIS OF THE PRACTICAL VALIDATION OF THE MULTI-CRITERIA DECISION MODELS IN THREE CASE-STUDIES:

(1) THABA YA BATSWANA DEVELOPMENT PROPOSAL

(2) SHERWOOD LOW-COST HOUSING DEVELOPMENT PROPOSAL

(3) TOURISM DEVELOPMENT AT THRELFALL : KOSI-BAY

CASE-STUDY 1: THABA YA BATSWANA DEVELOPMENT PROPOSAL

Table 1a: Priorities for the factors that define the criteria (at the fourth level of the hierarchy)

Rank	Biological Factors	Flora	Fauna	Mitigate	Pollution	Water species	Local Priority
1	Flora	1	4	2	3	1/3	0.409
2	Fauna	1/4	1	3	3	1/3	0.137
3	Mitigation	1/2	1/3	1	1/3	1/4	0.138
4	Pollution	1/3	1/3	2	1	1/2	0.137
5	Water species	3	3	4	2	1	0.070

Inconsistency = 0.137

Rank	Physical Factors	Mitigate	Pol.	L. U.	Locate	Geol.	Soil	Hydro.	Local Priority
1	Mitigation	1	1	1/3	1	1/4	1/4	1/4	0.260
2	Pollution	1	1	1/4	1	1/3	1/4	1/4	0.251
3	Land use	3	4	1	1	4	4	4	0.154
4	Location	1	1	1	1	3	4	1	0.153
5	Geology	4	3	1/4	1/3	1	1	3	0.069
6	Soil	4	4	1/4	1/4	1	1	2	0.057
7	Hydrology	4	4	1/4	1	1/3	1/2	1	0.055

Inconsistency = 0.087

Rank	Cultural Factors	A/H	Ethics	Educat	Local Priority
1	Archeological/historic value	1	1	2	0.400
2	Ethics	1	1	1/2	0.400
3	Education	1/2	2	1	0.200

Inconsistency = 0.000

Rank	Mental/physical well-being Factors	Aesth.	Poll.	Mit.	Noise	H.R	Local Priority
1	Aesthetics	1	1	3	3	1/7	0.343
2	Pollute	1	1	3	1/3	1/6	0.336
3	Mitigation	1/3	1/3	1	1/3	1/6	0.180
4	Noise	1/3	3	3	1	1/4	0.103
5	Health Risks	7	6	6	4	1	0.038

Inconsistency = 0.053

Rank	Built Environment Factors	UOS	Mitig	Poll	T&T	Mun. SD	Infra	Local Priority
1	Urban open spaces / Recreation facilities	1	2	1	7	5	5	0.359
2	Mitigation	1/2	1	3	1/2	1/5	1/6	0.256
3	Pollution	1	1/3	1	1	1	1/5	0.152
4	Transport & traffic	1/7	2	1	1	1/3	1/4	0.123
5	Municipal service delivery	1/5	5	1	3	1	2	0.059
6	Existing infrastructure	1/5	6	5	4	1/2	1	0.051
				Inconsistency = 0.125				

Rank	Economic Environment Factors	MD	Infra.	Rev.	PA	JC	S-E	Maint.	Local Priority
1	Market demand	1	1/3	1/2	1/2	3	1/3	1	0.221
2	Infrastructure	3	1	3	2	3	1	4	0.219
3	Revenue	2	1/3	1	3	3	2	3	0.209
4	Physical access	2	1/2	1/3	1	2	2	3	0.102
5	Job creation	1/3	1/3	1/3	1/2	1	1	1/2	0.092
6	Socio-econ. Status	3	1	1/2	1/2	1	1	1	0.086
7	Maintenance	1	1/4	1/3	1/3	2	1	1	0.072
				Inconsistency = 0.136					

Rank	Political Factors	Legis.	Equity	PP	CR	PN	Local Priority
1	Legislative compliance	1	1/4	1/4	3	1/4	0.476
2	Equity	4	1	1	2	2	0.167
3	Public participation	4	1	1	1	2	0.141
4	Conflict resolution	1/3	1/2	1	1	2	0.133
5	Political needs	4	1/2	1/2	1/2	1	0.082
				Inconsistency = 0.020			

Note: An inconsistency ratio of 1.5 and less was deemed acceptable in this study. The definitions of the various attributes, factors and objectives are provided in section 5.4.1 of chapter 5.

Table 1b: Priorities for the alternatives using pairwise comparisons

Water species	H/C	Comm	Priority
Hotel/conference centre	1	2	0.667
Commercial node	1/2	1	0.333
Inconsistency = 0.000			

Plant species	H/C	Comm	Priority
Hotel/conference centre	1	5	0.833
Commercial node	1/5	1	0.167
Inconsistency = 0.000			

Animal species	H/C	Comm	Priority
Hotel/conference centre	1	1/4	0.2
Commercial node	4	1	0.8
Inconsistency = 0.000			

Pollution	H/C	Comm	Priority
Hotel/conference centre	1	2	0.667
Commercial node	1/2	1	0.333
Inconsistency = 0.000			

Mitigate/remediate	H/C	Comm	Priority
Hotel/conference centre	1	3	0.750
Commercial node	1/3	1	0.250
Inconsistency = 0.000			

Physical location	H/C	Comm	Priority
Hotel/conference centre	1	5	0.833
Commercial node	1/5	1	0.167
Inconsistency = 0.000			

Current Land use	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Geological suitability	H/C	Comm	Priority
Hotel/conference centre	1	2	0.667
Commercial node	1/2	1	0.333
Inconsistency = 0.000			

Soil factors	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Hydrological factors	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Urban open space	H/C	Comm	Priority
Hotel/conference centre	1	4	0.800
Commercial node	1/4	1	0.200
Inconsistency = 0.000			

Municipal services	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Existing infrastructure	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Transport & traffic	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Health risks	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Aesthetic quality	H/C	Comm	Priority
Hotel/conference centre	1	5	0.833
Commercial node	1/5	1	0.167
Inconsistency = 0.000			

Noise	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Cultural/historical factors	H/C	Comm	Priority
Hotel/conference centre	1	2	0.667
Commercial node	1/2	1	0.333
Inconsistency = 0.000			

Education	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Ethics	H/C	Comm	Priority
Hotel/conference centre	1	2	0.667
Commercial node	1/2	1	0.333
Inconsistency = 0.000			

