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A TRANSDISCIPLINARY STUDY
ON DEVELOPING KNOWLEDGE BASED SOFTWARE TOOLS
FOR WILDLIFE MANAGEMENT IN NAMIBIA

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Foreword

This thesis describes the development of two software tools for wildlife management: a hypermedia Information System for Rare Species Management (IRAS) and a fuzzy logic Knowledge-based Decision Support System (KBDSS) for wildlife translocations. At the outset of this study it was assumed that the focus would be on providing technical solutions for wildlife conservation in Namibia, and that this thesis would be mainly concerned with a detailed description of these solutions. During the course of this study it became apparent that determining what constitutes a 'useful' software tool for wildlife management in a postcolonial African country opens up a number of issues many of which are controversial and which are usually discussed in the context of other disciplines.

As the German philosopher of science Juergen Mittelstrass observed, environmental and ecological problems are complex problems which can only be solved through cooperation of many subjects and disciplines¹. This necessity for interdisciplinary cooperation is mirrored in the many issues that arise, once the development of software tools for environmental purposes in an African country is considered in its cultural and social context.

This thesis is comprised of 11 chapters. Chapter 1 is an introductory chapter which outlines the project context in which the software tools were developed. Chapter 2 addresses the complexity of the transdisciplinary situation. The placement of Chapter 2 within the necessarily linear arrangement of the chapters of this thesis is problematic. On the one hand, it is essential to introduce the issues of complexity before the remaining chapters. On the other hand to illustrate the points, it proved essential to refer to the material in later chapters. Because issues of complexity became an overarching issue in this thesis, this chapter could have appeared in two places; either between Chapters 1 and 3, or after Chapter 11. Chapters 3 and 4 investigate issues of ethics; Chapter 3 gives an overview of selected environmental ethics positions and chapter 4 argues that computer ethics needs to address the dangers which computerisation poses to cultural diversity. Chapter 5 discusses some

¹ Mittelstrass, J. 1996. Stichwort Interdisziplinarität. Basler Schriften zur Europäischen Integration 22, 7-17.

of the information content of the IRAS system. Chapters 6 and 8 describe and discuss the structure of IRAS and its potential uses. Chapters 7 and 8 address issues of usability and usability evaluation with special emphasis on the African context. Chapters 10 and 11 describe and evaluate the wildlife translocation KBDSS.

Two of the chapters are co-authored. Chapter 1 is based on the original proposal for the Transboundary Mammal Project of which parts were written by Chris Brown of the Namibia Nature Foundation. Chapter 7 has been published as Winschiers, H., Paterson, B. 2004. Sustainable software development. In: Proceedings of the 2004 annual research conference of the South African Institute for Computer Scientists and Information Technologists on information technology research in developing countries (SAICSIT 2004) - fulfilling the promise of ICT, Association for Computing Machinery (ACM), October 2004, Stellenbosch, South Africa, eds. G. Marsden, P. Kotzé and A. Adesina-Ojo, pp. 111-115. South African Institute for Computer Scientists and Information Technologists, Republic of South Africa. The paper is the result of several discussions between the authors and was written in direct collaboration. HW provided the connection to computer science students of the Polytechnic of Namibia and integrated the usability test into the human and computer interaction course assignments.

Although Rowan Martin is not formally a co-author of Chapter 5, the species management plans which he developed for the Transboundary Mammal Project are extensively used and discussed.

I am the primary author of all remaining chapters, and incorporated comments by the thesis supervisors, Les Underhill, Tim Dunne and Britta Schinzel.

Abstract

Two software tools for decision making in wildlife management were developed as part of the Transboundary Mammal Project, a joint initiative between the Ministry of Environment and Tourism, Namibia (MET) and the Namibia Nature Foundation (NNF). This project aimed to improve the management of selected rare and high value species in Namibia by building a knowledge base for better informed decision making. The knowledge base was required to encapsulate current knowledge and experience of conservation experts and specialists. To provide an electronic representation of this knowledge base a hypermedia Information System for Rare Species Management (known as IRAS) was designed and implemented.

One aspect of species management is the translocation of animals into areas where the species has become locally extinct. Wildlife translocations into communal conservancies in Namibia serve a double purpose. On the one hand translocations increase the range of the species. On the other hand translocations provide rural people living in these conservancies a basis for economic development, such as tourism or game breeding.

A fuzzy logic Knowledge-based Decision Support System (KBDSS) was developed to work towards a national wildlife translocation programme based on informed and transparent decision making.

Developing "useful" knowledge-based software tools for wildlife management in an African country is a complex undertaking which requires examination of the historical, political, cultural, and ethical contexts of both wildlife management and computer technology. Wildlife management in Africa has been largely determined by Western influences (Anderson & Grove 1987). An examination of environmental ethics positions reveals that the field is dominated by the human/nature dualism which is at the basis of Western thought. Although there has been a shift away from the preservationist paradigm towards community based conservation, existing power structures are slow to change and consequently top-down decision making in African conservation prevails (Venema & Breemer 1999). This research provides a

framework against which conservationists may explore their own imperatives, so as to enable decision-making to be enriched by the elicitation of transparent but authentic ethical preferences.

The software tools developed as part of this thesis are the result of an attempt to achieve two goals: firstly to satisfy the present need of the Namibian Government for better informed decision making for wildlife management in a way, which accesses current expertise and is amenable to expansion, and secondly to provide mechanisms for increased public participation in the decision making process by MET staff in conservation and the communities in conservancy areas.

The architecture of the IRAS system includes an organisation system for species management knowledge which may be used as a template for future development of similar systems for other species and modification as future expertise emerges. The IRAS system has the potential to be further developed into an adaptive knowledge management system for wildlife management in Namibia. The wildlife translocation KBDSS provides standardisation and enhanced transparency of the decision process. The maps and bar charts which form the KBDSS output help decision makers to communicate the decision criteria amongst themselves and to the public.

Both systems were critically evaluated. A usability test of the IRAS system was carried out with MET wildlife managers and conservation biologists to improve the usability of the system. A further aim of the assessment was to compare different usability testing methods for their usefulness in a cross-cultural context. The wildlife translocation KBDSS was evaluated in terms of its appropriateness and robustness. A sensitivity analysis suggests that the system is robust towards input changes.

The research therefore explores the disciplinary interstices of information technology, conservation and ethics, against the cultural background of a post-colonial society in which the deficits of the past constrain the impact and the efficacy of technological interventions.

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First of all I have to thank Chris Brown for taking the idea for this research seriously and helping to design a proposal. It was Chris who suggested that I present the proposal to Les Underhill, who promptly and enthusiastically agreed to supervise my work. I am greatly indebted to all three of my supervisors Les Underhill, Tim Dunne and Britta Schinzel for all their guidance, expertise, encouragement and friendship.

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CHAPTER 1

University of Cape Town

The Transboundary Mammal Project: A Knowledge-based Approach to Transboundary Wildlife Management in Southern Africa

ABSTRACT

This chapter demonstrates a route to improving the management of transboundary resources using the Transboundary Mammal Project of the Ministry of Environment and Tourism of Namibia and Namibia's Caprivi Region as an example. The Transboundary Mammal Project aims to link local, national and transboundary levels of the management of high-value mammal species, which occur in the transboundary area of the Caprivi, through the development of national strategic species management plans. In order to achieve this aim the project addresses five main themes: information collection; strategy development; information management; computerised decision support and transboundary collaboration. All five themes relate to various forms of representing and managing wildlife management knowledge. The project had by February 2004 produced three detailed reports providing an overview over a total of nine species, i.e. buffalo *Syncerus caffer caffer* roan *Hippotragus equinus*, sable *Hippotragus niger niger*, tsessebe *Damaliscus lunatus lunatus*, reedbuck *Redunca arundinum arundinum*, waterbuck *Kobus ellipsiprymnus*, lechwe *Kobus leche leche* and puku *Kobus vardonii*, containing pertinent information regarding the biology of each species and conclusions and recommendations for management. The development of national strategic species management plans is not meant as a single species conservation approach. The relevant management practices identified within the management plans are designed to become part of the general local management practice, with monitoring, reporting and adaptive management responses. The management plans also address issues which have been identified as of transboundary concern. In order to appropriately manage this information a web-based Information System for Rare Species Management, IRAS, has been developed. Further exploring the potential of knowledge-based approaches to wildlife management the project designed a prototype decision support system using NetWeaver fuzzy logic modelling software. The underlying model is essentially a

network hierarchy of the factors relevant for wildlife translocation such as ecological suitability, socio-economic factors and threats.

INTRODUCTION

Southern Africa is largely an arid and semi-arid region, with 5% of the land under cultivation and limited potential for expansion (Cumming 1999). Although livestock can be supported on much of the land, both staple food and livestock production are failing to keep pace with population growth. Large tracts of this land are, however, well suited to wildlife and other natural resource management approaches. In southern Africa, community-based approaches to diversified natural resource management have shown considerable potential for both rural development and economic empowerment of rural communities, and enhanced biodiversity conservation (Namibian Association of Community Support Organisations 2003, 2004; Brown 2004). Many of the community-based initiatives are located in a transboundary context (Singh 1999). International borders are political not ecological boundaries and therefore often divide ecosystems, river basins, wildlife migration routes and populations of high-value species. In the past, shared ecosystems and divided populations were managed largely at the national level, with little account being taken of the larger picture (Singh 1999). In many cases, this approach exacerbated the decline of some species and the markedly sub-optimal status of others. As a result, more recent approaches have promoted the collaboration of neighbouring states to manage these transboundary resources together as a single continuous entity. The process of achieving greater ecological stability and productivity through transboundary conservation is also strongly influenced by non-ecological factors, including a desire to improve regional political cooperation and stability, and to promote economic growth and development (Singh 1999).

In May 2002 the Namibia Nature Foundation and the Ministry of Environment and Tourism (MET), Namibia, started the Transboundary Mammal Project to initiate improved transboundary management of rare and high-value mammal species in the Caprivi area. Here a route is demonstrated to achieving two main outcomes using the Transboundary Mammal Project and the Caprivi area as an example.

The first outcome is to facilitate transboundary collaboration and cooperation around the management of rare, endangered and high-value wildlife species, leading to the establishment of sustainable institutional arrangements for transboundary wildlife management, taking full cognisance of the community-based natural resource management approaches, the existing protected and designated wildlife areas, and working constructively with other initiatives currently being undertaken and planned. As such, this approach is a starting point from which dialogue and planning can commence, with partners in neighbouring countries. It is not prescriptive, but allows detailed planning to evolve as communication and collaboration develop.

The second main outcome is the development of strategic national management plans for selected mammal species, which serve both national management objectives as well as provide a basis for a common transboundary approach. The management plans provide guidance for local implementation based on supportive information systems consisting of biological information, e.g. distribution, numbers, habitat, population dynamics, as well as management actions and responses.

STUDY AREA

Bio-geographical

One of the transboundary areas in southern Africa with the greatest potential for both conservation and economic growth is that around the Caprivi Strip in Namibia, bordering onto northern Botswana, western Zimbabwe and southern Zambia – with the potential to link to south-eastern Angola – the so-called “four-corners” transboundary natural resource management area (Figure 1). This area has been identified as a priority area for transboundary collaboration, because of the many shared river basins, the rich and diverse ecosystems, biota and tourism potential (Mendelsohn & Roberts 1997, p.44), representing globally important shared natural resources.

Many of the endangered and high-value species in Namibia occur in the woodland and wetland biomes of the north-east of the country. These species are not confined to Namibia, but consist of populations shared with neighbouring countries, particularly Botswana and Zambia, and to a lesser extent Zimbabwe and Angola. The

management of these shared populations, for both ecological and economic returns, will remain sub-optimal as long as they are managed only at the national and local levels.

Although the international borders between Namibia and neighbouring countries are unfenced, the presence of veterinary control fences does limit the migration of wildlife and leads to the isolation of small populations (Singh 1999; Martin 2002). Maintaining linkages between sub-populations and associated veterinary implications have, amongst other concerns, been identified as transboundary management issues.

Political and institutional background

A number of initiatives in Namibia have a bearing on the transboundary approach to management plans. Similar initiatives are in place in the neighbouring countries. Together they form a cluster of opportunities that make the conceptual and operational framework for this approach possible.

At the regional level, the target area, consisting of the north-eastern region of Namibia, focused around the Caprivi and adjacent countries has a well-endowed institutional infrastructure: parks, wildlife management areas, conservancies and forestry reserves. The region has identified this area as a focal point for collaboration and development, and this initiative is being supported by the United States Agency for International Development, US-AID, within a project referred to as “the four-corners”. Namibia has signed the Southern African Development Community (SADC) protocol on wildlife, and is fully committed to transboundary initiatives for improved and sustainable natural resource management, thereby creating an enabling environment for cooperation and collaboration (SADC 1999).

At the national level, the Namibian Cabinet has approved a development process and conceptual plan for the Caprivi that is natural-resource based, with the protected areas, conservancies, wildlife and tourism potential of the area playing a leading role as the engines for local development. This plan fully embraces the need for transboundary partnerships and collaboration. The draft Parks and Wildlife Bill establishes the need for strategic national management plans for key species in Namibia such as species classed as specially protected (Republic of Namibia 2002).

These management plans should cover diverse issues such as: historic, present and core ranges; management goals, objectives and targets; monitoring approaches, information and adaptive management; support, partnership, benefits and incentives; and policy, legislation, protection and law-enforcement. One such national plan, for the black rhinoceros *Diceros bicornis bicornis*, has been in existence since 1989, and has been updated since then (Ministry of Environment and Tourism 2002a).

At the local level there are currently four main local management regimes in place to manage wildlife in the north-east of Namibia. The first is management within protected areas. There are four parks in the target area: Kaudum, BwaBwata (consisting of the former Mahango and West Caprivi Parks), Mudumu and Mamili. Parks are managed by park staff of the MET. The second management regime refers to open communal lands, covering the regions of north-eastern Otjozondjupa, Kavango and Caprivi, which are managed by regional staff of the MET. Thirdly, freehold farms are under individual land ownership, where farmers have conditional ownership over huntable game. The fourth regime refers to registered and emerging conservancies on communal land. Here wildlife is managed by local conservancy committees with the aid of community game guards and resource monitors, and supported by both MET staff and non-governmental organisations (NGOs). In 2003, there were five registered communal conservancies in the target area, with an additional four emerging conservancies at different levels of development. Conservancies are the institutional mechanism created under MET legislation (Republic of Namibia 1996) to devolve rights and responsibilities to communities to manage wildlife and other natural resources for their long-term benefit. The initiative seeks to promote social empowerment, improved livelihoods at the household level, rural development, biodiversity conservation and ecological sustainability. Considerable progress has been made by communal conservancies and their support organisations (NGOs and MET) to establish effective wildlife protection, monitoring and management practices. A fully-functional national programme of some 14 governmental and NGO partners implements the conservancy initiative in most regions of Namibia, with the Caprivi as one of the key focal areas. Mapping and monitoring services have been established, and community and MET rangers have been equipped and trained. Systems and institutional arrangements have been established and tested, including carrying out annual audits of performance and

progress. A number of wildlife surveys, from the air and the ground have been conducted in the Caprivi region (e.g. Rodwell *et al.* 1995; Stander *et al.* 2004).

Similar situations exist in neighbouring countries, e.g. in Botswana, with national parks and forestry areas, community initiatives in the Chobe enclave region, wildlife areas under concessions, and community lands. The development of national strategic species management plans can serve as a link between the monitoring and management work being done at the local level and the planning at the national and regional levels of management.

THE TRANSBOUNDARY APPROACH

The approach presented here is a modest one. The development of strategic management plans for species whose populations straddle international boundaries in the study area is seen as a step towards transboundary natural resource management in the area (Figure 2). The key idea is that each country manages their wedge of the population individually but collaborates on issues which are identified as having transboundary implications, such as issues of land use, illegal hunting, fire control, population estimates and hunting quotas. These transboundary issues need to be addressed in the national management strategies of each country. The Transboundary Mammal Project has identified five themes, which must be addressed in Namibia to improve the status of endangered and high-value mammal species with shared transboundary populations in the Caprivi area. Table 1 gives an outline of the steps involved.

Data Collection and Information Management

Many of the rare or high-value species in Namibia could attain or sustain higher population numbers and extended ranges. To achieve these increases, dramatic improvements in management would need to take place, at the local, national and transboundary levels. Institutional improvements would also need to occur, at all three levels, building on conservancy and park management, establishing national management goals, targets and approaches, and supporting collaboration and cooperation across national boundaries, requiring transboundary forums.

To provide the required research background it is necessary to compile all available information on each species, drawing on historic data and building an overview for each species, showing changes over time. At present, information on most rare, endangered and high-value mammal species in Namibia is collected in different ways, over different intervals and is held by different institutions. There is no one systematic approach to data collection, collation, curation and management. As a consequence, information on distribution, abundance, sub-populations, management objectives, documentation of past management actions and other pertinent information are not currently available. Because the relevant information is scattered in this way it is necessary to consolidate the species specific information in a central point. To this end the Transboundary Mammal Project had by February 2004 produced three species overview reports: a single species document focusing on buffalo *Syncerus caffer caffer* (Martin 2002) and two combined documents addressing roan *Hippotragus equinus*, sable *Hippotragus niger niger* and tsessebe *Damaliscus lunatus lunatus* (Martin 2003), and reedbuck *Redunca arundinum arundinum*, waterbuck *Kobus ellipsiprymnus*, lechwe *Kobus leche leche* and puku *Kobus vardonii* (Martin 2004) respectively as logical groups. These reports provide a comprehensive overview for each species, including biological information, such as past and present distribution, abundance and habitat requirements as well as the significance of the species in terms of conservation and economics. In addition each document identifies the main stakeholders for each species, provides an analysis of past and present management practices and offers recommendations for future management. A central question which the approach presented here seeks to address is how information, expertise and knowledge on rare species management can be expressed and represented in a way that supports exchange and debate and is more accessible than the usual paper-based format of printed documents. The species overview reports contain pertinent information regarding each species or species group that is both descriptive as well as strategic, in that the reports contain conclusions and recommendations for management. In order to appropriately manage this information an electronic Information System for Rare Species Management (IRAS) has been developed based on internet technologies such as hypertext and multimedia (Chapters 2, 6 and 8). Because of the often inadequate infrastructure and currently insufficient transfer rates and bandwidth in the region IRAS is also distributed on CD-Rom.

Identification, documentation and evaluation of the current management systems and approaches.

At present there is limited collaboration between neighbouring countries on most aspects of natural resource management. Management approaches, monitoring activities, law-enforcement, policy and legislative framework, devolution of management to local institutions and long-term planning are all done largely in isolation, despite the fact that many habitats and populations of important wildlife straddle national boundaries. The Transboundary Mammal Project seeks to promote collaboration between Namibia and neighbouring countries on species management issues through dialogue. This objective puts the project in line with a resolution adopted by the United Nations in 2001 to promote dialogue between nations (www.un.org/dialogue). The resolution encourages everyone to consider ways and “means at the local, national, regional and international levels to further promote dialogue and mutual understanding”.

Here a conservative, and fairly modest, approach is advocated to building transboundary partnerships and consensus, by

- sharing information on present practices,
- drawing on best practices and approaches in the region,
- examining possible targets and goals that could be established for various species,
- identifying threats and opportunities for enhanced biodiversity conservation and development by implementing different transboundary collaborative initiatives, and
- developing a series of options that could be applicable at national and regional (transboundary) levels.

While Namibia develops a knowledge base for selected species, neighbouring countries like Botswana are invited to make use of this information, to contribute ideas and to identify issues of common concern and transboundary importance. Through this process issues such as illegal hunting, fire management and hunting quotas have been identified as being of transboundary concern between Botswana and Namibia. These issues need to be addressed in national management plans for species

shared between the two countries. Thus by developing a national vision while at the same time sharing information and maintaining dialogue each country contributes towards the emergence of a larger region wide vision that extends beyond national boundaries.

National Strategic Species Management Plans

Wildlife management embraces a diverse array of issues and integrates different disciplines, such as ecology, sociology and economics. Consequently knowledge applied in wildlife management is highly complex. Wildlife management decisions are never based on technical information alone, but also integrate values, opinion and experience (Bell 1983). Limited data, scientific uncertainty, ambiguity and conflicting goals pose further ongoing challenges. Scientists, resource managers, farmers, politicians and business people are equally involved. In broad philosophical terms, these participants may be preservationists, conservationists or developers. In the Namibian context there is also ethnic diversity which results in the presence, challenging and enrichment of different cultural values. This diverse array of stakeholder involved in wildlife management scenarios perpetuates the complexities of wildlife management.

In 2002, with the exception of black rhinoceros, there were no current strategic national management plans for endangered and high-value mammal species in Namibia. As a result, there are no status targets, in terms of range, numbers and productivity, no coordinated national objectives or strategic approaches, no comprehensive census, monitoring and reporting systems, no incentives, partnership schemes, utilization and marketing strategies, and no established institutional mechanism to give bureaucratically free guidance and coordination.

In order to improve the management of rare and high-value species in Namibia the Transboundary Mammal Project developed draft national strategic species management plans based on the information contained in the species reports (Ministry of Environment and Tourism 2002b, 2003, 2004). These management plans address the above mentioned points as well as the transboundary issues, which were identified, and define concrete management goals and objectives for each species balancing the different stakeholder needs and interests.

Decision Support System

There is considerable experience in the wildlife sector in southern Africa, much of it captured in scientific papers, in reference works and in internal reports. However, a large part of the information is in the heads of older rangers and scientists nearing retirement. Many of these people have long been making management decisions based on both sound documented criteria, but also on “intuition”. In practice, this consists of many years of observations and a “feel” for the habitat, conditions and behaviour of species well known to them. The construction of such meaning is an important part of the knowledge creation process (Malhotra 2000). This process is highly individualised and based on a system of personal constructs or frames of reference, which determine how a person interprets and responds to empirical stimuli (Bannister & Fransella 1986, p. 10).

The project is exploring the possibilities of employing computerised decision support methods and techniques in order to capture the knowledge of experienced wildlife managers in a decision support system. Many of the wildlife departments in southern Africa have become staffed by young graduates with limited field-based conservation experience. It has become apparent that there is a need to provide access to the already existing stream of knowledge through both technology and the creation of a basis for communication and debate. The project has developed a prototype Knowledge-based Decision Support System (KBDSS) for wildlife translocation using NetWeaver fuzzy logic modelling software (Saunders & Miller 2004).

In the past wildlife in Namibia was reduced to the point that many areas have little wildlife left. In some areas species are locally extinct. With the recent growth in tourism, game farming and sport hunting, land is increasingly becoming available for the re-introduction of wildlife. The growth in communal conservancies is presenting Namibia with a conservation opportunity to re-establish wildlife species into their former ranges. The wildlife translocation KBDSS prototype recommends suitable communal conservancies for wildlife translocation. The underlying model is essentially a network hierarchy of the factors relevant for wildlife translocation such as ecological suitability, socio-economic factors and threats. The KBDSS produces

output in the form of maps showing how the conservancies compare relatively for each species and suggests priority areas for translocation (Chapters 9 and 10).

Transboundary institutional arrangements

It will be necessary to establish transboundary and national (in the case of Namibia) institutional arrangements based on the SADC Wildlife Protocol to continue this work into the future. This future focus would be on developing sustainable arrangements for (a) the preparation and updating of strategic management plans for other important transboundary species or species groups, (b) coordinating and partnering on transboundary management and monitoring, and (c) sharing important and relevant information, and responding to this shared information in ways that promote adaptive management and policy harmonisation, ultimately leading to joint management approaches for important transboundary natural resources.

CONCLUSION

To achieve the link between local, national and transboundary strategies for species management commitment from the relevant stakeholders is necessary. Particularly the government wildlife organisations need to be committed to the SADC Protocol on Wildlife and to transboundary cooperation and collaboration. The MET has to be fully committed to the development of strategic national management plans for endangered and high-value species and to developing institutional arrangements for the long-term implementation of national species management plans. Experienced species specialists from the region are being recruited on short-term contracts to assist in the data collection and checking and drafting of management plans. The specialists need to be willing to seriously engage in attempting to understand the aspects and criteria that contribute to intuitive decision-making, and to draw these elements out into an explicit computer-based intelligent model and framework. Staff in local protected areas, in regional offices, and in conservancies need the capacity, motivation and support to operationalise the results of the strategic plans at the local level. The “four-corners” area, particularly the Caprivi region, will have to become increasingly secure and stable, and conducive to regional tourism. The governments in the target area have to remain committed to full and bureaucratically free devolution of natural resource management to the lowest appropriate levels, and transaction costs of transboundary cooperation and joint management have to be low.

To achieve the required level of commitment the approach presented here is inclusive and exploratory, building from one process-based output to feed into the next. In the case of the Transboundary Mammal Project, guidance is provided by a small, experienced steering body of government, academia and NGO representatives. Species specialists are drawn in on an ad hoc basis and are directed by the project coordinator.

The development of national strategic species management plans must not be confused with a single species conservation approach. Rather the species management plans although identifying particular management issues pertinent to a specific species or species group define management strategies that overlap from one species to another. The management plans provide concrete guidance and targets for local planning. The development of management strategies for selected high-value species requires that objectives and targets are defined for both biodiversity as well as economic goals. This strategic approach promotes conservation management planning on both national and local levels. By implementing the strategies on the local level the species management plans will be knitted into a synergetic whole resulting in improved conditions which will relieve additional species.

Rural communities living in the target area will benefit from the improved status of currently rare and high-value species within their areas. In the case of Namibia, many of these communities are in registered conservancies, or in areas where communities are planning to form conservancies. As such conservancies emerge, people in these areas will have rights over wildlife and tourism, and access to the benefits that these rights infer. By improving the wildlife resource base - and particularly the high-value species - conservancies and their members stand to gain greater incomes from both consumptive and non-consumptive use of wildlife. Similar community-based programmes are operating in Botswana, Zambia and Zimbabwe. The management guidelines that form part of the Strategic Management Plans for the different species include components for local management. Conservancies in Namibia are in the process of developing local management plans, and protected areas (parks) are doing the same. As part of these processes, relevant management practices identified within the Strategic Species Management Plans will be translated and incorporated into local management plans, and then operationalised through annual work plans, where they

will become part of the general local management practice, with monitoring, reporting and adaptive management responses. In this way, local communities will be getting maximum benefit from the management objectives.

A second sector of important beneficiaries includes the respective wildlife departments, whose mandate and responsibility it is to ensure the optimal conservation status of biodiversity, often with an emphasis on high profile rare and endangered mammals that largely underpin the tourism sectors in the respective countries. At the regional, transboundary level, key stakeholders from the different countries are brought together to discuss the priority species, their needs, management requirements, population targets, core ranges, transboundary constraints, opportunities, and collaborative approaches to optimise conservation management and monitoring of these species. In this way the needs as well as the available expertise is made explicit and pooled together to build capacity. The resulting improved transboundary collaboration and communication will lead to optimised transboundary species management.

A benefit on the national level will be the compilation of all available information on the past, present and core ranges of the selected species, their status in different areas as well as trend data, habitat requirements and management options. The information system IRAS, which has been developed in close collaboration with staff within the Directorate of Scientific Services in the MET (Chapter 7), is a knowledge repository providing access to both pertinent descriptive knowledge as well as applicable strategic knowledge. IRAS is a computerised representation of the knowledge compiled in the species reports and management plans that have been produced by the project thus far, but unlike the printed documents IRAS provides more flexible access to the information and allows frequent and in-expensive updates. The system is designed to facilitate communication and dialogue between wildlife managers, researchers and policy makers. In addition the prototype DSS for wildlife translocation provides transparent and rigorous application of the criteria determining wildlife translocations.

The transboundary mammal project's approach to enhancing transboundary cooperation is a knowledge-based formula. At the centre lies the development of

appropriate knowledge repositories as well as the procurement of knowledge-based decision support within a specific decision making scenario.

With the aid of these systems the relevant knowledge about species management can more easily be communicated both to the local level to influence management of protected areas or communal lands as well as to the regional level to contribute to the greater picture, a strategy that transcends international boundaries between neighbouring countries.

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FIGURES AND TABLES

Themes	Activities	Results/outputs
1. To collect all relevant information on the selected species, including trend data and decision-making criteria, and to build an appropriate information management system to electronically hold this information in an accessible format	1.1 Select key species, in consultation with transboundary stakeholders 1.2 Recruit species specialists in region to gather comprehensive information with in-country stakeholders 1.3 Agree on information needs and format 1.4 Gather information and prepare species reports 1.5 Hold specialist workshop to review information and revise reports 1.6 Design computer-based information system to hold, curate and update information in user-friendly form 1.7 Enter information from specialist reports and test system 1.8 Design website	<ul style="list-style-type: none"> - Collaborative transboundary working group emerging - Species reports produced - Computer-based information system developed and tested - Website developed and running
2. To identify and document the current management systems, approaches and objectives in the target areas of the different countries, and to evaluate their appropriateness – together with other options – for future national and transboundary management	2.1 Hold transboundary workshop to review current management systems and future ideas 2.2 Identify elements of best practice in the sub-region on which to base a series of management options per species or species-groups 2.3 Identifying threats and opportunities for enhanced biodiversity conservation and development by implementing different transboundary collaborative initiatives 2.4 Examine possible targets and goals that can be established for various species and management practices at the transboundary level	<ul style="list-style-type: none"> - Workshop report reviewing management approaches in region - Report on best practices and future options, threats and opportunities - Preliminary targets and goals for species and management practices - Collaborative transboundary working group getting more established
3. To develop strategic management plans for the identified species, for application at both the national and transboundary levels, working to support the MFT in Namibia and other responsible institutions as appropriate in other neighbouring countries.	3.1 Agree on a draft format and contents for management plans that include at least the following: <ul style="list-style-type: none"> - Past, present and core ranges, and future targets - Population targets and management objectives, including monitoring - Partnership and incentives schemes for conservation and sustainable use - Transboundary collaboration mechanisms for optimal management and monitoring - Policy and legislative framework, and protective measures - Implementation process and update procedures 3.2 Circulate draft management plans for comments and review 3.3 Hold focussed national and transboundary meetings to review and refine plans, and to plan and coordinate implementation 3.4 Produce management plans and post on web	<ul style="list-style-type: none"> - Draft outline of generic management plan - Draft management plans - Proceedings of workshops - "Final" strategic management plans - Plans posted on website

Themes	Activities	Results/outputs
4. To develop a computer-aided decision support system for management of rare, endangered and high-value species	4.1 Analyse available data and information 4.2 Analyse decision making criteria 4.3 Develop knowledge acquisition methodology 4.4 Extract knowledge from species experts 4.5 Identify appropriate software environment for modelling extracted knowledge 4.6 Build decision support system	<ul style="list-style-type: none"> - Analysis of factors that determine decision making - Inventory of available data and knowledge about species - Computerised decision support system
5. To work towards developing transboundary institutional arrangements, based on the SADC Wildlife Protocol	5.1 Prepare terms of reference for transboundary working groups 5.2 Include collaborative and joint-venture requirements within Management Plans, including: <ul style="list-style-type: none"> - information sharing - joint monitoring - joint planning - policy harmonisation, etc. 5.3 Ensure that a focal point is established with adequate facilities 5.4 Develop good communications mechanisms for partners	<ul style="list-style-type: none"> - TOR and guidelines - Sections within Management Plans - Focal points established - Communications network, including website

Table 1 Key themes, activities and outputs of the Transboundary Mammal Project

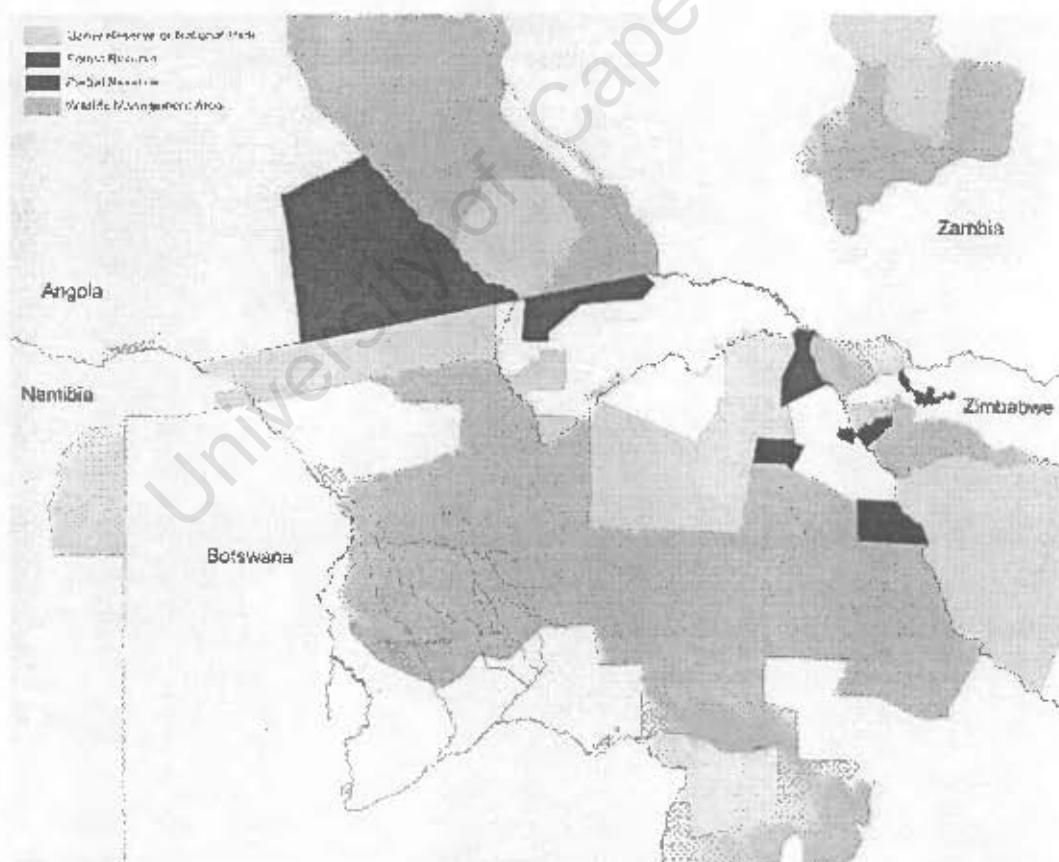


Figure 1 The transboundary conservation area shared between Namibia, Botswana, Angola, Zambia and Zimbabwe

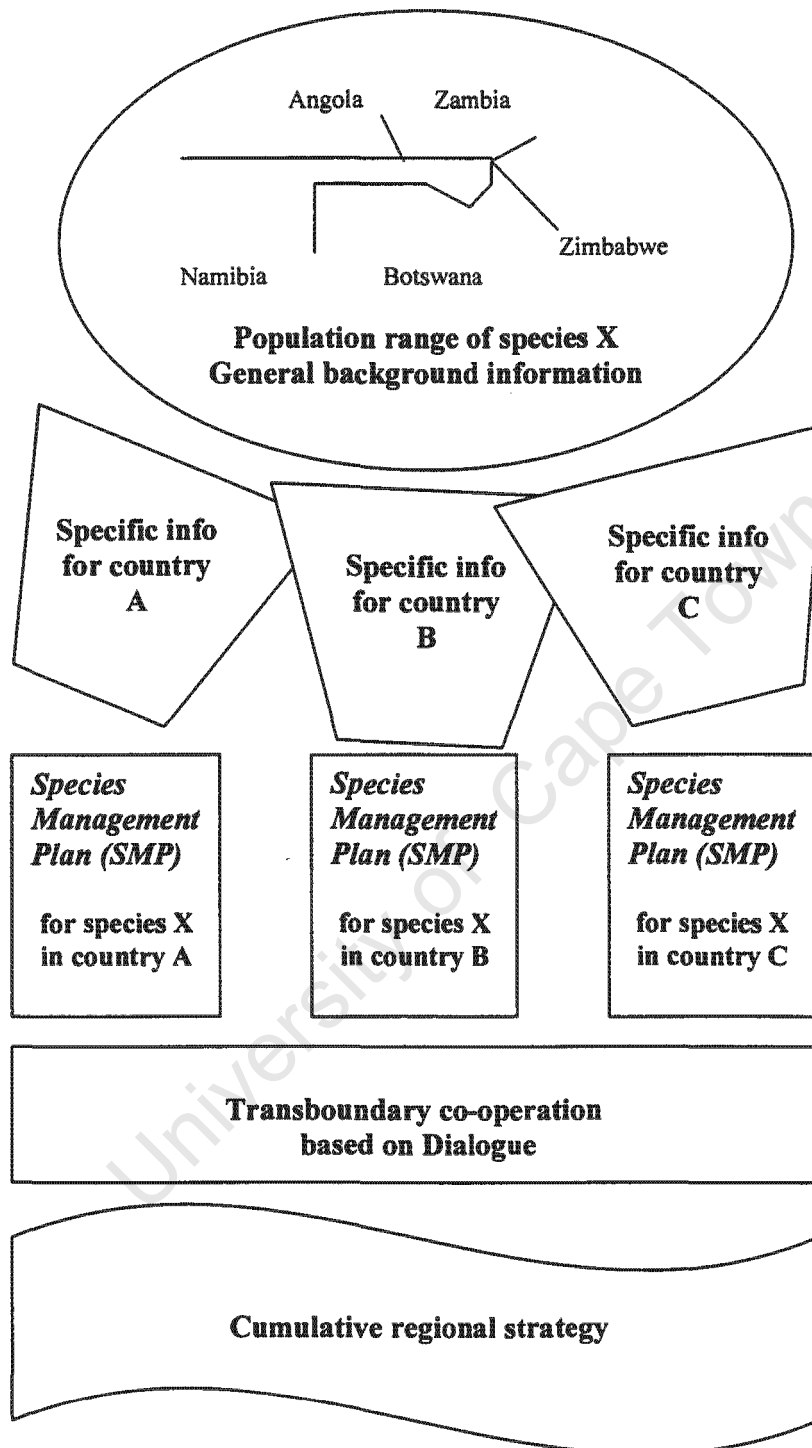


Figure 2 Conceptual design approach to developing species management plans fostering collaboration and cooperation between neighbouring countries with shared wildlife populations

CHAPTER 2

University of Cape Town

Complexity of developing software tools for wildlife management in Namibia

ABSTRACT

Computer tools can help to address the complex issues wildlife managers face, but computer tools also add complexity of their own. Wildlife management draws from different scientific disciplines which introduce different epistemological assumptions and research paradigms. Although wildlife conservation in Africa has shifted away from the protection paradigm toward community-based resource management, top-down approaches to conservation continue to influence conservation projects. Notwithstanding the importance of the social, political and cultural issues that impact on wildlife management there is a tendency to give preference to the positivist paradigm. The software tools on which this study is based are representations of conceptional wildlife management knowledge. This chapter goes beyond the positivist paradigm and examines the epistemological and cultural implications of developing software tools for wildlife conservation in Africa.

INTRODUCTION

Environmental planning issues require the careful balancing of both long-term and short-term interests. To achieve this balance, ecological as well as social and economic factors need to be taken into account. Environmental decision making thus requires not only sound knowledge of the ecological environment but also knowledge and expertise regarding the economic and social practices and needs of people.

Most environmental decision making involves a level of uncertainty due to the complexity of ecological systems and our restricted knowledge of their functioning. As more and more users place increasing demands on these ecological systems this complexity is aggravated by the complexity of social systems. The often conflicting interests of various stakeholders add to the difficulties faced by environmental decision makers.

Computer tools can help environmental managers to address complex issues. Electronic information systems provide access to data and information, quantitative simulation models help users to understand the consequences of possible management

actions and decision support systems help to bring multiple factors into focus. But computer tools add a new dimension of complexity of their own.

Two software tools were developed to support wildlife management decisions in Namibia: The first is a hypermedia System for Rare Species Management (IRAS) representing a knowledge repository for the management of some mammal species which are considered rare and of high value in Namibia (Chapter 1), such as roan antelope, buffalo and lechwe (see chapters 6 and 8 for further detail). The second is a fuzzy logic Knowledge-based Decision Support System for wildlife translocation into communal conservancies (KBDSS) (Chapter 10 gives a detailed description of the KBDSS).

In software development, the cross-cultural context is important on two levels: the choice and design of the software tool and the evaluation of software (Chapter 7). On both levels, criteria are necessary to define and evaluate whether the software matches the local context. Software development is characterised by western cultural assumptions and constantly defined by and evaluated against values prized in western cultures, such as rationality, efficiency and individualism, rather than, pleasure, creativity and community (Wunschiers 2001, Chapters 7 and 9). Cultural appropriation of both the software development and the evaluation process is necessary to create sustainable software for use in Africa by Africans. To achieve this aim, the methods, concepts and project goals need to be redefined according to the cultural milieu of the users.

The hypermedia system IRAS was created out of a need for an electronic storage and retrieval system for information pertinent to the management of rare and high value mammal species in Namibia. IRAS is essentially a collection of hypertext pages dealing with the background information on each species as well as the strategic information and management objectives. Because of the flexibility and ease of use of hypertext, IRAS has the potential to be used as a knowledge management system for wildlife management knowledge in Namibia (Chapter 8). The system provides an organisational scheme for species management knowledge which is potentially a first step towards capturing a standardisation of this kind of knowledge (Chapter 6).

The Knowledge-based Decision Support System (KBDSS) was developed for the Ministry of Environment and Tourism (MET) to help wildlife managers with wildlife translocation decisions (Chapter 10). Wildlife becomes available for translocation when population densities of a species in a protected area approach levels of carrying capacity. MET then captures some of these animals and makes them available for reintroduction into a conservancy, either because this species has become locally extinct in this area or because existing populations need to be boosted. The KBDSS is not concerned with the question of the provenance of the animals. The KBDSS is a network representation of the criteria pertinent to selecting an appropriate conservancy into which animals of a particular species can be translocated, or to selecting appropriate species for translocation into a particular conservancy. The presence of wildlife provides economic opportunities for people of a conservancy and there is therefore a degree of competition among conservancies to receive that wildlife which has become available for translocation. It is thus necessary to make the selection process transparent to ensure that the same criteria are applied in an equal and democratic way in all these decisions. It is also necessary to be able to communicate to conservancies that have applied for animals and have not been selected, the reasons for their non-selection and the nature of interventions they can undertake, in order to be considered in the future. The KBDSS provides graphical outputs in the form of bar charts and maps which communicate the degree to which selection criteria are being fulfilled. The KBDSS uses fuzzy logic to analyse the input data. Fuzzy logic is an extension of classical logic and is based on the concept of partial truth. Whereas classical logic holds that everything can be expressed in binary terms (0 or 1, black or white, yes or no), fuzzy logic enriches bivalent truth values by permitting degrees of trueness and falseness (Zadeh 1987; Dubris & Prade 2000).

WILDLIFE CONSERVATION IN NAMIBIA

Conservation in Africa has undergone a paradigm shift. Traditional wildlife conservation practices in Africa were based on nature reserves and parks, which were established by taking land away from local people. Such 'fortress' conservation was underpinned by top down approaches to natural resource management. Over the last two decades there has been increasing awareness of the need to enhance the participation of local communities in the management of natural resources. Consequently there has been a shift away from the protection paradigm toward the community-based resource management paradigm. Although it is frequently stated

that the community-based approach to conservation has replaced the traditional paradigm, top-down approaches to conservation continue to influence conservation projects (Venema & van den Breemer 1999). There are many possible reasons for this continuation, e.g. the hierarchical structure of government and development organisations and the fact that national interests are most important to government programmes. In general “power structures at the political and economic centre are not disposed to surrender their privileges and will use their power, including their abilities to shape policy and law, to maintain the monopolies of their position.” (Murphree 2003). Considering that “in the official ‘environmentalist rhetoric’ the poor people are regularly blamed” (Venema & van den Breemer 1999), the underlying dichotomy of people versus nature remains apparent. This dichotomy, which is equally apparent in mainstream environmental ethics (Chapter 3), has its roots in the European philosophical tradition and the separation of mind and body and human and natural environment (Merchant 1989). The result is a worldview in which humans and nature are separated and in which humans are seen as subjective agents and nature as the passive object. This view makes it difficult to envision people and the natural environment as mutually interdependent. Whereas the dependency of people on their environment is obvious, the natural environment seems to be better off without people. But viewing it this way again presupposes the separation of social systems and natural systems.

Conservation today is faced with the difficult task of managing natural and social systems as a whole. This extended goal requires a radical change of assumptions on which wildlife management actions are based.

Epistemological Assumptions

All decision making is based on underlying assumptions. A simple decision such as getting a glass of water from the tap in the kitchen, is based on a string of assumptions, such as that there is a kitchen with a water tap, that one is mobile enough to reach the tap, that there is a container to hold the water, that the tap can be opened and water will flow from it, that the quality of the water is drinkable, etc. Fundamentally these assumptions form our belief about the nature of the reality that surrounds us and the knowledge that we form about it. Fundamental beliefs about the nature of reality and our knowledge not only influence each person’s particular attitudes towards other people and the natural environment, they also influence the

way scientific research is conducted. In fact, such assumptions influence the very concept of what constitutes scientific research.

Wildlife management draws from several distinct scientific disciplines. On the one hand, information from the natural sciences such as biology and geography is required. On the other hand, insights from sociology, political sciences and economics are needed. The complexity of such multidisciplinary inputs is increased by the fact that different scientific disciplines introduce different epistemological assumptions and research paradigms.

A common sense understanding of science is that it is a process of discovering the truth about the world. Science is expected to provide answers to all humanity's questions by finding and examining facts about the world (Ellis 1994). Another understanding of science is that its findings depend on the kind of questions that are asked and are thus context dependent (Terre Blanche & Durrheim 1999). In this view truth is not something that is found or discovered but something which is constructed through consensus and practical assessment. These contrasting views characterise different research paradigms within science. On the one hand, there is the rationalist approach, according to which scientific research is an objective, logical and empirical activity following the hypothetico-deductive model. According to this model research is conducted by forming hypotheses which are put to empirical test. This model is based on the assumption that an objective reality exists and is made up of modular components, which are connected in time and space by causal relationships. Another assumption is that information can be abstracted from nature through measurement and that the resulting data can be manipulated by mathematics (Merchant 1989). Within the natural sciences this position is often referred to as scientific realism, whereas in the social sciences the term positivism is used (Terre Blanche & Durrheim 1999).

On the other hand, there is the constructivist approach, which asserts the importance of social factors on the formation and acceptance of scientific theories. This approach rejects the existence of an objective, law-like reality and views reality as something which is socially constructed through discourse. Within the natural sciences a constructivist position makes it difficult to explain the success of science in producing usable technology.

Between realism and constructivism there is the view that perceptions, scientific ideas and theories do not necessarily reflect the real world accurately, but are useful instruments to explain, predict and control our experiences. In the natural sciences this view is referred to as instrumentalism whereas in social science it is called the interpretative paradigm (Terre Blanche & Durrheim 1999).

These different ontological and epistemological assumptions inform the different ways in which wildlife managers react to the complexity of their task. At the one end of the scale there are “command and control” approaches, which narrow the context by defining a problem and looking towards scientific research for a solution. It is assumed that the problem is “well-bounded, clearly defined, relatively simple, and generally linear with respect to cause and effect” (Holling & Meffe 1996). At the other end there are integrative approaches, which are broad-based and transdisciplinary. These approaches are responses to today’s increasing awareness of the interconnectedness of all things (Ellis 1994) and need for holistic transdisciplinary approaches that view humans and the environment as a single system.

Use of metaphor

That social factors play an important role in science becomes visible in the use of metaphors. For instance, the scientific revolution effected a loosening of traditional controls over marriage and sexuality. The increasing social importance of sexuality in Linnaeus’ time is reflected in his scientific work, which makes extensive use of sexual metaphors (Schiebinger 1993). Linnaeus’ taxonomy also imported traditional notions about sexual hierarchy into botany by ordering plants first into Classes according to the number of stamens (male parts) and then into Order according to number of pistils (female parts). In the hierarchy of taxonomy, Class is above Order; therefore the male is prioritised over the female, although there is no empirical evidence for this ordinality. Such uses of metaphors, which reveal the social impacts on science, are not a thing of the past (Schiebinger 1993). Contemporary socio-biological literature is influenced by economic concepts, for example, plants are described as “channelling energies into investment portfolios” and reference is made to “reproductive success” measured against “mating investment” and “parental investment”. Plants thus “have tactics, make choices and engage in conflict” (Schiebinger 1993). Similarly zoologists refer to the “parental investment theory” which interprets the correlation between

increasing protectiveness of parents and increasing age of offspring as a result of the higher investment by the parent (Trivers 1972). Other biological terms drawing from economic concepts include “sperm competition”, “optimal foraging theory”, “parent-offspring conflict” and “sibling rivalry”.

Similarly, the environmental discourse and the area of wildlife management in particular, is dominated by two metaphors which are symptomatic of the dominance of the realist or positive research paradigm in conservation biology. These are the “stocks and assets” metaphor which “assumes that social reality can be captured through measurement” and the “environmental systems and carrying capacity” metaphor, which refers to the “scientific method” to assert its truth claim (Meppem and Bourke 1999). The different research paradigms represent different ways of viewing the world and what we can know about it based on different sets of assumptions. Although it is possible to draw on more than one paradigm, most research is conducted from within a single preferred paradigm (Terre Blanche & Durrheim 1999). In wildlife management there is a tendency to give preference to the realist or positivist paradigm and consequently there is a strong focus on “objective quantified data” and on “rational” decision-making (Meppem and Bourke 1999). Most research in conservation biology, for instance, focuses on quantitative studies (Fazey *et al.* 2005). One reason for this preference may lie in the value dualism underlying common sense thought, which implies that natural sciences are “hard” science and therefore better science whereas social sciences are considered “soft”, and therefore less rigorous and less “true” (Chapter 5 discusses the value dualism between hard and applied science). The western common sense reality is characterised by classical physics and the belief in an objective and stable external reality (Merchant 1989). It is an inherent characteristic of common sense to regard its tenets as direct factual experiences as opposed to reflections. Geertz’ (1983) comparative analysis showed that common sense is, however, an interpretation of immediate experiences based on culturally distinct presuppositions. By regarding its principles as natural facts, common sense portrays these beliefs as truths.

Consequently, it is widely expected that science “discovers” truth, and can and will provide answers to the questions which are posed, by “getting all the facts straight”. There is however no guarantee that the right questions are being asked. This high expectation and overestimation of science is caused by ignorance of (or lack of

interest in) the history and philosophy of science (Ellis 1994). The positivist paradigm is based on a mechanistic view of nature which is a product of the scientific revolution of the 17th century (Merchant 1989). Although this epistemology has been “leap frogged” by contemporary science, which emphasises relationships over control, its influence on environmental science prevails (Meppem & Bourke 1999).

Adaptive Management

Wildlife managers who support integrative approaches to management increasingly support adaptive management. Adaptive management is a cyclic learning-oriented approach to the management of complex environmental systems (Chapter 8). Adaptive management is the reaction to high levels of uncertainty. Instead of expecting answers and solutions from science, adaptive management monitors the results of past management actions, implemented on the basis of recommendations by scientific research. Adaptive management is underpinned by the belief that science is a process in the making and that truth is not an objectively existing entity but something that is the result of experience and consensus. To view negative or unexpected outcomes as learning opportunities rather than failures requires some fundamental shifts in perspectives, recognising that change and unpredictability are ongoing phenomena and that truth is context dependent. Science is no longer expected to produce solutions but to provide perspectives that recognise uncertainty and the existence of other knowledge systems; traditional communities are equally required to open traditional knowledge and management techniques to critique by other knowledge systems. Management needs to shift from direction to facilitation. Computer models are used in adaptive management as the primary method to integrate all stakeholder’s understanding of a situation, to assess the significance of data gaps and uncertainties and to predict the effects of management actions (Johnson 1999).

SOFTWARE FOR WILDLIFE MANAGEMENT

In adaptive management a computer model is a learning tool (Johnson 1995). There is, however, the danger that modelling results may be uncritically accepted as truth. When developing software for wildlife management, it is important to be aware of how the different epistemological assumptions influence the software development and implementation process.

Relationship between model and reality

Every computer representation of knowledge is a model of reality. Different underlying epistemological assumptions affect the way computer representations are assessed. The *correspondence position* assumes that an objective reality exists of which the model is a replica (Tarski 1983 as cited in Schinzel 2004). Information about the world is stored as data to be processed and manipulated and thus de-contextualised. According to this position, a model is verifiable in terms of correctness and completeness. The *constructivist position* assumes that model and reality are mutually interdependent (Schinzel 2004). There is no objective reality independent of the model. Perception is always influenced by mental concepts which are models in themselves. According to this position the aim of the model is relevant: a model can be verified according to its appropriateness to achieve a particular aim. Most computer scientists assume a *pragmatist position*, according to which a model is good if it can be worked with successfully (Schinzel 2004). Hence, all models are wrong, but some are useful (Box 1979). The ontological question about whether an objective reality exists is replaced by the question of whether or not the model fulfils its aim.

The danger is that the evaluation of the model according to correctness and completeness is presupposed and the model is mistaken for reality or treated as a true replica thereof. This tendency is exacerbated by the black-box phenomenon. Because few people are able to understand a complex computer system and the model it embodies, working with the system becomes a matter of faith. In addition the tendency to perceive computerized information as scientific, objective and true regardless of its accuracy leads to model outputs being taken at face value without critical evaluation (Chapter 4). Unless such a critical assessment is performed, software creates artefacts which may be misleading or outrightly wrong. The wildlife translocation KBDSS integrates the perception of various stakeholders as to what the relevant criteria for translocating wildlife into communal conservancies may be. The KBDSS is thus not a model of an objectively existing reality but the result of a hermeneutical process. In order to critically evaluate the wildlife translocation KBDSS, its appropriateness and robustness were examined (Chapter 11).

Cultural implications of computer use

Both the hypermedia system IRAS and the wildlife translocation KBDSS are representations of conceptional wildlife management knowledge. To assume a realist or positivist paradigm and to regard the computer as a tool for objective information processing is thus not appropriate. It is necessary to acknowledge the influence of the social reality within which the development of these information systems took place and to examine the possible social influences that these systems may have. In the context of Namibia as a postcolonial African country it is self evident that one should explore the possibility of cultural implications.

The computer is a product of the western world. The term “West” can have different meanings depending on its context. “Western” is no longer a geographical distinction but also a cultural and economic attribute. Here, “western world” is used to refer to societies of Europe and their genealogical, colonial, and philosophical descendants, such as USA, Australia or Argentina. The term “western culture” will be used to refer to the common system of values, norms and artefacts of these societies, which has been shaped by the historic influence of Greco-Roman culture, Christianity, the Renaissance and the Enlightenment.

The high regard for the computer in western societies, which is transmitted to other societies and other cultures of the world, is rooted in the mechanistic tradition, which emerged with the scientific revolution in Europe (Chapter 4). The influence of 17th century classical science on western culture is pervasive. Descartes’ sceptical, mathematical method underpins modern science and rationality shapes modern western consciousness (Watson 2002). The scientific revolution has given rise to the use of “mechanism” as a metaphor which has influenced western culture’s view of nature, history, society and the human being (Merchant 1989; Chapter 4). This metaphor has influenced the birth of economics with Smith’s (1776) “The Wealth of Nations”, which analysed market economies as self-governing mechanisms, regulated by laws and giving rise to an orderly society.

The scientific revolution has brought about a strong focus on quantification and computation. The industrial revolution and its emphasis on increasing production through mechanisation has given rise to a strong focus on economics attested by the development of both Capitalism and Marxism.

European conservation in Africa

In “The Death of Nature”, Merchant (1989) explained how the mechanical metaphor replaced the former organic view of nature. This organic notion of nature carried the dual connotation both of nature as a nurturing mother and nature as an unpredictable female who caused chaos through natural disasters. The increased mechanisation that followed in the wake of the new scientific “discoveries” not only provided a means to control and subordinate Nature, but also led to a mechanistic world view emphasising order and control. Whereas the image of earth as a living organism had served as a cultural constraint restricting human actions in relation to the environment, the scientific revolution and the increasingly rationalised world view portray nature as lifeless and thus sanction its exploitation. The resulting loss of natural resources triggered the realisation in Europe as early as the 17th century that natural resources require sustainable management and conservation (Merchant 1989). Conservation in Africa has been dominated by European ideas which are underpinned by the desire to conserve the African landscape as an ‘Eden’, a wild and natural environment that has been lost in Europe. As a result, traditional conservation policies focused on preserving ‘the wild’ in its ‘natural’ state rather than maintaining a complex and changing environment in which people have to live (Anderson & Grove 1987). An example showing that symbiotic behaviour between wild animals and humans is possible is the guiding behaviour of the Greater Honeyguide *Indicator indicator*. This African bird leads humans to bees’ nests to gain access to the comb after the bees have been removed. This behaviour can only continue to persist as long as honey-hunting humans can co-exist with wildlife in relatively natural situations (Short & Horne 2002)

The use of computer systems for wildlife conservation in Africa thus constitutes a paradoxical situation. A worldview which has created a record of environmental degradation is being imposed on Africans, and a tool which is the product of this very worldview is being introduced in order to improve the situation for Africans. In the light of the history of conservation in Africa it thus becomes apparent that the development of software tools for African wildlife conservation carries with it the responsibility of considering the interests of the people living with the wildlife.

Formalised knowledge

Western societies put strong emphasis on explicit formalised knowledge and thus value the computer as a medium for its transmission. However not all information can be formally systematised and transmitted: “[Such formal knowledge], if it is present at all, is only a fraction of the total knowledge of any adequately encultured individual” (Bateson 1983). Although it has successfully alerted the world to the environmental crisis, science has so far not affected a change towards environmentally-sustainable conduct. In the face of environmental pressures, insights which might help come to grips with the imminent environmental problem might come from knowledge systems other than scientific knowledge which have equal right to be preserved. There is a tendency to regard computer mediated information as better information, because computers “harden” data by making it look precise, objective and scientific, irrespective of its quality or accuracy. Conservation biologists, for instance, have used a suboptimal algorithm to minimize the number of reserves to conserve every species (Underhill 1994). Because the algorithm can produce correct results in particular cases it was wrongly assumed that it would do so in all cases.

Computer meditation thus supports the notion of data as the foundation for thought. However, formalisation and analysis are processes in which distinctions are made between what is considered important and what is unimportant. What is considered important is a value decision which is grounded in one’s culture (Chapter 7). Different cultural assumptions will therefore result in different computer applications. Culture is characterised by a sharing of language, ideas, customs, codes, institutions, tools, techniques, rituals, etc. The business culture, for example, differs from the academic culture. Computer tools are not culturally neutral in the sense that they are designed for particular purposes. Microsoft Excel, for instance, provides statistical analysis functions but these functions are designed primarily for business application and not for scientific analyses. But as Microsoft is becoming a *de facto* standard and therefore more and more people are using Excel, needs are adjusted according to what Excel can do, not according to what is required or best for the purpose. Hestres (2003) showed how the design of Microsoft Outlook manifests American cultural values which are rooted in rationalism and logic, such as high emphasis on individuality, competition and cooperation, time management and practicality. As this software is increasingly used internationally these values are transported and imposed on users in other societies who may not necessarily prize these values equally (Chapter 4).

If a software tool does not meet the culturally informed assumptions and expectations of its users, two things may happen: the tool may not be used, or the expectations may be adjusted (reverse adaptation). Which of the two phenomena actually happens depends on situational context, how much pressure there is to use the software and how marked the differences in cultural assumption are. Between total rejection of the software tool and complete adaptation by the human user is a range of intermediate behaviours. Having to use a particular tool at the work place but disliking it and being aware of the reasons for the dislike is one example.

Standardisation

Sutherland *et al.* (2004) suggest a format for collecting and disseminating the results of conservation research and management interventions in web-based databases. The aim is to replace the current practice of basing conservation management actions on common sense and personal experience with an evidence-based approach. Although the critique of management based on anecdotal information is justified, the suggested information format is highly formalised, dividing the information content into categories such as country, site name, habitat category etc. The type of problem and the broad conservation action can be selected from a menu. This approach is an example of how a computerised format may prescribe how a situation is conceptualised. Information which does not fit the prescribed format will be excluded.

The IRAS architecture also organises information by linking and grouping content under specific categories. However the categories used are topic headings with varying degrees of detail. The headings were designed as navigational aids, i.e. to assist the user in finding information, rather than in order to prescribe where an information item must be placed so that it can be retrieved. The organisation system underlying a relational database system such as Sutherland *et al.* (2004) suggest is exact whereas a hypermedia system such as IRAS relies on associative browsing for information retrieval.

The meaning of categories and the categorisation process are dependent on the underlying epistemological stance. Categorisation is necessary in order to recognise and understand objects. It is the process by which information about the world is organised and structured. The classical view of categorisation purports that categories are discrete entities, characterised by a set of properties which are shared by its

members (Lakoff 1987). This view assumes that reason is abstract and disembodied and that the process of categorisation is a process of discovering the objectively existing properties of objects. However, in practice it is often difficult to determine exactly to which category an object belongs. Natural categories are often ambiguous and fuzzy at the boundaries. More recent cognitive approaches accept this problem by describing categorisation as a process based on prototypes, which represent best examples of a category and can be used as benchmarks for the most representative attributes of the category. According to this view of categorisation, categories are not elements of an objectively existing reality, which are discovered. Categories are rooted in human experience and are therefore not identical for every speaker of a language and vary across different languages and cultures (Lakoff 1987). The possibility of different meanings for categories poses difficulties for knowledge representation, communication and information sharing. Standards are used to ensure that a particular meaning is invoked when a term is used.

The ease of transmission of electronic information via CD Rom or internet makes it possible to share the information and the way it is structured with an indefinite number of people in a very short time. The scope of electronic transmission may lead to the creation of standards which have not been tested adequately.

The positive image and high expectations of digitisation poses special demands for ethical and responsible use of computer mediation. During the software development process it must be ascertained how computerisation may render perspectives as facts and thus create truths, inadvertently as well as purposely. It must to be determined, which knowledges are relevant, which can be computerised and which cannot and what this contrast means for the field in which the software is implemented. In this context, the way in which the computer creates truth and how truth can be created otherwise need to be made explicit. As some bias is inevitable, this needs to be declared, to avoid the creation of false expectations or truth claims (Chapter 11).

Hypermedia allows the inclusion of different visual media formats, contextual formats such as text and visualisation, which tell a story in different ways than a collection of numbers does. This flexibility may allow the inclusion of knowledge that is difficult to express in the usual data driven digital formats. The content in IRAS is based upon scientific information and management experiences, which have been reported in the

literature, as well as personal comments. Future work to add further information content may consider including indigenous African perspectives (Chapter 6).

In the case of the wildlife translocation KBDSS many of the parameters relevant for deciding whether or not to favour a particular conservancy for the translocation of a particular species, are not easily expressed in quantitative terms. Other parameters can be expressed in quantitative terms but the relevant data are often not available. The KBDSS allows expert opinion to be used where empirical data are not available. It is thus possible to make use of subjective input without having to fear that the results will be flawed (Chapter 11).

Culture of silence

Like many post-colonial countries Namibia is characterized by low literacy levels and a “culture of silence” (Freire 2002; Winschiers 2000). Less-educated people tend to be more easily satisfied with computer interfaces than people with higher levels of education (Bodley & Warren 1992). This contrast may arise as a result of oppression and lack of education in that people are not able to express criticism towards authority figures. They are accustomed to accepting the status quo without having developed the ability to creatively form visions of the future. Lack of knowledge of the opportunity for technological improvement prevents the perception of a need for increased usability. Inability to use a programme satisfactorily may be attributed instead to lack of computer literacy; thus the difficulty is perceived as an inadequacy on the part of the human being, not the machine.

The fact that in Namibia critique is not the norm is relevant for software development because it potentially obstructs communication between users and developer of software. Users may not only have difficulty expressing criticism towards perceived authorities, such as a system developer, but they may also have difficulty developing a vision of what a useful system constitutes. Depending on their professional context, they may not know what is technically possible and therefore find it difficult to articulate specifications. They may also be unaccustomed to developing visions of their own, and instead expect to be told by authority figures what their needs are (supposed to be). System developers must be aware of this challenge and develop methods to tease out the users’ requirements, which can only be achieved through true dialogue (Chapter 9).

The black box phenomenon

Most wildlife managers base their decisions on anecdote, experience, and traditional practices because scientific information is either not available or cannot be obtained (Pullin et al 2004, Chapters 6, 8, 10 and 11). Experience based decision-making has the disadvantage that the details which have influenced the decision and the logic which has led to the result are never made fully explicit (Starfield & Beloch 1991). The person making the decision may not have thought the problem through explicitly either. As a consequence there is little transparency and it is difficult to criticize the method which led to the result. There is no certainty whether the method is valid and will be valid in another situation. Computerised decision support systems for wildlife management aim to provide the decision maker with the necessary information and are expected to bestow greater transparency on the decision making process (Starfield & Beloch 1986).

However, the more sophisticated a system becomes the less transparent are its workings to those using it. The situation is then an exact parallel of the intuitive decision maker whose criteria are not transparent to anyone, possibly even herself. In a sense, the situation is worse, because a human can be questioned in ways that a computer programme cannot. To access, comprehend and evaluate the validity of the computer programme, special expertise is required. Computers thus increase the reliance on experts. There are also costs involved for the purchase of equipment and software, maintenance, updating, etc. The ever-decreasing intervals between software releases and new hardware developments create the need for ongoing purchases. Conservation budgets are, however, generally tight and are seldom capable of covering the high costs of specialised expertise.

The problem of expert dependency is prominent in the context of an African developing country such as Namibia. Foreign colonial rule, the postcolonial development crisis and the resulting dependency on foreign aid emphasise the need for empowerment through local expertise. The need for building local capacities is widely accepted (Bounemra et al 1999). Local software developers are few. Many graduates leave the country or pursue careers where they can get higher salaries than the environmental sector in Namibia can offer. In order to reduce dependencies on external experts and to avoid the black-box phenomenon, software should be locally developed, affordable and easy to maintain (Chapter 7).

The hypermedia format which was chosen for IRAS is easy to use; the system is essentially a collection of files which are linked by hyperlinks. The structure is easily understood and does not require a high level of computer expertise. It is easily updated and can be adapted and modified according to changing needs. It is therefore not only an appropriate format to represent the ever changing state of knowledge in an adaptive management situation, but is itself an adaptive knowledge representation.

The wildlife translocation KBDSS was also deliberately kept simple, in order to avoid the black-box phenomenon. For example, although the NetWeaver software allows inclusion of a wide range of mathematical operators, only the logical operators AND and OR were used. The model was developed in close cooperation with managers and conservation scientists and will be operated by a small dedicated group of conservation scientists at MET. As further knowledge about the critical factors of wildlife translocations is obtained (i.e. knowledge about the conservancies, their capacities and potentials) updates of both the input values and also the model structure are likely to become necessary. No sophisticated user interface has been developed for the KBDSS. This decision was explicitly made so that use of the model requires a basic understanding of the structure and workings of the model itself. But because the model is kept simple, understanding of the model does not require special expertise. A sophisticated user interface which hides the workings of the computer system from the user may ease the handling of the system, but also takes all responsibility and control away from the user. As soon as the system ceases to produce acceptable results, an external expert is needed to make the necessary adjustments. By leaving the workings transparent to the user, the user is empowered to do all necessary maintenance procedures herself. It is important that the model outputs are constantly re-evaluated from within an adaptive paradigm. There is, of course, the danger that an inexperienced user might meddle with the system. Trying to hide the system workings is not necessarily the best solution, however, and the focus should instead be on developing the necessary competencies.

User-Developer relationship

Software tools for environmental management cannot be bought off the shelf but must be custom-built. Special development of software has the potential advantage that the software product will meet specific requirements and be optimally suited to the problem. There is, however, the danger that such software will be inadequately tested.

An important part of the software development process is the specification of the product according to the client's need. For the average person, a computer system resembles a black box whose inner workings remain a mystery. The developer is considered to be the computer expert and is expected to understand these inner workings. However today's complex computer systems are seldom, if at all, understood by one single person. The developer might not fully understand the client's domain, for which she is expected to design a software application; the client on the other hand cannot make his requirements fully explicit without having some understanding of how these needs will be realised. Thus, although developer and client might never fully comprehend each other's domain, their knowledge and actions determine and influence each other. It is the developer's responsibility to ensure optimal communication between herself and the client in order to avoid subliminal enticement and to make sure that her recommendations are based on the clients needs (Birrer 1998). Dysfunctional communication is the most frequent reason, besides lack of financial and human resources, for failure of software projects in Namibia (Shoopala 2004).

Most software development in the Namibian environmental sector is funded by foreign aid. The client and the end-user are thus not the same person, but both must be satisfied. However, the production of software to deadlines and budgetary limitations imposes constraints. The results tend to be simplifications, which do not allow adequate interactions between developer and user of the software and may result in gaps between theory and practice.

The first prototype of IRAS was developed with very few specification from MET personnel who were going to be the users of the system. Attempts to receive input from potential end users resulted in very broad criteria: the system had to adequately represent the information collected on species by the Transboundary Mammal Project; it had to be compatible with existing information systems and it had to be easy to use and maintain. It became apparent that the funding agent and the MET department directors, who formed the steering committee of the project, believed, that I should anticipate the requirements. The resulting prototype was accepted by the steering committee. However to in order to adequately evaluate the prototype and to possibly elicit further specifications a workshop was initiated with 14 MET wildlife managers and conservation scientists who were likely to use the system in the future

(Chapter 7, 9). The aim of the workshop was to assess the usability and functionality of the system by taking the cross-cultural context into account. Aware that the cultural differences between developer and user are likely to aggravate the usual communication barriers, Namibian computer science students acted as usability testers in place of the developer, so that user and tester shared the same ethnic background.

The decision to develop the wildlife KBDSS based on fuzzy logic using the NetWeaver software, was essentially a decision made by the funding organisation. Prior to the project it had already purchased this software. A critical evaluation of the system suggests that the approach is appropriate and robust, i.e. not sensitive towards fluctuations in input (Chapter 11). For the wildlife translocation KBDSS no usability test was performed. The KBDSS is more complex than the IRAS system and involves a series of steps in which data are manipulated. At present there is no user interface which hides these processes from the user. Usability is compromised in favour of transparency. It is assumed that the system will be institutionalised, i.e. will be used and integrated into existing decision making and management implementation processes. In the course of this process it may become apparent whether usability can be improved without in turn compromising transparency. In order to develop specifications for both improved functionality and usability, it will be necessary to expose users to the system.

SUSTAINABLE SOFTWARE DEVELOPMENT

To achieve useful software tools for environmental management in an African context the following must be taken into account: The cultural origins of computing; the colonial origins of environmental management and the difficulty of integrating different knowledge systems. Computing experience in Namibia is characterised by low internet bandwidth and frequent power cuts. Software solutions must be tailored for these conditions. Although IRAS is available online, an offline version for distribution on CD Rom will also be made available. Neither IRAS nor the wildlife translocation KBDSS involve processes which are susceptible to loss of data should a power cut occur.

An additional reason to keep solutions simple is to allow people to develop their own needs and requirements while actually using the software. Users need to be actively

involved in the development process by developing their own software specifications rather than reiterating familiar but practically meaningless criteria that are frequently used in the discourse on computers but which originated elsewhere. Passivity and culture of silence are attributes which are linked to the colonial past and are additional hurdles which have to be overcome in the user-developer relationship through dialogue.

In the southern African context, with the associated problems of technology transfer, system specification should start with first establishing “what is available?”; Then “what can be made of it?”; finally “how can it be realized?” (Winschiers 2001). This process is a pragmatic approach preferable to identifying a problem and then designing a “solution” which will fix it.

Software aimed to support decision making in wildlife management should not only support adaptive management but the software development and maintenance process must be adaptive too. Rather than providing fixed solutions, the software and the outputs it produces require constant re-evaluation in order to reflect changed conditions, especially increase of information through explicit experience. This requires that developers are open to critique during the design and development process (Winschiers 2001).

Prototyping is a good method for guiding the interaction between developer and user, because people can see what the developer is producing rather than confront formal specifications they do not understand. It is still important, however, to use the prototype as a tool for communication and to make sure it is not mistaken for a solution. In the case of IRAS, the steering committee members would have accepted the prototype without any further changes. During the interactive workshop more concrete specifications and critique from users emerged.

Transdisciplinarity and Participation

Wildlife management in Africa requires transdisciplinary cooperation and it is important that software tools for wildlife management support such an approach. In the case of the wildlife management KBDSS, a workshop was held with participants from both MET and the NGO sector in Namibia in order to elicit input values for the system. Participants were conservation ecologists, wildlife managers, policy makers

and NGO people who work closely with communal conservancies, helping them to implement community-based natural resource management (CBNRM) practices. During the workshop it became apparent that experts tended to focus on their area of expertise and were not good at taking all criteria into account. For example, when trying to make an overall decision, ecologists tended to focus on biophysical factors and to disregard social criteria such as management capacity or economic potential of the conservancy (Chapter 11). The knowledge elicitation process forced experts to focus on a single criterion at a time and, by pooling their knowledge in group discussion, they were able to make inputs for criteria outside their special expertise. The knowledge elicitation workshop thus encouraged transdisciplinary dialogue.

Community Participation

There were, however, not many different disciplines represented during the workshop, because not all who were invited could attend. In particular, there were not many CBNRM experts and there were no representatives of communal conservancies, although some of the MET staff had stakes in particular conservancies, because they or their families lived or farmed there. A possible argument against direct involvement of communities in generating the input values may be that conservancy representatives do not assess their area “objectively”, because they have a vested interest. The evaluation of the KBDSS, however, suggests that the input generated by the government officials is biased, too (Chapter 11). The robustness of the system towards subjective input suggests that it will be beneficial and important to further explore how conservancies can be directly involved in the decision making process (Chapter 11). Such participation would add to the transparency of the process.

Environmental decision making needs to take the views and perspectives of all interested parties into account. Informal knowledge systems such as local and indigenous knowledges as well as formal scientific knowledge should be included in environmental management, not only for egalitarian reasons but also because science has failed to affect a change towards environmentally-sound behaviour. Local indigenous knowledge is not easily included in computerised approaches and stakeholder participation is time consuming and costly. Further research may focus on how these goals can be achieved.

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CHAPTER 3

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The importance of ethics discourse in wildlife conservation: Why should we conserve rare and endangered species?

ABSTRACT

Conservationists mostly agree that biological diversity is valuable and that the untimely extinction of species is bad. Justifications for this belief range from stressing the instrumental value of wildlife to asserting the intrinsic value in wild species from which follows a duty to protect them. Because of the lack of opportunity to include such ethically-charged values in the conservation discourse many stakeholders are inept at expressing environmental values. This paper reviews practical arguments for the conservation of wildlife as well as several environmental ethics positions. The aim is to open the environmental ethics debate to conservation biologists, ecologists and natural resource managers; to provide an opportunity to connect with explicit ethical positions in order to reflect upon and debate about environmental values.

INTRODUCTION

Although there is disagreement regarding the proper human relationship towards the rest of the natural world, conservationists mostly agree that biological diversity is valuable and that the untimely extinction of species is bad (Cafaro & Primack 2001). Justifications for these principles vary, ranging from arguments that emphasize the instrumental value which species have for humans, to ethical theories which assert that wild species have intrinsic value.

In the face of increasing human populations and the related pressures on non-human species and their habitats conservation efforts have to reconcile the conservation of nature with the needs of people. Especially in developing countries people's livelihoods depend on natural resource extraction. It is therefore not surprising that arguments for the conservation of wildlife stress the instrumental value that particular species have for people, a value that can often be translated into economic terms. Such reasoning does not necessarily suggest the reckless exploitation of the environment. Rather these arguments support the notion that species should be

carefully managed as natural resources for human benefit. In fact most international environmental policy making is underpinned by a broadly anthropocentric approach to environmental value. At the level of popular political debate the ethical agenda is largely composed of resource management concerns (Palmer 2003). The most commonly cited definition of sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development 1987) is anthropocentric (Cafaro & Primack 2001). Accordingly, it can be argued that species deserve to be protected and conserved in as far as they are good for people. The preamble to the Convention of Biodiversity, however, affirms the intrinsic value of biological diversity even before listing other values such as ecological, genetic and economic value (Secretariat of the Convention on Biological Diversity 2003).

The question whether intrinsic value can indeed be found in anything but human beings is controversial. The environmental ethics debate is largely concerned with finding out whether intrinsic value in non-humans is possible or even necessary in order to develop universal theories why humans should protect their natural environment. This debate is of interest to conservationists because if species are intrinsically valuable the burden of justification would be removed from the conservationist toward the developer. Conservationists would no longer have to prove that species conservation is worthwhile, instead those proposing a development would have to show that the activities involved do not cause significant harm as is affirmed in principle 6b of the Earth Charter (www.earthcharter.org). A possible reason why human-centred resource management approaches remain dominant is that tangible, rational values such as ecological and economic benefit are more readily defined than less tangible values, such as are expressed in the propositions that there is intrinsic value in nature or that there is a duty to conserve wildlife. There is a preoccupation with quantification and measurability amongst ecologists and conservation biologist (Robin 1997; Fazey *et al.* 2005), which consigns the discussion of such values to the private realm. Because of the lack of opportunity to include such values in the conservation discourse many stakeholders are inept at expressing environmental values that are “deeply held or not available to consciousness at a moment’s notice” (Satterfield 2001). However, Satterfield’s study shows that this difficulty is caused merely by an absence of opportunities for expression, not an absence of these values.

This inarticulacy problem not only leaves the discussion of environmental values to elite groups such as policy makers and ethicists (Satterfield 2001), it also leaves conservation workers stumbling blindly without explicitly knowing their own environmental values and beliefs.

This chapter does not attempt to prove or disprove intrinsic value in wildlife nor to give a complete overview of environmental ethics. The aim is to open the environmental ethics debate to conservation biologists, ecologists and natural resource managers by reviewing some approaches which support the conservation of wildlife species in different ways. It is a first pass at proposing to enable the conservation worker to connect with explicit ethical positions.

INSTRUMENTAL VALUE IN WILDLIFE: WHAT SPECIES ARE GOOD FOR

There are several frequently employed arguments for the conservation of wild species. These arguments have in common that they focus on the value species have for humans. Such values are instrumental for the well being of people and arguments that stress the instrumental value of species are in consequence called anthropocentric. In this view, wild species are only good in as much as they are *good for something* and have a use or a value for humans. The following list is not exhaustive, but attempts to capture the commonly cited arguments.

Economic argument

Wildlife has great economic value, both direct and indirect (Myers 1983). Some wildlife species are of high economic value for tourism, hunting and live sale (Child 1970). The value of an animal in a live sale transaction or the value of a hunting trophy can be expressed in direct cash terms. Indirect economic values accrue from the roles species play in recreation and eco-tourism, waste disposal, climate regulation, protection of soil and water resources.