Provide infrastructure	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Generate revenue	H/C	Comm	Priority
Hotel/conference centre	1	3	0.750
Commercial node	1/3	1	0.250
Inconsistency = 0.000			

Access to resources	H/C	Comm	Priority
Hotel/conference centre	1	2	0.667
Commercial node	1/2	1	0.333
Inconsistency = 0.000			

Socio-economic status	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Job creation	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Public opinion	H/C	Comm	Priority
Hotel/conference centre	1	4	0.800
Commercial node	1/4	1	0.200
Inconsistency = 0.000			

Job creation	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Public opinion	H/C	Comm	Priority
Hotel/conference centre	1	4	0.800
Commercial node	1/4	1	0.200
Inconsistency = 0.000			

Equity/empower	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Political needs	H/C	Comm	Priority
Hotel/conference centre	1	1	0.500
Commercial node	1	1	0.500
Inconsistency = 0.000			

Legislation	H/C	Comm	Priority
Hotel/conference center	1	2	0.667
Commercial node	1/2	1	0.333
Inconsistency = 0.000			

Conflict resolution	H/C	Comm	Priority
Hotel/conference centre	1	3	0.750
Commercial node	1/3	1	0.250
Inconsistency = 0.000			

Table 1c: Rating of the project alternatives on the intensities

Criterion		Priority	Significance Rating of Alternatives	
			Hotel/Conference Centre	Commercial Node
Biological Factors	Water species	0.019	Weakly significant	Slightly significant
	Flora	0.114	Significant	Moderately Significant
	Fauna	0.069	Significant	Moderately Significant
	Pollution	0.038	Moderately significant	Moderately significant
	Mitigation/remediation	0.038	Significant	Weakly Significant
Physical Factors	Physical location	0.043	Slightly significant	Weakly significant
	Land use	0.043	Slightly Significant	Slightly Significant
	Geological suitability	0.019	Moderately Significant	Slightly Significant
	Soil factors	0.016	Significant	Significant
	Hydrological factors	0.015	Weakly Significant	Weakly Significant
	Pollution	0.070	Moderately significant	Moderately significant
	Mitigation/remediation	0.072	Significant	Weakly Significant
Built Environment	Urban open spaces	0.017	Very Significant	Very Significant
	Municipal services	0.003	Moderately Significant	Slightly Significant
	Existing infrastructure	0.002	Moderately Significant	Moderately Significant
	Transport & traffic	0.006	Moderately Significant	Moderately Significant
	Pollution	0.007	Significant	Slightly Significant
	Mitigation/remediation	0.012	Significant	Slightly Significant
Mental/physical well-being	Health risks	0.003	Weakly significant	Weakly significant
	Aesthetic quality	0.023	Very Significant	Very Significant
	Noise	0.007	Weakly Significant	Weakly Significant
	Pollution	0.023	Significant	Slightly significant
	Mitigation/remediation	0.012	Significant	Slightly significant
Cultural Factors	Historic/archeological	0.039	Very significant	Very significant
	Education	0.020	Slightly significant	Slightly significant
	Ethics	0.039	Slightly significant	Slightly significant
Economic Factors	Generate revenue	0.025	Moderately significant	Moderately significant
	Provide infrastructure	0.026	Slightly significant	Slightly significant
	Job creation	0.011	Slightly significant	Slightly significant
	Socio-economics	0.010	Slightly significant	Slightly significant
	Market demand	0.026	Moderately significant	Slightly significant
	Maintain infrastructure	0.009	Moderately significant	Moderately significant
	Access to resources	0.012	Significant	Significant

Criterion		Priority	Significance Rating of Alternatives	
			Hotel/Conference Centre	Commercial Node
Political Factors	Public opinion	0.016	Moderately significant	Weakly significant
	Equity & empowerment	0.019	Weakly significant	Weakly significant
	Political needs	0.009	Significant	Slightly significant
	Legislative compliance	0.053	Moderately significant	Weakly significant
	Conflict resolution	0.015	Significant	Weakly significant
Total	Normalised		0.609	0.391

CASE-STUDY 2

SHERWOOD LOW-COST HOUSING DEVELOPMENT

2.1 Judgements from the perspective of the middle-class community located adjacent to the proposed development site

Note: An inconsistency ratio of 1.5 and less was deemed acceptable in this study. The definitions of the various attributes, factors and objectives are provided in section 5.4.1 of chapter 5.

Table 2.1(a): Pairwise comparisons of the sub-criteria with respect to the main goal, to assess the potential environmental impacts associated with the low-cost housing development proposal

Rank	Factor (Overall goal)	Biophysical	Social	Economic	Political	Priority
1	Biophysical	1	5	8	6	0.64
2	Social	1/5	1	4	2	0.18
3	Political	1/6	1/2	5	1	0.133
4	Economic	1/8	1/4	1	1/5	0.047
			Inconsistency = 0.089			

Table 2.1(b): Priorities for the factors that define the criteria (at the third level of the hierarchy).

Rank	Factor (Biophysical)	Biol.	Phys.	Local Priority
1	Biological	1	9	0.900
2	Physical	1/9	1	0.100
	Inconsistency = 0.000			

Rank	Factor (Social)	Built	Health	Culture	Local Priority
1	Built	1	9	1	0.474
2	Culture	1/9	9	1	0.474
3	Health	1/9	1	1/9	0.053
	Inconsistency = 0.000				

Table 2.1(c): Priorities for the factors that define the criteria (at the fourth level of the hierarchy).