Economic arguments provide a basis for valuing and protecting species, especially when the concept of economic value is expanded from short-term profits to longer-term and indirect benefits. This line of argument, if used alone, presents ongoing challenges for endangered species conservation, since many rare and endangered

species have little economic value. Management actions which are designed to benefit economically valuable species can be detrimental to other species. Economic considerations can equally lead to arguments for extinguishing some species or for saving one species rather than another.

Aesthetic argument

Species contribute to the diversity and beauty of the planet (Myers 1979). The safari and eco-tourism industry attest the aesthetic value people attach to particular wildlife species, which induces tourists to travel long distances and to pay large amounts of money for game viewing safaris. At least for developed nations, where opportunities to observe wildlife are steadily decreasing, it can be said that the quality of life will decline substantially with the loss of species diversity. In many developing countries game viewing and trophy hunting generate considerable sums of money and the aesthetic value of wildlife can thus be directly linked to an economic value.

An interesting question arises here, namely to what degree and in what way do rural communities see wildlife as valuable for quality of life? Members of developed nations translate the wildlife experience into a monetary value for local communities. But what value do the local communities attach to wildlife? Newmark *et al.* (1993) have shown that the support or opposition for protected areas in Tanzania by neighbouring community members is based on economic values, as had previously been found in Rwanda and Brazil. Kangwana & Mako (2001) on the other hand state that later surveys indicate “that people living around the [Tarangire National] Park hold cultural values which drive their desire to see that wildlife continues to exist in their surroundings” and that “Wildlife is seen [by local people] as having a value beyond its simple economic costs and benefits”. In Namibia traditional tribal authorities support the establishment of protected areas to see wildlife return to their homelands (Mauney 2004).

Nature and wildlife are also a great philosophical and spiritual resource, serving as inspiration for religious, philosophical and spiritual thought and experience. This claim is not only true for the direct wildlife experience but the mere idea that we share the earth with blue whales, orang-utans, cheetahs etc. can be inspiring. What is valued

here is the simple possibility that a species exists and survives, although one might never see it (Fisher 2001).

However, appeals to aesthetics suffer similar limitations as the economic argument because not all species are attractive and capture popular imagination. Accepting attractiveness as a value implies accepting un-attractiveness as a disvalue. Charismatic species are used as flagships, in the hope that the management actions will benefit the entire ecosystem. However this approach does not always work, and is indeed contradictory if the flagship species receives special treatment, such as supplementary feeding and other species do not (Simberloff 1997). Aesthetics can also be detrimental to a species, because rarity increases the interest of collectors, who may diminish numbers even further.

Biodiversity as a genetic resource

Many species, including endangered ones, are expected to have agricultural, industrial, and medical benefits. To lose such species diminishes the genetic stock of wild animals, so it is prudent to save them. Again, not all species are useful. Since we cannot not know now, which species may turn out to be useful in the future, conservation should extend from obviously useful species to those that are currently considered less useful. Myers (1979a) urges us to “conserve our global stock”, to conserve species in order to protect useful genetic material. The purpose of protecting species is thus for their “enlightened exploitation” (Rolston 2001).

However, arguing that a species deserves conservation because it may prove useful in the future is difficult, if this species is currently harmful to humans. This line of argument is unconvincing if species are perceived as harmful, such as pests or a type of bacteria that causes disease. Not everyone would agree that such species be kept alive because they may prove useful in the future.

Ecosystem stability

It is frequently argued that many species which are not necessarily directly useful to humans still play important roles in the ecosystem. As such they are of use to other species, which are in turn useful to humans. Although the loss of a few species might not be too serious now, the loss of many species will threaten the processes and interdependencies of the ecosystem on which we as humans depend, in ways that

cannot possibly be foreseen. Thus species are part of a life support system: the earth is seen as a biological habitat or home. Every species contributes to the planet's biodiversity, which keeps ecosystems healthy (Ehrlich & Ehrlich 1982). But how does one apply this argument in the context of ecosystems whose balance has been disturbed and which need human interference through management action? Management actions which are aimed at saving one species may be harmful to others. A real dilemma occurs if two species require contradicting management actions (Simberloff 1998).

Scientific argument

Species also serve as indicators of ecosystem health. We need to study species and their roles within ecosystems to understand their interdependencies and to predict the impacts of our actions on the environment. Species offer clues to understanding natural history and are records of past processes and as such have historical value. This argument views species as a biological Rosetta Stone which may enable the deciphering of the hieroglyphs of natural history (Rolston 2001). According to this argument species have value because they provide humans with insights into the text of natural history, which humans need in order to understand their own environment. Some species are curiosities and a source of fascination to enthusiastic naturalists. Generally speaking, wildlife species can be a basis for creative and intellectual thought. One of the outcomes of such thought is a better informed perspective on the natural history of the planet and its life forms. But again it is possible to argue that some species are obviously harmful. Is it justified to conserve such species simply to satisfy our curiosity?

Myers claims that the scientific argument, and equally the ecosystem argument and the aesthetic argument are "unlikely to stand up against man-made pressures to modify and disrupt natural environments". He concludes that wildlife must pay its way and economic benefits must be stressed to ensure that wildlife will survive in the face of other profitable forms of land use (Myers 1979, p. 56). The practical advantages of this view are obvious. But perhaps one should draw attention to the Hobbesian worldview that underpins this rationale. "The man-made pressures to modify and disrupt natural environments" are taken for granted. Humanity is seen driven first and foremost by self-interest. Without external checks, such as incentives,

benefits or legislation, we are, according to this view, in profound conflict with each other and with our natural environment. Hobbes (1588-1679), who did not believe that human beings were naturally endowed with social and moral qualities, declared “the life of man is solitary, poor, nasty, brutish, and short” (Hobbes 1991). Accordingly ethics is seen as the cumulative human effort to understand and to control the more natural tendency to pursue selfish goals (Taliaferro 2001). Ethical behaviour is something that humanity had to learn in order to live peacefully and productively in an extended group. Acting ethically in this view, is very much like fighting an addiction. The addict is never entirely free of the struggle. This view of humanity and ethical behaviour is fundamentally pessimistic. Its consequence is that we cannot rely on members of our own species in order to protect endangered species unless we make use of the very character traits that endangered them in the first place.

Arguments that are based on the instrumental value of species are limited for several reasons. First of all they do not work equally well for all species. Secondly the conservation of a species is only justified as long as the costs of conservation do not exceed the benefits. The fact that valuable species have been driven to extinction shows that utility doesn't insure security. Richard Routley, who later changed his name to Sylvan, argued that positions which only stress the instrumental value of non-human species do not provide sufficient ground for environmental ethics. He presented the last man argument, a thought experiment in which he asked if the last person on earth, well knowing that no human being will ever inhabit the planet afterwards and equipped with the means to eliminate all life on the planet would be justified do so. Sylvan suggests that most people would intuitively say “no” and call such destructive behaviour morally wrong although no human being would remain to experience the consequences (Sylvan 1998).

INTRINSIC VALUE IN WILDLIFE: WHY WE OUGHT TO PROTECT SPECIES

A possible reason why someone might respond negatively to the “last man argument” is that there is indeed intrinsic value in non-humans and that from this a duty follows to conserve other species. Arguments for the intrinsic value of non-human species are varied and what follows are a few examples.

Extensionist environmental ethics

One way of identifying the intrinsic value of non-humans is to extend traditional moral theory, which concerns itself with interaction between humans, to also include members of other species.

Animal rights and reverence for life ethics are examples of such extensions. Animal rights advocates seek to articulate similarities between humans and non-humans. The search for features common to humans and other animals is an attempt at building a particular type of moral community. Most people have no difficulty in recognising the moral bond between parents and children for example, or between friends or partners. As we extend moral obligations beyond the boundaries of our immediate environment, we naturally look for features, which give an inferential foundation for this extension. Consequently so called extensionist arguments ask, what qualities give intrinsic value to humans, and then assert that some other beings possess these qualities, too. In the Kantian tradition (Downie 1995) this moral criterion is rationality and one common justification for valuing animals intrinsically is that some have been shown to possess some rudimentary form of reasoning. Chimpanzees and gorillas have been taught sign language, predators such as wolves and lions have the ability to coordinate hunts. Dolphins, whales and other cetaceans send complex signals that we are only beginning to understand. But basing intrinsic value on these abstract capacities seems to rule out most animals, for example most invertebrate species.

According to Peter Singer (2001) the aim of ethical behaviour is to maximise pleasure over pain – pleasure being understood to possess intrinsic value, while pain possesses intrinsic disvalue. His position is grounded in the utilitarian tradition of Jeremy Bentham (1748–1832), who pointed out that the question to ask is not “Can they reason? Nor Can they talk? But, Can they suffer?” (Bentham 1789, p. 283). The moral criterion here is sentience. The argument is that because animals share the ability to experience their environment and are able to suffer, human actions which inflict suffering on animals are morally wrong. This sentience based view overcomes the limitations of the earlier instrumental arguments by providing a basis for sentient beings to be morally considerable, independent from their instrumental value. Using sentience as the moral criterion does include a wider class of animals within an

extended ethical domain, but still restricts it to sentient animals. Plants, fungi and single-celled organisms are effectively ruled out.

Extensionist ethical theories are direct applications of modern mainstream moral theory. What is common to all extensionist theories is that they take the ego as point of departure: I am intrinsically valuable because I possess the moral criterion, and I must grant others who possess the criterion, the same rights. The problem with this line of argument is obvious: the scope of moral consideration will either extend only to some but not all species or lead to a very demanding code of conduct, because it is then morally wrong to kill individuals of any species, unless justified through an appeal to our own survival. What is more, extensionist arguments focus on individual organisms rather than on whole species. Such individualist approaches allow no moral consideration of animal or plant populations, nor of endemic, rare or endangered species, let alone biotic communities or ecosystems, because entities and aggregations such as these have no apparent psychological experience. Conservationists however are concerned with the conservation of species and ecosystems rather than individual animals. Hence it is questionable whether these individualist approaches can serve as an ethical underpinning for wildlife conservation (Cafaro & Primack 2001).

Holistic Environmental Ethics

In contrast with individualist environmental ethics some ethicists state that viewing nature as an aggregation of individuals is a distortion that does not appreciate nature's organic, integrated and dynamic character (Palmer 2003). It is for this reason, amongst others, that some ethicists argue that a completely new ethics is required, that environmental ethics needs to challenge the philosophical tradition and develop arguments that go far beyond the scope of simply extending traditional moral arguments (Sylvan 1998). Holistic environmental ethics focus on ethical consideration of ecological wholes (Palmer 2003), which encompass all levels of individuals, aggregations, relationships and processes. Such non-extensionist approaches, also called naturalistic or biocentric, seek for arguments to support the preservation of species, because all species represent unique biological solutions to the problem of survival (Rolston 2001). More diverse biological communities seem to be better able to deal with environmental disturbances; therefore, if we value some species we should arguably protect the entire system of interdependent species.

A possible response to this challenge would be to question whether species are in fact “real”. Darwin (1968, p. 108) interpreted the term species “as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other”. This interpretation implies that a species is merely a category, an element of a man made system; a species is routinely named after the “author” who “erected” the taxon. What is more, taxonomists regularly revise species and move the boundaries of classification. There are several different concepts of species within science, so is there enough factual reality here to allow one to speak of a duty towards species? Rolston (2001, p. 407) maintains that species are not just arbitrary classifications but really existing entities. He calls a species a “living historical form [...], propagated in individual organisms, which flows dynamically over generations”. A species is a “natural kind” encoded in the gene flow and expressed in individual organisms. In this sense species exist “as living processes in the evolutionary ecosystem – found, not made by taxonomists.” Species are phenomena like mountains and rivers that are being mapped. The boundaries are sometimes fuzzy and we can expect that, being “living processes”, one species will evolve into another over time.

The Land Ethic

An example of a holistic environmental ethic is Aldo Leopold’s Land Ethic. *A Sand County Almanac* is famous and highly esteemed in conservation circles, but many contemporary philosophers have questioned its philosophical respectability. J. Baird Callicott however defends the Land Ethic and attributes the professional neglect and confusion to the fact that it is “from a philosophical point of view, abbreviated, unfamiliar, and radical” (Callicott 1998, p. 102).

This paper focuses on Callicott’s biocentric interpretation of the Land Ethic; others like Bryan Norton (1996) argue that Leopold’s emphasis on management supports an anthropocentric reading. Leopold understands the history of ethics both in biological as well as philosophical terms. From a biological point of view an ethic “is a limitation on freedom of action in the struggle for existence. An ethic, philosophically, is a differentiation of social from anti-social conduct” (Leopold 1970, p. 238). The latter definition poses little difficulty but the former needs to be investigated more closely. The phrase “struggle for existence” reminds one of

Darwinian evolution. It is not immediately obvious how the origin of ethical conduct can be located in evolution. How can there be room for “limitations on freedom of action” in the competitive struggle for existence, the “survival of the fittest”?

Callicott explains that Leopold’s Land Ethic and his understanding of the origin of ethics was clearly informed philosophically by David Hume and Adam Smith and biologically by Charles Darwin (Callicott 1998). Hume and Smith argued that ethics rests upon feelings or “sentiments”, which may of course be amplified and informed by reason (Callicott 1998). Darwin points out that there are parental and filial affections in animals, which allow the forming of small closely related social groups. If these affections are extended to less closely related individuals, the family group is enlarged. If the family group proves to defend and provision itself more successfully, the fitness of its members is increased. In this way the familial affections or “social sentiments” are spread throughout an evolving population (Callicott 1998).

Leopold concludes that “the thing [ethics] has its origin in the tendency of interdependent individuals or groups to evolve modes of co-operation...all ethics so far evolved rest upon a single premise: that the individual is a member of a community of interdependent parts” (Leopold 1970, pp. 238-9). In the course of history the community of morally relevant individuals has grown, from the spatially bounded tribal community to today’s global village, “The Land Ethic simply enlarges the boundary of the community to include soils, waters, plants, and animals, or collectively: the land” (ibid, p. 239).

Callicott describes the logical foundation of the Land Ethic as such: Natural selection has endowed human beings with moral responses to perceived bonds of kinship, community membership, and identity. The natural environment is represented as a community, the biotic community and an environmental ethic or Land Ethic is therefore not only necessary, but also possible (Callicott 1998).

Leopold presents an energy circuit model of the ecosystem, where solar energy “flows through a circuit called the biota” (1970, p. 252). Energy enters the biota through the leaves of green plants and courses through the food chains. Energy courses are composed of individual animals and plants. The maintenance of the ecosystem’s

complexity and its smooth functioning “as an energy unit” are the summum bonum of the Land Ethic. The extensionist theories discussed earlier are limited in that they are based on a moral criterion that establishes human resemblance. Since sentience or rationality are properties of the individual these approaches cannot argue for the conservation of species. The Land Ethic differs in that it focuses on the community rather than the individual. Qualities such as integrity and stability are thus of primary value and species ought to be conserved because they “preserve the integrity, stability, and beauty of the biotic community.” (ibid, p. 262).

It is important to note that ecosystem complexity is not considered a good because it represents the life support system on which we as humans depend, but rather a good in itself. The ecosystem does not exist in order to support humans. *Homo sapiens* are a part of it like other species.

Holmes Rolston III: An ethic for species

Another example of a non-extensionist environmental ethic is the logically compelling biological view defended by Rolston. As his point of departure Rolston points out that it is culture, which sets humans apart from animals and that “to treat wild animals with compassion learned in culture does not appreciate their wildness.” Culture is advantageous for humans but it can very often be a bad thing for animals, as in the case of battery animals. Rolston therefore rejects extensionist arguments, which are inevitably grounded in culture and claims that “biology and ecology - neither justice nor charity, nor rights nor welfare - provide the benchmark for an (environmental) ethics” (1991, p. 76). Rolston goes on to explain that while pain is a bad thing in culture, pain in the ecosystem is instrumental pain, part of the process through which an animal is naturally selected. Adaptive fitness is the fundamental value on which Rolston’s biocentric ethics is based. He defines an organism as a spontaneous, self-maintaining system that sustains and reproduces itself, continuously executing and checking its genetic programme against its environment. “The physical state that the organism seeks, idealized by its programmatic form is a valued state. Value is present in this achievement” (Rolston 1991, p. 80). The organism defends its life. It has its own standard and its own know-how. It has its own good.

Leopold sees ethics as a product of evolution located in the biotic community, whereas Rolston views organisms as amoral. Rolston points out that within the cultural community, norms need to be judged, because they represent personal options, but that there is no such need in the biotic community. Organisms in the biotic community are amoral normative systems, seeking a good of their own. There are no cases where this impetus can be called morally wrong. Therefore the distinction between having a good of its kind and being a good kind, which exists in the cultural community, disappears within the biotic community. In this sense, “everything with a good of its kind is a good kind and thereby has intrinsic value” (Rolston 1991, p. 81). In other words, every organism is a *holder* of value, even if not a *beholder* of it (Palmer 2003).

Although only humans can act morally, Rolston argues that intrinsic value can be found in animals and in fact in all natural organisms, and therefore a moral duty towards non-human organisms does exist (Rolston 1991). But this duty still refers to individual organisms. How can a duty towards species be derived from this view? Rolston argues that although a species has no self, the genetic program that identifies the individual is as much a property of the species as the individuals; therefore identity is a discrete pattern over time. Through adaptation the speciation process ensures the continuation of both the individual and the species. According to Rolston it makes no sense to value the organisms without valuing the processes that produced them. Species defend themselves and therefore have a right to live. Right is meant here in the biological sense denoting an adaptive fit that is right for life. Throughout the evolutionary process the information encoded as genes has had to prove itself. The genetic programme of the species has proved to be right, has so far guaranteed survival. Species defend the speciation process without which there would be no evolution, no environment, as we know it, constantly renewing, changing, and improving itself. As such they are “a good of their kind” (Rolston 2001).

Rolston’s environmental ethic centres on adaptive fitness and the speciation process aiming to achieve a desired state. It seems at first sight problematic to apply this line of argument to the conservation of rare species, since their rarity might indicate a lesser degree of fitness. Rolston states however that although there is no intrinsic value in rarity as such, a rare species, left undisturbed might present a perfect fit

concepts. Death is the end of a life whereas extinction is the end of the opportunity for birth.

Daisaku Ikeda: The oneness of self and its environment

Callicott's and Rolston's approaches present just two examples of environmental ethics that defend intrinsic value of the natural world. However, approaches which prioritize the whole over the individual, in particular when the whole is the wild biotic community are widely viewed as ethically unacceptable or even fascist (Palmer 2003). The focus on the ecological system results in a picture of human beings as not only not being vital to the workings of the system but being detrimental to it. Rolston goes so far as to conclude that sometimes the protection of the environment takes precedence over feeding hungry people (Rolston 2003). Such misanthropic positions sharpen the dichotomy of human versus environment and are unlikely to be helpful in balancing the interests of people with the protection of the environment which lies at the heart of the wildlife management challenge. Hence the intrinsic value debate has been criticized as being of little use for environmental policy making (Light & Katz 1996, p. 4). Whether or not non-human entities can have intrinsic value is considered by environmental pragmatists a purely theoretical discussion. The origin for the discussion on intrinsic value may lie embedded in the tradition of western philosophical thought. Modern thinking is strongly influenced by Descartes (1596-1650) who divided the world into matter and mind thus creating a dualism that regards humans and their environment as separate entities (Taliaferro 2001).

Eastern philosophy on the other hand is not based on this dichotomy (Allwright 2002, p.45). An excellent example of eastern thinking can be found in the work of Daisaku Ikeda. Ikeda's approach provides a bridge between eastern and western thinking that is a valuable contribution to environmental philosophy.

Ikeda's philosophy is based on Buddhist thought, central to which is the concept of dependent origination. According to the concept of dependent origination, no being exists in isolation; everything in the world comes into being in response to causes and conditions and exists or occurs because of its relationship with other beings and phenomena. "According to this view, when one particular cause or set of causes exists then a certain result comes about; when one entity comes into being, so does another

entity” (Xianlin *et al.* 2001, p. 9). In other words, each person, each living thing, in fact all phenomena are sustained by the interdependent web of life. This concept is compatible with the biological concept of symbiosis. Each human being exists within the context of interrelationships that include not only other human beings but all living beings and the natural world. The relationship between human beings and nature is not one of opposition but mutual dependence.

Dependent origination, the interdependency of all things and all phenomena manifests the ordering principle of the cosmos. Ignorance or the failure to recognize the interdependence and interrelatedness of all life is the most fundamental delusion. Such ignorance gives rise to greed, meaning that people seek the fulfilment of their desires at the cost of others and leads to a destructive attitude when these desires are frustrated. Ignorance of dependent origination thus leads to a self-destructive egocentrism, which severs the strands of the web of life that support one’s own existence. Awareness of the interrelated nature of life, on the other hand, enables a person to overcome instinctive self love. Such awareness manifests as maintaining an emphatic relationship with others, i.e. other people, other living beings and nature. The process through which someone tries to establish such conduct, however, requires effort and is termed ‘human revolution’.

The concept of dependent origination is the basis of another concept: the oneness of life and the environment. Ikeda explains the Japanese term for this concept *esho funi* as follows: *shō* is short for *shōhō* which refers to the individual life, *e* stands for *ehō* the environment, which supports the individual. *Funi* means ‘two but not two’ referring to the impossibility to separate the two, individual and environment. The individual life influences its environment but is at the same time dependent on it (Toynbee & Ikeda 1982, p. 45). To explain Ikeda uses the analogy of a body and its shadow: the body creates the shadow and when the body moves the shadow changes. But in a sense the shadow also creates the body, because the absence of the shadow means that there is no bodily form. Similarly the individual receives form and identity through the environment and vice versa (Ikeda 1982). In other words we shape our environment but we are also products of our environment. According to Ikeda this dialectic is vital for the understanding of the interrelationships between human existence and the environment. He explains that this dialectic relationship between

human beings and the environment means that humans must maintain the supporting energy of the environment. Life cannot flourish in an environment that is altered without maintaining its supporting energy just as food that is eaten without digesting it doesn't nourish a body (Ikeda 1982). "And if we wish to describe the mutual relations that exist between human beings and the environment in these terms, we would say that the living self depends upon the environment for its existence. That is, human beings depend on the workings of the environment or natural ecological conditions for their growth and development. And conversely, as indicated by the statement above that 'without life there is no environment,' the environment must wait for the activities of human beings in order to take on a particular shape or undergo changes. Human beings thus play a key role in the creation of a particular environment, and must bear the responsibility for such creation." (Xianlin *et al.* 2001, p. 19). This inference is not to say that the natural world does not exist independent of human beings, but that the environment of each individual is as much a product of the actions of the individual as the individual is a product of its environment.

Because individual life and environment are inseparable, the state of the environment is a reflection of the mind of the people that inhabit it. Environmental degradation is thus a reflection of people's ignorance of the true nature of life and the cosmos: the interrelatedness of all things. Actions based on this fundamental delusion result in a downward spiral of negativity. Awareness of the fabric of relatedness gives rise to the desire for mutually supportive coexistence with others as well as with the natural environment.

Thus the concept of dependent origination is the theoretical foundation and the compassionate desire for harmonious co-existence is the practical manifestation of environmental ethics.

CONCLUSION

There are several practical arguments for the protection and conservation of species. These arguments have in common that they stress the instrumental value other species have for humans. These arguments provide "practical muscle for conservation where it counts, on the ground" (Myers 1979). However, these arguments are limited as they do not work equally well for all species and utility is only an argument for

conservation as long as the utility value outweighs the costs for conservation. Whether or not wildlife species apart from instrumental value do also have intrinsic value, is a question that forms a large part of the environmental ethics debate and has great stakes for conservationists because it removes the burden of justification for conservation and encompasses all species. If a species has intrinsic value it is unethical to cause its extinction independent from economic issues. Thus the burden of justification shifts from the conservationists towards those who are proposing actions which are potentially harmful to species. The intrinsic value question cuts to the core of the values and beliefs of conservation workers. Conservationist Richard Bell points out that "in any decision-making situation, it is found that, after the technical issues have been dissected away, a kernel remains of value, principle, or emotion, that eventually determines the outcome" (1983). In other words all conservationists do have an environmental ethic, much like everyone has a life philosophy. But to render these values explicit requires being exposed to different viewpoints and arguments and entering constructive dialogue about different values and perspectives. Philosophers such as Leopold, Rolston and others call for a rethink of our moral frame work by drawing directly from ecological concepts rather than a human centred reference frame.

However, approaches which prioritize ecological wholes over individual human beings sharpen the dichotomy of human versus environment and are unlikely to be helpful to wildlife managers who face the difficult challenge of balancing the conservation of biodiversity with the needs of people. The theoretical debate whether non-humans have value independent of humans is criticised by environmental pragmatists who claim that while philosophers argue the environment burns.

Ikeda's philosophy of dependent origination transcends the man - nature dualism in the tradition of Buddhist thought. This approach provides a bridge between environmental ethics and the resolution of practical environmental problems. Ikeda's environmental philosophy is not the attempt to develop an abstract and universally applicable theory, but rather the empowerment of the individual to lead "a contributive way of life [...] based on an awareness of the interdependent nature of our lives - of the relationships that link us to others and our environment" (Ikeda

2002). Such a way of life is centred on empowerment through dialogue and inspiration.

Policy and legislation provide managers with necessary guidelines but especially at the grass roots level more is needed to face up to the daily challenges of human interactions. Governments and institutions have an important role to play, but it is vital that people take responsibility for their environment on an individual level.

In order to be effective ethics must be charged with natural and spontaneous sentiment (Ikeda 2002). People need to emphatically understand each other's realities and they arrive at such understanding through dialogue and open exchange about values and principles. It is through making such efforts that renewed awareness and determination to act arise.

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FIGURES

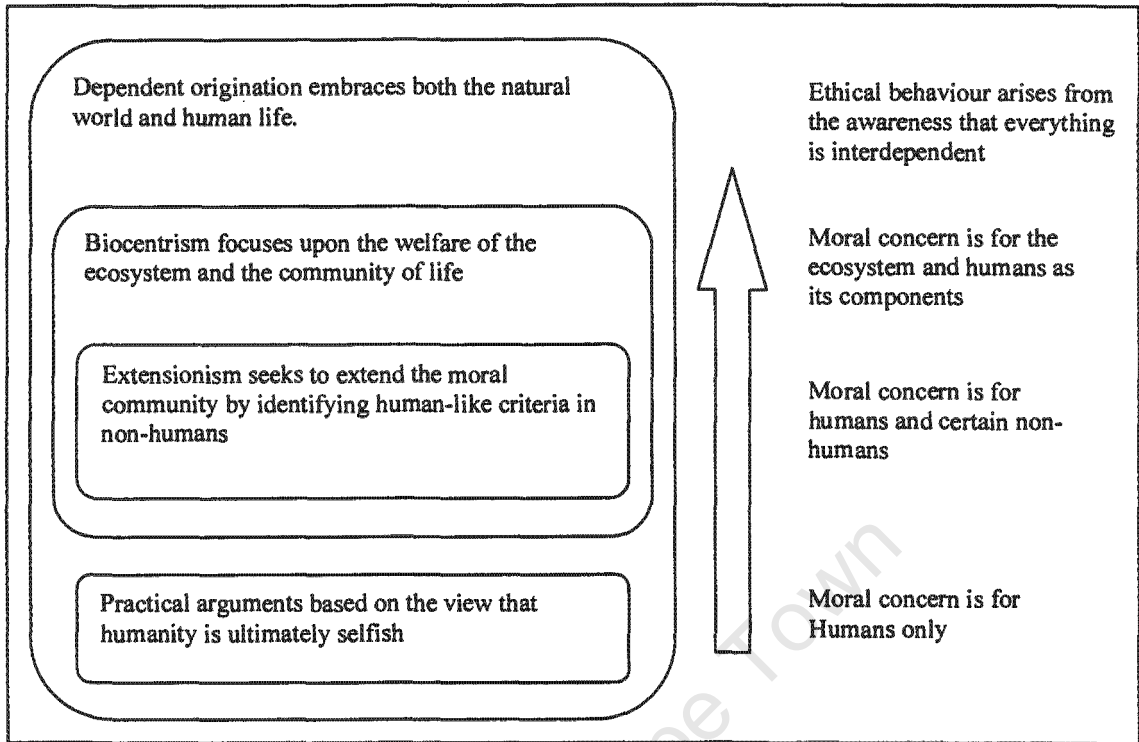


Figure 1 A mapping of ethical concern

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CHAPTER 4

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We cannot eat data: The need for computer ethics to address the cultural and ecological impacts of computing

ABSTRACT

Computer ethicists foresee that in this information age important ethical issues will increasingly be computer related and that computer ethics will become global both in the geographic sense and in that it will be relevant in all aspects of life. These views seem to ignore that the effects of the computer revolution are experienced differently by people in different parts of the world. At the beginning of the 21st century the divide between the industrialised nations and the developing world is immense. Information technology is seen as an essential component of development and strongly promoted by international development agencies implying that unless developing countries apply information technology they will be left behind. The notion that computers are the solution to bridge the gap between the rich and the poor overlooks the fact that computers are the product of a particular worldview that promotes values such as efficiency, speed and economic growth. Not only is there the danger that the computer revolution will marginalise cultural traditions other than the western one, but the western way of life has also caused environmental degradation to the extent that we are now facing an environmental crisis of global warming, natural resource depletion and accelerated species extinction. If computer ethics is to fulfil the expectation of producing a global ethic, the field has to critically address the links between computing and its effect on cultural diversity and the natural environment. This paper highlights some of the issues and interrelationships and proposes that the Earth Charter can function as a framework for such holistic research.

INTRODUCTION

Computer ethics is a fast growing and increasingly important field of practical philosophy. Computer ethicists foresee that in this information age, as information and communication technology (ICT) is increasingly pervading more and more aspects of life, important ethical issues will increasingly be computer related. Deborah Johnson (1999) predicts that because the majority of moral problems will be computer

ethics issues, computer ethics will cease to be a special field of ethics (Bynum 2000). Kristina Górnjak-Kocikowska (1996) predicts that the computer revolution, will give rise to a revolution of ethics and that computer ethics will become a global ethics relevant to all areas of human life. Bynum & Rogerson (1996) and Moor (1998) suggest that the second generation of computer ethics should be an era of “global information ethics”. These views seem to ignore the reality that the effects of the computer revolution are experienced differently by people in different parts of the world. While for some the challenge is to keep up with the continuous new developments, others are still struggling to put in place the infrastructure that may allow them to ride the waves of the information tide and participate in its benefits.

Nelson Mandela has stated that the gap between information rich and the information poor is linked to quality of life and that therefore the capacity to communicate is likely to be the key human right in the 21st century (Ng’etich 2001). However at the beginning of the new century the digital divide between the industrialised nations and the developing world is immense. 80% of the worldwide internet activity is in North America and Europe (Gandalf 2005). Although these areas represent 19% of the worldwide population. The ratio of internet users to non- users in developing countries is 1:750 compared to the 1:35 in developed countries (Ng’etich 2001). Poverty and illiteracy prevent many Africans from accessing computer technology.

Many believe that these hurdles are simply a question of infrastructure (Grant Lewis & Samoff 1992; Anyian-Osigwe 2002). In the first world, computing is experienced as a crucial element in the competitive market and therefore is also promoted in the third world as a vital part of development. The notion that computers are the solution to bridge the gap between the rich and the poor overlooks the fact that computers are the product of a particular worldview that promotes values such as efficiency, speed and economic growth (Bowers 2000; Berman 1992).

Computer use requires people to act and think in a prescribed unified way (Kocikowski 1999 as cited in Gorniak-Kocikowska 2001; 2004; Heim 1993 as cited in Gorniak-Kocikowska 2001; 2004). Not only is there the danger that the computer revolution will marginalise cultural traditions other than the western one, but the western way of life has also precipitated environmental degradation to the extent that

we are now facing an environmental crisis of global warming, natural resource depletion and accelerated species extinction. Different cultures have unique ways of storing, representing and transmitting knowledge, such as mythologies, story telling, proverbs, art and dance. These modes cannot all be equally well represented through computerisation, but all are equally valid and deserve to be preserved (Hoesle 1992). We cannot assume that computer technology will solve the complex social and environmental problems at hand. In order to adequately address these complex issues a diverse body of knowledge is required and we simply cannot afford to lose any sources of knowledge.

Although the increasing gap between the first and the third world, and the environmental crisis present some of the most pressing and difficult moral issues (Hoesle 1992) there is only a small body of research in computer ethics which addresses the problem of the digital divide between the first and the third world and the relationship between computing and the environmental crisis (Górniak-Kocikowska 2004; Capurro 1990; Floridi 2001). Just as computerisation is a product of the west, most computer ethics is explored and defined by western scholars. Although writers such as Johnson (1997) and Górniak-Kocikowska (2004) acknowledge that computer technology was created from within a particular way of life, most current computer ethics research ignores the cultural origins of the technological determinist stance. This stance is prevalent in writing on computing and also effects computer ethics (Adam 2001; Winner 1997). The evolutionary view of progress and its impact on the human world leaves other cultures no choice but to adopt computerisation and to assimilate the values that are embedded in computerisation (Bowers 2002). Moreover current computer technology adopts a logico-rational paradigm often relying on convergences by eliminations and aggregations. It is not clear that computers will develop in such a way as to mimic or represent values or value choices which invoke those elements at the core of any human being. This consequence might not only lead to information colonialism but arguably reinforces a worldview that is ecologically unsound.

To fulfil the expectation of emergence to a global ethic, computer ethics has to critically address the links between computing and its effect on cultural diversity and the natural environment. This paper highlights some of the issues and

interrelationships and proposes that the Earth Charter can function as a framework for such holistic research.

TECHNOCRATIC IDEOLOGY

The notion of computer revolution carries the theme of a technology out of control, ever developing while humans are limping along, hardly able to keep up with the innovations but always looking forward towards the inevitable next step in computing power (Curry 1995). In this view technological progress is unavoidable and determines society rather than being determined by human need. Innovation has become a goal in its own right (Veregin 1995). This technological determinism takes the objectivity of the world for granted and ignores the complex relationships between society and technology, thus obstructing analysis and critique of technological development (Adam 2001).

The prevalence of technological determinism has cultural roots (Bowers 2000). The 17th century idea of the universe as a mechanism governed by discoverable laws and the celebration of reason as the power by which man understands the universe led to the belief that western science is universal and human history is a record of general progress. The western common sense view of the world is still largely influenced by classical physics. Although "it is an inherent characteristic of common-sense thought [...] to affirm that its tenets are immediate deliverances of experience", common sense is an organised cultural system composed of conclusions based on presuppositions (Geertz 1983, p. 75). It is thus a cultural characteristic of the West to view change as linear and progressive.

Although successfully challenged, the notion that science equals truth prevails and causes technology to be regarded as a value free tool (Veregin 1995). But this tool-based model of technology ignores the perspective that technological innovation takes place against a background of social context and profit motives and that every technology imposes limits on thought and action (Veregin 1995; Pickles 1995; Winograd & Flores 1986). The more technology becomes an integral and indispensable part of life the greater is its influence. It ceases to be merely a tool. According to Veregin's (1995) analysis the tool-based model of technology is not only inadequate as a basis for judging technological impact, it also carries the

implication that technology develops independently of social and scientific contexts, thus supporting the technological determinist stance.

Ongoing technological development is leading to increasing complexity of information systems and increasing dependency on experts who understand them. For the average person a computer system resembles a black box, whose inner workings remain a mystery. The expert, who may understand the inner workings to a large extent, does not fully understand the context in which the system is being applied. Although expert and client can never fully comprehend each other's domain, their knowledge and actions determine and influence each other (Birrer 1998). The expert needs to anticipate the client's needs and values; the client relies on the expert's knowledge to develop his wishes and make them explicit. The communication barrier between expert and client can, according to Birrer, cause subliminal enticement. No single person seems to understand a computer system in its entirety. This proposition is certainly valid if the social context of the user is considered part of the system. The absence of transparency leads to computers being regarded as autonomous drivers of change within society (Curry 1995). The resulting dominance of technical knowledge leads to technological determinism and thus reinforces existing socio-political tendencies. For Birrer the expert's role as advisor is more complex and carries greater responsibility than is generally assumed, and poses the most pressing ethical question in information technology development.

Technological determinism goes hand in hand with a highly influential and widely popular ideology that Winner termed *cyberlibertarianism* (Winner 1997; Adam 2001). Cyberlibertarianism combines extreme enthusiasm for computer mediated life with "radical, right wing libertarian ideas" (Winner 1997). Cyberlibertarians assume, inter alia, that the workings of the free market create egalitarian, democratic societal structures. Inequalities are not addressed by challenging social structures. Instead it is assumed that by focussing on the freedom of the individual and propagating self-interest and rights without responsibilities, a global, decentralised, non-hierarchical, non-bureaucratic democracy will arise (Adam 2001). The focus on the individual and individual liberty ignores and obscures the social, political and cultural structures underlying current asymmetric relationships. Adam argues that a liberal stance that favours freedom and absence of interference supports those who are already favoured

by existing social arrangements. The liberal values of cyberlibertarian ideology assume free and equal interactions and equal opportunities provided by information technology. Adam's analysis of cyberstalking examples, however, shows that women's experiences on the internet differ from men's due to differently constructed social roles. She also points out that current research in gender and computer ethics shows that women's access to information technology is still limited and their representation in computing remains low. It follows that computer mediation does not neutralize asymmetric social structures, such as gender, in the way cyberlibertarians assume.

The assumption that progress is linear and inevitable also largely underpins the field of computer ethics. This observation is not only true for the more popular writings and those dealing with professionalism, as pointed out by Adams (2001), but also for the more academic computer ethics research. For example, James Moor (1998) states that "[the] computer revolution has a life on its own. [...] The digital genie is out of the bottle on a world-wide scale". Kristina Gõrniak-Kocikowska (1996) predicts that the computer revolution will affect all aspects of human life, and that consequently computer ethics will become the global ethics of the future not only in a geographic sense but "in the sense that it will address the totality of human actions and relations". Such an evolutionary view of progress places different cultures in a competitive struggle. Seeing computerisation as inevitable means non-technological cultures must adopt computerisation or become extinct (Bowers 2000). According to Gõrniak-Kocikowska (2004) the computer revolution is likely to lead to "a takeover and ruthless destruction of traditional values of local cultures by the new digital civilisation". The computer is a product of western civilisation and the field of computer ethics is dominated by western scholars who tend to overlook problems outside their cultural experience. This ethnocentrism marginalises the need to consider the long term implications of displacing diverse cultural narratives.

Bowers (2000) warns that the globalisation of computer-based culture is not only a form of colonialism but that the cultural assumptions and lifestyles reinforced by the digital culture are ecologically problematic. The western way of life with its focus on technology is rooted in the mechanistic philosophy of the 17th century. The ontological assumption of classical 17th century science that nature, like machines, is

made up of discrete parts which are causally connected, has become the framework of the western common sense view of reality (Merchant 1980). Merchant stresses that this mechanistic view of nature sanctioned exploitative environmental conduct. While rural communities are aware that environmental conditions are unpredictable and scarcity is a possibility, the modern western way of life is based on the false assumption that progress does not depend on the contingencies of natural systems. Thus the predominant challenge of the 21st century will be the environment.

THE COMPUTER AS A PRODUCT OF WESTERN CULTURE

The computer has its roots in the Europe of the 16th and 17th century an era of increased mechanisation and increased focus on mathematics. The scientific revolution replaced the organic view of nature as a living organism with the mechanistic view of nature as a machine (Merchant 1980, p.2). The project of classical science was to gain mastery of nature based on several assumptions which rendered nature equivalent to the machines and mechanical devices which increasingly influenced everyday life. Classical science's view of nature was based on the assumption that nature was made up of discrete parts governed by laws that were discoverable by science and describable by mathematics. Regarding the structure of reality as independent of its context this view held that information in the form of discrete sense data could be abstracted from the natural world to be subjected to formalisation and mathematical analysis.

The mechanic philosophy which emerged during the renaissance and the scientific revolution was based on the assumption that sense data are discrete and that problems can be analysed into parts which can be manipulated by mathematics. For Hobbes the human mind was a machine and to reason was to add and subtract (Merchant 1980, p. 232). The binary system and its significance for machines were advocated by Leibniz in the latter half of the 17th century (Freiberger & Swaine 2003). As more and more processes of daily life were being mechanised the desire to also automate cognitive processes such as calculation came naturally. The computer is the result of the effort to achieve both high speed, high precision automatic calculation and a machine capable of automatic reasoning (Mahoney 1988).

The classical view of reality is still influential in western common sense thought and in the notion that western science is objective, value free, context free knowledge (Merchant 1980). Twentieth century information theory, the mathematical representation of transmission and processing of information, and computerisation manifest the view that problem solving is essentially the manipulation of information according to a set of rules (Ibd, p. 231). The method of computer science is formalisation, i.e. symbolisation of the real world phenomena so they can be subjected to algorithmic treatment. The computer is thus a result and a symptom of western culture's high regard for abstraction and formalisation; it is a product of the mathematician's worldview, a physical device capable in the realm of abstract thought.

Western culture's rational worldview that emerged with the scientific revolution gave rise to technological advances that helped to harness nature's power for the benefit of humanity. The increasing use of mechanical innovations shaped a worldview which put into focus aspects of the world that could be understood within the metaphor of mechanisation. The resulting mechanic philosophy rendered nature dead instead of a living nurturing organism. As a consequence cultural constraints which previously restricted destructive environmental conduct lost impact and were replaced with the machine metaphor, i.e. images of mastery and domination which sanctioned the exploitation of nature.

INFORMATION TECHNOLOGY AND DEMOCRATIC AND ECONOMIC DEVELOPMENT

Information technology is seen as an essential component of development and strongly promoted by international development agencies. This promotion implies that unless developing countries apply information technology and join the fast train of the computer revolution, they will be left behind (Berman 1992). This line of argument not only supports technological determinism but subscribes to a development ideology that is based on a particular conception of history. The conception is just as linear as the conception of technological progress, assuming that every society has to go through the same stages until it reaches the same economic level as countries considered as developed. Information technology is expected to

enhance the democratic practices in developing nations and to provide opportunities for economic development. Ogundipe-Leslie (1993) argues that development itself is characterised by cultural imperialism and ethnocentrism and interferes with the natural internal processes in the society to which it is introduced. It is therefore questionable whether information technology development per se can actually hold the promise of greater democracy and better lives through economic development.

Democratic development through information technology

Arguments supporting the enhancing function of information technology on democratic development of developing nations are that computer technology is inherently neutral and blind towards socially constructed categories such as nationality, ethnicity, gender or class and therefore provide equal opportunities for everyone to participate in global information exchange and communication (Grant Lewis & Samoff 1992). Information is seen also as a prerequisite for democratic decision making (Grant Lewis & Samoff 1992). Computer technology is regarded as improving decision making not only through access to information but also by providing timely, accurate, objective and hence *better* information. Computer technology is thus seen as a tool providing the power of information to the people (Johnson 1997). Information is power because information enhances knowledge and thus empowers people who are on the receiving end of information. Information is also power in the hands of those who provide information because it convinces and persuades and shapes the behaviour of people, e.g. through advertising. The scope of online communication, which allows information to be sent almost instantly to a vast number of people anywhere in the world creates enormous power. Moral implications arise because those with great power are expected to take greater care (Johnson 1997). However, a closer analysis reveals that none of these arguments are convincing.

Computer technology is democratic because it does not discriminate

Assuming that computers provide equal opportunity regardless of socially constructed categories ignores the existence of asymmetric social relationships and their consequent power imbalances. Research on gender and computing shows gender imbalances in computing have been in existence since the beginning of the field and little has changed for women over the years. Even assuming that computers are inherently neutral, although this position is challenged by Bowers (2000) who exposes

that there are inherent biases in the material design of computers, existing social structures and practices do not allow equal access to information technology and equal participation in the computer revolution. Only a small proportion of the world population do have access to or can afford computers. Of these even fewer have access to the information produced by those who are already information rich (Veregin 1995). Access to information in non western countries may be restricted by political intervention e.g. through censorship as in China, or a small number of internet gateways act like bottlenecks constricting the volume of information or through cross-cultural communication barriers (Duncker 2002). Emphasising the advantages that information technologies have for those who adopt the technology always also implies non-adoption and results in a polarisation of users and non users (Pickles 1991). Information itself is not neutral. It is generally partial, owned and hence often not fully accessible, inherently structured and hence subject to unconscious and conscious interpretive bias.

Computer technology enhances decision making

Computers are assumed to improve information because of their advanced data processing capabilities. Because computers are superior to humans when it comes to numerical calculation, quantitative analysis and categorical structuring and organisation computerised information is considered better information. It is implicitly assumed to be accurate and up to date. This argument implicitly denies that computers cannot improve the quality of data, ignoring that the GiGo principle (garbage in - garbage out) applies. Computers merely tend to “harden” data by making it appear precise, objective and scientific, regardless of its quality or accuracy. The danger is that the high regard for computerised information and the assumption that digital information is better obscure errors and biases when such data are applied in the social context (Berman 1992). Furthermore the importance that is given to the availability of digital information as a prerequisite for decision-making implies that those who do not have access to this type of information are seen as necessarily empirically less equipped to make decisions. This implication presupposes that only those with access to computerised information act coherently in social contexts. Thus there are antidemocratic features inherent in the use of computer technology (Curry 1995).

Computer technology is democratic because it gives power to the people

Democracy is seen as a value because it is associated with autonomy of the people, power given to the people. Information is linked to democracy because it is itself regarded as power: getting information empowers people and sending information is the power to influence others (Johnson 1997). The unequal distribution of access to information technology is therefore an unequal distribution of empowerment. People also do not simply require information per se; they require appropriate and useful information. As long as the public sphere continues to prioritize information from the North over information generated in the South (Lor & Britz 2002) it is questionable whether people in Africa and other “developing” nations actually do have access to appropriate and useful information. Simply providing the infrastructure to tune into the North – South information flow, cannot bridge the gap between the information rich and the information poor. The information poor have to generate information for and about themselves.

Identifying appropriate information is a major issue for all because of the volume of information available on the internet. Search engines, which provide the gateway to this wealth of information, make use of filtering mechanisms to reduce the number of sites returned by search queries. However the filtering criteria are not transparent to the user and a study by Introna & Nissenbaum (2000) suggests that search engines systematically exclude particular sites which runs counter to the democratic value associated with the internet. As Deborah Johnson (1997) points out the filtering and validation of information is becoming an increasingly important issue but little attention is being given to how this filtering should be conducted. “Those who filter and package information for us in the [global information infrastructure] will hold enormous power over us.” What Johnson sees as an issue of the near future is already a reality for Africa and other so-called third world countries, whose voices are marginalised in the global information scenario.

Computer technology enhances democratic practices

Joint deliberation is a characteristic feature of democracy. Views which purport that information technology enhances democratic practices generally refer to the access to data and information and the scope of online communication which allow people to engage with a vast number of other people all over the world. It is however questionable whether access to data and computer-mediated communication facilitate

democratic decision making. Bowers (2000) purports that the learning of moral norms is of higher importance to democratic decision making than access to information. However, the learning of moral norms is based on joint deliberation of people who have to find ways of living together in spite of differences. This process is profoundly different in so called cyber communities than it is in real life. Global communication, although spanning a much broader geographic scope, tends to join like-minded people who share a common interest. Online communities provide little opportunity for participants to understand the needs of others and one's responsibility to them (Johnson 1997; Bowers 2000; Adam 2001). The more time people spend communicating online with like-minded people the less time is spent communicating with those whose geographic space they share. As a result people engage less in debate and tend towards already formed biases. The paradox of growing insularity through increasing connectivity raises according to Johnson (1997) an old question: is democracy possible without shared geographic space? In the African context where multi-ethnicity is the norm rather than the exception, and tribalism and ethnic discrimination are a major obstacle for democracy, the question is extremely pertinent. In the light of Johnson's and Bowers's analyses it seems as if there is a danger that computer mediated communication can exacerbate the existing ethnic divide in many African countries by harbouring insularity.

Computers are a tool of domination

Berman points to the origins of computer technology by stressing that during and after World War II and the subsequent period of expansion of the welfare state, economic planning data were used by the state to gain control over people. African countries inherited the concept of authoritarian state control in colonial rule. The computer's logical structure which emphasises hierarchy, sequence control and iteration, reflects the structure of bureaucratic organisations. This focus on control is obscured by the assumption of scientific objectivity. Hence the power, which is exercised through computer application, is hidden behind the appearance of expert decision. The computer is thus a technology of command and control (Berman 1992). Not only do computers reinforce authoritarianism; they become a symbol of advanced development and efficiency. But because computers narrow the scope to quantifiable information, indigenous knowledge is further marginalised, which makes it difficult for the state to take the qualitative aspects of social structure and culture into account.

The complexities of distributed computing result in increasing reliance on experts. As long as these experts are predominantly of western origin, either by nationality or through western education, this reliance reinforces the domination of African nations by western standards (Chapter 7). Roberts & Schein (1995) analyse how notions of dominance and control are embedded in language and imagery of advertisements for geographic information systems (GIS). A GIS is designed to “interrogate” and “manipulate” data. Such “informatics of domination” (Harraway 1991) reinforce the kind of domination logic that has been shown by feminist philosophers such as Caroline Merchant (1980), and Karen Warren (1990) to underpin western thinking and that is used to justify the subordination of nature, women and indigenous people.

Economic development through ICTs

ICT development and development ideology

African governments and foreign aid agencies have accepted the implication that ICTs are vital for economic development. The common assumption is that computerisation is a necessary condition to be part of the glorious future promised by the computer revolution (Bermann 1992). Publications on ICT development in Africa are underpinned by the linear view of history that is characteristic of development ideology. African societies are “lagging behind” (Schaefer 2002), ICT structures resemble “the North American picture [...] in the first half of the twentieth century” (Kawooya 2002). This view is based on the assumption that every society shares the same values characterising “developed” societies, such as efficiency, speed and competitiveness. These values are evoked through references to the super-information-highway that will lead African countries into a future of material security and possession of particular goods and services that are typical for industrial societies. This eurocentric point of view is used as a standard of measurement so that societies who do not conform are not perceived as different but as primitive, traditional or underdeveloped (Ogundipe-Leslie 1993). The notion of development as an economic upliftment ignores a nation’s values, aspirations, beliefs and patterns of behaviour. As a consequence measures to develop according to the western economic model interfere with the natural internal processes in society and uproot the individual and collective lives of the people. Ogundipe-Leslie (1993) criticises development not only

for its cultural imperialism and ethnocentrism but also for ignoring the social costs that people have to pay for the interruption of their social dynamics. The perception that ICTs are necessary for economic development ignores that technology invents its own need. The multitude of new consumer products and the rate at which they are introduced indicate that producers create needs where none existed (Veregin 1995). The global ICT market is characterized by ever-decreasing intervals of software releases forcing African countries to continuously invest in new software in order to avoid a further widening of the digital gap (Chapter 7). While some level of ICT may be important for development in the sense of improved well being and decreased suffering, no level of ICT will be a sufficient condition for these hopes.

Human resources are rationalised

One of Africa's hidden and untapped assets are its human resources (Britz 2002). Computerisation is seen as a means to provide information, education and economic opportunity to all people to overcome the problem of unemployment. However, in the industrialised world where computerisation is permeating society it is becoming apparent that computerisation rationalises humans out of work processes (Bowers 2000). Increasingly fewer people do more complex tasks in shorter time thus excluding more people from this process. There is a danger that computer technology in Africa might further enforce and enlarge the gap between the advantaged and disadvantaged.

ICT as an extension of the industrial revolution

The notion of knowledge and information as strategic resources points towards the link between computerisation and the industrial revolution. The main characteristic of the industrial revolution was the transformation of utility value into exchange value (Capurro 1990). Computerisation commodifies information and anything else that falls under its domain. In this sense the computer revolution "represents the digital phase of the Industrial revolution [...] it perpetuates the primary goal of transferring more aspects of everyday life into commodities that can be manufactured and sold, now on a global basis" (Bowers 2000). There are "connections between computers, cultural diversity and the ecological crisis" (Bowers 2000). The market has become a universal principle encompassing all forms of human activity commodifying the relationships between humans and between humans and the environment. The

mapping and subdivision of lived space based on national or global grids nullify places of local meaning while playing an important part in the functioning of capitalist economy by creating space as an exploitable resource (McHaffie 1995). GIS have further depersonalised this process. The parallel between information and nature is not accidental: both are considered as resources, nature is a shared resource which is vital for human survival and information is a resource which we share amongst people. Critiques of western style development such as Vandana Shiva (1988) have pointed out how the commodification of natural resources which is typical of the western paradigm excludes natural systems from the economic model. In this paradigm a river in its natural state is not considered productive unless it is dammed. The natural system has to be modified in order to produce value; the use value of the river has to be transformed into exchange value. The preoccupation with quantification contributes not only to the commodification of nature but also to the widespread acceptance of data as the basis of thought. Unless information can be computerised it is not considered valuable and hence undermines the importance of indigenous knowledge.

The global computer revolution perpetuates the assumption underlying development ideology that it is merely a question of time until developing countries will reach the level of the industrialised nations. Hoesle (1992) asserts that this assumption is impossible to be fulfilled. The ecological footprint of the so-called developed nations is not only far heavier than that of the third world, it is also unsustainable. It would therefore become an ecological impossibility for the whole world to adopt the same lifestyle. Hoesle infers that because "the [western] way of life is not universalizable [it is] therefore immoral". He questions the legitimacy of a world society built according to western values which have brought humankind to the verge of ecological disaster.

EPISTEMOLOGICAL ISSUES OF COMPUTERISATION

It is important to form a critical awareness of how the computer prescribes the abstraction of information. Thinking about computers and their impact on society has been influenced by the rationalistic tradition which rests on the correspondence theory of language as one cornerstone (Winograd & Flores 1986, p. 19). Quantification and computer representations are taken as models of an objective reality. However, any computer representation is essentially a transformation from the analogue to the

digital, which inevitably involves loss of precision (Schinzel 2004). Modern information systems are characterised by extensive metamorphoses of analogue and digital information. Although modern techniques reduce the loss of precision through augmentation they do not necessarily lead to greater accuracy.

Humans receive information in analogue format through their senses and have developed a complex system of languages to interpret, store, copy or transmit this information. Computers facilitate the external processing of information in digital format by representing it in binary form. Thus computers reduce experience to numerical abstraction. As a consequence the natural and social worlds are treated as being made up of discrete and observable elements that can be counted and measured. Reality is reduced to what can be expressed in numbers (Berman 1992).

Users of computer applications perceive the restrictions imposed by digitisation when data have to be manipulated to fit into a computer compatible format. This prescriptive tendency of the computer is a “reverse adaptation” of existing goals to accommodate a new technical means (Winner 1977 as cited in Veregin 1995). GIS, for instance, is based on the point/line/area data model. However, area class maps for soil, vegetation or land cover describe data types, which are not exactly definable by area boundaries or spatial homogeneity. GIS is one example showing how the computer enables specific aspects of the world to be seen while blocking others from view (Chapter 11).

Database categories are examples of the way computerisation influences which elements of information are stored and which may be lost. Categorisation is a socially constructed process based on the ambiguities of language (Lakoff 1987). The computer influences the way research problems are selected, the assumptions, languages, techniques and models which are applied (Veregin 1995). In order to assess the appropriateness of computer applications such biases of convenience and underlying assumptions have to be made explicit.

Computer-based experience is a partial experience, predominantly limited to the visual. The manipulation of objects displayed on the screen emphasises the interaction between the active subject and the passive object, which is characteristic of a scientific mind. This approach has been exposed as being male and disembodied

(Keller 1985). This interaction is underpinned by a domination logic that objectifies both the natural world and people as other, e.g. women or indigenous people, to justify their exploitation (Merchant 1980).

The disengagement between subject and object reinforces a psychological distance between the individual and the social and natural environment (Weizenbaum 1976; Veregin 1995). Computer-based experience is individualistic and anthropocentric, and no longer influenced by geographic space. Computerisation creates an alternative, non-natural-environment or “infosphere” Floridi (2001). The computer has created a different world, in which most activities not only involve information technology but the concepts regarding these activities are shifting and becoming “informationally enriched” (Moor 1998). Digitisation has become a worldview in itself (Capurro 1990). Such views may adequately describe the experiences of people whose lives are permeated by computerisation but emphasise how different these experiences are from the realities of the majority of people on the planet. Although it is now well accepted amongst scholars that technology is value laden (Johnson 1997), the belief that scientific knowledge and progress have a justified truth claim and the preoccupation with quantification prevail. A survey of research publications in conservation biology, for instance, shows that the majority of work is quantitative (Fazey *et al.* 2005). The value dualism of hard vs. soft information ignores the reality that the computerised abstraction of the world is not absolute, but dependent on cultural context, scientific paradigm and technological feasibility. The digital world excludes and obscures important aspects of the realms of society and natural environment.

Many social practices are being reshaped for computerised expression. The results are often very different from what existed before. Cultural practices are being influenced in a process that resembles a vast ongoing experiment, whose long term ramifications are not comprehended (Winner 1997). Although computers are capable of facilitating information management it does not follow that they are suitable for managing any particular kind of information. It is possible that computerised information systems are unsuitable for the particular information that is most important in a given context (Grant Lewis & Samoff 1992). For instance, the activities of rural African people, especially women, are often not part of the money economy and therefore rarely

included in statistical indices, and thus rendered unnoticed (Berman 1992). Another example is the computerisation of cartography which has fragmented the mapping process, reduced the amount of field work and thus alienated the cartographer from the end product, i.e. rationalised, increasingly depersonalised representations of the world (McHaffie 1995). Mapping, locating and differentiating territory have gone hand in hand with discovery, penetration, conquest and possession of areas of the world (Roberts & Schein 1995). The truth claim associated with the rationalisation of computer aided mapping obscures the political and economic biases that, in the case of historic maps, are obvious to hindsight. GIS is just one example of the new forms of computerised discourse which influence the worldview of those who use them. In Africa, computerisation conditions the interactions between Africa and the rest of the world by specifying the language and symbols of discourse, advantaging some while disadvantaging others and entrenching rather than transforming existing asymmetries. However, not all philosophic traditions subscribe to the subject-object dualism and the separation of self and environment that underpin computer mediation and are characteristic of western philosophy. Contrary to the individualism of computerised experience African thought emphasises the close links between knowledge of space, of self and one's position, as opposed to status, in the community. Although African traditions and cultural practises are diverse there are underlying affinities which justify particular generalisations (Wiredu 1980). African thought does not know the sharp distinction between the self and a world that is controlled and changed. In African philosophy a person is defined through her relationships with other persons, not through an isolated quality such as rationality (Shutte 1993; Menkitti 1997, p. 158). The world is a place in which people participate in community affairs. Participation is the keystone of traditional African society. Participation integrates individuals within the social and natural networks of the world. Setiloane (1986) calls participation "the essence of being"; 'I think, therefore I am' is replaced by 'I participate, therefore I am' (Taylor 1969, p41). The individual's personhood is dependent on the community, but the continuation of the community depends on the individual. The concept of community does not refer to an aggregation of individuals (Menkitti 1979, pp. 165-167), but prioritises the group over the individual while still safeguarding the dignity and value of the individual (Senghor 1966). Through being affirmed by others and through the desire to help and support others the individual grows and personhood is developed and personal freedom comes into being (Shutte

1993). The individual belongs to the group and is linked to the members of the group through interaction; conversation and dialogue are both purpose and activity of the community. Consequently African socialism aims to realise not the will of the majority but the will of the community (Apostel 1981) and therefore rejects both European socialism and western capitalism because both are underpinned by subject-object dualism, which produces relationships between a person and a thing rather than a meeting of forces (Shutte 1993). Subject-object dualism, as is reinforced through computerisation, alienates the individual from others. While western rational thought values individuality, African tradition is afraid of solitude and closed individuality and values solidarity, consensus and reconciliation.

Computerisation and particularly the global information infrastructure increasingly enforce Western ideology onto other cultures. Computerisation is shaping consciousness and bodily experience to accept computer mediation as normal; as a consequence computer illiteracy is considered socially abnormal and deficient, and those who do not use computers are less developed and less intelligent. Bowers (2000) points out how progress in developing countries goes hand in hand with more widespread use of computers and the emergence of western individualism and subjectivism. Capurro (1990) confirms that the influence of modern information technology is shaping all aspects of social life. He warns that a critical awareness of how information technology is used to manipulate ourselves and the natural environment is necessary. Users who share the cultural assumptions embedded in the technology are not aware of the inherent bias, but members of other cultures are aware that they have to adapt to different patterns of thought and culturally bound ways of knowing (Bowers 2000; Duncker 2002; Walton & Vukovic 2003; Chapter 7). The uncritical acceptance of the computer obscures its influence on the user's thought patterns. The digital divide is seen as a problem of providing access to technology. However, it may be that the digital divide is an expression of the dualisms inherent in the cultural concepts underpinning computerization. Hoesle (1992) stresses, that the main issue of contrast between industrialized countries and the third world is cultural. He questions the legitimacy of a world society built according to western values, which have brought human kind to the verge of ecological disaster. Bowers (2000) agrees that the "ecological crisis is a crisis of beliefs and values". Computerization is instrumental in shaping the ecological problems we are facing, because

computerization decontextualises knowledge and isolates it from the ambiguities and complexities of reality. The tendency to fraction complex holistic processes into a series of discrete problems leads to the inability of addressing ecological and social issues adequately. Hoesle (1992) therefore stresses the importance of myth as a source of knowledge and insight. Myth brings values back into focus and recognizes that humans are part of the cosmos. Modern subjectivism and the sectorial and analytic character of scientific thinking has almost forgotten the advantages of a holistic approach to reality. The value and legitimacy of Africa's rich tacit knowledge has been undermined because this knowledge is largely informal and does not fit the computer imposed data formats (Adeya & Cogburn 2001; Harris *et al.* 1995). Cultures are reservoirs of expression and symbolic representations with a truth claim of their own and thus need to be preserved (Hoesle 1992). However, Lor & Britz (2002) call attention to the limited contribution that information generated in the South is making to the global knowledge society and point towards the bias of the public sphere towards information generated in the North. Only a minute proportion of internet hosts is located in Africa although most countries on the continent have achieved connectivity to the internet (Maloka & le Roux 2001). The pressing issue is not providing access to technology in order to turn more people into receivers of information that was created elsewhere and may not be useful to them, but, as suggested by Capurro (1990), to find ways how African countries can promote their identity in information production, distribution and use. In terms of a global "information ecology" he stresses the importance "of finding the right balance [...] between the blessings of universality and the need for preserving plurality".

THE EARTH CHARTER AS A GLOBAL ETHICS

There are several positions in computer ethics which purport the global character of computer ethics. Gõrniak-Kocikowska (2004) predicts that the computer revolution ethics and values are being debated and transformed without the constraints of a specific religion or culture. Through the computer revolution computer ethics will become the global and universal ethic of the future addressing the "totality of human action". Johnson (1985) predicts that the new "species of generic moral problems" which computer ethics addresses will become so central that computer ethics will cease to be a special application of ethical theories. The second generation of computer ethics is expected to be an era of "global information ethics" (Bynum &

Rogerson 1996; Moor 1998). These views ignore the observation that the digital divide is a divide between a minority of people whose lives are permeated by computerisation and a majority of people whose lives are largely unaffected by the computer. These views also seem to ignore that computerisation is itself a product of a particular culture and worldview. In spite of the advantages computerisation and information technology have to offer, there is the danger of traditional worldviews and cultural practices being transformed and replaced with western values embedded in the technology. This replacement is a form of information colonialism and a threat to the environment endangering human survival. Gõrniak-Kocikowska (2004) predicts that although it would be desirable that the emergence of a new global ethic is a participatory process of dialogue and exchange, it is more likely that western cultural values and worldviews will be imposed through computerisation. It is the responsibility of computer ethics to prevent such ethnocentrism. To avoid that computerisation enforces the adoption of a western worldview a broad cross-cultural dialogue is necessary. Such dialogical ethical research requires a balanced frame work that takes cultural diversity and the need for ecological sustainability into account. A suitable framework for global ethical dialogue is already in place in the form of the Earth Charter a set of principles which lay down an inclusive ethical vision that recognizes the interdependencies of environmental protection, human rights, equitable human development, and peace.

The Earth Charter

The Earth Charter (www.earthcharter.org) development began in 1987 with the Brundtland Report "Our Common Future" calling for a 'Charter for Nature' (WCED 1987) that would set forth fundamental principles for sustainable development. The Earth Charter was again addressed during the 1992 Rio Earth Summit and taken forward when Maurice Strong and Mikhail Gorbachev, launched the Earth Charter Initiative in 1994. In a decade long participatory and consultative process involving all major religions and people from different cultures and all sectors of society, the present list of principles of the Earth Charter was developed and finalized in 2000. The Earth Charter consists of a preamble, 18 principles and numerous sub-principles and a conclusion suggesting "the way forward". The preamble expresses that the future depends on the choices we will make, and that "we must join together to bring forth a sustainable global society founded on respect for nature, universal human

rights, economic justice, and a culture of peace". The Earth Charter locates humanity as part of the cosmos and stresses the interdependencies between peoples and between people and nature. The preamble emphasises that the foundations of global security are threatened by patterns of consumption and production which undermine communities and cause environmental degradation. These trends are seen as "perilous but not inevitable". The Earth Charter emphasizes that every individual shares the "universal responsibility" of facing the challenges of using knowledge and technologies to build a just, democratic and ecologically sound future. The earth charter principles address four themes: respect and care for the community of life; ecological integrity; social and economic justice; democracy, nonviolence, and peace. As the "way forward" the Earth Charter calls for the development of a sustainable way of life based on a "collaborative search for truth and wisdom" in which cultural diversity is valued.

The Earth Charter and computer ethics

A global ethic is necessary and since computerisation will doubtlessly affect the lives of more and more people on the planet, computer ethics may play an important role in developing such a global ethic. However, such an ethic must be global in both content and scope. A global ethic has to be universally applicable but it also has to be widely shared across cultures (Dower 2005). For an ethic to be global it is not enough to be universally applicable within one cultural framework only. It is therefore important to critically reflect on the linkages between computerisation, cultural diversity and the environment.

Information technology bears both opportunities for scientific and cultural exchange and the danger of information colonialism. The challenge is to find the balance between the blessings of universality and the need for preserving plurality (Capurro 1990). In order to find this balance a "great conversation" is necessary that transcends limitations of discourse amongst members of particular social groups (Berman 1992; Moor 1998). Such a global dialogue must be cross sectoral, cross-cultural and transdisciplinary. Capurro (1990) reminds us that the electronic revolution is only a possibility which has to be inserted responsibly into existing cultural and social contexts in order to produce the necessary knowledge pluralism to address the complex social and ecological issues we are facing.

Because computing is the product as well as the extension of a way of life and world view which has largely caused the environmental crisis and because computers are directly linked to the concept of third world development, computer ethics has to locate itself more explicitly within the broader context of the environmental issues on the one hand and development ethics on the other. The earth charter framework not only helps to address particular issues in light of their compliance with ecological integrity and respect for nature, but also stresses the gap between rich and poor and global responsibility to address poverty. By stating that “when basic needs have been met, human development is primarily about being more, not having more” the Earth Charter prioritizes qualitative criteria to measure development over quantitative.

The Earth Charter is a global ethic in terms both of its content and its scope in that the set of values and norms are universally applicable and are widely shared across the world (Dower 2005). The core principles of respect for nature, social justice, commitment to human rights and democracy, peace and respect for diversity reflect core values which are needed for a sustainable future. The Earth Charter provides a framework of values that can help to put particular issues into a broader context. This framework is of value for computer ethics. By addressing whether the earth charter can be endorsed by computer professionals computer ethics can examine the Earth Charter’s justification. The results of such an examination will be fruitful for both the Earth Charter and Computer Ethics. Using the Earth Charter to address particular computer ethics issues will help putting them into a larger global context, supporting a more critical and inclusive examination taking both the natural environment and other cultures into account.

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CHAPTER 5

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Strategic species management plans for rare and high-value mammal species in Namibia

ABSTRACT

Management plans provide problem solving strategies based on socially constructed assumptions. This paper introduces and discusses three national species management plans for rare and high-value mammal species in Namibia. Each management plan gives clear technical advice, grounded in a thorough analysis of the ecological factors and the biology of the focal species. Although each plan emphasises the need for devolution of authority to and participation by communal conservancies, there is no concrete advice how these political goals can be achieved. Instead the plans focus on maximised financial returns as incentives for increased conservation commitment by rural communities. The underlying assumption that socio-economic development of rural communities is linked and beneficial to biodiversity conservation is prevalent in environmental development projects but seldom questioned (Flintan 2000). This paper argues that the balance sheet metaphor is employed to support the truth claim of the assumption that western style progress and the associated economic model are desirable for all. This claim, based on “rational choice”, may not hold in the light of cultural norms and collective values of African rural societies.

INTRODUCTION

It has been claimed that, because conservation needs are steadily increasing while conservation budgets are getting tighter, both the scale and the efficiency of conservation efforts must be enhanced (Simberloff 1998). Instead of focusing on single species conservation, efforts should concentrate on the management of ecosystems and landscapes. Ecosystem management is seen as a unified method designed to benefit all the species inhabiting it. However both single species and ecosystem conservation pose problems (Simberloff 1998). Recent management approaches in southern Africa shift the focus towards utilisation. This approach is aimed at improving people’s livelihoods through sustainable use. In this framework natural resources are treated as having significant economic value (Brown 2004). The Transboundary Mammal Project (Chapter 1), a joint project between the Ministry of Environment and Tourism of Namibia (MET) and the Namibia Nature Foundation

(NNF) aimed to improve the management of specific rare and high-value species, which could sustain larger population numbers and extended ranges in Namibia. One of the objectives of the project was the drafting of strategic species management plans for several ungulate species of high economic value.

Management plans are essentially problem solving strategies based on an underlying definition of what is perceived to be “the problem”. Defining the problem is the first and most important step in any problem solving scenario because the problem definition is not an objective entity, that can be discovered, and to which only one rational and therefore “correct” solution exists. A problem definition is an analytical and social construct based on numerous assumptions, which directly influence the way a solution is conceived and implemented (Dery 1984; Asher & Healy 1990; Clark *et al.* 1996). In order to find the best possible approach a systematic and contextual consideration of the whole situation is required. An attempt to illuminate the underlying assumptions must be made, taking disciplinary, cultural, organisational and valuational biases into account. Once this explication has been performed to the best possible extent, the formulated goals and objectives should emerge clearly and should focus on that manageable set of factors which is meaningful to decision makers (Clark *et al.* 1996).

This paper introduces and evaluates three species management plans which were drafted by the Namibian Ministry of Environment and Tourism to improve the management of buffalo *Syncerus caffer*, roan antelope *Hippotragus equinus*, sable antelope *Hippotragus niger*, tsessebe *Damaliscus lunatus*, southern reedbuck *Redunca arundinum*, common waterbuck *Kobus ellipsiprymnus*, red lechwe *Kobus lechwe* and puku *Kobus vardoni*.

METHODS

I developed a generic format for strategic species management plans in co-operation with the Ministry of Environment and Tourism of Namibia, in particular the Directorate for Scientific Services (DSS) and the Directorate for Parks and Wildlife (DPW). The generic management plan format outlines the content of the strategy documents: a description of the present and desired conservation status of the species, both locally and in relation to the metapopulation; reasons why the species is in need

of a management plan and a description of the role of the management plan within the annual planning cycle; a vision of the species long term direction; the underlying assumptions and risks involved; the timing and duration of the strategy; strategic objectives which translate the vision into specific targets; a description of the steps necessary to achieve each target. A set of key issues must be addressed:

- Expansion of Range
- Biological management
- Threats and protection
- Support and incentives
- Coordination and collaboration, such as information sharing, joint monitoring, joint planning
- Policy and legislative framework
- Capacity and sustainability

An analysis by Gerber & Schultz (2001) on recovery plans for endangered species suggested that a strong focus on focal species biology strengthens management strategy. Background studies were therefore undertaken on each species, including analyses of past surveys and other available data, expert assessments and a literature review. An overview report presenting the results was compiled for each species or species group (Martin 2002, 2003, 2004). These reports served as the basis for the development of draft species management plans for buffalo *Syncerus caffer*; roan antelope *Hippotragus equinus*, sable antelope *H. niger* and tsessebe *Damaliscus lunatus*; southern reedbuck *Redunca arundinum*, common waterbuck *Kobus ellipsiprymnus*, red lechwe *K. lechwe* and puku *K. vardonii* (Ministry of Environment and Tourism 2002, 2003, 2004). The draft documents were then circulated within MET and non governmental stakeholders for review and revision.

SUMMARY OF STRATEGIC SPECIES MANAGEMENT PLANS

The following summaries are taken from the strategic species management plans with minor edits (Martin 2002, 2003, 2004).

Southern savanna buffalo *Syncerus caffer*

Namibia has a population of about 3000 buffalo in the Caprivi which is connected with the much larger neighbouring population in Botswana. Buffalo used to be

abundant north of the Caprivi in Zambia and Angola, but the present state of these populations is critical (Martin 2002). Although not threatened at present, the Namibian population in the Caprivi is well below carrying capacity. There are also two populations of disease free buffalo in the main body of the country: some 200 animals are in the Waterberg Plateau Park which lies south of the main veterinary cordon fence; About 70 animals are held in a game camp in the Nyae Nyae Conservancy near Tsumkwe north of the veterinary fence. Both populations are approaching or exceeding carrying capacity. Being disease-free these buffalo are extremely valuable and can be used to raise funds through life sale or to start founder populations elsewhere in the country, the latter option being subject to the agreement of the veterinary authorities.

The potential range for buffalo in the Caprivi is *ca* 10,000km² which should carry at least 15,000 buffalo (Martin 2002). Buffalo are of high value in the international safari hunting industry. If the buffalo population was at carrying capacity the net income from wildlife in the Caprivi could be tripled (Martin 2002). This income would benefit both the State and Conservancies. Even before reaching its ceiling value the revenue would be sufficient to meet the full budgetary requirements of the Directorate of Parks and Wildlife in the Caprivi. Thus in order to increase buffalo numbers the species management plan focuses on (i) limiting the fragmentation of buffalo range through land use planning, mitigation of veterinary control fences and enhancing linkages with the Botswana buffalo population; (ii) improving buffalo habitat through fire management and additional surface water; (iii) maximising financial returns from safari sport hunting and the sale of disease free buffalo.

The Ministry of Environment and Tourism has to initiate dialogue with other Ministries in Namibia and to collaborate with the corresponding authorities in neighbouring countries, especially in Botswana (Martin 2002).

Participation by rural communities has to be increased. To maintain the integrity of the buffalo range, vital corridors are needed through the Conservancies to link the main State Protected Areas and to give buffalo access to riverine habitats. It is assumed that any investment by Conservancies in increasing buffalo numbers will more than double their present returns from wildlife management as a form of land

use, if buffalo populations reach the numbers expected. It is further assumed that equal and equitable sharing of the financial returns will be an incentive for increased commitment to buffalo conservation (Martin 2002).

Some of the management measures prescribed by the species management plan are designed exclusively to benefit buffalo, particularly those involving veterinary controls. However the majority of the required actions will benefit all wildlife species in the Caprivi (Martin 2002).

**Roan antelope *Hippotragus equinus*, sable antelope *H. niger*,
tsessebe *Damaliscus lunatus***

Roan, sable and tsessebe were abundant and widely distributed in north-eastern Namibia at the turn of the century. Today, the population levels of all three species are a matter for concern. Based on optimistic estimates the number of roan in Namibia is about 800, sable 1,200 and tsessebe 350 (Martin 2003). Although none of these species occurred naturally in areas where the mean rainfall was lower than 400mm, today more than half of the animals in each of these species populations are on commercial farms and, of these, more than half are in areas with a mean annual rainfall below 400mm. In the areas above 400mm of rainfall, which should support substantial, viable populations of all three species, the numbers are low and the populations are dispersed in small isolated groups. There is a correlation between population numbers and cumulative rainfall deficits, which indicates that little can be done for roan, sable and tsessebe in marginal areas when the cumulative rainfall is in deficit mode (Martin 2003). In order to increase the number of these antelope the species management plan for roan, sable and tsessebe focuses therefore on an aggressive strategy of establishing new populations of all three species in suitable areas and addresses the management factors needed to overcome potentially limiting factors and to maximise the probability of population increase (Figure 1).

There is a potential range of at least 50,000km² for roan, sable and tsessebe in north eastern Namibia where all three species could achieve densities in the tens of thousands and thus be of major economic significant for the safari hunting and tourism industry (Martin 2003).

In favourable conditions populations of all three species can achieve growth rates above 10%. The contribution to the wildlife economy would be substantial long before the populations achieve carrying capacity. This contribution would benefit both the state and conservancies. The potential revenue for the state would be sufficient to meet the full budgetary requirement of the Directorate of Park and Wildlife (DPW) in north-eastern Namibia (Martin 2003).

Adequate authority must be devolved to the Directorate of Parks and Wildlife to be able to timely respond to the imperatives of the Plan. It is assumed that given this authority, DPW will make full use of it. A similar devolution of authority is needed for both private and communal landholders on whose land it is hoped to establish successful roan, sable and tsessebe populations (Martin 2003).

It is further assumed that maximising the increased financial returns and the equal and equitable sharing of these benefits among stakeholders will provide the incentives required to generate the impetus which will result in effective management institutions being formed (Martin 2003).

Southern reedbuck *Redunca arundinum*, common waterbuck

Kobus ellipsiprymnus*, red lechwe *K. lechwe* and puku *K. vardonii

Reedbuck, waterbuck, lechwe and puku are all highly rainfall dependent and their populations in Namibia are at the edge of the species range in southern Africa. The 'natural range' for these species in Namibia is limited to the Caprivi Region. Within the Caprivi the species are restricted to the floodplains. These habitats are also sought after by the rural population for agriculture and cattle grazing. Habitat degradation has been identified as the single most limiting factor of the populations of these species (Martin 2004).

The population levels of all four species are a matter for concern: puku are almost extinct; there are no records waterbuck exceeding 20 animals since 1994; lechwe are fewer than 200 animals; and reedbuck numbers are about 200 at best (Martin 2004). Significant numbers of reedbuck, waterbuck and lechwe have been established on private land in northern Namibia. The number of reedbuck is uncertain but there are

more than 3,500 waterbuck and over 200 lechwe. However, all four species are dependent on rainfall and these populations are outside the 'natural range' of the species. The management plan focuses therefore on the floodplains of the Caprivi, where the species should be abundant (Figure 2). If viable breeding nuclei of all four species are maintained when the long term rainfall regime is in a deficit mode, populations will be able to respond rapidly when environmental conditions are favourable, provided habitats are available and other potentially limiting factors are minimized. Waterbuck and puku numbers may have fallen below the threshold where they can recover and it is recommended that viable breeding nuclei are re-established by introducing significant numbers of these species to the Caprivi (Martin 2004).