Rank	Biological Factors	Flora	Pollution	Local Priority
1	Flora	1	9	0.900
2	Pollution	1/9	1	0.100
		Inconsistency = 0.000		

Rank	Physical Factors	Locate	L. U.	Geol.	Soil	Hydro.	Poll.	Local Priority
1	Location	1	9	9	9	9	9	0.608
2	Geology	1/9	7	1	9	1	1	0.163
3	Hydrology	1/9	1	1	1	1	1	0.068
4	Pollution	1/9	1	1	1	1	1	0.068
5	Land use	1/9	1	1/7	1	1	1	0.047
6	Soil	1/9	1	1/9	1	1	1	0.046

Inconsistency = 0.127

Rank	Cultural Factors	A/H	Educate	Ethics	Local Priority
1	Education	9	1	4	0.709
2	Ethics	5	1/4	1	0.231
3	Archeological/historic value	1	1/9	1/5	0.060

Inconsistency = 0.068

Rank	Mental/physical well-being Factors	Aesth.	Poll.	Noise	H.R	Local Priority
1	Aesthetics	1	7	5	9	0.669
2	Pollute	1/7	1	3	5	0.187
3	Noise	1/5	1/3	1	3	0.100
4	Health Risks	1/9	1/5	1/3	1	0.044

Inconsistency = 0.110

Rank	Built Environment Factors	UOS	Poll	T&T	Local Priority
1	Urban open spaces / Recreation facilities	1	9	9	0.818
3	Pollution	1/9	1	1	0.091
4	Transport & traffic	1/9	1	1	0.091

Inconsistency = 0.000

Rank	Economic Environment Factors	MD	Infra.	Rev.	PA	JC	S-E	Maint.	Local Priority
1	Physical access	3	5	5	1	2	1/2	3	0.235
2	Job creation	1	1	1	1/2	1	1/5	1	0.078
3	Market demand	1	1	1	1/3	1	1/5	1	0.072
4	Socio-econ. Status	5	8	7	2	5	1	5	0.072
5	Maintenance	1	1	1	1/3	1	1/5	1	0.072
6	Revenue	1	1	1	1/5	1	1/7	1	0.064
7	Infrastructure	1	1	1	1/5	1	1/8	1	0.063
					Inconsistency = 0.011				

Rank	Political Factors	Legis.	Equity	PP	CR	PN	Local Priority
1	Public participation	1	5	1	1	3	0.313
2	Conflict resolution	1	3	1	1	2	0.254
3	Legislative compliance	1	2	1	1	1	0.210
4	Political needs	1	2	1/3	1/2	1	0.145
5	Equity	1/2	1	1/5	1/3	1/2	0.079
				Inconsistency = 0.030			

Table 2.2(a): Pairwise comparisons of the sub-criteria with respect to the main goal, to assess the risks associated with the low-cost housing development proposal from the point of view of the middle class community

Rank	Risk factors	Environ.	S.E.	Political	Priority
1	Environmental	1	7	9	0.785
2	Socio-economic	1/7	1	3	0.149
3	Political	1/9	1/3	1	0.066
		Inconsistency = 0.077			

Table 2.2(b): Priorities for the factors that define the risk criteria (at the third level of the hierarchy)

Rank	Environmental risks	Hydro.	Flora	Fauna	Land	Air	Priority
1	Hydrology	1	1	4	4	7	0.363
2	Flora	1	1	1	6	8	0.321
3	Fauna	1/4	1	1	1	9	0.169
4	Land pollution	1/4	1/6	1	1	9	0.121
5	Air pollution	1/7	1/8	1/9	1/9	1	0.027
			Inconsistency = 0.134				

Rank	Socio-economic risks	Economics	Access	Culture	Priority
1	Economic loss	1	2	4	0.584
2	Access	1/2	1	1	0.232
3	Culture	1/4	1	1	0.184
		Inconsistency = 0.051			

Rank	Political risks	Conflict	Unrest	Priority
1	Conflict	1	9	0.900
2	Unrest	1/9	1	0.100
		Inconsistency = 0.000		

2.3 Judgements from the perspective of the poor community to be located in the proposed low-cost housing development site

Table 2.3(a): Pairwise comparisons of the sub-criteria with respect to the main goal, to assess the potential environmental impacts associated with the low-cost housing development proposal

Rank	Factor (Overall goal)	Biophysical	Social	Economic	Political	Priority
1	Social	7	1	5	3	0.576
2	Economic	6	1/5	1	2	0.217
3	Political	5	1/3	1/2	1	0.161
4	Biophysical	1	1/7	1/6	1/5	0.046
		Inconsistency = 0.107				

Table 2.3(b): Priorities for the factors that define the criteria (at the third level of the hierarchy)

Rank	Factor (Biophysical)	Biol.	Phys.	Local Priority
1	Physical	1/2	1	0.667
2	Biological	1	2	0.333
	Inconsistency = 0.000			

Rank	Factor (Social)	Culture	Health	Built	Local Priority
1	Culture	1	1	5	0.466
2	Health	1	1	4	0.433
3	Built	1/5	1/4	1	0.100
	Inconsistency = 0.005				

Table 2.3(c): Priorities for the factors that define the criteria (at the fourth level of the hierarchy)

Rank	Biological Factors	Flora	Pollution	Local Priority
1	Flora	1	9	0.900
4	Pollution	1/9	1	0.100
	Inconsistency = 0.000			

Rank	Physical Factors	Locate	L. U.	Geol.	Soil	Hydro.	Poll.	Local Priority
1	Location	1	9	9	9	9	9	0.608
2	Geology	1/9	7	1	9	1	1	0.163
3	Hydrology	1/9	1	1	1	1	1	0.068
4	Pollution	1/9	1	1	1	1	1	0.068
5	Land use	1/9	1	1/7	1	1	1	0.047
6	Soil	1/9	1	1/9	1	1	1	0.046

Inconsistency = 0.127

Rank	Cultural Factors	A/H	Educate	Ethics	Local Priority
1	Education	9	1	4	0.709
2	Ethics	5	1/4	1	0.231
3	Archeological/historic value	1	1/9	1/5	0.060

Inconsistency = 0.068

Rank	Mental/physical well-being Factors	Aesth.	Poll.	Noise	H.R	Local Priority
1	Aesthetics	1	7	5	9	0.669
2	Pollute	1/7	1	3	5	0.187
3	Noise	1/5	1/3	1	3	0.100
4	Health Risks	1/9	1/5	1/3	1	0.044

Inconsistency = 0.110

Rank	Built Environment Factors	UOS	Poll	T&T	Local Priority
1	Urban open spaces / Recreation facilities	1	9	9	0.818
3	Pollution	1/9	1	1	0.091
4	Transport & traffic	1/9	1	1	0.091

Inconsistency = 0.000

Rank	Economic Environment Factors	S-E	MD	Maint.	Infra.	JC	PA	Rev.	Local Priority
1	Socio-econ. Status	1	2	2	6	5	9	8	0.339
2	Market demand	1/2	1	3	5	8	9	9	0.297
3	Maintenance	1/2	1/3	1	1	8	8	8	0.156
4	Infrastructure	1/6	1/5	1	1	6	7	9	0.128
5	Job creation	1/5	1/8	1/8	1/6	1	1	1	0.030
6	Physical access	1/9	1/9	1/8	1/7	1	1	2	0.028
7	Revenue	1/8	1/9	1/8	1/9	1	1/2	1	0.023
				Inconsistency = 0.080					

Rank	Political Factors	Equity	PP	PN	CR	Legis.	Local Priority
1	Equity	1	1	5	6	6	0.436
2	Public participation	1	1	2	4	3	0.294
3	Political needs	1/5	1/2	1	1	2	0.113
4	Conflict resolution	1/6	1/4	1	1	1	0.081
5	Legislative compliance	1/6	1/3	1/2	1	1	0.075
				Inconsistency = 0.026			

Table 2.4(a): Pairwise comparisons of the sub-criteria with respect to the main goal, to assess the risks associated with the low-cost housing development proposal

Rank	Risk factors	Environ.	Political	Social	Priority
1	Environmental	1	1	9	0.490
2	Political	1	1	7	0.451
3	Socio-economic	1/9	1/7	1	0.059
			Inconsistency = 0.007		

Table 2.4(b): Priorities for the factors that define the risk criteria (at the third level of the hierarchy)

Rank	Environmental risks	Hydro	Flora	Fauna	Land	Air	Priority
1	Hydrology	1	1	4	4	7	0.363
2	Flora	1	1	1	6	8	0.321
3	Fauna	1/4	1	1	1	9	0.169
4	Land pollution	1/4	1/6	1	1	9	0.121
5	Air pollution	1/7	1/8	1/9	1/9	1	0.027
			Inconsistency = 0.134				

Rank	Socio-economic risks	Economics	Access	Culture	Priority
1	Economic loss	1	1	1	0.333
2	Access	1	1	1	0.333
3	Culture	1	1	1	0.333
		Inconsistency = 0.000			

Rank	Political risks	Conflict	Unrest	Priority
1	Conflict	1	1	0.500
2	Unrest	1	1	0.500
		Inconsistency = 0.000		

Table 2.5: Rating of the urban poor and middle-class communities on the intensities

Criterion		Significance Rating of Alternatives			
		Urban poor	Priority	Middle-class	Priority
Biological Factors	Flora	Very significant	0.0060	Weakly significant	0.5186
	Pollution	Significant	0.0070	Weakly significant	0.0576
Physical Factors	Physical location	Very significant	0.0090	Moderately significant	0.0389
	Land use	Very Significant	0.0007	Weakly significant	0.0030
	Geological suitability	Weakly significant	0.0024	Weakly significant	0.0105
	Soil factors	Weakly significant	0.0007	Weakly significant	0.0030
	Hydrological factors	Very significant	0.0010	Weakly significant	0.0043
	Pollution	Significant	0.0010	Weakly significant	0.0043
Built Environment	Urban open spaces	Very significant	0.0343	Weakly significant	0.0697
	Transport & traffic	Weakly significant	0.0038	Weakly significant	0.0077
	Pollution	Significant	0.0038	Weakly significant	0.0077
Mental/physical well-being	Health risks	Weakly significant	0.0079	Weakly significant	0.0004
	Aesthetic quality	Very Significant	0.1208	Moderately significant	0.0063
	Noise	Very significant	0.0180	Weakly Significant	0.0009
	Pollution	Significant	0.0337	Weakly significant	0.0018
Cultural Factors	Historic/archeological	Very significant	0.0117	Weakly significant	0.0051
	Education	Very significant	0.1377	Very significant	0.0603
	Ethics	Very significant	0.0449	Moderately significant	0.0197
Economic Factors	Generate revenue	Weakly significant	0.0084	Weakly significant	0.0030
	Provide infrastructure	Very significant	0.0469	Weakly significant	0.0030
	Job creation	Weakly significant	0.0108	Weakly significant	0.0036
	Socio-economics	Very significant	0.1244	Very significant	0.0195
	Market demand	Very significant	0.1087	Very significant	0.0034
	Maintain infrastructure	Very significant	0.0573	Very significant	0.0034
	Access to resources	Slightly significant	0.0101	Very significant	0.0110
Political Factors	Public opinion	Very significant	0.0573	Very significant	0.0416
	Equity & empowerment	Very significant	0.0849	Very significant	0.0105
	Political needs	Very significant	0.0220	Very significant	0.0193
	Legislative compliance	Weakly significant	0.0146	Weakly significant	0.0280
	Conflict resolution	Weakly significant	0.0158	Weakly significant	0.0338
Normalised Total		0.637		0.334	

Table 2.6: Rating the levels of risk associated with the proposed low-cost housing development in an urban open space, for the urban poor and the inhabitants (middle-class community) adjacent to the proposed site for the development, on the intensities.

Risk factors		Priority	Levels of Risk Rating of Alternatives	
			Urban poor	Middle-class community
Environmental	Fauna	0.1325	Very high	Very high
	Flora	0.2517	Very high	Very high
	Land degradation	0.0950	Very high	Very high
	Hydrology	0.2850	Very high	Very high
	Air pollution	0.0212	Weak	Weak
Socio-economic	Economic loss	0.0869	Very high	Weak
	Access	0.0345	Very high	Weak
	Cultural heritage	0.0274	Weak	Weak
Political	Conflict	0.0592	Very high	Very high
	Unrest	0.0066	Very high	Very high
	Normalised Total		**0.531**	**0.469**

CASE-STUDY 3

TOURISM DEVELOPMENT IN KOSI BAY

3.1 Judgements from the perspective of stakeholders who were in favour of the development project.

Note: An inconsistency ratio of 1.5 and less was deemed acceptable in this study. The definitions of the various attributes, factors and objectives are provided in section 5.4.1 of chapter 5.