All four species require greater areas of floodplain than are available in the protected areas in the Caprivi. The future for the wetland grazers is thus tied to the future of the floodplains in the Caprivi. Only the formation of a joint stakeholder association, whose objective is to improve floodplain management, can influence current settlement and cattle grazing practices (Martin 2004). For the institution to be effective there must be a common appreciation by all stakeholders that there is a valid case for attempting to improve floodplain conservation and that it is within the stakeholders' powers to take and implement decisions which will bring about the changes.

Waterbuck and lechwe are important species for the sport hunting industry and puku are significant for non consumptive photographic tourism, but reedbuck play no role in either of these forms of utilisation. The funds invested would enhance the overall land use values of the Caprivi to the extent that the project funding could be repaid from the increased returns from land within five years, which makes the project financially viable (Martin 2004).

Collaboration with the Botswana wildlife authorities is required to maintain linkages with the larger Botswana populations of wetland grazer (Martin 2004).

DISCUSSION

The management plans provide a problem definition by describing the factors limiting each species population and give clear guidance to MET about the steps necessary to

improve the status of each species. The technical advice is grounded in a thorough analysis of the ecological factors. All three species management plans are the result of detailed analysis of the biology of the focal species. The limiting factors for each species population are clearly stated and the goals and targets derived are unambiguous and focus on a manageable set of factors, which is meaningful to decision makers. In terms of institutional advice there is strong emphasis in each document that for the strategy to be effective devolution of authority is required both within the DPW as well as to the communal conservancies so that planning and acting can take place in a timely manner and in a bureaucratically free environment.

Participation by all parties who have a stake in the focal species population, especially communal conservancies is stressed as a pre-requisite for the success of the strategy. Utilisation is the underlying policy framework and each management plan is based on a detailed financial analysis of the conservation costs and the financial returns that can be expected. These analyses make a strong case for the conservation of the focal species based on the high financial returns that can be achieved through sport hunting.

How a problem is defined based on underlying assumptions shapes its solution (Dery 1984). It is important to address why a situation appears to be a problem and by whom this perception is held (Clark 1996). All three management plans highlight biophysical symptoms as the main limiting factors of the focal species, i.e. rainfall dependency and habitat degradation caused by human activity. Consequently competing human land-use practices are considered the main cause for the decline of the species which needs to be addressed. The three management plans emphasise maximising financial returns from each species or species group as the solution which will lead to increased conservation commitment and will cause existing land use practices to shift towards wildlife as the land use practice yielding the highest returns. A possible critique is that a management regime of sustainable utilisation allows continued environmental destruction in the name of modern resource management, especially because positions vary as to the meaning of sustainability (Meffe & Carrol 1994; Simberloff 1998). However, different conditions apply in different parts of the world. Southern African rainfall regimes, which are below 600 mm, drive economic systems that are different to areas where rainfall is higher. In dry areas, higher returns can be yielded from indigenous species which are adapted to the ecological conditions

than can be expected from agriculture and exotic species. Thus, in the more arid parts of Southern Africa, market forces are working for conservation, not against it (Barnes 2001; Barnes *et al.* 2002; Brown 2004).

The species reports, on which the management plans are based, provide the necessary research background for the wise management of the focal species. Both the background documents and the management plans are meant to be tools to help managers address the complexities of managing rare species in Namibia. Part of the reason why this task is so complex is that multi-disciplinary approaches are required and furthermore a diverse array of stakeholders with different interests and from different ethnic and cultural backgrounds are involved. A multidisciplinary approach to wildlife management in southern Africa requires the bridging of cultural differences, not only in the ethnic but also in the disciplinary sense.

Traditionally the paradigm in which natural resource management takes place has a strong focus on the bio-physical factors, the research background being conservation biology and ecology. Although it is now generally acknowledged that conservation has to take place in a multidisciplinary framework, most conservation biology research focuses on quantitative studies (Fazey *et al.* 2005) and most training of managers is focused on biological and technical considerations and thus inadequate for the complexity of the task (Clark 1996). There is a prevalent notion which dichotomises science into “pure” and “applied” disciplines. While there is nothing wrong with this distinction *per se*, there is an implicit value dualism according to which the former is considered superior to the latter. The history of conservation science is characterised by the effort to be seen as a pure rather than an applied science (Robin 1997).

Science, which was once expected to produce solutions for all humanity’s problems, had by the latter part of the 20th century lost its value-neutral status and its implication in destruction and pollution has been highlighted and identified (Ellis 1994). There is also a growing awareness of the interconnectedness of all things and Ellis (1994) suggests that in view of these facts, scientists in the 21st century “should strive to take responsibility for husbanding the planet”. Seen in this light there is no reason why ecologists or conservation biologists should consider their science

inferior. However, science does not produce absolute truths. Schiebinger's (1993) analysis of the history of taxonomy exposes how the use of metaphor causes the focus to be on particular aspects and excludes others (Chapter 2). Similarly Meppem & Bourke (1999) reveal that environmental policy making is influenced by the "stocks and assets" narrative an approach calling for "solutions based on objective quantified data and rational decision making". This narrative is only one amongst others, but its attractions are the focus on "measurable reality" and the use of the balance sheet metaphor which operate to support its truth claim. Meppem & Bourke (1999) explain that the reason why this view is dominant is not because it is more true than other views but because it is backed by a cultural framework that believes in analytical tools such as surveys, models and figures, without realizing that these tools are in fact extensions of a particular narrative. From within a particular cultural framework it is impossible to accept views backed solely by a different cultural paradigm. For this reason true transdisciplinary engagement is necessary (Meppem & Bourke 1999).

Although Namibia has a proven and internationally-recognised Community-based Natural Resource Management (CBNRM) record, the terms of reference for the background studies were drawn up from within a disciplinary framework that favours bio-physical factors and traditional economics. Opponents of full devolution of rights assume that local people are the main cause for the decline of wildlife numbers and that devolution of rights will aggravate the situation because it takes away the possibilities of external control. On the other hand the species management plans propose that full devolution together with maximised returns from wildlife will create a situation in which financial benefits serve as incentives for people to change land use practises towards sustainable utilisation of wildlife. This view is based on several assumptions. The main assumption is that safari hunting will continue to generate the high returns that are currently yielded. However, the present high prices that are being yielded are linked to low numbers. What are the effects of increased numbers on the market? Higher numbers of a species such as buffalo may result in lower prices, which would result in lower returns. High returns from safari hunting are dependent on the existence of a foreign client base of safari hunters. The possible effects of economic recessions; world oil prices affecting air transport and tourism in general; perceptions of national insecurity or unrest; and international anti-hunting lobbies should not be ruled out.

The possibility of maximising returns from wildlife alone is not enough to ensure that the generated funds can and will be distributed in a manner that is meaningful to all members of a community. It has to be ensured that the returns can indeed pay for the loss of opportunity to utilize the land otherwise. It could be questioned whether larger financial returns will in fact lead rural people to change land use practices. The problem definition underlying the management plans does not include an investigation of the history of the conflict between agriculture and wildlife from the perspective of the people who are claiming the species habitats for agricultural purposes. All three management plans assume that increased returns from wildlife management will cause a change in social behaviour. This assumption is underpinned by the belief that individuals act to maximise their interests through the calculation of costs and benefits. Although the “rational choice” approach is thought to be the key to understanding human actions and behaviour (Philipson & Posner 1995), Fox (2002) argues that much individual behaviour is shaped by cultural norms and “ways of life”. Mufune (2001) points out that there is a marked non-rational element in many human actions and that the cultural norms and collective values of a society may counter act the rational choice assessment of the individual. While subsistence agriculture may not yield returns as high as those possible from wildlife these practices may be anchored in traditional lifestyles, which are not as easily changed as assumed. What is more, Shiva (1989) showed that development projects not only create wealth but can in contrast create material poverty while they remove culturally perceived poverty. This anomaly is due to the underlying assumption that western style progress and the economic model it involves were desirable for all. Specifically, women as substantial users of environmental resources are often displaced by development projects and their practices undermined (Shiva 1989), although the links between gender roles and women’s use of environmental resources show that they are even more responsible for environmental management (Barrett & Browne 1995). This argument is not to say that the management of high-value species for maximum financial return will be to the detriment of local people, but simply that the assumption, that higher financial returns from wildlife management are possible and desirable to local people and will therefore trigger conservation practices and changes of land use, has to be tested. Instead, the management plans are based on valuation that is only undertaken in terms of bio-diversity and economics. The underlying assumption that socio-economic development of rural communities is linked and beneficial to biodiversity

conservation is prevalent in environmental development projects but seldom questioned (Flintan 2000) and hence seldom substantiated.

Although the management plans emphasise stakeholder participation there is no reference to detailed analysis of the socio-economic realities and the history of present land uses in the relevant areas. Such an analysis may not necessarily have led to a different management strategy but would have eliminated the current valuational bias towards bio-diversity and traditional economics. While ecological economics is a rapidly growing field (Constanza 1991; Constanza *et al.* 1997; Barrett & Farina 2000) little focus has been on integrating ecology with sociology and human behaviour (Liu 2001). A financial analysis of the potential monetary benefits is not enough; traditional values, desires and aspirations of the people need to be factored into the equation.

It is important to acknowledge that development projects undertaken from within a scientific and economic framework can disenfranchise communities or particular sections or members of a community. Communities are not homogeneous; this facet poses challenges to participatory approaches. Wise environmental management relies on sound scientific underpinning; this foundation requires establishing not only what is biologically and physically possible, what can be afforded and what gives best value, but also what the personal and societal preferences are – these elements determine how people and communities define an improved situation (Ellis 1994). Ecological studies that treat human factors as exogenous are inadequate to understanding the patterns and processes of wildlife habitat fragmentation and to predicting human behaviours and their impacts on habitats and wildlife populations (Liu 2001).

There is a growing realisation amongst conservationists of the importance of understanding the needs and perspectives of local people and of interactive communication (Roe *et al.* 2000). These sociological and psychological aspects should have been included into the terms of reference for the species overview documents in order to provide a more complete research background for the management plans. It may be argued that a species management plan is not the appropriate place to address detailed sociological questions; however, considering the

highly interdisciplinary character of their field, environmental managers require guidance as to how to achieve the required participation prescribed in the management plan documents. To assume that economic incentives alone will guide people's behaviour in the "right" direction is a too simplistic view of human behaviour.

Another possible critique against the high-value species approach is that it advocates a single species focus as opposed to ecosystem conservation. Single species management generally focuses on indicator, umbrella and flagship species. These approaches pose difficulties (Simberloff 1998): The concept of ecosystem health is ill-defined and there is therefore no consensus on what is supposed to be indicated; whether or not many species fall under the umbrella is often a matter of faith rather than fact and the management of flagship species is often expensive and can call for contradictory management strategies. Conserving particular species on behalf of the rest of the ecosystem is a contradiction in terms if this strategy results in special treatment, such as supplementary feeding, because other species do not receive the same treatment. The high-value species approach is vulnerable to the same critique. But on the other hand the ecosystem approach is problematic, too: There is no consensus definition on what in fact is ecosystem management (Grumbine 1994; Simberloff 1998; Warren & Cheney 2001). Because the focus is on ecological processes some conservationists fear that species loss may be permitted as long as the overall functioning is not affected (Simberloff 1998). What makes the ecosystem approach attractive is its promise of a unifying panacea. Ecologists have, unsuccessfully, been searching for a unifying synthesis throughout the history of their discipline. This imperative is the heritage from a philosophy of science, which defines "good science" as the search for universal solutions as opposed to practical and interdisciplinary application (Robin 1997).

In conflict scenarios between wildlife and humans it is often easier to measure and quantify negative values than positive values. As a consequence the negative values receive greater emphasis (Clark *et al.* 1996). All three documents make a strong case for the conservation of the focal species based on the expected high returns, thus supporting the high-value species approach. The strategies do not advocate specialised treatment such as supplementary feeding, but concentrate on habitat

improvements. It is assumed that such measures will be for the benefit of other species sharing the same habitat. The high-value species approach thus combines aspects of both the single species and ecosystem conservation.

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FIGURES

Figure 1 Management Strategy for roan, sable and tsessebe in Namibia

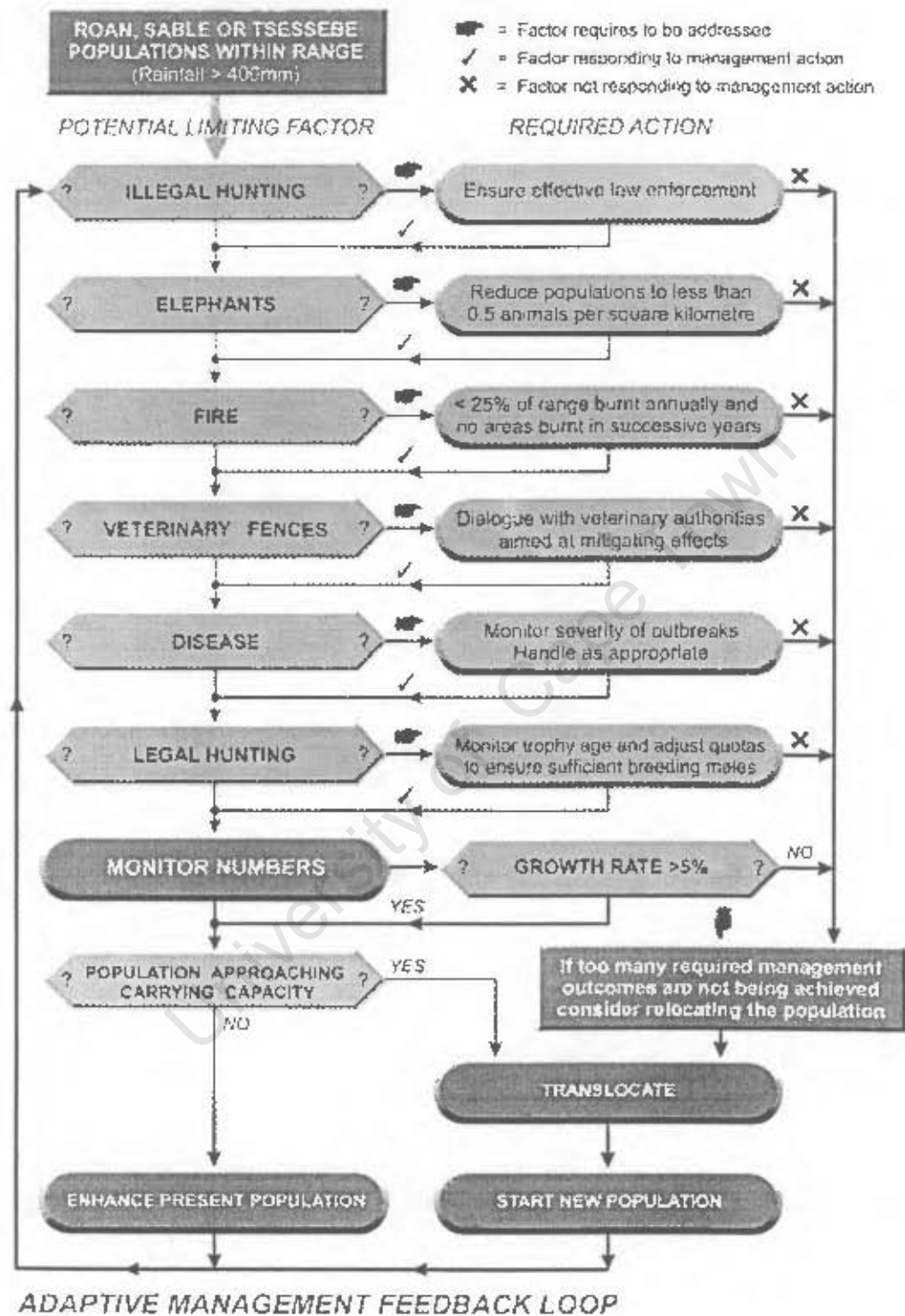
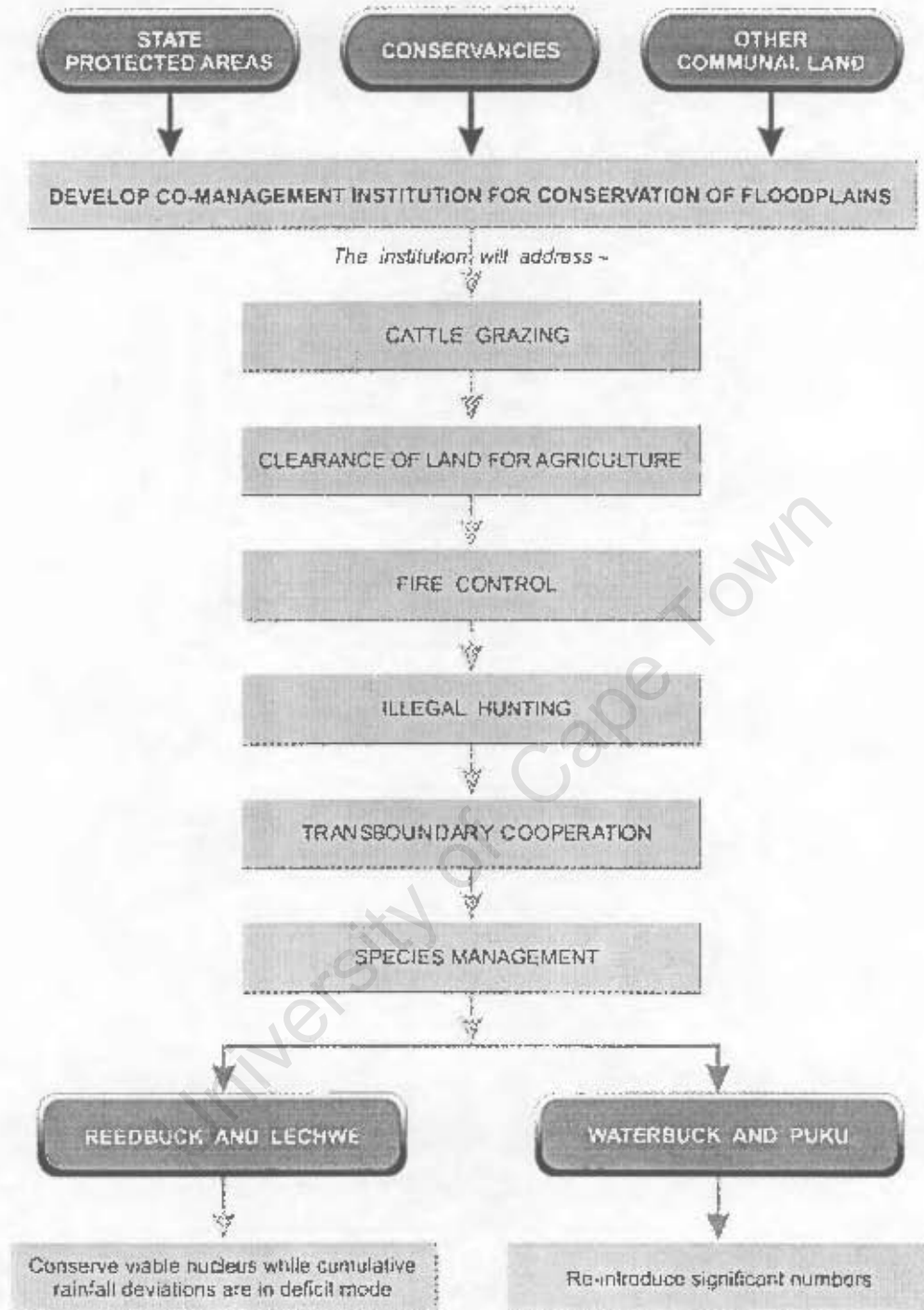


Figure 2 Management Strategy for Reedbuck, Lechwe, Waterbuck and Puku in Namibia



CHAPTER 6

University of Cape Town

IRAS – A static hypermedia representation of strategic species management knowledge

ABSTRACT

This paper presents the knowledge organization scheme for the hypermedia Information System for Rare and High Value Mammal Species in Namibia (IRAS). This system was developed for the Ministry of Environment and Tourism in order to make a start at bringing together all available relevant information on particular selected rare wildlife species. It is suggested that the knowledge organization scheme may be seen as a first step towards a standardized classification system for this type of knowledge which can be used to develop content covering other species both in Namibia and elsewhere. The paper discusses advantages and disadvantages of this approach.

INTRODUCTION

The wise management of wild species is a complex task which involves all kinds of information and requires knowledge of disciplines as diverse as biology, economics and sociology. This kind of information is seldom available in one central place, let alone from a single person. It is distributed between different specialists, and is located in books, scientific papers and reports, often referred to as the “grey literature”. To find the relevant and appropriate information easily and quickly is frequently impossible; searching through libraries and information collections is too time consuming for decision makers. As a result, wildlife managers often rely on anecdotal rather than documented information and in turn very little documentation about the success of management actions is being collected in a way which makes it available to wider audience of wildlife managers (Pullin *et al.* 2004; Sutherland *et al.* 2004). This dilemma suggests that a specially designed computerised information repository providing access to relevant information in a way that can easily be updated and maintained will be of great benefit to wildlife managers.

There are different ways in which information can be represented in computerised format. This paper argues that natural language, with its high degree of generality, flexibility and contextualisation, is best suited for representation of species management knowledge and that hypermedia provides a suitable method to represent

contextual knowledge. Hypermedia is a highly inclusive and interactive mixture of heterogeneous information, providing seamless transitions between numerical data and non-numerical information such as text, graphics, images and audio. In abstract terms, a hypermedia system is a network of information units which are connected by "links". Links are electronic cross-references which connect logically related units (Figure 1). The WWW is one of many applications of hypermedia. The structuring of information, or information architecture, is a central issue in the development of a hypermedia system. This paper presents the information architecture for the Information System for Rare Mammal Species in Namibia (IRAS). IRAS was developed in the context of the Transboundary Mammal Project, a joint initiative of Namibia's Ministry of Environment and Tourism and the Namibia Nature Foundation in order to make a start at bringing together all available relevant information on specific selected rare wildlife species. IRAS can be explored online at <http://www.rarespecies.org.na>.

HYPertext AS A KNOWLEDGE REPRESENTATION

Wildlife managers use information systems technology for curatorial purposes, such as relational databases and geographic information systems (GIS), to support informed decision making with the aid of decision support systems, and to predict the outcome of management interventions with the help of simulation models. Decision support systems are used for various problem scenarios including forest management (Nude *et al.* 2003) and complex wildlife and habitat problems (Wong *et al.* 2003). For a list of ecological simulation models see Jorgensens *et al.* (1996). These applications are essentially quantitative and numerical.

Another type of information system is hypermedia, the format which underpins the World Wide Web (WWW). For a review of hypermedia systems used in agriculture, see Carrascal *et al.* (1994). Schanse & Legget (1989) demonstrated the effectiveness of hypertext in biological research for information management and dissemination of research results. Twery *et al.* (2000) described the use of hypermedia to represent forestry management goals and strategies as part of a larger suite of software tools designed to help resource managers produce management plans.

All information systems make use of language to represent information. In the case of quantitative simulation models this language is formal and mathematical and in the

case of hypermedia it is a natural language such as English or Spanish, with the addition of particular formatting rules, known as “tags”. The languages of decision support systems, databases and GIS are not as formal as mathematics but nevertheless very precisely defined. Each system prescribes how data elements have to be structured in specific compatible formats to be included and accessible in the system.

Rauscher & Reynolds (2003) organised information systems in terms of three attributes: generality, ambiguity and problem-solving power (Table 1). Mathematical representations are precise and have high problem-solving power, i.e. they are effective in enabling mathematicians to communicate precisely, but only for a limited range of very specific problems which can be expressed algebraically. Natural languages such as English have great generality, but lack precision, which is why almost anything can be communicated in the form of language.

Data – Information – Knowledge

Knowledge and information are distinct entities (Figure 2); confusion between knowledge and information has led organizations to invest in information systems with marginal results (Malhorta 1998). Data constitute the result of observations and measurements. They are a set of discrete facts about events and are generally regarded as the building blocks of information and knowledge bodies. However, on their own data are meaningless. It is only through the perception and interpretation by the individual that data are located in a meaningful and useful context and become information. Unlike data, information involves a message and changes the way the receiver perceives something and has an impact on subsequent judgement and action. Learning is the process by which information is analyzed and leads to knowledge. Hence knowledge is information combined with human experience, context, interpretation and reflection. Already existent old knowledge forms the basis for the analysis, storage and networking of new knowledge. “What we understand is based on what we already know, and what we already know comes from being able to understand” (Winograd & Flores 1986, p. 30). In a sense knowledge is information that matters to people, given their values, frames of reference and contexts. The information that was to be represented in IRAS had been collated by a wildlife management expert who drawing on raw data, published research results and personal experience compiled the information into a coherent report. The report is thus a result of the compiler’s knowledge. It was thus self evident to want to capture not only the

data and information content but also the knowledge which had put these into the larger context. Because the information was already largely in text format with the addition of visual content such as graphs and maps, hypermedia suggested itself as the most appropriate format.

Advantages of hypermedia over printed documents

A reader's focus is always on the content of a document. Most printed documents are sequential, i.e. the reader relies on the author to lead her carefully from one idea to the next. The structure of the document is secondary. This sequentially is true for most documents, but encyclopaedias, for example, are different. Here the reader focuses on the structure of the document in order to find the desired content, and does not follow a linear sequence. Structure is also important when reading a hypermedia document, which is a collection of individual information units, each unit being self-contained and independently understandable, similar to the requirements for tables and figures in journals. A link between units provides one of many possibilities for readers to navigate. Units can be connected in more than one way, thus creating a web of information through which the reader navigates by following those links which appear to be most useful or interesting. Information can thus be extracted in any order that is most appropriate to the user's needs. The main difference between hypermedia and conventional paper documents is that printed documents are essentially linear whereas hypermedia documents are not. But this multi-linearity of the text also means that the author has no control over the order in which the reader visits units and the reader cannot rely on the author to guide her from one preparatory subject to the next. As a consequence, the structure of a hypermedia document becomes of crucial importance.

One may argue that structure is not important as long as the reader is able to retrieve the desired content. It may seem that users are not consciously concerned with the structure of a hypermedia document. After all, we use a tool without thinking much about it, i.e. without forming a mental representation of it, as long as it is working satisfactorily. But the moment the tool breaks, we start thinking about it. In the case of a hypermedia system we are not concerned with its structure as long as we are finding the information we are looking for. But, if the information is not organised intuitively, using the system is much like using a hammer that has a broken handle. We are consciously aware of the tool, its structure and its being broken. Anyone who has ever tried to work with a broken hammer is likely to agree that the best thing to do is to get

a new hammer. Consequently structure is important for the success of any hypermedia system.

The links between units simulate the mental associations of the author (Rauscher & Reynolds 2003). The meaning of a single hypertext unit is influenced by its connection to other units. This interrelatedness means that “the role of any hypertext unit depends on the navigational path it happens to be part of according to the user’s choices” (Mancini & Shum 2001).

Hypermedia systems have to be designed carefully. Although there is a theory and practice of how to author powerful hypermedia systems (Rosenfeld & Morville 2002), the typical document one most frequently finds on the internet is essentially a paper document in electronic form. This constraint is especially true for documents of scientific and academic content, which are often published on the internet in the same linear, sequential form as the original and are in fact meant to be printed rather than read in the electronic form.

Hypermedia forces the author to make the structure of the system explicit prior to exposing the user to the contents. This disclosure is to ensure that the user does not become lost while browsing, i.e. traversing from link to link.

Information architecture

Information architecture is an emerging discipline concerned with the structuring and classification of content to help people find and manage information (Rosenfeld & Morville 2002). Information architecture also refers to the structural design of an information collection based on a combination of organization and labelling of information units, and navigation schemes, all of which serve to facilitate intuitive access to content (Van Greunen & Wesson 2004). Information architecture discusses the main components of an information system: organization, the way information is categorized; labeling, the terms used in headings, menus, links, etc; navigation, the way the user is enabled to move or browse through information; and searching, the facility to find particular terms in the information system (Van Greunen & Wesson 2004). Organisation system is the central component of information architecture, because it forms the foundation for both navigation and labelling systems. A good

organisation system is important for the success of a hypermedia system (Rosenfeld & Morville 2002).

The development of an information architecture begins with a review of existing materials and an exploration of the 'information ecology', i.e. "a system of people, practices, values, and technologies in a particular local environment" (Nardi & O'Day 2005). Rosenfeld & Morville (2002) divided the concept of information ecology into three overlapping sub-concepts: context, content and users (Figure 3). In the case of species management, *context* refers to the interdisciplinary field of wildlife management, its goals, and the diverse community of agents. The context is further defined by the political, cultural and economic backgrounds against which wildlife management takes place, the available technological infrastructure, resources and constraints. *Content* refers to the information which is represented by the system and its format, volume, existing structure and frequency of turnover, i.e. the time it takes for a unit of information to become stale. *Users* describes those areas of the information ecology which deal with the audience, the people for whom the system has been designed and who are going to use the information provided by it. This notion includes the user's information needs, methods of seeking information and levels of experience.

IRAS – A HYPERMEDIA SYSTEM FOR WILDLIFE MANAGEMENT

Content development

The hypermedia system IRAS was developed to curate and manage the body of information, which was gathered in the process of developing strategic species management plans for rare and high value species in Namibia, described fully in Chapter 5. An independent consultant was tasked with reviewing the scientific literature as well as other sources of information such as handbooks, grey literature, popular articles and expert opinion. This information was then compiled into a series of three reports which provided a broad background on eight high-value mammal species: a single species document focusing on buffalo *Syncerus caffer caffer* (Martin 2002) and two multi-species documents, the first addressing roan *Hippotragus equinus*, sable *Hippotragus niger niger* and tsessebe *Damaliscus lunatus lunatus* (Martin 2003) and the second, reedbuck *Redunca arundinum arundinum*, waterbuck

Kobus ellipsiprymnus, lechwe *Kobus leche leche* and puku *Kobus vardonii* (Martin 2004). These reports provided a comprehensive overview for each species, including biological information, such as past and present distribution, abundance, reproduction and habitat requirements as well as the significance of the species in terms of conservation and economics. Each background report identified the main stakeholders for these species, provided an analysis of past and present management practices and made recommendations for future management. Spreadsheet population models were developed for each species to predict the impacts of mortalities and off-take on population growth. Each report provided an extensive bibliography on the focal species. These were printed reports, and hence suffered the linear constraints of the paper medium.

Based on this background information, strategic species management plans were drafted for each species or species group (Ministry of Environment and Tourism 2002, 2003, 2004). These management plans defined national objectives, including status targets, in terms of range, numbers and productivity and describe strategic approaches for each species. Clear justification was given for the choice of each action with reference to the accompanying species background report and the literature and scientific evidence presented therein. Methods to monitor the outcome of management actions are described and alternative actions are discussed where appropriate. For a critical review of the management plans see Chapter 5.

All the species documents produced, are comprised of data and information to enhance descriptive, predictive and strategic knowledge of wildlife managers. In addition to the text, the documents contained tables, figures, maps and spreadsheet models.

The species reports and management plans provided the information content for IRAS. The documents were analysed in terms of recurring themes and edited into concise stand alone information units. A prototype hypermedia system was developed and a usability test was carried out with a group of Namibian conservation biologists and wildlife managers (Chapters 7 and 9). The prototype was then modified in response to the results of the usability analysis, which guided improvements to the organisation and categorisation of the content. Based on these findings the knowledge organisation system for IRAS was improved.

AN ORGANISATION SYSTEM FOR WILDLIFE MANAGEMENT KNOWLEDGE

I designed an organisation system for wildlife management knowledge which was able to map the heterogeneous collection of information in the reports in such a way that navigation and searching for information were possible. The organisation system was arranged by species, topic, and sub-topic (Figure 4). The content was structured using two types of organisation schemes: The primary organisation by species is an exact scheme whereas the secondary and tertiary organisation schemes are topical and thus ambiguous. "Exact" and "ambiguous" refer to the expectation of the user. To find information about a particular species it is clear that this information will be found organised under the species name. But it is not always clear under which topic a particular piece of information may be stored.

Categorisation system

A categorisation system for wildlife management was designed on the basis of existing categories and terminology frequently used within the wildlife management community. This ontology serves to categorise the information and is a first step towards a standardised or "controlled" vocabulary, to be used consistently throughout the information system. Each term was carefully defined, and each use of the term was linked to this definition. The next sections amplify the information categories used in the information system (Figure 5). The content of both the species background reports and the species management plans was edited into individual stand-alone information "chunks" which were then organised under the following headings.

Management

The first category or topic is "management" which included the management objectives that have been defined for the focal species and the strategies to achieve them. This topic also included monitoring techniques to check whether the strategy is working, information on survey methods and sustainable utilisation. The factors limiting the population numbers of the species were described, as was the status of the species in Namibia and in a southern African context.

Habitat

The next category described the currently believed habitat requirements of the species. The habitat niches, which the species occupies are characterised and the food species are listed.

Distribution

The category “distribution” provided information on where the species actually occurs, giving a regional distribution overview and describing populations in the country as well as in neighbouring countries.

Numbers

The category “numbers” provided count data and estimates based upon past censuses for all populations, inside the national boundaries as well as in neighbouring countries.

Economics

Ecological economics is a rapidly growing field (Constanza 1991; Constanza *et al.* 1997; Barrett & Farina 2000) and economic knowledge is relevant for any species management plan to determine what budget can be afforded and what returns can be expected. Under the category “economics” all relevant financial data, such as the budget for the species management plan, budgets for protected areas, the viability of conservation projects and the economic significance of the species were described.

Biology

The category “biology” included all biological information that was not already covered by habitat distribution and numbers. It provided valuable background information for the management of the focal species, such as information about food preferences, behaviour and reproduction and other life history parameters.

Transboundary issues

Any information relevant to the international co-management of species populations which cross international boundaries was organised under the category “transboundary issues”.

Wildlife as land use

As international subsidies are phased out the comparative advantages of land use based on domestic livestock can be expected to decline while the comparative advantages of wildlife land uses increase over time (Barnes *et al.* 2001). The category “wildlife as land use” deals with the concept of wildlife as an economic form of land use.

From structure to navigation

The hierarchical knowledge organisation provides the primary navigation scheme for the hypermedia system (Figure 6): across the top are links to the species which are covered, and to additional information such as maps and literature references. The navigation bar down the left side of the screen gives access to the nine topical categories: *management, habitat, distribution, numbers, economics, biology, sociology, transboundary, wildlife as landuse* and their respective sub categories. Thus the hierarchical structure has been flattened to give the user an immediate picture of all the categories and sub categories IRAS contains. Because categories are not absolute (Lakoff 1987), each user may approach IRAS with a different conceptual model of how the information should be organised. By making explicit how the information in IRAS is categorised and organised, misunderstandings can be avoided.

The design for the species specific sub-sites is management-task oriented. All topics are centred on the management objectives for each species or species group. The management objectives for each species are displayed in table format organised by the relevant secondary category, i.e. *habitat, distribution, numbers and economics*. Embedded contextual links throughout the text give access to details and background information. This table ties the entire species specific sub-site content together.

Content management

The flexibility and ease of use of a hypermedia system such as IRAS allows that additional information can easily be added. Such additional information does not have to be restricted to updating the current information or adding information about subjects not currently covered. Additions could also contain viewpoints different from those expressed in IRAS at present, or reports on the results of management actions, thus fulfilling the need for better documentation (Sutherland *et al.* 2004). IRAS has

the potential to evolve into a knowledge management tool for adaptive management (Chapter 8), if its information content is managed appropriately.

The IRAS system as it is presented here is a simple static hypermedia system without automatic content management functionality. The processes involved in updating and curating the information within a hypermedia system could be automated with the use of a content management system. These systems greatly reduce the effort involved in keeping track of the information units and their relationships to each other, but they also produce an additional technological hurdle.

A content management system is yet another system whose functionality needs to be learned and whose user-friendliness may be questioned. While maintaining a large hypermedia system “by hand” may be tedious and time consuming, its advantage lies in its simplicity. The simpler a system is, the more easily it is learned and the greater the number of staff members who will know how to operate it.

A simple hypermedia system is straightforward to update and operators can easily perform the necessary tasks. As a country aiming for an independent knowledge-based economic system, Namibia places emphasis on the development of local software (National Planning Commission 2002). However, given the shortage of expertise and financial resources, software development must be sustainable. That characteristic can only be achieved through acculturation of the process and appropriation of the product. Learning from environmental and community projects, it is clear that sustainability can only be achieved through a bottom-up process, thus user participation in the software development process is vital (Chapter 7). The more complex an information system is, the more it resembles a black box and the more likely it is that experts are required to maintain and update it (Chapter 2).

A simple system can be learned easily and used by many. Because users are working with the system the need for improvements will arise and users will more readily get involved in the development process. The simplicity of the system makes it sustainable in the sense that it does not rely on expensive technology or human experts. By following technological development a few stages behind, developing countries can avoid large investments in current technology which later turn out to be unsuitable in the local political or cultural context (Ellis 1995).

DISCUSSION

This paper presents a knowledge organization system for wildlife species management for the development of hypermedia information systems. The publishing of information in print is a time consuming process whereas electronic information can be made available almost instantaneously. As Pullin *et al.* (2004) showed, time is a serious constraint for wildlife managers trying to access information in support of their decision making. A central information repository like IRAS, providing access to information specific for wildlife managers, is thus a useful aid. Because Hypermedia is high in generality and inclusiveness, it allows the combination of heterogeneous information. For wildlife managers this inclusivity means that monitoring data, experiences, viewpoints and scientific information can all be brought together into one web of information and made accessible to a wide community of users.

Although the publishing of information in print may be time consuming it does generally involve a process of editorial review to ensure the quality of the information published. The electronic format, while easing access to and dissemination of information, makes it difficult to maintain quality standards. The computer stores information potentially indefinitely, irrespective of whether information becomes obsolete, out of date or superseded. Notwithstanding the care that is taken to design appropriate knowledge organisation structures an information system like IRAS is only as good as its content. It will therefore be vital to ensure that appropriate procedures are in place to maintain the information content. It will be necessary to identify, who will be responsible for updating and maintaining the system. An analysis and assessment of the present knowledge and information sharing procedures within the MET will need to be done in order to protect the knowledge represented in IRAS and to maintain its reliability.

Every information system is located within its own information ecology and thus requires its own unique information architecture (Rosenfeld & Morville 2002). Nonetheless the approach presented here is a starting point from which similar developments to collate and represent information and knowledge on other species may follow. The suggested organization scheme for wildlife management knowledge may be seen as a first step towards a standardized classification system for this type of knowledge and can be used to develop content covering other species. Such

standardisation, however, has to be carefully considered to ensure that all relevant knowledge is included. The content of IRAS is restricted to the information gleaned from the species documents that were produced for the transboundary mammal project. This information is only a starting point.

The flexibility of the system makes it very easy to include further information, especially contrasting viewpoints in order to work towards a more complete view of the subject. Further research in this regard may concentrate on how other knowledge systems may be tapped such as the views and experiences of the indigenous communities involved in wildlife management. As has been suggested in Chapter 5, there is a need for wildlife managers to listen more carefully to the needs and preferences of the rural people who are living with and off the resource wildlife. It may be useful to include a further category into the organisation system, which may deal with the personal and societal preferences which determine how people and communities define an improved situation. In order to manage natural resources for the benefit of the people living with these resources it is important to treat the natural environment and the people living in it as parts of one system. It is important not only to understand how the behaviours of the people impact on the environment but also how the environment impacts on the lives of the people. Such an analysis of stakeholders, the socio-economic realities and the history of present land uses in the relevant areas may be grouped under the heading “stakeholder sociology”.

Namibian society is characterised by authoritarian structures, a result of the history of oppression that Namibia shares with other African countries. This characteristic puts special emphasis on the need to develop structures for information sharing, which not only prescribe action in a top-down manner, but also provide means for people to share experiences. Present wildlife management approaches aim to harmonise the needs of people with a healthy environment. Wildlife management as one aspect of community-based natural resource management (CBNRM) is part of Namibia’s development agenda. Progress in this regard is predominantly measured in terms of increased financial returns from wildlife-based enterprises and increased job opportunities on the one hand and increased wildlife numbers on the other hand. But success of CBNRM programmes is also a question of empowerment, a notion which is not as easily measured. However in most projects there will be people whose efforts are making a difference, either for themselves or the entire community. It may be a

useful to provide the opportunity to share these personal experiences with a wider community of people. The category “wildlife as landuse” could be used as a location for these “stories”.

IRAS was in the first instance developed as an information system for MET wildlife managers and conservation scientists. In the beginning maintenance of the system will focus on reflecting the Ministry’s policy on wildlife management issues. Future research may investigate possibilities of addressing a wider audience. Such widening in scope may also involve expanding content creation. The “wikiweb” concept, which enables hypermedia documents to be written collectively using a web browser, may be useful in this regard (wikipedia 2005). The main constraints for such democratization of content creation are not technological but are rooted in the authoritarian character of society and government driven conservation, which are not conducive to information and knowledge sharing.

Hypermedia allows the inclusion of a potentially unlimited number of different information “chunks”, which suggests that by including different perspectives an increasingly more complete picture of a subject can be achieved. Paradoxically, the structure of hypermedia seems to make complete knowledge of a subject impossible. The author of a book will guide her reader from one preparatory subject to the next. But when researching a subject on the internet, the reader has the opportunity of following new lines of inquiry as and because new links are becoming accessible. The onus of staying focused on the original thread of the enquiry lies with the reader. Associative connections are thus more important than the adequacy or completeness of a description. However, plurality of different views may today be more important to wildlife managers than a systematic view of knowledge.

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Les Underhill, Tim Dunne, Britta Schinzel and Drummond Densham read earlier drafts of the paper.

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FIGURES AND TABLES

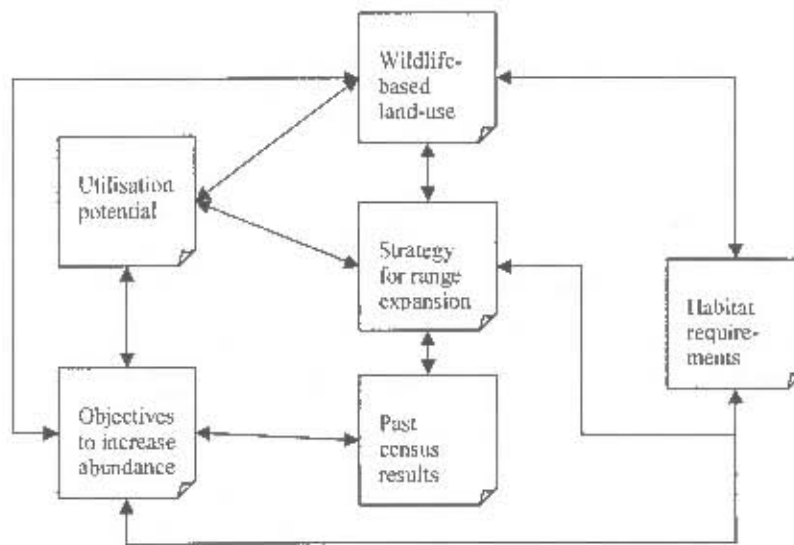


Figure 1 Hypermedia is a network of units and links

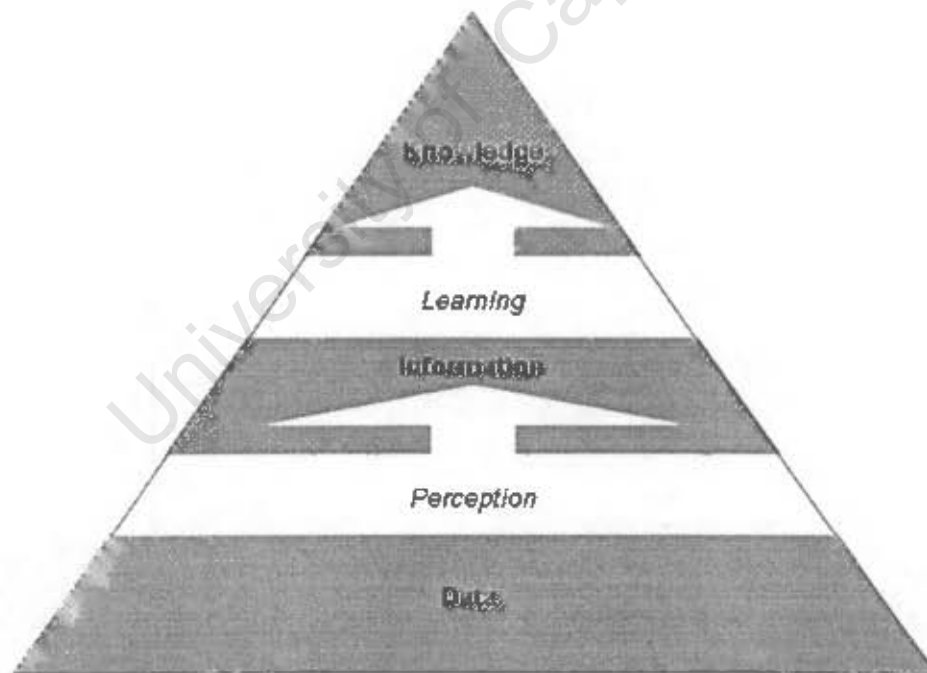


Figure 2 Knowledge Pyramid – Data are the objective building blocks which form information through subjective perception; Learning is the processing of information which leads to knowledge.

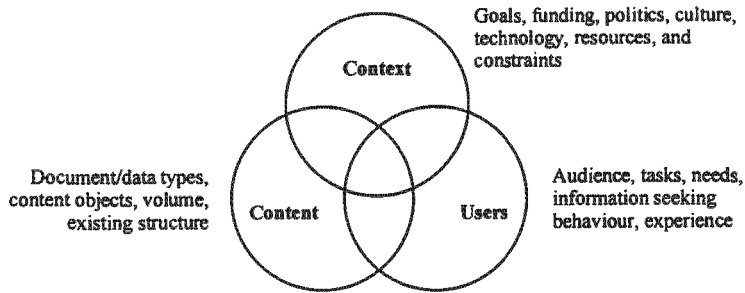


Figure 3 An information ecology is defined by context, content and users (Rosenfeld & Morville 2002)

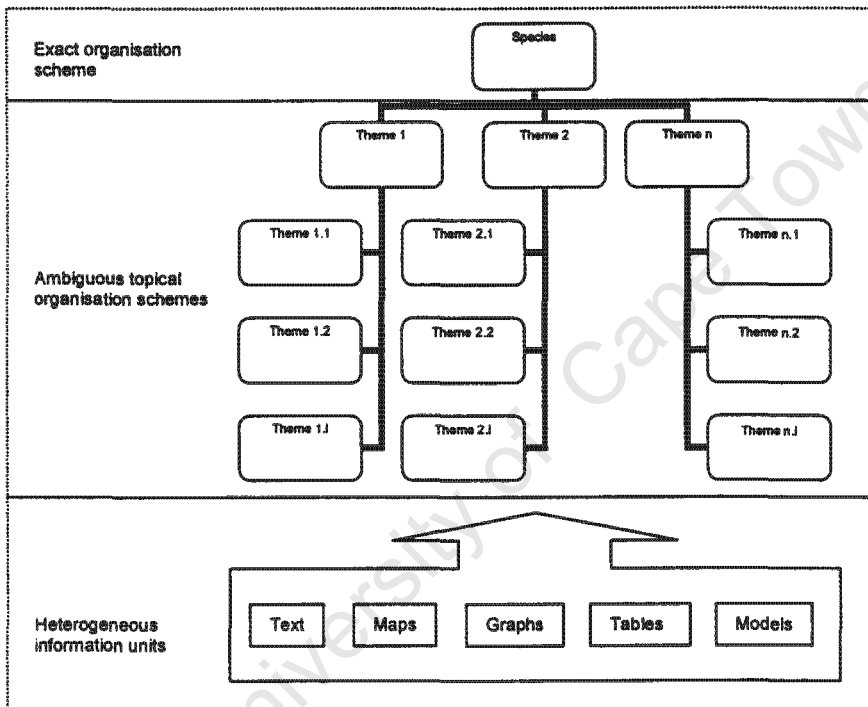


Figure 4 IRAS organisation system for wildlife management knowledge. Information is formatted in different ways and organised by species. For each species different themes and sub-themes organise the information further.

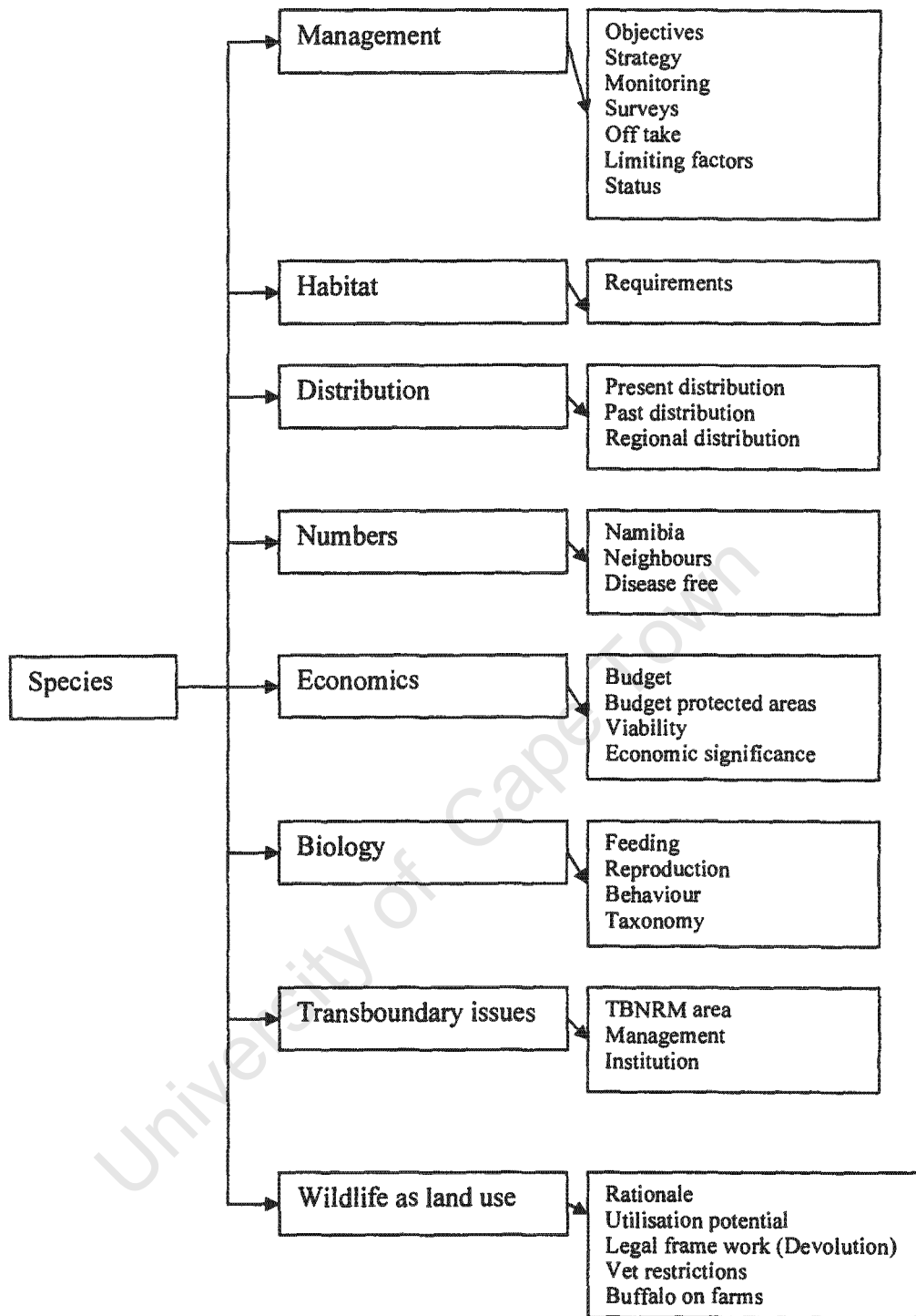


Figure 5 Suggested ontology for wildlife management knowledge as implemented in the current IRAS system prototype.

The screenshot shows the IRAS website interface. At the top, there are navigation links: 'Home', 'Facts', 'Dable', 'Tressébe', 'Reedbusk', 'Mitrabud', 'Lechive', 'Puku', 'Map', and 'Life story'. A 'home' logo is on the left. Below the navigation bar is a vertical menu with categories: 'management', 'objectives', 'habitat', 'distribution', 'numbers', and 'economics'. The main content area is titled 'Southern Savanna Buffalo >>' and 'Objectives'. It contains a table with four columns: 'Habitat Objectives', 'Distribution Objectives', 'Numbers Objectives', and 'Economics Objectives'. Each column has sub-headers 'How?' and 'Why?' and contains specific text-based objectives for the buffalo population.

Figure 6 The knowledge organisation system is reflected in the primary navigation scheme of IRAS: information pertinent to each species can be accessed via links across the top; the themes and sub-themes are accessible via the navigation bar on the left. Contextual links on this page provide shortcuts to information.

Table 1 Language based representation methods organized according to problem solving power and generality (Rauscher & Reynolds 2003)

Natural language systems		Artificial language systems		
		Logic	Mathematics	
Natural language documents	Hypertext documents	Qualitative simulations	Numerical equations	Analytical equations
High	←	Generality	→	Low
High	←	Ambiguity	→	Low
Low	←	Problem Solving Power	→	High

CHAPTER 7

University of Cape Town

Sustainable Software Development

ABSTRACT

Information and Communication Technology (ICT) transfer to so-called developing countries has failed to fulfil its promises. In order to harvest the benefits of ICT, the potential for local software development must be enhanced. Considering the resource constraints, Namibia and other African countries should strive for sustainable software development. This, however, can only be achieved through a cultural appropriation of the software development process itself, meaning that methods, concepts and project goals need to be redefined within the local context. Here a usability evaluation case study is used to demonstrate how Namibian cultural variances should be considered in such a process. Once software modules have been evaluated locally, re-use and community appropriation should be promoted to foster sustainability.

INTRODUCTION

The global Information and Communications Technology (ICT) market is characterized by ever-decreasing intervals of software releases. African countries have no choice but to continuously invest in new software in order to avoid further widening of the digital gap. However, ICT transfer, as practiced today, leads to vendor dependencies, thereby endorsing neo-colonialism. Moreover, the usefulness of imported products has not been evaluated sufficiently in the local context, leading to growing stockpiles of unused software. For African countries to harness the benefits of ICT, technology transfer has to be overlaid by local ICT development. As a country aiming for an independent knowledge-based economic system, Namibia places emphasis on the development of local software (National Planning Commission 2002). However, given the shortage of financial and human resources in Namibia, we need a different paradigm in software development. Learning from community development or environmental projects, we should consider sustainability to be a relevant quality criterion for software development. Following this approach, sustainable software development could be achieved through acculturation of the process and appropriation of the product.

ACCULTURATION OF THE SOFTWARE DEVELOPMENT PROCESS

Limited software development is taking place in Namibia, but success is hampered by a number of constraints. A recent survey conducted among resident developers by the IT department of the Polytechnic of Namibia reveals that local software projects mainly fail for two reasons: insufficient financial and human resources and dysfunctional user developer communication. End-users are described to be unmotivated with a lack of interest in the development process, which leads to incomplete and wrong requirement specifications (Shoopala 2004).

Although developers are able to identify the causes for project failures they do not reflect on the part they play in aggravating the situation. Most developers use methodologies like waterfall development and prototyping only to confirm initial requirements but not in order to evaluate usability. However, a system that has not been adequately evaluated by its users within its embedding context, whether developed within the country or imported, will once more add to the list of software relics.

Equal user-developer participation is the key for sustainable software development. However, to attain effective user contribution, the mutual dependency of culture and IT development has to be understood (Winschiers 2001). It has been widely recognized that cultural differences have implications for design and usability (Marcus & West Gould 2000. Seppälä & Vainio-Mattila (2002) consider culture to be an opportunity for development if common assumptions influencing the interaction between development intervention and its context are studied.

Developers' culturally biased model-monopoly

Western cultural assumptions are omnipresent in software development due to the value-based concepts, methods and decisions of the developer team (Winschiers 2001). Software development entails modeling, which is a process of abstraction, i.e. separating the unimportant from the important. What is perceived as important in a specific problem context is included in the model. Perception itself is not objective but an active interpretation process (Mueller 1991). Developmental psychology promulgates that individual perception matures only in cultural contexts. This

corresponds with the post-modern, post-structural position that observations are always made from a specific position, which includes the class, gender and culture of the observer. The observer is not simply influenced by these variables but makes choices as to what to look for and where to look. (Smith 1993 as cited in Kober 1997). Thus, software developers recreate reality according to their backgrounds, experiences, knowledge, interests, intentions and emotional interrelations with reality (Winschiers 2001). The perception of the environment from within which the system development originates is central as it determines the definition of the problem for which a software solution is to be found. In other words, 'In software development, we construct the problem as well as the solution' (Floyd 1996).

Unfortunately, developers hold a monopoly on conceptual models and symbolic representations, thereby maintaining an asymmetry of communication in which the perspective of the user is swallowed by the developer (Bråten 1983). In other words, the software developers' model is preserved through the system development methodologies. Especially traditional methods maintain the distance between the users and the developers through assigning roles into specific task categories (Jones 2000).

Therefore, in many African software development scenarios the western-trained software developer solves self- or pre-defined problems technically well yet fails to include the users' perspective and perceive the local problem correctly. 'When IT is introduced in developing countries it will typically be in the form of applications and systems that are 'first world solutions' to 'first world problems'. Such IT solutions are most easily exploited in areas of developing countries that are at best only imitations of the first world' (Braa 1996).

Western concept and method definitions

Information technology solutions are constantly being defined by and evaluated against the values prized in western cultures. Software experts often have an intrinsic belief that these values are superior to those of non-western cultures. This ethnocentrism in software design affects not only information architecture but also the definition of usability and the choice of evaluation methods thereof. Human Computer Interaction, which is concerned with usability evaluation, is rooted in the modernist or

enlightenment tradition which values rationalism, information and efficiency over pleasure, collaboration, creation and community (Muller 1997; Trillo 1999). Industry-recognized methods for evaluating a system's usability (such as GOMS) tend to focus solely on efficient and accurate performance (Badre 2002). However, this may not be applicable in the African context. Mismatches between the African culture of respect, politeness and listener-satisfaction and common evaluation methods like questionnaires and prototyping hinder a critical and reliable evaluation (Winschiers 2001). Standard usability testing therefore encompasses a twofold bias. Firstly through the definition of usability according to western standards and secondly through methods which aim to test an already biased objective.

Cultural validity in support of sustainability

The intrinsic influence of the developers' culture during the development process leads to incompatibility between the product and the embedding context. Therefore, we require an acculturation of the process itself. This includes a redefinition of concepts and an appropriation of methods, which have been assumed to be globally alid. It can only be realized through dissolving the developers' model monopoly and entering into a symmetric dialogue with the user to establish a culturally valid development process. Thus, a generic, culture-driven framework for software design in a non-western context has been developed by Winschiers [2001], in which cultural variances are determined within the specific development context. The following case study, a usability evaluation in the Namibian context, attempts to illustrate the discovery of local cultural factors to promote sustainable software.

CASE STUDY

The project entails the development of a web-based information system for rare species management for the Ministry of Environment and Tourism. The end-users will be Chief Wardens and Conservation Scientists whose main tasks are the technical support of biodiversity conservation and wildlife population management. All end-users are both content consumers and content-providers. Currently the Ministry staff rely on specially compiled paper-based species management reports which can not claim validity of information over a longer period as data are changing frequently. To support a reliable knowledge-based decision process, the Ministry requires an electronic information system. The system should provide current and consistent

information. Both information representation and information retrieval functions have to be in accordance with the users' conceptual model of the knowledge domain.

In the first phase of the project, the developer implemented a web-application prototype based on the paper reports. Management approved the prototype without requesting changes. However, doubting the acceptance of an unevaluated system, we planned a usability-testing workshop with the end-users.

Usability testing workshop

Currently there are neither usability laboratories nor usability testers in Namibia. In support of the workshop, the Polytechnic of Namibia equipped a computer laboratory of 15 PCs with cameras, screen recording software and audio devices to allow parallel recording of user activities during the workshop. B. Tech. Human Computer interaction students were trained in observation, recording and interviewing techniques. Prior to the workshop, the students did a heuristic evaluation and a cognitive walkthrough of the prototype. Weaknesses in the conceptual model and navigation scheme were discovered. Key issues were reviewed and changed in the existing prototype.

The workshop was attended by 14 users, 14 students, two facilitators, one developer and one visiting professor. The one day workshop consisted of different activities with specific objectives and methods as described in Table 1.

FINDINGS

Besides the workshop's industry-driven aim of evaluating the current prototype and obtaining input for the next version, our aim was to arrive at a tentative redefinition of usability and an evaluation of methods in the local context. We deliberately used multiple methods to collect the same data in order to be able to compare the methods against each other. The outcome will enable us to create a new framework for the evaluation of recorded data rather than using predefined metrics of performance and error rates. (An elaboration of the detailed findings is beyond the scope of this paper; we will therefore highlight a few examples only.)

Quality criteria

The users were asked to think of good systems they know as well as to discuss in a small group what a good information system would be. The most frequently named criterion was user-friendliness (ease of learning and handling). Little importance was attached to speed or accuracy. The validity of these evaluation criteria was confirmed through the use of the prototype: the users were enthusiastic about the system irrespective of whether or not they succeeded in solving the given problem. Although most did not complete the tasks, they felt they had mastered the system quickly and easily, and were therefore satisfied with the system. The widely assumed correlation between user satisfaction and efficient and effective task completion does not hold in this local context.

Inadequacy of questionnaires

The individual observations and the questionnaire provide contradictory data. The observations by the usability testers and the analysis of the recordings revealed that most participants had difficulty finding the specific information that was needed to solve a task. In many cases, the user eventually found the information by chance. In the questionnaire, however, all users rated the navigation system highly but indicated that the information contained in the system was inadequate. The questionnaire method can therefore be considered to be an inadequate tool to elicit usability indicators. This confirmed previous findings concerning the reliability of questionnaires in the Namibian context (Winschiers 2001).

Conceptual mismatch

Users oriented their evaluation on the content rather than the functionality of the system. Several users started by first trying to establish how the system compared with their own knowledge before trying to find the information that they needed to solve the task. When they failed to find this information, confidence in the system decreased and they started avoiding the system to solve their tasks. There seemed to be the expectation that the system prototype already contained all possible information. The strong focus on content made it difficult to evaluate functionality. Furthermore, the categorization of the information - which seemed intuitive to the western developer - proved to be a jungle for the local end-users. Content-related

expectations need to be studied in depth and considered within further design and usability tests.

Gender and ethnicity

four out of 14 users and three out of 14 observers were women. To eliminate gender bias we allocated the three women observers to three women users. By comparing how user and observer got along during the test, it became apparent that pairings of equal ethnic background performed better than pairings of equal gender but different ethnic background. It is therefore imperative that local social factors have to be considered in the grouping to achieve optimal results.

APPROPRIATION OF SOFTWARE

Sustainability is further supported through trends in software engineering, like component-based development relying on re-use. Modules, once culturally validated, can be shared cost-effectively within the community. The Open Source model, in contrast to proprietary software, opens up new opportunities in this direction, thus promoting the local appropriation of software. It also solves the problem of financial constraints and dependency of western market trends. Access to the source code permits flexible maintenance. However, the current lack of skilled human resources in Namibia hinders a broad implementation and adaptation of the available technologies. Small-scale projects like School Net Namibia are evidence of sustainable Open Source development with successful local maintenance. However further investigations into local appropriation of software are necessary to get a more detailed view of the possible implications and benefits. Those are beyond the scope of this chapter.

CONCLUSION

Current constraints for sustainable software in Namibia are likely to apply in other African countries. With ICT transfer having failed to fulfil its promises, new trends should be established by the local industry to harvest the benefits of ICT. Although ICT developers claim to adopt user-centred approaches, they still keep a clear line between the users' input and their own choice of methods, interpretations and implementation of the system. The ICT community has to recognize that methods - much the same as software solutions - cannot be applied universally, but have to be

adapted to the local context (Winschiers 2001). Current usability testing methods are based on the assumption that an effective and efficient task completion correlates with user satisfaction. Our findings, however, imply that user satisfaction in the Namibian context is independent of task-solving success. It is therefore necessary to redefine usability and its evaluation method in the local context. The concept of user involvement needs to be extended. User input is required for the choice of methods and the interpretation of data. This means that usability evaluation becomes a twofold process: The establishment of the required methods and evaluation framework followed by the usability tests. By involving the end user in the design of the evaluation process, local validity of the developed components can be achieved. Once the components are evaluated within the local context, they can be re-used and maintained, thereby promoting sustainability. We hope to initiate a discussion on validated methods in the southern African context, thereby establishing a framework for the local evaluation of components implemented within or outside the region to support sustainable software development.

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TABLES

Table 1 Structure of the usability workshop

Activity	Objective	Method
Introduction	Ensure that all participants internalize the aims of the workshop.	Facilitators' slide show, comparison of SW development with the planning of a house construction
Icebreaker	Familiarize with each other and divide in groups for the following activity.	Allocation of nametags by each other in form of a team game
Users' own quality criteria	Obtain high level goals and individual expectations of the system unbiased by the existing prototype or standard usability definitions.	Individual questionnaire on experiences with 'good' and 'bad' systems. Small group discussion on quality criteria and sharing with the whole group later
Individual paper tasks	Determine users' information behavior, namely information retrieval and processing.	Ranking and sorting exercises of reports. Each user was observed by one student while solving a domain specific task with the original species report.
Individual computer tasks	Evaluate the current prototype for usability.	Domain-specific tasks had to be solved using the system. Each user was recorded and observed by one student.
Post-test interview	Identify the degree of satisfaction with the Prototype.	Each student interviews one end-user.
Post-test questionnaire	Obtain quantitative satisfaction measurement of specific items like navigation, layout, etc.	Questionnaire
Feedback session	Obtain specific suggestions on what needs to be improved on the prototype to improve usability	Group discussion

CHAPTER 8

University of Cape Town

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Hypermedia as a knowledge management tool in wildlife management

ABSTRACT

The importance of wildlife as a renewable natural resource has long been recognized in Namibia. Wildlife management embraces a diverse array of issues and integrates different disciplines, such as ecology, sociology and economics. Consequently knowledge applied in wildlife management is highly complex. In order to improve the management of rare and high-value species in Namibia, knowledge on these species needs to be made available to and shared between scientists, wildlife managers and other stakeholders through improved knowledge management. Knowledge Management is not only a question of appropriate technology but is embedded in a social context and involves such intangible elements as experience, know-how and expertise. The knowledge management process corresponds with the adaptive management model. A simple hypermedia system, which is a computerized network of information, can be used as an appropriate knowledge management tool in wildlife management, because of its non-linearity and flexibility. A prototype of a hypermedia Information System for Rare Species Management (IRAS) was tested by wildlife managers and researchers in a workshop, and five high level quality criteria for information systems in wildlife management were introduced: ease of use, compatibility with other systems, affordability, inclusiveness and co-ownership. Because of the constraints observed in Namibia, we concluded that it is first important to institutionalise knowledge management process and nurture a culture of information sharing and discourse.

INTRODUCTION

The importance of wildlife as a renewable natural resource has long been recognized in Namibia. To optimize sustainable utilization this resource has to be managed responsibly. In May 2002 the Ministry of Environment and Tourism of Namibia (MET) launched the "Transboundary Mammal Project" in order to improve and to link local, national and transboundary levels of the management of rare and high-value species (Paterson 2003a, 2003b).

Many of the rare or high-value species in Namibia could attain or sustain higher population numbers and extended ranges. To achieve these increases, dramatic improvements in management would need to take place, at the local, national and transboundary levels. Institutional improvements would also need to occur, at all three levels, building on conservancy and park management, establishing national management goals, targets and approaches, and supporting collaboration and cooperation across national boundaries, requiring transboundary forums.

To provide the necessary research background it is necessary to compile all available information on each species, drawing on historic data and showing changes over time. To this end the transboundary mammal project had by April 2004 produced species reports for buffalo, *Syncerus caffer* (Martin 2002), roan antelope, *Hyppotragus equinus*, sable antelope, *Hippotragus niger*, tsessebe, *Damaliscus lunatus* (Martin 2003), reedbuck, *Redunca arundinum*, waterbuck, *Kobus ellipsiprymnus*, puku, *Kobus vardonii*, and lechwe, *Kobus lechwe* (Martin 2004). Based on these comprehensive overviews, the project then facilitates the drafting of national strategic species management plans for each species.

Wildlife management embraces a diverse array of issues and integrates different disciplines, such as ecology, sociology and economics. Consequently knowledge applied in wildlife management is highly complex. Wildlife management decisions are never based on technical information alone, but also integrate values, opinion and experience (Bell 1983). Limited data, scientific uncertainty, ambiguity and conflicting goals pose further ongoing challenges. Scientists, resource managers, farmers, politicians and business people are equally involved. In broad philosophical terms there are preservationists, conservationists and developers. In the Namibian context there is also ethnic diversity which results in different cultural values. This diverse array of players involved in wildlife management scenarios perpetuates the complexities of wildlife management.

In order to improve the management of rare and high-value species in Namibia the available knowledge on these species needs to be made available to and shared between all stakeholders through improved knowledge management. I argue that a simple hypermedia system can be used as a knowledge management tool in wildlife

management. The notion of knowledge management will be examined and paralleled with the concept of adaptive management. A prototype of a hypermedia system for the management of rare and high-value mammal species (IRAS) will be described and five high level quality criteria for information systems in wildlife management will be introduced.

ADAPTATIVE KNOWLEDGE MANAGEMENT

The prevalent view of knowledge management is focused on making knowledge accessible through the aid of information technology. It is, however, important to realise that knowledge management is not simply a question of appropriate technology (Malhotra 1998). Knowledge is always embedded in a social context and involves such intangible elements as experience, know-how and expertise. Thus knowledge cannot simply be handed over from one person to another like a product and the communication of knowledge is not a trivial problem. Organisational processes and the people that form the knowledge management process are equally important. Knowledge management is always embedded in a social context. The most sophisticated technical solution will invariably fail if it does not recognize the importance of the social context (Malhotra 2002).

The Munich model (Figure 1) describes knowledge management as a cyclical process (Reinmann-Rothmeier 2001). Knowledge needs to be represented in a format or model, which allows it to be applied and communicated. The process of applying and communicating knowledge is at the same time a test and an opportunity to share perspectives. This process then results in the generation of new knowledge. It is important to recognise that new knowledge is always created based on existing old knowledge. Thus knowledge management is an ongoing dynamic process in which new knowledge is constantly created based on existing old knowledge.

This cyclical process corresponds with the adaptive management model. Adaptive management is a learning oriented approach to environmental management that recognises that natural systems are complex and our knowledge of system processes is characterised by high levels of uncertainty. Consequently it is often impossible to accurately predict the potential ecological, social and economic impacts of different management options (Jacobson 2003). Adaptive management acknowledges that it is uncertain what policy or practice is "best" for the particular management issue. Instead

the best "available" knowledge provided by research is used to develop a strategy. A management strategy is a form of knowledge representation as it is based on concepts and models we form to help us understand the ecological processes we want to manage. By implementing the strategy this knowledge is being applied. Strategy evaluation takes place through constant monitoring, which reveals which critical knowledge is currently lacking and where further research is needed to improve the strategy. Adaptive management can thus be understood as a knowledge management process and an information system, which supports and facilitates adaptive wildlife management practices, and as a knowledge management tool for wildlife management.

HYPERMEDIA AS A TOOL FOR REPRESENTING WILDLIFE MANAGEMENT KNOWLEDGE

Advantages of hypermedia

Because of the inherent complexity wildlife management problems are seldom specific to distinct information categories. Wildlife management decision scenarios integrate complex and diverse issues and a tool for representing wildlife management knowledge must therefore be inclusive. Natural language as a medium for knowledge representation is inclusive and general (Rauscher & Reynolds 2003). Polanyi (1966) stated that knowledge can only be expressed through language. For this reason the word "processor" is the de facto knowledge management tool in natural resource management (Rauscher & Reynolds 2003). Hypermedia, the format of the World Wide Web (WWW) provides the added flexibility of a multi-linear structure. A hypermedia system is a computerised network of information units such as text, images and graphics. Contrary to the linear structure of printed documents which freeze information into a static format, hypermedia documents are easily updated and linked to external information. Pages can be viewed in flexible order, depending on what is most useful in a given context. The meaning of a single hypertext unit is influenced by its connection to other units. So being able to visit pages in different orders is like viewing content from different angles and can lead to a different perception of the same content (Mancini & Shum 2001). The links between documents simulate associations (Rauscher & Reynolds 2003), which may enhance comprehension because it is similar to the way humans store and retrieve information by means of associations.

Adaptive management is based on the notion that “truth is context- and even observer dependent” (Jacobson 2003). The inclusive character of language and the flexibility of hypermedia allow wildlife related information to be embedded in different contexts, thus allowing it to be perceived from various perspectives. This inclusivity opens the stage for a host of new associations and connotations to take place in the mind of the reader, which leads to a change of perspectives and new perceptions that support both strategy development as well as strategy implementation. Rather than forcing consensus, a dynamic representation of the diverse knowledge on wildlife and its management can thus emerge and be communicated between stakeholders. Consequently hypermedia can be regarded as an appropriate knowledge management tool for wildlife management.

Case study: A hypermedia information system for rare species management (IRAS)

The comprehensive knowledge that was compiled in the species overview reports (Martin 2002, 2003, 2004) and species management plans (Ministry of Environment and Tourism of Namibia 2002, 2003, 2004) has been captured in the hypermedia Information System for Rare Species Management (IRAS). IRAS contains detailed descriptive information regarding the biology of each species, i.e. taxonomy, physical description, reproduction and population dynamics, habitats, distribution, numbers, behaviour and limiting factors, as well as the significance of the species in terms of conservation and economics. In addition the main stakeholders for each species are identified and an analysis of past and present management practices is provided.

There are also status targets defined as well as possible incentives and strategies for utilisation and marketing. IRAS functions like a website and the information contained in the system is organised as a web, with each component being linked to others (Figure 2). Wildlife managers can look up any relevant information on the biology or management of the species. They can visit the management objectives that have been defined. For each objective they find management steps described which need to be taken in order to achieve the set goal. For each objective and management strategy there is a host of background information available which explains why this objective has been set or how the management steps are interlinked (Figure 2). Managers can

incorporate the strategy defined for a given species into their planning processes. The experience the managers gain while implementing the strategy are generally captured in the form of reports and memos. Because of the flexible nature of the medium this valuable information can be incorporated into updated versions of the system. IRAS provides an easily accessible and updatable knowledge and information repository. This system integrates the advantages of a printed document on a particular species, a management plan for that species with the interactive navigability of a website.

A prototype of IRAS was tested by wildlife managers and researchers in a uniquely designed usability workshop (Chapter 7). Five high level quality criteria for information systems in wildlife management emerged: ease of use, compatibility, affordability, inclusiveness and co-ownership. **Ease of use** was the most cited quality criterion during the workshop. An information system should provide the required functionality involving only a short learning curve. The software should live up to the user requirements, not the other way around.

Compatibility is important to take advantage of systems that are already in place and are familiar to the end users. It must be possible to link to external information as well as import and export information between systems.

Affordability is an important requirement as the use of information technology within natural resource management in Namibia, especially within the government sector, is still at a fledgling state. One of the ways to reduce the cost is to seek alignment with software that most organisations already possess and also public domain software (Dent 1999).

Wildlife management is a complex and inclusive knowledge domain. **Inclusiveness** is therefore a key requirement for any information system that seeks to support decision making in wildlife management.

Co-ownership plays an essential psychological role in information system development and sustainability (Chapter 7) and is fundamental to the success of any information system. Due to the complexity of wildlife management decision scenarios and our incomplete understanding of natural systems information, systems cannot be

expected to provide right solutions or right decisions. They are however useful tools to support the adaptive management model. In this sense, information systems need to evolve to reflect the learning process underlying management strategies and practices. Unless the potential users take ownership of the information system and provide the essential input that allows the system to evolve, the most sophisticated technology will be of little use.

Because of the often inadequate infrastructure and insufficient transfer rates and bandwidth in certain areas of Namibia, IRAS is distributed online as well as on CD-Rom.

CONCLUSION

The current prototype of IRAS represents a simple hypermedia knowledge management solution. All information is administered and updated from a central point by a dedicated systems administrator. More value could be added if these processes were at least partially automated, so that content providers can edit and maintain their content through a decentralized process. Open source content management systems are available and low cost solutions are technologically possible.

The present constraints, however, lie in the hierarchical structure of the MET as an organization and the resulting information culture, which is authoritarian and characterized by top-down decision-making. Another constraint in Namibia is the lack of qualified personnel to adequately maintain a sophisticated content management system. In addition Namibia as a postcolonial country is characterized by a "culture of silence" (Winschiers 2001), which hinders critical thinking and discourse.

Therefore, in order to take full advantage of the potential of hypermedia as a knowledge management tool, it is less important to employ the latest technology than to institutionalize knowledge management processes and nurture a culture of information sharing and discourse. The non-linearity and flexibility of hypermedia make it an appropriate medium for the representation and management of wildlife management knowledge.

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FIGURES

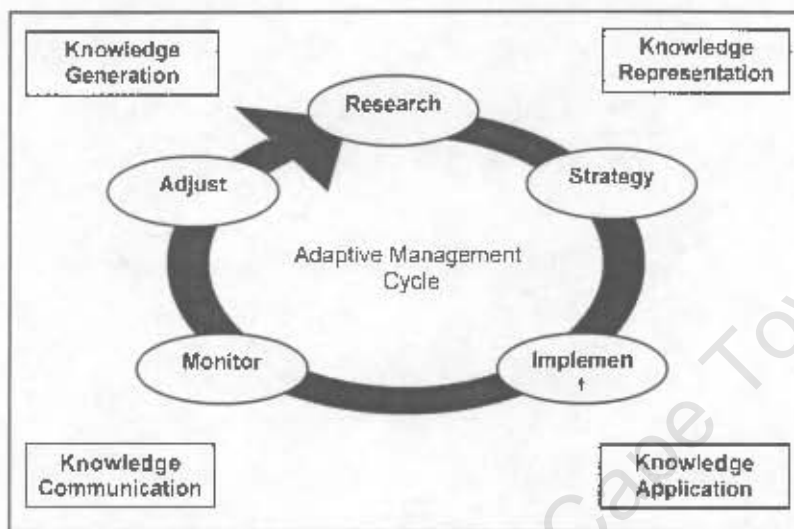


Figure 1 Adaptive management cycle within the Munich Model of Knowledge Management Processes. Knowledge is generated by research, then represented in a model, which allows it to be applied. This application is implemented, monitored and communicated. The process results in the generation of new knowledge, which is used to adapt all processes. Adapted from the Munich Model (Reinmann-Rothmeier 2001).