Table 3.1(a): Pairwise comparisons of the sub-criteria with respect to the main goal (sustainable development), to assess the potential environmental impacts associated with the Kosi-Bay tourism development proposal

Rank	Factor (Overall goal)	Social	Economic	Political	Biophysical	Priority
1	Social	1	6.3	4.2	4.9	0.614
2	Economic	1/6.3	1	3	1.7	0.181
3	Political	1/4.2	1/3.0	1	2.3	0.120
4	Biophysical	1/4.9	1/1.7	1/2.3	1	0.085
			Inconsistency = 0.128			

Table 3.1(b): Priorities for the factors that define the criteria (at the third level of the hierarchy)

Rank	Factor (Biophysical)	Biol.	Phys.	Local Priority
1	Biological	1	1.7	0.631
2	Physical	1/1.7	1	0.369
	Inconsistency = 0.000			

Rank	Factor (Social)	Culture	Health	Built	Local Priority
1	Culture	1	1/7.6	1/6.8	0.589
2	Health	7.6	1	1/2.3	0.348
3	Built	6.8	2.3	1	0.063
	Inconsistency = 0.098				

Table 3.1(c): Priorities for the factors that define the criteria (at the fourth level of the hierarchy)

Rank	Biological Factors	Flora	Mitig.	Water spp.	Pollution	Fauna	Local Priority
1	Flora	1	1/2.1	7.9	2.3	6.4	0.374
2	Mitigate	2.1	1	2.8	2.7	4.2	0.352
3	Water species	1/7.9	1/2.8	1	1.6	1/7.9	0.120
4	Pollution	1/2.3	1/2.7	1/1.6	1	1/1.5	0.088
5	Fauna	1/6.4	1/4.2	7.9	1.5	1	0.066

Inconsistency = 0.148

Rank	Physical Factors	Mitig.	Soil	Hydro.	Geol.	Locate	L.U.	Poll.	Local Priority
1	Mitigate/remediate	1	1.7	1.9	1.9	1.9	5.3	4.6	0.266
2	Soil	1/1.7	1	1.8	1/1.6	1/1.1	2.5	5.5	0.174
3	Hydrology	1/1.9	1/1.8	1	1.6	1	2.9	1.8	0.138
4	Geology	1/1.9	1.6	1/1.6	1	1	2.5	1.3	0.134
5	Location	1/1.9	1.1	1	1	1	1.9	1/2.0	0.116
6	Land use	1/5.3	1/2.5	1/2.9	1/2.5	1/1.9	1	5.6	0.097
7	Pollution	1/4.6	1/5.5	1/1.8	1/1.3	2	1/5.6	1	0.073

Inconsistency = 0.140

Rank	Cultural Factors	A/H	Ethics	Educate	Local Priority
1	Archeological/historic value	1	5.8	5.8	0.739
2	Ethics	1/5.8	1	2.1	0.162
3	Education	1/5.8	1/2.1	1	0.099

Inconsistency = 0.059

Rank	Mental/physical well-being Factors	Aesth.	H.R	Mitig.	Poll.	Noise	Local Priority
1	Aesthetics	1	1.9	1.6	4.3	6.9	0.387
2	Health Risks	1/1.9	1	1/1.2	1/1.8	1/6.1	0.234
3	Mitigate/remediate	1/1.6	1.2	1	3.6	1/1.1	0.205
4	Pollute	1/4.3	1.8	1/3.6	1	1.4	0.088
5	Noise	1/6.9	6.1	1.1	1/1.4	1	0.085

Inconsistency = 0.111

Rank	Built Environment Factors	Service	UOS	T&T	Mit.	Poll.	Infra	Local Priority
1	Municipal service delivery	1	1.6	1/1.7	3.9	1.7	4.7	0.277
2	Urban open spaces / Recreation facilities	1/1.6	1	2	2	1.2	5	0.231
3	Transport & traffic	1.7	1/2.0	1	1/1.7	1.4	1/1.8	0.150
4	Mitigate/remediate	1/3.9	1/2.0	1.7	1	1.4	2.3	0.138
5	Pollution	1/1.7	1/1.2	1/1.4	1/1.4	1	1/1.1	0.109
6	Existing infrastructure	1/4.7	1/5.0	1.8	1/2.3	1.1	1	0.095
			Inconsistency = 0.141					

Rank	Economic Environment Factors	JC	PA	S-E	MD	Rev.	Maint.	Infra.	Local Priority
1	Job creation	1	1.7	3.1	3.1	6.5	5.9	8.3	0.341
2	Physical access	1/1.7	1	1.1	5.6	1/1.7	6.2	6.5	0.230
3	Socio-econ. Status	1/3.1	1/1.1	1	1/1.1	1.7	1.6	6.8	0.126
4	Market demand	1/3.1	1/5.6	1.1	1	1.3	1.9	5.9	0.101
5	Revenue	1/6.5	1.7	1/1.7	1/1.3	1	1/2.6	1.9	0.096
6	Maintenance	1/5.9	1/6.2	1/1.6	1/1.9	2.6	1	3.3	0.080
7	Infrastructure	1/8.3	1/6.5	1/6.8	1/5.9	1/1.9	1/1.3	1	0.026
				Inconsistency = 0.134					

Rank	Political Factors	Legis.	Equity	CR	PP	PN	Local Priority
1	Legislative compliance	1	1.9	1/1.5	2.5	3.6	0.303
2	Equity	1/1.9	1	1	7.6	3.1	0.293
3	Conflict resolution	1.5	1	1	4.2	3.5	0.245
4	Public participation	1/2.5	1/7.6	1/4.2	1	4	0.100
5	Political needs	1/3.6	1/3.1	1/3.5	1/4.0	1	0.06
			Inconsistency = 0.132				

Table 3.2(a): Pairwise comparisons of the sub-criteria with respect to the main goal, to assess the risks associated with the Kosi-Bay tourism development proposal

Rank	Risk factors	Non-complete	S.E.	Environ.	Political	Health	Priority
1	Non-completion	1	3.1	1.8	5.6	6.5	0.443
2	Socio-economic	1/3.1	1	2	1.8	5.6	0.213
3	Environmental	1/1.8	1/2.0	1	1/2.0	7.2	0.166
4	Political	1/5.6	1/1.8	2	1	1.7	0.132
5	Health	1/6.5	1/5.6	1/7.2	1/1.7	1	0.046

Inconsistency = 0.121

Table 3.2(b): Priorities for the factors that define the risk criteria (at the third level of the hierarchy)

Rank	Health risks	Disease	Accident	Long-term	Priority
1	Diseases	1	2.3	3	0.567
2	Accidents	1/2.3	1	1.3	0.243
3	Long-term effects	1/3.0	1/1.3	1	0.190