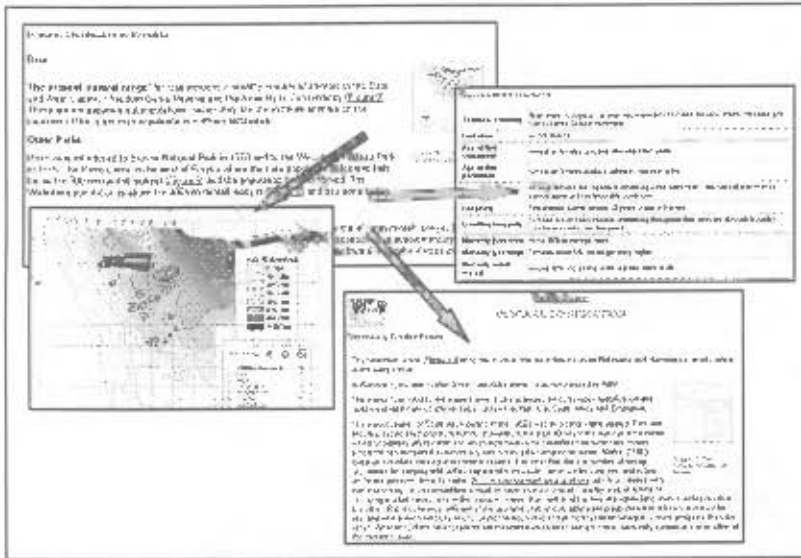


Figure 2 Hypermedia represents a web of information which, contrary to printed documents, can be accessed in flexible order. Example of hypermedia created for the roan antelope, *Hippotragus equinus*, in Namibia.

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CHAPTER 9

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Testing usability of information systems: a case study based on a hypermedia system for rare species management in Namibia

ABSTRACT

The pervasiveness of western developed software is creating global standards irrespective of local culture. Software development and usability testing are strongly influenced by western cultural assumptions. Most usability testing focuses on speed and efficiency (Rosenfeld & Morville 2002). These values however may not be equally important in an African context and may be overshadowing other cross-cultural dimensions. Thus there is a need to develop an appropriate methodology for usability testing in the southern African context (Chapter 7). Winschiers (2001) and Duncker (2002) suggest that traditional evaluation methods are inappropriate in a cross-cultural context and emphasis must be on dialogical approaches. This paper presents the results of a usability test of a locally developed hypermedia information system prototype for the management of rare species in Namibia (IRAS). Contradictions between questionnaire data and interviews and observations confirm that questionnaires on their own are unreliable in a cross-cultural context. This contrast suggests that African usability engineers need to be trained in qualitative research methodologies.

INTRODUCTION

The usefulness of an information system depends on whether the functionality of the system in principle allows completion of a task. But usefulness alone does not guarantee that anyone can make use of this functionality. Whether or not people can use a system successfully determines its “usability”, loosely defined as testing all aspects of the user experience and gaining insights into the strengths and weaknesses of software design from the perspective of the user. Usability cannot be taken for granted; its evaluation should be an important part of any information system development, although it is often neglected (Nielsen 2001). Usability, as a field within human-computer interaction, is a sub-discipline of computer science, and is concerned with evaluating how people interact with software.

This chapter is concerned with the usability of hypermedia systems, typically a set of HTML files that are viewed over the internet. Initial usability studies of hypermedia systems have targeted navigation and display. Interactive components are expected to increase user engagement and satisfaction whereas having to scroll down long pages is assumed to be detrimental to usability (Smart *et al.* 2000). However, Smart *et al.* (2000) proposed that in reality users judge a hypermedia system based on its content, and initial research suggested that search fields achieve little in increasing the users' success in locating information (Nielsen 1998). Spool (1998) found that users prefer to scroll than to view a succession of screen-sized pages and are able to locate information more successfully on longer pages.

Furthermore, software development and usability testing are strongly influenced by western cultural assumptions (Trillo 1999; Winschiers 2001; Chapter 7). Hestres (2003) showed how the design of Microsoft Outlook manifests American cultural values, which are rooted in rationalism and logic, such as high emphasis on individuality, competition and cooperation, time management and practicality. Consequently, the current paradigm in which usability is evaluated is also based upon a definition of usability according to western standards (Chapter 7), with an almost exclusive emphasis on efficient and accurate performance (Badre 2002). The pervasiveness of western-developed software is creating a global standard which fails to take account of local culture. For example, in their evaluation of locally-developed web-based learning tools in South Africa, Van Gruenen & Wesson (2004) described a user interface designed to look like Microsoft Outlook as intuitive assuming that most people are familiar with the design.

Most usability testing is concerned with how long it takes the user to learn how to use a system and how long it takes the user to complete a task (Rosenfeld & Morville 2002), thus emphasising speed and efficiency. These values however may not be equally important in an African context and may be overshadowing other cross-cultural dimensions, such as the importance of community. Thus there is a need to develop an appropriate methodology for usability testing in the southern African context (Chapter 7).

The usability of a hypermedia system is closely linked to the user's information seeking behaviour. For example, Marsden (2003) found that, because many South

Africans have had little experience with libraries, the basic metaphor of information structure, such as chapter, section, subsection, is problematic. Preliminary research by Walton & Vukovic (2003) suggested that the difficulty arises from the implicit use of the concept of hierarchy, as exemplified in a family tree, which is problematic to many South African internet users. Similarly, Duncker (2002) found that for many? Maori users in New Zealand the use of electronic online libraries is problematic because of the underlying metaphor that assumes familiarity with library concepts.

Walton & Vukovic (2003) found that many South African students use inappropriately general search queries when researching subjects on the internet and overlook relevant sources because they expect a brief 'point-form' summary. This point was also stressed by Sayed (1998) who stated that South African students struggle with research because they assume the existence of a single source containing all necessary answers, similar to the material provided by their high-school teachers. Walton & Vukovic (2003) observed that computer users assumed that the computer understood and remembered their intentions and previous actions. Winschiers (2001) found that questionnaires were unreliable for software evaluation among computer science students in Namibia, because many students came from a culture in which authority figures (and the developers of computer software are authority figures) are respected; they did not feel comfortable answering questions truthfully in writing, and preferred to give answers which were positive. Similarly, in New Zealand, Duncker (2002) found in her study that the use of questionnaires was inappropriate because the Maori users tended to answer every question as positively as possible. Controlled experiments with no observer interference failed because Maori users refused to 'think aloud', i.e. to accompany their actions with an oral commentary for the benefit of the observer. Both Winschiers (2001) and Duncker (2002) suggested that traditional western evaluation methods, such as written questionnaires, cannot be assumed to be appropriate in cross-cultural contexts and that there needs to be an emphasis on dialogical methods, i.e. verbal evaluation based on a dialogue between user and assessor.

This paper presents the results of a usability test of the prototype version of a locally-developed hypermedia Information System for the Management of Rare Species in Namibia (IRAS) (Chapter 6 describes the IRAS information content and its organisation; Chapter 8 discusses the potential of IRAS as a knowledge management tool). The test was undertaken in order to improve the prototype and results were

incorporated into the subsequent version of IRAS. Another purpose of the test was to gain insight into the appropriateness of usability test methods and to work toward a methodology for usability engineering appropriate to an African context (Chapter 7 describes the structure of the usability workshop).

METHODS

14 potential users from two Directorates, Scientific Research and Resource Management, of the Namibian Ministry of Environment and Tourism (MET) tested the system during a one-day workshop. All participants had tertiary qualifications (Table 1) and were familiar with the use of computers. None of the users spoke English as a first language (Table 2). I observed the workshop from the point of view of finding common difficulties which the users were having.

The user-participants were supported by 14 BCom Human Computer Interaction (HCI) Students of the Polytechnic of Namibia. The students, who prior to the workshop had performed a heuristic evaluation and a cognitive walkthrough of the prototype, also acted as observers during the workshop.

The assumption was made that the inevitable communication barrier between user and developer (Chapters 2 and 3) may be aggravated by cultural differences. Wherever possible it was tried to pair the user with an observer who shared the same home language, and had the same gender. It was assumed that an observer who shared the cultural background and the home language of the user would be able to discern more information from the user's behaviour and would be in a better position to interpret these. In so doing we hoped to introduce a different and perhaps richer cultural paradigm into the usability experience.

During the workshop the users were asked to solve 8 tasks, which had been designed with input from the MET to resemble real life scenarios. The tasks were divided into a group of computer-based tasks which users were required to solve using the IRAS system and a group of paper-based tasks which users were required to solve with the help of printed information from those documents which are the basis of the content of IRAS. Each user was paired with a student, who made observations and maintained supportive dialogue during the task solving exercises and undertook a structured interview afterwards. All interviews included open questions, as well as closed

questions in which interviewees were asked to answer yes/no or according to a scale form 1 to 5. Video and voice recordings were made while the users were working with the system and the screen logs were captured. At the end of the workshop the users filled in a questionnaire about their experience of the system. Each student analysed the results and wrote a report (see Box 1 for structure) as part of the HCI course assignments. The results were later incorporated into the second prototype.

Box 1. The structure of the reports written by the Human Computer Interaction students

- Introduction
- User profile
- Raw observation data per task
- Interview answers
- Interpretation of data according to
 - Media used
E.g. did the user make use of metastructure such as tables of content and headings? Were maps and graphs consulted?
 - Navigation
E.g. did the user lose orientation? Did links lead to expected content? Did the user appear to be confident?
 - Goal orientation
E.g. did the user know what to look for or browse aimlessly?
 - Subject's perception of content representation
E.g. did the user seem satisfied with the information?
 - Interaction
E.g. was feedback received from the system and was it perceived as helpful? Did the user acclimatise to the system easily?
 - General method of information behaviour
E.g. browsing; searching; trial and error
 - Prior knowledge of user
Were tasks solved by finding information in IRAS or knowledge the user already had?
 - Efficiency
 - Emotional satisfaction
E.g. did the user show signs of frustration?
 - Observed concordances and discordances between data from observation, questionnaire and interview
- Design recommendations

RESULTS

The prior heuristic evaluation revealed weaknesses in the conceptual model and the navigation scheme of the hypermedia system, such as lack of controlled vocabulary, structural as well as design inconsistencies, lack of informative feedback and an

insufficient number of shortcuts. These issues had been reviewed and the prototype adjusted prior to the workshop.

The student reports varied in quality. Although the majority were detailed none provided a complete set of observational data. Some reports captured direct recommendations made by the users or stated recommendations from the observers based on interpretation of the data. Other reports were abbreviated to the point of uselessness. Eleven usability reports were submitted by the students. Each user solved 5 computer-based tasks. Out of a possible 70 videos, 14 were recorded. Of the 14 video recordings, four were usable (Table 2). Two videos had no data, one had no sound, in seven videos picture and sound were not synchronised. Of the seven unsynchronised videos, two had incomprehensible sound. Out of a possible total of 70 screen captures, three screen captures were saved documenting the navigational paths for three different users.

Interviews

In answers to open questions, workshop participants stated that they typically used the computer for data analysis, information seeking and data communication (Table 4). Participants did not make frequent use of the internet (Table 5). Of the 14 users 3 expected the IRAS system to be difficult to understand, complicated or challenging, 2 expected to be presented with a lot of information (Table 6).

Four participants stated that the search option was a feature they liked (Table 7); at the other extreme, three participants stated that the search option was a feature they found most confusing (Table 8). Interestingly, of the four users who mentioned the search option as a feature they liked, three also stated it as a feature they found confusing or disliked. Apart from the search functionality, missing information and graphics were stated as features found confusing or disliked most (Table 8, Table 9). Scrolling was not mentioned in response to any of the questions nor were categories, terminology or labels.

Interview answers to closed questions referring to ease of use and getting started were predominantly in the medium range. Users rated their own understanding of the system medium to low and their computer proficiency medium to high. Most users stated that they could perform the tasks during the workshop easily, but more than

half of them would not be able to spend 40% of their working day using the system without getting frustrated. The degree to which IRAS covered their daily tasks was rated medium (Table 10).

Questionnaires

In the questionnaires, participants were asked to rate their overall reaction to IRAS, the use of terminology throughout the system, their orientation within the system, the quality of the maps and the ease of learning to operate the system using a scale from 1 to 9. The majority of responses lie in the medium to high and high range; only 22 out of 297 responses were scored below 5; the most frequently used score was 7; responses regarding the terminology used in the system were in the medium-high to high range; answers to the question whether participants got lost were evenly spread across the middle to high range; most participants stated that backtracking was easy; inadequacy of information was the only point that scored a 1 and discernability of map colour scored most frequently in the low range (Table 11).

Individual observations

Analysis of the individual observations is based on the students' reports. Each report is an observer's account of the user's behaviour during each task solving exercise. Thus analysing the observations means interpreting the users' behaviour through the eyes of the observers.

Paper-based tasks

All users made use of meta-structure, such as the table of content and headers, and scanned rather than read text. Three users could not find specific information by using the table of contents, because the information was not where they expected it to be. They had to page through the document in order to find it under an unexpected heading.

Computer-based tasks

Some five out of 12 users solved every task, six solved at least one task and one did not solve any task (Table 12). Two users expressed that they considered the information inadequate; the majority of users had problems accessing information; more than half of the participants had problems orientating within the system; some six out of 11 users completed their tasks easily and six either expressed that the

quality of the maps was bad or had problems interpreting the maps (Table 13). Six users had difficulties with the search option, three did not use the search at all (Table 14).

Single source solution (expectation that system understands user intention)

When the search was used unsuccessfully the failure resulted because the search string was not found at all or too many results were returned due to inappropriately general search queries. One user who was trying to determine the habitat requirements of Sable antelopes typed "sable" into the search field. The same user is quoted in the report as describing the WWW/internet to be "the best thing" but "too wide in spectrum". According to the report this user wanted the system to give him exactly the information for which he was seeking "I want the search to be contextual and only give me what I want to see". He named the search function both as the feature he enjoyed the most and as the feature which he did not enjoy. Another user stated that she wanted all the information for which she seeks quickly, without having to look for it much. A third user expected a single map displaying water availability per conservancy and vegetation type per conservancy. Although this information can be deduced by examining the available maps displaying rainfall, conservancies and vegetation type respectively, he lost confidence in the system. Before trying to locate the information for the next task he stated that he did not think he would find the information he was searching for.

Judging site content

Most of the reports made no reference to the users' perceptions of the content (Table 13). However, there were frequent references to missing information and one user commented on a table, containing data she considered incompatible. Some users seemed to lose confidence in the system once they had failed to locate a particular item of information they required. One report stated that the user thought that "the information is confusing but not the system itself; if the information is correct and up to date, then the system will be fine".

Categorisation

There are no references in the reports regarding the adequacy of terminology used in the system (Table 13). However, according to the observers, one user struggled to figure out under which headline the specific information for which she was looking would be found and another user did not solve a single task because she "could not

find what she was looking for”. Another user “indicated that it wasn’t easy to find the necessary information” and that he “would have liked the system to have a header/link for conservancies”.

One of the tasks was to calculate a hunting quota for buffalo in a specific protected area, Mamili National Park. IRAS is primarily organised by species and by wildlife management topic. The information necessary to calculate off take quota for buffalo is organised under the general category management and the specific category “utilisation”. Some 5 users expected to find this information as particular information on Mamili National Park.

Contradictions between individual observations, interview data and questionnaire data as stated in the reports

At least five of the 11 reports indicated contradictions between the questionnaires and related interview answers and the observations: Two users stated in their questionnaires that they never got lost but according to the observer did so on several occasions. Three users stated in the questionnaire that it was easy to accomplish tasks but did not complete all of them. One user stated in the questionnaire that learning and exploring was easy but did not manage to solve any task. One user stated in the questionnaire that the system was easy to learn; the observer however stated in the interview that he did not find it easy to learn the system. One user who according to the observer had “complained about the maps often” rated the quality of the maps high in the questionnaire. Another user who had made it explicit that she considered the quality of the maps very poor, did not rate the quality of the maps very low. One user who, according to the observer “had a rough time using the search” stated in the interview that he liked the search option. One user who had called the information insufficient during the exercise rated the information adequate in the questionnaire.

DISCUSSION

Paper-based tasks

The paper-based tasks revealed structural weaknesses of the printed documents which form the basis of the IRAS content. Some specifiable information was not found by users, because it was categorised in unexpected ways. The underlying categorisation system is obviously highly ambiguous. The IRAS prototype that was tested during the

workshop used the same categorisation scheme as the printed information sources. The content has been re-analysed and a knowledge organisation system was developed specifically (Chapter 6).

IRAS usability

Scrolling was not mentioned as a difficulty and therefore does not seem to have been an issue with users. The search functionality caused confusion for some users, because particular information, such as the name of a specific conservancy, were only included on a map or other graphics and were therefore not returned by the text search. Most of the people who stated that they liked the search function also stated that they found it confusing or did not enjoy using it. There was obviously a conflict between the user's expectation and his or her actual experience.

The reports showed that at least two users seemed to expect that the system would understand their intention and would generate a custom-made solution that would address all their information needs. When searching for hunting quotas five users expected to find the calculated quota for a particular area. These users seemed to understand solving the tasks as a search for a single screen containing all answers rather than the need to develop a synthesis of information gleaned from a series of screens. This user expectation confirms the findings of Walton & Vukovic (2003) and indicates that the conclusion by Sayed (1998) also holds in the Namibian context. It may also explain why some users overlooked relevant information. Most of the participants had problems accessing information, and less than half solved all tasks although the required information was included in the system. Those users who solved all tasks did so using the categorization system successfully, and used the search function rarely or not at all. A search component requires careful tuning and the results indicate that, although many users like to have an interactive search component, unless it is well-designed and can be maintained, it may be better exclude the component.

Content was the most frequently mentioned point in the interviews and there were frequent references to missing information in the reports. This pattern indicates that content was an important criterion by which the users judged the hypermedia system. This point confirms the conclusion made by Smart *et al.* (2000) that content must be included when evaluating hypermedia systems.

There was no indication that hierarchical concepts were misunderstood by the participants, as suggested by Marsden (2003) and Walton & Vukovic (2003). However, this proposition was not explicitly tested. Some users seemed to struggle with multi-level hierarchies and categories which were found only at deeper levels. This difficulty can be addressed by flattening the hierarchical structure and making more sub-categories visible at a higher level.

There do not seem to have been any problems directly related to the categorisation and labelling system.

Usability testing methodology

The questionnaire data did not indicate that the usability of IRAS needs any improvement. The interviews and observations however revealed that less than half the participants were able to solve all tasks and that many struggled with the search function. This study confirmed previous findings by Winschiers (2001) that Namibians tend to answer questionnaires as positively as possible. The same tendency was also found by Duncker (2002) with Maori users in New Zealand. Winschiers (2001) suggested that this tendency is grounded in Namibia's "culture of silence". As a consequence of oppression experienced during colonial rule and the subsequent apartheid era, societal structures are authoritarian and written critique is not openly exercised. Without the interviews and observations many issues would not have been laid open during the usability testing. The contradictions between the questionnaire data and the interviews and observations suggested that questionnaires on their own can be unreliable in a cross-cultural context, as found previously by Duncker (2002) and Winschiers (2001). Quantitative methods for measuring usability, e.g. by means of questionnaire data and measuring the time needed for solving a task, are less time consuming and allow statistical analysis. This may be why such methods are popular. However, when evaluating usability in a cross-cultural context, open questions and dialogical methods seem to be more appropriate, or at least offer richer texture of opinion, and a greater likelihood of uncovering the real difficulties in the use of an information system.

The reliance on technology for data collection was a weakness of the usability test, due to equipment failure. The need for technical support was not included in the

project planning but became apparent during the workshop. As a consequence little of the raw data was available for analysis. The interpretation of user behaviour during the workshop was based on the students' reports, not all of which were useful. HCI students in Namibia are not currently trained in qualitative research data collection and analysis methods (H. Winschiers pers. comm.). Future research in this field may concentrate on developing appropriate usability testing methodologies for Africa by working closely with social scientists. As our findings suggests such research cannot be conducted from within a solely positivist paradigm, but needs to be based on interaction and communication. The political and social realities particular to Namibia have to be incorporated into the methodologies.

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TABLES

Table 1 Gender and qualification of users who participated in the workshop n=14

	Conservation scientists			Wildlife managers	
	BSc	Honours	Msc	Diploma	BTech
male	1	0	2	6	1
female	1	1	2	0	0

Table 2 Home languages spoken by users who participated in the workshop n=14

Home Language	
Oshiwambo	6
Otjiherero	2
Lozi	2
Subia	1
RuGciriku	1
Afrikaans	2

Table 3 Length and quality of video sequence per testing user-student couple n=14

User	Video 1 (min)	Video 2 (min)	Video 3 (min)	Quality
1	5:15	21:28	10:39	Good
2	0:10	18:37	9:11	Good
3	00:35	18:37	9:11	Good
4	00:35	0:22	0:18	No sound
5	01:21	11:30	10:10	Picture and sound not synchronised
6	03:16	4:06	01:32	Picture and sound not synchronised
7	No data	No data	No data	No data
8	05:5	02:18	No data	No data, only testing equipment
9	08:30	05:56	No data	Good
10	14:12	No data	No data	Picture and sound not synchronised
11	04:56	04:55	05:09	Incomprehensible sound
12	1:01:01	No data	No data	Incomprehensible sound
13	14:08	15:08	04:19	Picture and sound not synchronised
14	14:13	06:20	10:17	Picture and sound not synchronised

Table 4 Frequency of interview responses stating typical computer usage n=11 multiple responses possible

Usage	
Access database	7
Information/searching	5
Internet	4
Produce maps/graphs	4
Spread sheets	3
E-mail	2
GIS	1
Assessment	1
Archives	1
Music	1
Games	1
Analysis	1

Table 5 Frequency of interview responses describing internet usage n=11

How often do you use the internet?	
Daily	6
Not a lot	2
Every two days	1
Never	1
No data	1
What do you use the internet for?	
Email	6
To get information	5
Search	3
Work	3
Surf	1
No data	2

Table 6 Frequency of users stating expectations of IRAS n=11 multiple responses

Difficult to understand / complicated / challenging	3
Lots of information	2
Increase knowledge	1
More specific information	1
Easy to work with	1
General information	1
Data needed by the system	1
Like a normal system	1
System keeping track of what user is doing	1
Information about endangered species	1
No expectations	1

Table 7 Frequency of interview responses stating features of the system which users liked n=11 multiple responses

Feature	
Graphical information	5
Useful information	4
Search option	4
Information distribution	2
Front page	2
Visual	1
User interface	1
Easy navigation	1
Easy access of different files	1
Straight access to content	1
Information availability	1
Clear index	1
Easy to use	1
Speed	1
Library	1
Links	1
Back button	1
Referral and directions	1

Table 8 Frequency of interview responses stating features of the system which were found confusing n=11 multiple responses

Feature	
Maps	4
Lack of information or missing information	4
Search option	3
getting to info	3
Categories	2
Animal population	1
No zoom option	1
Home page	1
Library	1
Tables/Graphs	1
Too trivial	1
Sub menus	1

Table 9 Frequency of interview responses about what was enjoyed the most and the least while working on the system n=11 multiple responses

Enjoyed most	
Information / availability of information	5
Figures and maps	3
Links	3
User friendly / easy to work on	2
Layout	1
Easily navigable	1
Clear direction	1
Graphic user interface	2
Limited typing	1
Search functionality	1
Efficiency	1
Speed	1
Enjoyed least	
Search isn't good	5
Figures/maps/graphs	4
missing information	3
Too much info	1
Having to click a lot	1

Table 10 Interview responses to closed questions n=11

	No data	1	2	3	4	5
How easy did you find acclimatizing to the system?	0	0	2	6	3	0
How challenging was it to get started?	0	0	3	5	3	0
What is the degree of your understanding of the system?	0	2	5	4	0	0
To what extend does the system cover your typical daily tasks?	1	0	4	5	1	0
How proficient are you in using the computer?		0		4	3	4

	No data	YES	NO
Would you say that you could perform the tasks easily?	0	9	2
Would you be able to spend at least 40% of your working day on the system without getting frustrated?	1	4	6

Table 11 Frequency of ratings stated in questionnaires n=11

	No data	1	2	3	4	5	6	7	8	9
Overall reaction										
Terrible-wonderful		2	0	0	0	1	5	1	1	1
Frustrating-satisfying		2	0	0	0	1	2	3	2	0
Dull-stimulating		1	0	0	0	0	1	3	3	2
Difficult-easy		2	0	0	1	0	0	1	3	2
Inadequate info-adequate info		2	1	1	0	1	2	2	0	1
Inaccessible-accessible		2	0	0	0	0	1	1	3	3
Terminology										
Use of terminology throughout system: Inconsistent-consistent		1	0	0	0	0	0	5	2	2
Work related terminology: Inadequate-adequate		2	0	0	0	1	0	1	2	2
Terminology relates well to the work you are doing?		1	0	0	0	0	1	1	2	3
Orientation in the system										
Computer keeps you informed about where you are: Never-always		1	0	0	0	1	3	1	1	2
You get lost: Easily-never		2	0	0	0	1	2	2	1	2
Performing an operation leads to a predictable result: Never-always		1	0	0	0	1	3	0	4	2
Links are: Confusing-clear		1	0	0	0	2	1	2	1	4
Screen layouts helped orientation: Never-always		1	0	0	0	0	1	2	4	1
Backtracking through former pages: Difficult-easy		1	0	0	0	2	1	0	1	3
Ease of operation depends on your level of experience: Never-always		1	0	0	0	1	0	2	1	3
You can accomplish tasks: Difficult-easy		1	0	1	0	0	1	2	3	3
You can use features/shortcuts		1	0	1	0	0	3	1	1	3
Multimedia										
Quality of maps: Bad-good		1	0	0	0	3	1	0	1	5
Resolution of maps: Bad-good		1	0	1	1	0	1	1	2	3
The size of the maps is adequate: Never-always		1	0	0	1	2	1	2	2	1
Colours are distinguishable: Never-always		1	0	2	2	0	1	0	2	3
Learning										
Learning to operate the system: Difficult-easy		1	0	0	0	0	1	0	4	3
Getting started: Difficult-easy		1	0	0	0	1	1	0	4	3
Time to learn to use the system: Long-short		1	0	0	0	0	1	3	2	3
Exploration: Difficult-easy		1	0	0	0	0	0	3	3	3
Discovering new features: Difficult-easy		1	0	0	1	1	2	0	1	4

Table 12 Number of participants solving tasks n=11

All tasks	5
Some	6
None	1

Table 13 Interpretation of user behaviour based on observations and compared across all users n=11

	No Data	Low	Medium	High
User's opinion of information adequacy	8	2	1	0
User's ease of access to information	0	4	5	2
User's opinion of adequacy of terminology	11	0	0	0
Ease of orientation	0	2	4	5
Expectations of results of operations are met	4	1	6	0
Ease of task completion	0	4	1	6
User's opinion of the quality of maps	4	6	1	0
User's ease of learning	3	2	2	4

Table 14 References to use of search option n=11

Not used at all	3
Unsuccessfully used	6
Seldom used	1
No data	1

CHAPTER 10

University of Cape Town

A fuzzy knowledge-based decision support model for wildlife translocations into communal conservancies in Namibia

ABSTRACT

Wildlife translocation is a valuable conservation tool with benefits for both local communities and wildlife populations. Wildlife management decision scenarios are characterised by limited data and scientific uncertainty and knowledge applied in wildlife management decisions is highly complex. Experienced conservationists who need to weigh up the relevant factors determining translocation success often struggle to communicate the reasons for the decisions to communities and senior decision makers. A knowledge-based decision support system (KBDSS) was developed in order to help develop a standardised decision making approach and to help decision makers to motivate their decision and communicate the reasons to the stakeholder community.

INTRODUCTION

Wildlife management embraces a diverse array of issues and integrates different disciplines, such as ecology, sociology and economics. Wildlife management decision scenarios are characterised by limited data and scientific uncertainty. When information is available it is often ambiguous and wildlife management decisions are never based on technical information alone, but also integrate values, opinion and experience (Bell 1983). Consequently, in order to solve the difficult task of balancing the often-conflicting goals of the various stakeholders in terms of conservation and development, the knowledge applied in wildlife management decisions is highly complex (Chapters 2, 8).

With Namibia's recent growth in tourism, game farming and sport hunting, more and more land is becoming available for the re-introduction of wildlife. The establishment of conservancies and private nature reserves is presenting Namibia with a unique conservation opportunity to re-establish wildlife species into their former ranges

(Figure 1). The growth in communal conservancies has made almost 10 million ha of land available for the expansion of wildlife ranges since 1998.

A well-managed wildlife translocation programme is a valuable conservation tool. It has benefits at both ends of the process. In areas that are fully stocked, the capture process is a management tool to prevent overpopulation. Controlling population sizes relieves pressure on the veld, reduces drought-related mortalities and serves to rejuvenate remaining populations. The introduction process re-establishes or boosts game populations so that wildlife-based industries have a chance of competing with alternative forms of land use such as agriculture. This has obvious benefits for incentives based conservation, diversification of the rural economy and poverty relief.

Wildlife introduction is an expensive exercise but waiting for population numbers to increase naturally is often a risky strategy because of the expectations that benefits can be gained from conserving wildlife. Waiting too long for benefits can erode the fertile ground for conservation that we currently see in Namibia.

With the large benefits of game introductions difficult situations arise of having to decide which areas get wildlife and which do not. Although wildlife translocations are a popular and potentially powerful conservation tool, they are often carried out in an ad hoc fashion without careful monitoring (Fisher & Lindenmayer 2000). A national game introduction approach, based on pre-defined criteria, will go a long way to reduce the conflict and misunderstandings that often arise during introduction exercises.

Whilst the suitability of habitat is obviously a fundamental criterion, there are in addition, a multitude of other factors that need to be weighed up:

- The opportunity to re-establish species into their former ranges;
- the contribution of the area to national biodiversity conservation (including securing key ecosystem processes);
- the potential of the area for wildlife-based enterprises;
- the threats to wildlife (poaching, competing forms of land use);

- the commitment shown by the local community and their management efficiency;
- the socio-economic development needs in the local area;
- the numbers of existing game populations and success of previous introductions; etc.

Experienced conservationists naturally weigh up these and other considerations but often struggle to communicate the reasons for the decisions to communities and senior decision makers. A knowledge-based decision support system (KBDSS) was developed in order to help develop a standardised decision making approach and to help decision makers to motivate their decision and communicate the reasons to the stakeholder community.

The use of knowledge-based systems in wildlife management is still a new field. However, Xie *et al.* (2001) developed a knowledge-based system for white-tailed deer management, Yamada *et al.* (2003) elicited expert knowledge to be used as baseline information for wildlife management. Knowledge-based systems are used for ecological modelling in forest management (Nute *et al.* 2003; Twery & Hornbeck 2001) and analysis of watershed condition (Reynolds *et al.* 2000). Mackinson (2000) developed a fuzzy expert system for predicting structure, dynamics and distribution of herring shoals. Ducey and Larson (1999) used fuzzy sets in forest management.

MATERIALS AND METHOD

NetWeaver and GeoNetWeaver

The KBDSS for wildlife translocation into communal conservancies in Namibia was developed using NetWeaver, a graphical tool for knowledge engineering and GeoNetWeaver, a spatial analysis extension to NetWeaver. The KBDSS models the decision scenario as a dependency network hierarchy of the criteria involved.

NetWeaver

NetWeaver is a knowledge engineering tool for the development and maintenance of knowledge bases (Saunders & Miller 2004). The primary structural element of a NetWeaver knowledge base is the network, whose function is to evaluate a

proposition (Reynolds *et al.* 2000). The truth-value of a network expresses the degree to which the proposition is true based upon the premises of the proposition. For example the proposition that an area is a **high priority translocation area** is evaluated in terms of its logical antecedent networks **strong management capacity, low threats, good rationale and compatible land use** (Figure 2) and is true to the degree that the propositions that are represented by the antecedent networks are true. These networks are evaluated in terms of their own antecedent networks and so on. A NetWeaver knowledge base is a hierarchical network and the most elementary level of each network is the data link. Data links provide the interface between the network and input data (Figure 3).

Fuzzy logic

Data links and networks are connected by logical operators such as “AND” and “OR”. Logical operators in NetWeaver are fuzzy logic operators. Fuzzy logic is based on the concept of the fuzzy set (Zadeh 1965). The boundaries of a fuzzy set are not sharp; the transition between set membership and non-membership is gradual rather than abrupt. Instead of only two truth values fuzzy logic provides a continuous measure. Traditionally the value of a logical AND is TRUE if all antecedents are TRUE and FALSE if at least one antecedent is FALSE. Unless an antecedent is FALSE in which case the fuzzy AND evaluates to FALSE, NetWeaver calculates the value of AND by finding the weighted average of all antecedents, which allows compensating for missing data.

GeoNetWeaver

GeoNetWeaver is a NetWeaver extension, which allows a knowledge base to be evaluated and analysed spatially. Using GeoNetweaver the NetWeaver knowledge base can be linked to ArcView shape files. The truth-value of a network associated with an area is displayed graphically using graduated colour ramps to express the degree of trueness (Figure 4).

Knowledge base design

Problem domain

The purpose of the model is to support decisions regarding wildlife translocations into communal conservancies. The model provides information concerning the following questions:

Which species can be introduced into area x?

Which area is most suitable for species A?

Can species A be introduced into area x?

The KBDSS models the main factors that determine the answers to these questions. Some of the factors are species-specific criteria that need to be fulfilled before a particular species may be introduced into the area, e.g. ecological suitability, access to water, etc. Other factors address the suitability of an area in general terms independent of which species is being considered, e.g. existing threats to wildlife, the management capacity of the conservancy members and the tourism potential of the area. It was therefore decided to develop the model in two steps, a model of area factors and a species-specific model. The primary topics for area were the management capacity of the conservancy, possible threats to wildlife, whether existing land use patterns are compatible with wildlife and the rationale for translocating wildlife into this area. In species-specific terms the topics were ecological suitability, access to water, the size of existing populations of the same species, and whether good reasons exist for translocating this species into this area.

The spatial units for analysis of wildlife translocation were defined by the boundaries of registered conservancies. Temporal considerations were excluded from the analysis. The model is only concerned with the assessment of existing conditions. However the descriptions of existing conditions can be updated regularly.

Knowledge elicitation

The Wildlife Translocation model includes expert knowledge on two levels, the knowledge-based representation of the problem domain and the data input. A small team of domain experts identified the relevant factors for game translocations (Table 1), which were then translated into dependency networks. For each data link a concise

proposition was formulated. These propositions were presented to a larger team of domain experts comprising Ministry of Environment and Tourism researchers and field staff involved with wildlife management and community-based conservation as well as various experts from local non-governmental organisations dealing with community-based wildlife management issues. These experts evaluated each proposition against a given scale and filled in data sheets for all areas and all species. The resulting tables of scores provided the input data for the model.

In a broad sense the KBDSS development parallels the first three stages of multiple criteria decision analysis (MCDA), i.e. identification of the problem, problem structuring and model building (Belton & Stewart 2002).

Knowledge base evaluation

To allow evaluation of the KBDSS results, the experts were asked to assess each conservancy overall for each species using a scale of 1 to 10. Comparison of these scores with the truth-values of the top-level networks provides a means of verification and control.

RESULTS

Knowledge base structure

The wildlife translocation KBDSS evaluates the suitability of conservancies for wildlife translocation in both general and species-specific terms.

For the general conservancy assessment the primary networks are **strong management capacity, low threats, good rationale and compatible land use**. Each network evaluates a specific proposition about the conservancy (Table 1). The proposition that a conservancy is a high priority translocation area is true to the degree that the people of the conservancy have the capacity to manage wildlife, that the threats to wildlife are low in this area, that other land uses harmonise with wildlife and that there are good reasons for translocating wildlife to this area. A good rationale for translocating wildlife into a conservancy is based on the development needs of the area, the potential for wildlife-based enterprises or whether the area is important in terms of national biodiversity strategy.

Unlike the primary networks, which are all equally important to assess an area's suitability, the antecedent networks for **good rationale** are linked by an OR node, which means **good rationale** evaluates to TRUE, when any of the child networks evaluate to TRUE and FALSE when all the child networks evaluate to FALSE. The truth-value of **good rationale** is calculated by choosing the value of the truest network.

For the species-specific assessment the primary networks are **good ecological suitability, good access to water, low population numbers, good rationale and compatible land use**. The proposition that this species can be introduced into this conservancy is true to the degree that the antecedent networks evaluate to true. **Ecological suitability, good access to water, low population numbers and compatible land use** do not have any antecedent networks but one data link each. **Good rationale** depends on the role the species plays in this area for tourism, trophy hunting or wildlife farming or for other national strategies or the cultural value that people in this area associate with this species.

Sample analysis

The knowledge base was used to assess the suitability of 31 communal conservancies in Namibia for wildlife translocation. General area assessment and species-specific assessment were done separately. The species-specific suitability of each conservancy was evaluated for 22 species. Disease free buffalo were treated separately, which brings the total number of species to 23. For both general and species-specific assessment the KBDSS provides map output showing the computed truth-value for the proposition in question, e.g. the proposition that a conservancy is a high priority translocation area (Figure 5). Selecting a network in the right hand pane displays the truth-values for this network and its associated proposition on the map. This facility makes partial evaluations and detailed analysis possible, e.g. map output showing the relative degrees of development needs for each conservancy. Bar charts display output by conservancy, showing the truth-values of all dependency networks side by side (Figure 6).

DISCUSSION

The KBDSS contains expert knowledge on two levels: the network structure of relevant factors and the scores for each area, which are included via data links. During the knowledge elicitation workshop it became apparent how important it is to phrase the proposition, which experts are to evaluate as unambiguously as possible. Assumptions must be made clear; some assumptions were not anticipated and only arose during the workshop. Some experts expressed difficulty to assess an area for wildlife introduction without taking a specific species into account. Although they were frequently encouraged to make use of the whole scale of scores available some experts avoided using the lower scores. Elicitation methods will need to be adjusted to account for this propensity.

The analysis of factors into area and species specific criteria worked well. However it was not always easy to determine whether a factor was species-specific or area specific. In the case of **compatible land use** it was necessary to include this factor into both models. It is possible to assess an area in terms of the amount of area left for wildlife and the degree to which the dominant types of land use are compatible with wildlife. However different species respond differently. Some species are easily disturbed by the presence of humans while others such as kudu are more tolerant to non-wildlife based forms of land use. The next step in model development must be to combine both area-specific and species-specific models into one homogeneous translocation model.