Inconsistency = 0.000

Rank	Environmental risks	Land	Hydro.	Flora	Air	Fauna	Priority
1	Land pollution	1	1.8	1.7	5.6	5.6	0.412
2	Hydrology	1/1.8	1	2	1/1.2	3.1	0.214
3	Flora	1/1.7	1/2.0	1	1.6	3.1	0.178
4	Air pollution	1/5.6	1.2	1/1.6	1	1/1.4	0.114
5	Fauna	1/5.6	1/3.1	1/3.1	1.4	1	0.081

Inconsistency = 0.084

Rank	Socio-economic risks	Culture	Access	Socio-eco.	Priority
1	Culture	1	1.8	1.9	0.477
2	Access	1/1.8	1	1.5	0.298
3	Economic loss	1/1.9	1/1.5	1	0.225

Inconsistency = 0.014

Rank	Political risks	Unrest	Conflict	Priority
1	Unrest	1	7.2	0.878
2	Conflict	1/7.2	1	0.122
Inconsistency = 0.000				

Rank	Risk of non-completion	Eco.	Finance	Priority
1	Economic climate	1	4.7	0.825
2	Financial stability	1/4.7	1	0.175
Inconsistency = 0.000				

3.3 Judgements from the perspective of those who were opposed to the development project.

Table 3.3(a): Pairwise comparisons of the sub-criteria with respect to the main goal, to assess the potential environmental impacts associated with the Kosi-Bay tourism development proposal

Rank	Factor (Overall goal)	Biophysical	Social	Economic	Political	Priority
1	Biophysical	1.0	2.0	6.3	7.6	0.522
2	Social	1/2.0	1.0	3.7	7.0	0.306
3	Economic	1/6.3	1/3.7	1.0	7.0	0.133
4	Political	1/7.6	1/7.0	1/7.0	1.0	0.039

Inconsistency = 0.127

Table 3.3(b): Priorities for the factors that define the criteria (at the third level of the hierarchy)

Rank	Factor (Biophysical)	Biol.	Phys.	Local Priority
1	Biological	1.0	7.0	0.875
2	Physical	1/7.0	1.0	0.125

Inconsistency = 0.000

Rank	Factor (Social)	Culture	Health	Built	Local Priority
1	Culture	1.0	2.0	7.0	0.576
2	Health	1/2.0	1.0	6.8	0.358
3	Built	1/7.0	1/6.8	1.0	0.066

Inconsistency = 0.048

Table 3.3(c): Priorities for the factors that define the criteria (at the fourth level of the hierarchy)

Rank	Biological Factors	Water spp	Flora	Fauna	Mitig.	Pollution	Local Priority
1	Water species	1.0	2.6	1.4	6.4	3.4	0.374
2	Flora	1/2.6	1.0	2.8	7.2	3.5	0.352
3	Fauna	1/1.4	1/2.8	1.0	7.2	3.5	0.120
4	Mitigate	1/6.4	1/7.2	1/7.2	1.0	1/2.0	0.088
5	Pollution	1/3.4	1/3.5	1/3.5	2.0	1.0	0.066

Inconsistency = 0.125

Rank	Physical Factors	L.U.	Hydro.	Locate	Soil	Poll.	Geology	Mitig.	Local Priority
1	Land use	1.0	3.5	1/1.3	5.9	6.8	5.9	3.8	0.341
2	Hydrology	1/3.5	1.0	1.1	5.9	1.3	3.0	2.9	0.188
3	Location	1.3	1/1.1	1.0	1.8	1.8	2.7	3.8	0.184
4	Soil	1/5.9	1/5.9	1/1.8	1.0	5.6	1.6	1/1.6	0.097
5	Pollution	1/6.8	1/1.3	1/1.8	1/5.6	1.0	1/1.6	1.7	0.065
6	Geology	1/5.9	1/3.0	1/2.7	1/1.6	1.6	1.0	1.5	0.063
7	Mitigation	1/3.8	1/2.9	1/3.8	1.6	1/1.7	1/1.5	1.0	0.062

Inconsistency = 0.138

Rank	Cultural Factors	Ethics	A/H	Educate	Local Priority
1	Ethics	1.0	1/1.3	5.3	0.458
2	Archeological/historic value	1.3	1.0	2.4	0.419
3	Education	1/5.3	1/2.4	1.0	0.123

Inconsistency = 0.119

Rank	Mental/physical well-being Factors	H.R.	Aesth.	Poll.	Noise	Mitig.	Local Priority
1	Health Risks	1.0	1/2.0	2.0	1.5	2.8	0.528
2	Aesthetics	2.0	1.0	7.3	6.8	6.8	0.191
3	Pollute	1/2.0	1/7.3	1.0	2.7	2.4	0.131
4	Noise	1/1.5	1/6.8	1/2.7	1.0	1/4.0	0.095
5	Mitigate/remediate	1/2.8	1/6.8	1/2.4	4.0	1.0	0.054

Inconsistency = 0.088

Rank	Built Environment Factors	Infra.	T&T	Poll.	UOS	MSD	Mitig.	Local Priority
1	Existing infrastructure	1.0	1/1.2	1/1.6	2.4	1.9	1.9	0.277
2	Transport & traffic	1.2	1.0	1/1.1	1.1	1.4	2.9	0.231
3	Pollution	1.6	1.1	1.0	1.9	1/1.5	2.9	0.150
4	Urban open spaces / Recreation facilities	1/2.4	1/1.1	1/1.9	1.0	4.2	1/1.1	0.138
5	Municipal service delivery	1/1.9	1/1.4	1.5	1/4.2	1.0	2.0	0.109
6	Mitigate/remediate	1/1.9	1/2.9	1/2.9	1.1	1/2.0	1.0	0.095

Inconsistency = 0.116

Rank	Economic Environment Factors	PA	S-E	JC	Infra.	MD	Maint.	Rev.	Local Priority
1	Physical access	1.0	1.3	2.3	1.4	3.7	4.0	2.3	0.258
2	Socio-econ. Status	1/1.3	1.0	1.4	1.3	5.3	5.0	4.0	0.244
3	Job creation	1/2.3	1/1.4	1.0	1.4	3.8	4.0	4.4	0.189
4	Infrastructure	1/1.4	1/1.3	1/1.4	1.0	1/1.4	1/1.4	1.1	0.101
5	Market demand	1/3.7	1/5.3	1/3.8	1.4	1.0	1.0	3.5	0.082
6	Maintenance	1/4.0	1/5.0	1/4.0	1.4	1.0	1.0	3.5	0.081
7	Revenue	1/2.3	1/4.0	1/4.4	1/1.1	1/3.5	1/3.5	1.0	0.045

Inconsistency = 0.082

Rank	Political Factors	PP	CR	Equity	Legisl.	PN	Local Priority
1	Public participation	1.0	1/1.5	5.5	4.0	6.2	0.422
2	Conflict resolution	1.5	1.0	1/1.7	1.8	3.4	0.234
3	Equity & empowerment	1/5.5	1.7	1.0	3.7	3.2	0.206
4	Legislative compliance	1/4.0	1/1.8	1/3.7	1.0	1.9	0.085
5	Political needs	1/6.2	1/3.4	1/3.2	1/1.9	1.0	0.053

Inconsistency = 0.143

Table 3.4(a): Pairwise comparisons of the sub-criteria with respect to the main goal, to assess the risks associated with the Kosi-Bay tourism development proposal

Rank	Risk factors	Environ.	S.E	Health	Political	Non-complete	Priority
1	Environmental	1.0	6.6	2.3	7.2	7.2	0.557
2	Socio-economic	1/6.6	1.0	1.6	5.2	5.2	0.204
3	Health	1/2.3	1/1.6	1.0	1.2	1/1.1	0.111
4	Political	1/7.2	1/5.2	1/1.2	1.0	1.4	0.065
5	Non-completion	1/7.2	1/5.2	1.1	1/1.4	1.0	0.063

Inconsistency = 0.125

Table 3.4(b): Priorities for the factors that define the risk criteria (at the third level of the hierarchy)

Rank	Health risks	Disease	Accident	Long-term	Priority
1	Diseases	1.0	1/2.1	1/1.2	0.480
2	Accidents	2.1	1.0	1.7	0.286
3	Long-term effects	1.2	1/1.7	1.0	0.234
			Inconsistency = 0.000		

Rank	Environmental risks	Flora	Fauna	Land	Hydro.	Air	Priority
1	Flora	1.0	1.1	1.7	1.7	7.0	0.316
2	Fauna	1/1.1	1.0	1/1.7	1.4	5.5	0.239
3	Land pollution	1/1.7	1.7	1.0	1/1.8	1.9	0.190
4	Hydrology	1/1.7	1/1.4	1.8	1.0	1.8	0.188
5	Air pollution	1/7.0	1/5.5	1/1.9	1/1.8	1.0	0.067
			Inconsistency = 0.077				

Rank	Socio-economic risks	Access	Culture	Economic loss	Priority
1	Access	1.0	1/1.1	2.0	0.402
2	Culture	1.1	1.0	1/1.3	0.312
3	Economic loss	1/2.0	1/1.3	1.0	0.286
			Inconsistency = 0.118		

Rank	Political risks	Conflict	Unrest	Priority
1	Conflict	1.0	2.1	0.68
2	Unrest	1/2.1	1.0	0.32
		Inconsistency = 0.000		

Rank	Risk of non-completion	Eco.	Finance	Priority
1	Economic climate	1.0	3.9	0.797
2	Financial stability	1/3.9	1.0	0.203
		Inconsistency = 0.000		

Table 3.5: Rating the significance of the impacts of the proposed project site alternatives on the intensities with regard to the goal of sustainable development

Criterion		Priority	Significance Rating of Alternatives	
			Old Trading Store	Threlfall
Biological Factors	Water species	0.0064	0.425	0.536
	Flora	0.0200	0.36	0.712
	Fauna	0.0035	0.389	0.473
	Pollution	0.0047	0.438	0.761
	Mitigation/remediation	0.0188	0.515	0.599
Physical Factors	Physical location	0.0036	0.551	0.761
	Land use	0.0030	0.536	0.36
	Geological suitability	0.0042	0.438	0.473
	Soil factors	0.0054	0.438	0.522
	Hydrological factors	0.0043	0.312	0.522
	Pollution	0.0023	0.438	0.522
	Mitigation/remediation	0.0083	0.515	0.761
Built Environment	Urban open spaces	0.0089	0.36	0.677
	Municipal services	0.0107	0.22	0.312
	Existing infrastructure	0.0037	0.297	0.36
	Transport & traffic	0.0058	0.459	0.312
	Pollution	0.0042	0.438	0.761
	Mitigation/remediation	0.0053	0.515	0.599
Mental/physical well-being	Health risks	0.0501	0.459	0.312
	Aesthetic quality	0.0829	0.551	0.677
	Noise	0.0182	0.171	0.248
	Pollution	0.0189	0.438	0.761
	Mitigation/remediation	0.0437	0.515	0.599

Criterion			Significance Rating of Alteratives	
			Old Trading Store	Threlfall
Cultural Factors	Historic/archeological	0.2674	0.438	0.599
	Education	0.0357	0.312	0.312
	Ethics	0.0586	0.677	0.36
Economic Factors	Generate revenue	0.0173	0.438	0.599
	Provide infrastructure	0.0048	0.36	0.599
	Job creation	0.0617	0.677	0.677
	Socio-economics	0.0228	0.677	0.761
	Market demand	0.0182	0.438	0.599
	Maintain infrastructure	0.0144	0.438	0.473
	Access to resources	0.0415	0.438	0.234
Political Factors	Public opinion	0.0120	0.677	0.515
	Equity & empowerment	0.0353	0.677	0.515
	Political needs	0.0072	0.374	0.374
	Legislative compliance	0.0364	0.677	0.551
	Conflict resolution	0.0294	0.515	0.389
Antagonists	Normalised Total		**0.458**	**0.542**
Supporters	Normalised Total		**0.480**	0.520

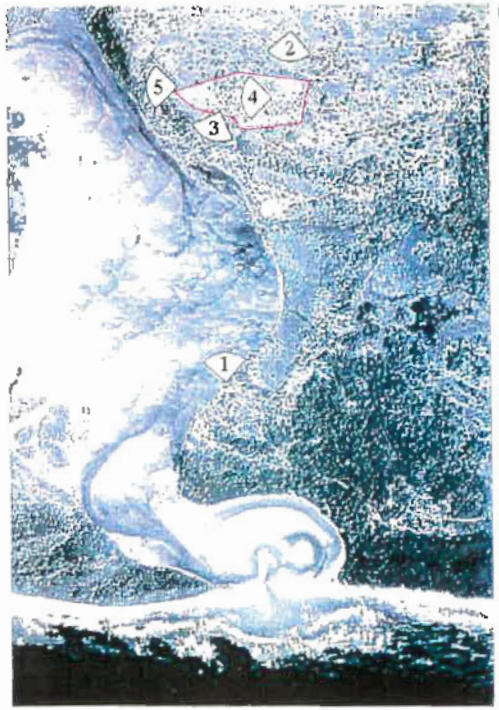
Table 3.6: Rating the levels of risk associated with the proposed project site alternatives on the intensities

Risk factors		Priority	Levels of Risk Rating of Alternatives	
			Old Trading Store	Threlfall
Health	Accidents	0.0112	0.413	0.333
	Acute disease	0.0261	0.184	0.199
	Long-term	0.0088	0.184	0.243
Environmental	Fauna	0.0134	0.619	0.39
	Flora	0.0296	0.466	0.466
	Land degradation	0.0682	0.543	0.543
	Hydrology	0.0355	0.466	0.619
	Air pollution	0.0189	0.2	0.113
Socio-economic	Economic loss	0.0480	0.234	0.395
	loss of access	0.0636	0.312	0.36
	Cultural heritage	0.1017	0.263	0.438
Political	Conflict	0.0161	0.551	0.36
	Unrest	0.1162	0.234	0.283
Cultural Factors	Financial stability	0.0774	0.122	0.093
	Economic climate	0.3652	0.36	0.312
Antagonists	Normalised Total		0.503	0.497
Supporters	Normalised Total		0.491	0.509

APPENDIX 6

ILLUSTRATIONS OF THE PROPOSED TOURISM DEVELOPMENT NEAR THE KOSI MOUTH

1 - View from the fish traps towards the site



2 - View of the arrival to the site

Main activity in the bay

Typical vegetation of the riverbank

3 - Overall view from the accomodation

4 - View of the location of the reception lodge

5 - Overall view of the bay from the restaurant and lounge

Plate 1: Various site views of the proposed tourism development at the Threlfal site near the Kosi mouth (Source: Denniston Architects & Planners, August 1998).

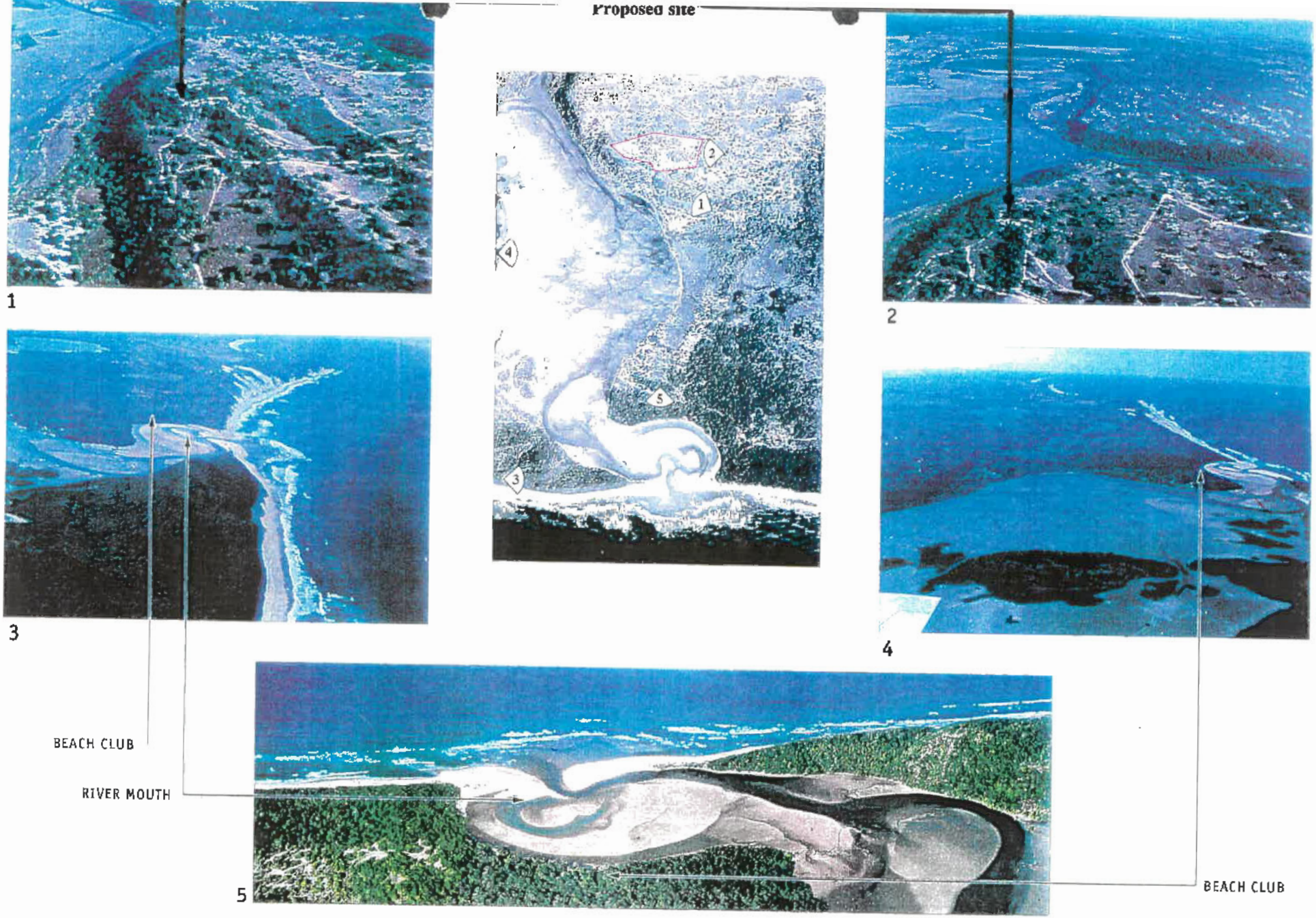


Plate 2: Aerial views of the proposed tourism development site (Source: Denniston Architects & Planners).

PLATE 3

CONCEPT FOR LOW IMPACT BEACH FACILITIES

(Source: Denniston Architects & planners, August 1998)