The GeoNetWeaver map output allows comparison of all conservancies in respect to a particular translocation factor. The possibility to drill down by selecting antecedent networks for map display allows for detailed analysis. The bar charts provide the possibility to analyse how a particular assessment was arrived at for a particular conservancy. These graphical outputs provide a useful tool to communicate and motivate decisions. The wildlife translocation KBDSS supports the application of rigorous criteria and is a step towards a standardised national wildlife translocation programme that is robust, equitable and transparent.

ACKNOWLEDGEMENTS

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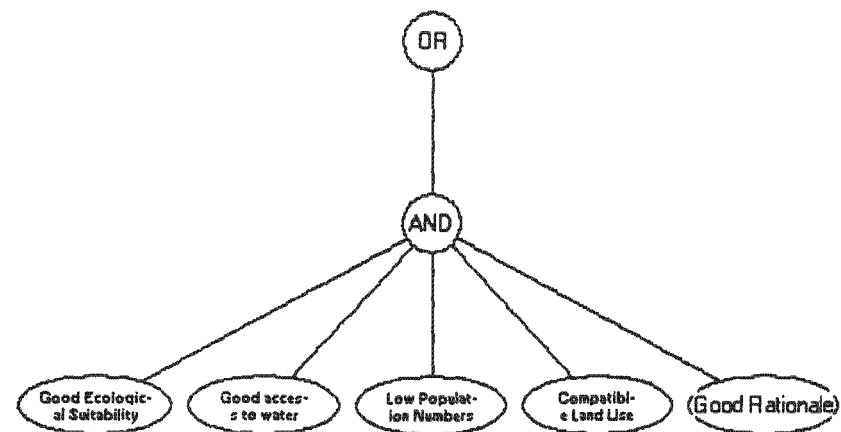


Figure 2: Species specific top level criteria are represented as a dependency network. Each criterion represents a sub-network. The OR node at the top is a NetWeaver convention, which all dependency networks must follow.

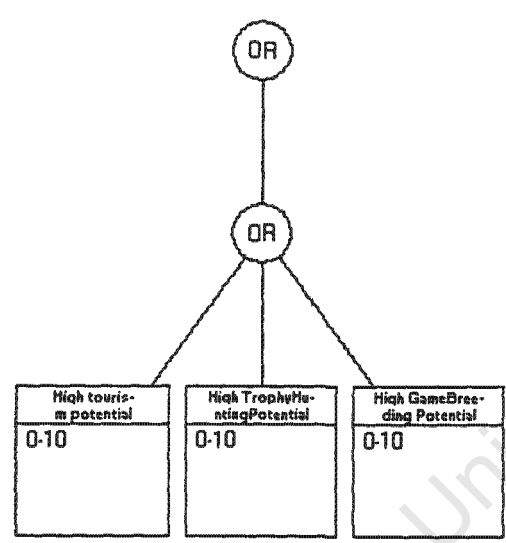


Figure 3: The data links are the lowest level of the network hierarchy and are evaluated on the basis of input data. The OR node at the top is a NetWeaver convention, which all dependency networks must follow.

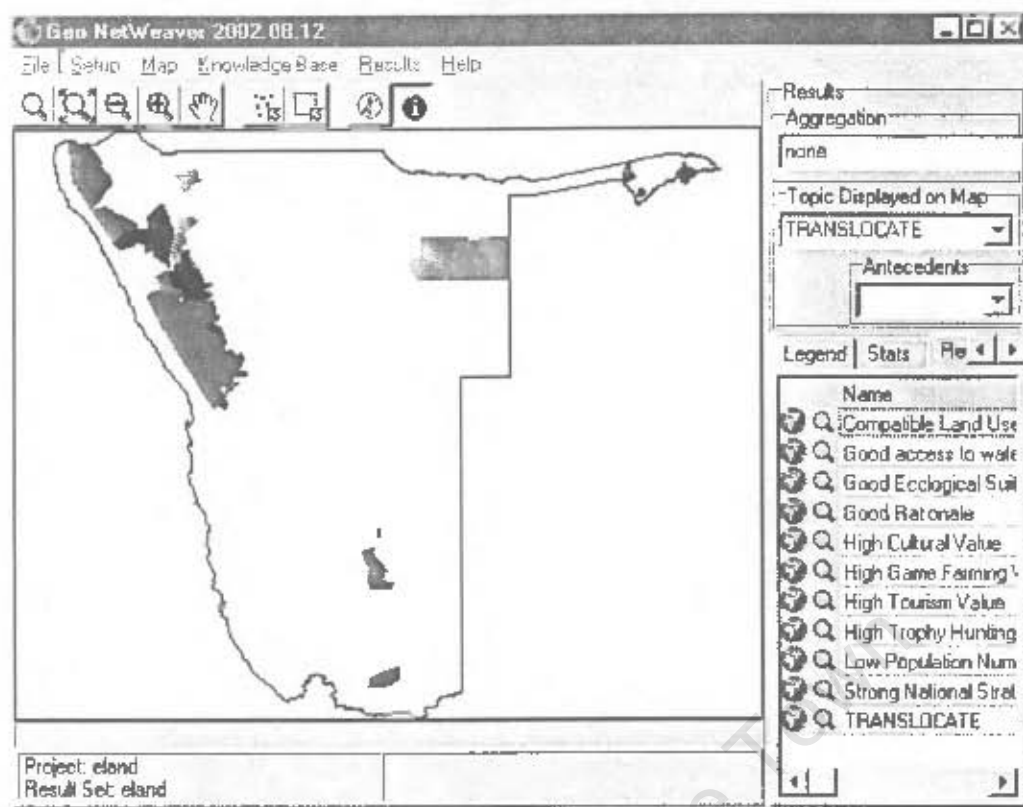


Figure 5 The KBDSS calculates the truth value of the proposition “translocating this species into this conservancy is a priority” for each conservancy and displays the results on a map. The lighter green a conservancy is displayed, the truer is the proposition for this area. The brighter red a conservancy is displayed the higher is the degree of falseness of the proposition for the area.

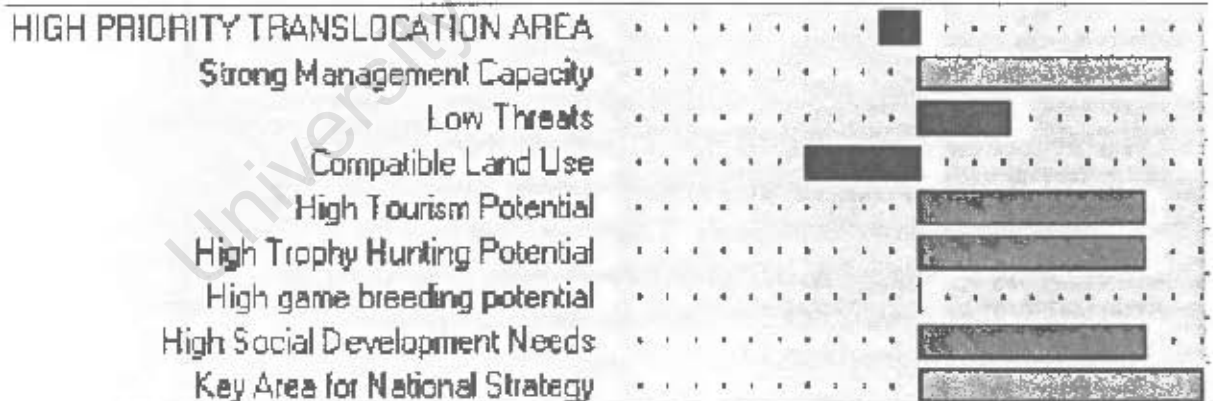


Figure 6 The KBDSS calculates truth values for each sub-network. Networks and corresponding truth values can be displayed as bar charts to enable comparison between networks.

Table 1 Propositions associated with networks and data links antecedent to translocation area network. Names of networks are displayed in italics, names of data links in bold.

Network name	Proposition
<i>High management capacity</i>	The management capacity of this conservancy is exceptional
Strong management capacity	The management capacity of this conservancy is strong
Good track record	This conservancy has an exceptional track-record
<i>Low threats</i>	There are no threats to wildlife
Low external threats	There are absolutely no threats to wildlife and the conservancy from external sources
Low internal threats	There are absolutely no internal threats to wildlife in this conservancy
<i>Good rationale</i>	there are good reasons for putting wildlife into this conservancy
<i>High Social Development Needs</i>	The social development needs of this conservancy are high
High impact on livelihoods	Livelihoods are very low and need to be improved
High Own Use Need	'Own use' is a critical source of protein
<i>High Wildlife Use Potential</i>	There is high potential for wildlife utilisation in this conservancy
High Trophy Hunting Potential	The Trophy Hunting potential of this area is exceptional
High tourism potential	The Tourism potential of this area is exceptional
<i>High wildlife breeding potential</i>	There is high wildlife breeding potential
Good utilisation potential	Harvesting and marketing of wildlife/venison are extremely easy for this conservancy
High Ecological Productivity	The productivity of this area is very high
<i>Key Area for National Strategy</i>	This area is critical to national conservation objectives
National strategy	This area is critical to national conservation objectives
<i>Compatible land use</i>	The land uses in this area are compatible with wildlife
Land use	There is no impact from other forms of land use or the conservancy has set aside an exclusive wildlife area and it will be maintained

CHAPTER 11

University of Cape Town

Evaluation of a fuzzy knowledge-based decision support model for wildlife translocations into communal conservancies in Namibia

ABSTRACT

A knowledge-based decision support system for wildlife translocation (KBDSS) was developed using NetWeaver, a commercially available tool for the construction and maintenance of fuzzy logic knowledge bases, and GeoNetweaver a spatial analysis extension for NetWeaver. The Wildlife Translocation KBDSS is a collection of dependency networks representing the criteria for identifying a suitable area for wildlife translocation. The purpose of the wildlife translocation KBDSS is to identify the relevant components of the decision problem and to facilitate communication between stakeholders during the decision making process. Evaluation of the KBDSS was performed regarding the acquisition of expert knowledge, the appropriateness of the knowledge representation and inference mechanism for the knowledge domain, i.e. wildlife translocation and the appropriateness of the model outputs. A sensitivity analysis was performed to evaluate the robustness of the model. The evaluation suggests that the approach is appropriate and the model is robust. Care has to be taken, however, in the use of the system and the design of the outputs to avoid misinterpretations.

INTRODUCTION

Usually, informed decision making in wildlife management requires knowledge about the external environment. Knowledge about the complex natural systems is, however, incomplete and characterised by uncertainty. Conservation biologists and wildlife managers use modelling in order to extend the available knowledge.

Purposes of modelling in resource management therefore range from statistical description of data, mechanistic description of system processes, the prediction of future system dynamics based on explicit assumptions to determining how to apply a control measure such as harvest quotas, to meet specific objectives.

A knowledge-based decision support system for wildlife translocation (KBDSS) was developed using NetWeaver, a commercially available tool for the construction and maintenance of fuzzy logic knowledge bases, and GeoNetweaver a spatial analysis extension for NetWeaver. Both NetWeaver and GeoNetweaver were developed at Penn State University (Saunders & Miller 2004).

The Wildlife Translocation KBDSS is a collection of dependency networks representing the criteria for identifying a suitable area for wildlife translocation. (Chapter 10). A NetWeaver knowledge dependency network is a representation of a proposition such as *area x is a priority area for translocation of species y* and the logical relations among the factors influencing the truth value of the proposition.

The purpose of the wildlife translocation KBDSS is to identify the relevant components of the decision problem and to facilitate communication between stakeholders during the decision making process. The model is somewhat minimalist. In the sense, that wildlife translocation is a management intervention, the wildlife translocation KBDSS falls into the control category. However, unlike the calculation of quotas it does not tell the manager how many animals to translocate or how to go about it. The KBDSS is also not a habitat suitability model nor includes population viability analysis. It is a model of the necessary criteria that an area needs to fulfill to be considered for wildlife translocation. The model is based on the assumption that there is wildlife to be translocated and suggests destinations based on a predefined set of criteria. The wildlife translocation KBDSS is not concerned with the origin of the animals.

Criteria for a good model are, for example, appropriateness, correctness, completeness, comprehensibility, ease of communication, user friendliness, efficiency, flexibility, ease of maintenance, portability, modularity and reusability. These criteria are anchored in the interest of the modeller and depend on the modeller's epistemological position regarding the relationship between model and reality (Schinzel 2004). Explicitly representative computer modelling usually follows the correspondence theory (Tarski 1983) regarding the model as an image or reproduction of the objective reality. The correctness of the model is thus a measure of the trueness of the image. The constructivist position (Winograd & Flores 1990)

rejects the assumption that an objective reality exists and that model and reality presuppose each other. The pragmatic position replaces the ontological question whether reality exists with the end-means relation. A model is good if it operates successfully.

In the case of the wildlife translocation KBDSS it is difficult to identify the section of reality that is being modelled. The value judgements and preferences of the decision maker are included into the model (Belton & Stewart 2002). The criteria which are represented in the model represent the more or less diffuse concepts of the experts and the modeller. These concepts are clearly the result of a hermeneutical process and thus a model in themselves. Because the KBDSS cannot be considered a reflection or image of an objectively existing reality it is impossible to verify it according to correctness and completeness. It is however possible to evaluate the wildlife translocation KBDSS in terms of appropriateness and usability.

METHODS

Evaluation of the KBDSS was performed regarding the acquisition of expert knowledge, the appropriateness of the knowledge representation and inference mechanism for the knowledge domain, i.e. wildlife translocation, the robustness of the model and the appropriateness of the model outputs.

Knowledge acquisition

The knowledge which is modelled in the translocation KBDSS was elicited during two workshops (Chapter 10). During the first workshop a group of domain experts and the model developer identified the relevant criteria for translocating wildlife into communal conservancies and their relationship to each other. The model developer then constructed the logical structure as a NetWeaver knowledge base, i.e. a hierarchy of dependency networks which have data links for data input at their lowest level (Figure 1). The data links return truth values between 100% false and 100% true based on the input data. The developer's definition of the data link determines which maximum input value corresponds to 100% false and which minimum value corresponds to 100% True. The definition also determines the value marking the switch from falseness to trueness (Figure 2). The truth values are propagated upwards through the hierarchy.

During the second workshop the necessary input values were elicited from a wider group of domain experts. The NetWeaver model was then populated with the elicited input values. Thus, the experts determined the criteria and input data, whereas the model developer influenced the relationships between the criteria and the design of the data links, depending on the experts' input and her interpretation of the data. The model developer defined the data links over an input range of $\{0..10\}$, the only exception being ecological suitability which was defined over a range of $\{0..4\}$. During the second workshop tolerance settings were defined for some criteria, which narrow the range of suitable input values. These tolerance settings determine for instance that in the case of black rhino the input value for parameter *high management capacity* needs to be between 6 and 10 for this parameter to return a degree of trueness (Figure 2).

The longer the scale over which a data link is defined, the smaller is the influence of a chosen input value. For instance, if the scale is $\{0..10\}$, it is of lesser consequence whether the expert chooses 2 rather than 3 than it is if the input scale is $\{0..5\}$. Because of the high degree of uncertainty and the subjectivity of the input data the longer scale was chosen. A longer scale however may be more difficult for the expert to apply, in which case a trade off between the coarseness of the scale and the robustness of the system may be necessary. In order to assess the appropriateness of the scale six semi-structured interviews with experts were carried out. Each expert was given scores for several criteria, to which he then was asked to give a meaning. The meanings were captured and analysed according to whether the expert struggled to give descriptors or was able to impose meanings and hence differentiate between scores that are close together on the scale.

Appropriateness of the modelling approach for the domain

Literature on modelling approaches in conservation biology and natural resource management are reviewed. Frequently used inference mechanisms were compared in terms of their usefulness for the decision problem of translocating wildlife.

Appropriateness of results

A group of experts were asked to use the same set of predefined criteria that were incorporated into the model to evaluate the proposition “I strongly recommend that this species should be introduced into this conservancy” for 22 species and 30 conservancies on a scale from 0 to 10. The model output in the form of truth values between 100% false and 100% true was mapped onto a scale of 1 to 10 to allow direct comparison with the expert assessment. The degree of difference between expert assessment and model output was also examined as well as whether experts and KBDSS made the same recommendations for translocation. The truth values returned by the model are not absolute but reflect degrees of trueness or falseness. Hence a proposition for which the model returns a value on the lower half of the trueness scale is only “less than half true”, so to speak. This contrast is also reflected in the colouring on the graphical output, as the colour for values below 40% true are so dark as to be almost black. For a model output to be considered a recommendation, it must therefore be at least 40% true. This truth value corresponds with a rating of 7 out of 10 by experts. By comparing conservancies which score 7 or higher by the experts with conservancies for which the KBDSS returns a truth value of 40% true or higher, it is possible to examine which areas are recommended by the experts and which areas are suggested by the model. Model output and expert assessment were compared for all 22 species and 30 conservancies creating a total of 660 records. However, for five species some experts did not complete a data form, which means that data are lacking for those species in respect of 12 areas. The total number of records is therefore reduced to 600 records. For the comparison of recommendations our data set considers only the 17 species for which a complete data set is available.

Sensitivity analysis

A sensitivity analysis was undertaken to establish the robustness of the model. Model inputs were successively incremented and the model outputs compared. Five tests were performed:

- (i) each parameter at a time was incremented by 1 scale unit while all other parameter remained constant;
- (ii) two parameters were changed at a time while all other parameter remained constant;

- (iii) all parameters were incremented by 1 scale unit;
- (iv) each parameter at a time was incremented until the upper limit of the input interval was reached;
- (v) eight of the 16 parameters were randomly selected and incremented simultaneously until the upper limit of the input interval was reached. Increasing beyond the upper limit of the input parameter, i.e. 4 for parameter 1, or 10 for all other parameters, has no effect on the output value because values equal to and above the upper limit are evaluated as 100% true.

The sensitivity tests (i), (ii) and (iii) were undertaken for four sample species, disease free buffalo, hartebeest, gemsbok and roan antelope. This selection covers two common species (hartebeest and buffalo), two high value species with high tolerance settings, which may affect the model robustness and for which data are available for all relevant conservancies (roan and disease free buffalo). Most of the high value species only occur in the Northeast of Namibia, so ecological suitability rules out those conservancies, which are situated in other parts of the country, thus resulting in a small dataset. (The model correctly outputs 100% false because of the 100% False for ecological suitability, but this property is trivial). Disease free buffalo has the highest tolerance settings (besides Rhinoceros for which some experts did not provide data during the workshop, resulting in an incomplete data set) but only two conservancies are relevant for translocations. Roan antelope is being considered for seven conservancies and has second highest tolerance settings. Test series (iv) and (v) were undertaken for roan antelope and gemsbok: a rare and high value species, and a common plains game species, respectively.

Appropriateness of output formats

It is possible to export the inference results in numerical format as dBase files, but the primary NetWeaver output formats are visual. Bar charts describe the trueness or falseness of the listed criteria. The higher the degree of trueness, the further the “trueness-bar” extends to the right and is depicted in a lighter shade of green; the higher the degree of Falseness, the further the “trueness-bar” extends to the left and is coloured in a lighter shade of red. In the KBDSS a bar chart is created by grouping several criteria into a “goal group”. The goal group “All species” for instance,

visualizes for each species to what extent it is true that this species should be introduced into the selected conservancy (Figure 3). The goal group “Roan Overview” shows to what extent the listed criteria are fulfilled in the case of the selected conservancy (Figure 4).

GeoNetWeaver, an extension to the NetWeaver environment allows the visualization of the numerical output in the form of maps, making use of Geographic Information System (GIS) technology. The maps show spatial overviews that allow comparison of all conservancies in respect of the same criteria (Figure 5). It is possible to generate maps for any criteria defined in the NetWeaver knowledge base.

Conservancies for which the truth statement associated with a criterion evaluates to true are depicted in shades of green relative to the percentage of trueness. Areas which evaluate to false are depicted in shades of red, relevant to the degree of falseness.

Visualisation technology such as GIS is becoming increasingly popular in wildlife management and is being applied in Namibia's Community-based Natural Resource Management Programme (CBNRM) (Tagg *et al.* 1996). A critical debate on GIS has been taking place since the mid 90's. The relevant literature was reviewed and the KBDSS output formats were evaluated in the light of the findings.

RESULTS

Knowledge acquisition

Of the six experts interviewed, four had no problems giving descriptors for any of the scales nor did they struggle to differentiate between points on the scale for any of the criteria with which they were presented. One expert could not provide linguistic descriptors for two criteria, but instead suggested expressing the criterion *existing population size* in percentages of carrying capacity; he did not seem to have difficulty differentiating between points on the scale for the remaining criteria. Another expert struggled to differentiate between points on the scale and preferred to bundle 2-3 points into one. This expert had no difficulty with the criterion *population size*; he also had no difficulty with the scores between 5 and 10 for the criterion *water*

availability. He struggled however to give meaning to scores lower than 5 and suggested that scores 1-3 be bundled into one meaning, which would result in a scale of {0...8}. For the criterion management capacity he suggested bundling scores 1 and 2, 4 and 5, 6-7 into one meaning respectively which would result in a scale of {0...6}

Appropriateness of the modelling approach for the domain

In natural resource management, knowledge-based and simulation models are generally used to manage predictive knowledge whereas decision support systems are used for managing prescriptive knowledge (Rauscher & Reynolds 2003). Traditional simulation models are often mechanistic and feature hard computing, which is oriented towards analysis of physical processes and characterized by precision and formality (Rudas 2003). Because knowledge in natural resource management and conservation biology is incomplete and often imprecise, soft computing methods, which are oriented towards analysis and design of intelligent systems (Rudas 2003) have gained in popularity. Examples of soft computing methods are rule-based systems (RBS), artificial neural networks (ANN), probabilistic inference, and fuzzy logic.

Rule-based systems

An RBS generally consists of a knowledge base, containing conditional rules and facts, and an inference engine which evaluates the rules. Rules are generally of the format “if x then y”, i.e. they consist of an antecedent and a consequent component. The inference engine will evaluate the consequent based on its antecedent: if the antecedent is true the consequent is true or, in the case of the consequent defining an action, the action will be executed. RBS have been applied in plant ecology to simulate plant functionality and behavior (Room *et al.* 1994; Room & Prusinkiewicz 1996; Colasanti & Hunt 1997), in forestry to simulate the effect of forest cutting on landscape patterns (Wallin *et al.* 1994), in conservation biology to predict vegetation formation (Lenihan & Neilson 1993; Strittholt & Boerner 1995) and impacts of climate change (Plochl & Cramer 1995) and to evaluate the mechanisms of changes in species distribution (Skelley & Meir 1997).

Artificial neural networks (ANN)

A neural network consists of a number of interconnected processing units. The processing units are generally simple computation devices. Each processing unit can receive inputs from several other units but will only generate one output signal. The inputs are aggregated to calculate the activation state of the unit, and output or transfer functions are used to limit the output to a finite interval. The connection strength between units is represented by weighted links. Through repeated training cycles the connection strengths are adjusted. For a more detailed overview over ANN see Kiang (2003). Examples of ANN in conservation biology and natural resource management are used for characterisation of environmental suitability for forest types (Hilbert & Muyzenberg 1999), for the ageing of forests (Kimes *et al.* 1996), for predicting the effects of climate change on tree growth (Keller *et al.* 1997), on river ecology (Poff *et al.* 1996; Clair & Ehrmann 1996) and on species abundance (Lusk *et al.* 2001).

ANN applications have been used to predict habitat suitability (Bradshaw *et al.* 2002), human wildlife conflict (Touren *et al.* 1999), vegetation distribution (Hilbert & Ostendorf 2001), plant diversity and abundance (Lek-Ang 1999 *et al.*), grassland community changes (Tan & Smeins 1996), grass quality (Mutanga & Skidmore 2004) and species distribution and abundance (Yen *et al.* 2004).

Bayesian inference

A frequently used probabilistic statistical inference mechanism is Bayesian inference. Bayesian inference interprets probabilities as degrees of belief, which are adjusted in the light of new evidence. *Prior probabilities* are assigned to two or more alternative hypotheses. Then the *conditional probabilities* of the observations, which are used as evidence, are calculated under each hypothesis. The *posterior probability* $P(H_0|E)$ that a specific hypothesis (H_0) is true is thus based on the *prior probability* $P(H_0)$ that H_0 is true and the *conditional probability* $P(E|H_0)$ of observing the evidence (E) given that H_0 is true.

$$P(H_0|E) = \frac{P(E|H_0) P(H_0)}{P(E)}$$

Bayesian inference is used in conservation biology and natural resource management to analyse data from animal surveys (Johnson 1989; Link & Sauer 1996), to evaluate the suitability of landscape states (Prato 2000), to predict macrofaunal communities (Braak *et al.* 2003), to estimate tree diameter (Green & Clutter 2002), to predict the effects of climate change on plant communities (Kienast *et al.* 1996), and to estimate model parameters to make up for lack of quantitative data (Lexer & Hoenninger 1998; Steinberg *et al.* 1997). Prato (2001; 2004) uses Bayesian inference for adaptive area management. Marcot *et al.* (2001) describe a Bayesian belief network to evaluate wildlife population based on a mix of empirical data and expert judgments.

Fuzzy logic

Fuzzy logic is based on the concept of the fuzzy set (Zadeh 1987). The boundaries of a fuzzy set are not sharp; the transition between set membership and non-membership is gradual rather than abrupt. Instead of only two truth values, e.g. (0, 1) or (-1, 1), fuzzy logic provides a continuous measure. This characterisation is similar to the linguistic categories applied in natural language. For instance, when trying to map the scale of human heights to a set of terms {short, medium-sized, tall} it is difficult to define exact numerical thresholds. Fuzzy logic inference has been used in conservation biology and natural resource management to develop evaluation frameworks for the effectiveness of protected areas (Lü *et al.* 2003), for assessing environmental impact indicators (Ferraro *et al.* 2003), for evaluating riverine wetlands (Castella & Speight 1996) and strategies for sustainable development (Andriantiatsaholiniaina *et al.* 2004). Fuzzy logic modelling has been applied to predict the influence of fire on landscapes (Roberts 1996), to represent knowledge on the relationship between field margins and spider assemblages (Kamplicher 2000), and to predict coral reef development under anthropogenic influence (Meesters *et al.* 1998).

Appropriateness of results

Direct comparison of the model outputs with the expert ratings revealed that out of a total of 600 records, some 433 records show a difference between model output and expert rating that is smaller or equal to 2 on the 0-10 scale. The remaining 167 records can be grouped into three categories: E_{NEG} indicates cases where the experts' overall

rating is far lower than the model output, but both expert rating and model output are negative. $E_{CONTRAST}$ indicates that the expert rating is negative but the model output is positive. E_{POS} indicates cases where the expert rating is 10, i.e. 100% positive, although individual scores are low (Table 1).

The Experts scored more frequently at the extreme ends of the range whereas model outputs lie more in the middle of the range (Figure 6).

Some eight records of category $E_{CONTRAST}$ show an expert rating of 0 and a model output corresponding to greater than 7. Of these records three are for conservancy Uukwaludhi. For Uukwaludhi there is a further record where the model output is 8 but the expert rating is greater than 3 and another where the expert rating is 0 but the model output 7.

Some 11 of the 25 records of category E_{POS} refer to Nyae Nyae conservancy. The experts rated 10 although they had scored individual criteria lower. The model's overall output for these records is therefore lower. For a further two records the expert rating for Nyae Nyae was below ten but higher than the model output. For one record the model output is higher than the expert rating. The remaining records for Nyae Nyae show concordant expert and model ratings. For 22 records of this category the input value for parameter *high ecological suitability* is 10, i.e. 100 % suitable. For the remaining three records the input value for parameter *high ecological suitability* is 8 and the input value for *existing population* is 10, indicating that the area is well below carrying capacity. For all these records a minimum of two and a maximum of five other parameters are lower than 10. In all cases the input value for *high management capacity* is lower than 10 and for 15 records the parameter *good access to water* is lower than 10.

There are two records for which the parameter ecological suitability was scored 0, but the overall expert rating is 6.

Comparison of expert recommendations with model recommendation shows that for 10 out of 17 species corresponding areas are scored highest by both experts and

KBDSS (Figure 7 and Figure 8). These species are eland, oryx, buffalo (disease free), common impala, giraffe, hartebeest, reedbuck, roan, tsessebe and waterbuck. Although the expert ratings for these species may differ from the output values, both experts and model recommendations list the same priority areas (areas with highest score) for the introduction of the respective species. For one species, i.e. lechwe, there is no correspondence between expert and model. For the remaining six species the model recommendation is similar to the experts' recommendation. 'Similar' means that the same areas are recommended by the experts and by the model output, but that the values differ and either the expert recommendation or the model recommendation includes a larger number of areas.

Sensitivity analysis

(i) After incrementing each parameter by 1 unit on the input scale while holding all other parameter constant, the comparison of the maximum differences for each parameter shows that changing the input values for parameters 1 (*Historic Range*), 2 (*Existing Population Size*), 3 (*Access to Water*) by 1 point caused the greatest change of output values (Figure 9). Parameter 1 shows the greatest difference. Examination of the output values and differences shows that the highest differences were associated with changing the input parameter 1 from 0 to 1. The input value interval for this parameter is [0,4] with 0 being 100% false, 1 being undetermined and 4 being 100% true. Increasing the input from 0 to 1 is therefore equivalent to a change from 0 to 5 for a parameter with input interval [0,10]. An input error of that magnitude is unlikely to occur because records with input value 0 for parameter 1 are records for areas which lie 100% outside the historic range for the species in question. It is more likely that errors occur in the interval [1,4], i.e. assessing to what degree an area does fall within the historic range. However, maps which clearly depict the boundaries of the historic ranges of all species addressed are available.

After excluding areas, which were previously rated 0 for parameter 1, i.e. are completely outside the historic range of the species, the extremely high difference values for parameters 1 and 2 disappeared. The parameters which are most sensitive to input change are now 2 and 3 (Figure 10). The average difference between output values before (out_1) and after incrementing input values (out_2), excluding areas

outside the historic range of the species, are highest for Parameters 2 and 3. The highest difference occurred for parameter 3 for Roan (0.120).

(ii) After increasing input values by 1 unit for combinations of two parameters the highest differences between out_1 and out_2 were caused by the increased input values for the parameter combinations 2/6 (*Existing Population Size / High Management Capacity*) and 3/8 (*Access to Water / High Tourism Potential*) (Figure 11). The average differences between out_1 and out_2 after incrementing the input values for 2 parameters at the time by 1 unit are below 0.1 for all parameter combinations. Parameter combinations 2/6 and 3/7 (*Access to Water / Good Track Record*) show the highest average differences with the highest occurring for Oryx (0.0685) for parameter combination 2/6.

(iii) After increasing all parameters by 1 and re-running the model with the changed input data sets the highest difference occurred for oryx (0.441), followed by hartebeest (0.379). The lowest difference occurred for disease free buffalo (0.317) followed by roan (0.326) (Figure 12). The average differences between out_1 and out_2 lie between 0.09 and 0.24 with the highest difference occurring for roan.

(iv) Increasing each parameter at a time continually for oryx and for roan, excluding areas which are completely outside the historic range of the species, revealed that the parameters which are most sensitive to input change are 2 (1.547 for oryx; 0.245 for roan) and 3 (0.512 for oryx; 0.944 for roan) and 16 (*Competing Land Use*) for oryx (0.228) (Figure 13, Figure 14). The average difference between out_1 and out_2 after incrementing 1 parameter at a time until each parameter had reached the upper limit input value is highest for parameter 2 (oryx) and 3 (roan). The highest average difference occurs for Roan (0.29).

(v) The randomly selected 8 parameters were 3, 5 (*Strong National Strategy Contribution*), 6, 7, 8, 9 (*High Trophy Hunting Potential*), 12 (*High Utilisation Potential* for breeding). Each time the input is incremented by one the maximum output increases by 0.200 until it levels out at 0.800, for oryx, and at 1.000 for roan (Figure 16). The average output difference stays below 0.200 for oryx and below 0.400 for roan.

Appropriateness of output formats

The primary output formats of the numerical KBDSS results are block charts and maps. The maps are produced with the aid of the NetWeaver GIS extension GeoNetWeaver. GIS is about the handling and representation and visualisation of spatial information. The term GIS refers to a way of thinking about spatial data as well as to the strategic tools for collecting and manipulating spatial data (Pickles 1995). GIS is a popular tool in environmental management. A literature survey of the critical debate on GIS suggests that although or maybe *because* GIS is a powerful tool, there are epistemological, political and ethical issues and problems associated with its use, which have a bearing on this application of GIS as well.

A mimetic model of the world

GIS is a product of computers and information technology in that it creates electronic spatial representations of digital data (Pickles 1995). The computer enables new aspects of the world to be seen and described, while blocking other aspects from view, thus changing the relationship between researcher and world (Veregin 1995). The emphasis is on mapping and visualisation and on quantitative, positivist research methodologies. But vision is a cultural construction that has been learned and cultivated. The history of vision is linked to the history of art, technology and social practices, what Mitchell (2002) calls “the ethics and politics, aesthetics and epistemologies of seeing and being seen”. The communicative power of visualisation has led to an increased popularity of GIS technologies in environmental science and management. Euphoria and criticism alike accompany this “pictorial turn” (Mitchell 1994).

Historically mapping used to be done mainly in the field, but the application of military aerial photography to civilian mapping programmes has resulted in an increasingly fragmented process. The scientific management of the process is reflected back in the form of rationalised, increasingly depersonalised representations of the world (McHaffie 1995).

GIS with its reliance on Cartesian/Euclidean conceptions of space represents research subjects as spatial entities, i.e. points, lines and polygons or objects belonging to a particular class. But a GIS database is a necessarily incomplete and generalised

abstraction of the much more complex real world. Which properties are selected for representation depends on the cultural context, scientific paradigm and technological feasibility and necessity. "Putting something on the map" or "leaving something off the map" are important decisions that influence thoughts and actions of those who use the map. The benefit of hindsight allows us to read error and bias, exploitation and colonialism into historic maps (Pickles 1995). Reading a map is thus an act of faith; faith in the mapmaker and the technologies of measurement, the idea that the boundaries and symbols on the map correspond to real things. In GIS accuracy has become an end in itself; accuracy is implicit in the notion of visual representation as an "unquestioned and unquestionable ideal" that is its own autonomous driving force (Curry 1995). But not only is visualisation a social construction, the point-line-area data model also induces errors, because data types such as soil, vegetation and land cover are spatially heterogeneous and characterised by gradual transitions. These data types are strongly scale dependent and are not exactly definable by area boundaries (Veregin 1995). Nonetheless, a fundamental assumption underlying GIS is its promise to give a mimetic reproduction of the world as shown by the Roberts & Schein (1995) analysis of GIS adverts. The danger is that the user may be tempted to ignore that the images are socially constructed, and mistake them for reality or for perfect copies of reality (Robert & Schein 1995).

Democracy

The potential of GIS has created a false sense of egalitarianism (McHaffie 1995). Value-neutral GIS do not exist. GIS is an extension of institutional goals and integrally linked to issues of equality in terms of access to data, information and knowledge (Harris *et al.* 1995). "On the one side GIS is claimed to enhance public access to information and can be used to enhance democratic practices. On the other side GIS seems to foster the interests of particular users and produces increasingly constrained and controlled public spheres" (Pickles 1995). GIS technology is culturally embedded in a several hundred year history of western concepts of Cartesian space and the separation of subject and object. The images from aerial photography, satellite and GIS are constructed images, constructed within rules of vision, representation and space. Curry (1995) explains that the notion that availability of large data collections means better understanding of the world leads to seeing people to whom these data refer as "other", as existing in Cartesian space and

technical chronological time, rather than lived space, place, and narrative human time. While the researcher sees herself as acting freely, making decisions in the human world, the other is thought of as an object. Moreover, seeing the availability of information as a prerequisite for decision making leads to seeing the “other” as empirically less equipped to make decisions. Thus there are inherent features in the use of GIS which are fundamentally anti-democratic. “In a discourse wherein one speaks of a person as an “other” one quite simply cannot treat that person as an autonomous individual (Curry 1995).

The military origins of GIS alert to the role of the state as central actor in the story of GIS (Roberts & Schein 1995). Within national borders the state may use spatial information to allocate resources through land use planning and environmental management or to supervise and discipline social activity. Beyond national borders the knowledge of spaces enables strategic military and economic planning and action (Roberts & Schein 1995). Many GIS applications draw on satellite data produced by the governments of USA, Russia and Europe who have the necessary space technology. The data are thus controlled by the governments of western affluent nations. The high costs of establishing GIS limit this technology to state agencies or large private corporations. The result can be unequal access to data, technology and expertise, which puts small users, local government and non-profit community agencies at a disadvantage. If careful attention is not paid to this fact, GIS will inevitably mirror the agency/funder mindset and value system (Harris *et al.* 1995).

GIS technology is interwoven with the production of knowledge. Updated and newly created thematic representations of resources create a standardisation of the understanding of resources by all parties. This standardisation however is likely to be towards rational planning. Elwood (2000) showed how the successful application of GIS in a neighbourhood association in the USA, created barriers for some people through changed language practice and emphasis on rational planning, which ultimately changed the aims of the organisation. Through GIS technologically more adapt people gain more control while others are excluded from the process (Schurman & Pratt 2002).

The possibilities of combining and analysing spatial and non-spatial information about people and their environments “presume a notion of closure”, that it is possible to obtain measurable knowledge about individual citizens. The implication of “a closed society” is fundamentally anti-democratic (Curry 1995). The action of viewing, especially from above, is an act of establishing dominance and superiority. The observer is separate from the view, situated outside the data, which become subject to control, management and manipulation. GIS technology allows “imagined proprietorship” (Robert & Schein 1995) of part of the world. This sense of proprietorship and the inherently engendered notions of dominance manifest in the language of adverts for GIS, which are directly addressed to state agencies as the major purchaser of GIS (Robert & Schein 1995). The voyeuristic view from above, of the earth from space, from aircraft, is embedded in the spatial practices of military programmes (Robert & Schein 1995).

Moreover, GIS is a gendered product of a scientific mind which Keller’s analysis (1992) showed to be conceived as male and disembodied. Space, considered inherently feminine and passive is the conquest of the temporal, the domain of the active masculine history making. Passive space is implied in the transformation of the earth’s surface into spatial data (Robert & Schein 1995). A GIS is designed to capture, edit, restructure and manipulate data as “everything you need appears on screen in seconds, ready for further integration or manipulation” (GIS advert cited in Robert & Schein 1995). As the user manipulates, cuts and recombines elements at will, Harraway’s (1991) “informatics of domination” is played out in GIS (Robert & Schein 1995).

The subdivision of lived space based on national grids or global grids such as longitude and latitude void places of local meaning but plays an important part in the functions of capitalist economy: the mapping commodifies spaces and the natural resources within them, it creates “space as an exploitable resource” (McHaffie 1995). Mapping, locating and differentiating territory has gone hand in hand with discovery, penetration, conquest pacification and possession of vast areas of the world (Roberts & Schein 1995).

The upshot of the critical analysis of GIS is that it is not simply a descriptive tool, but also influences thought and behaviour through defining and inscribing environmental and social patterns (Pickles 1995).

DISCUSSION

Knowledge acquisition

Most of the experts who were interviewed had no or few difficulties to give meaning to individual scores and seemed to be able to differentiate between scores which are closely spaced on the scale. A trade off between coarseness of scale and robustness of the model is therefore not necessary. However provision of tight descriptors will assist experts and may improve the scoring (Table 4).

The majority of the experts participating in the workshop were natural resource managers or biologists. Although invited, no representatives of the NGOs directly involved with the conservancies were present. The absence of sociologists and economists led to an imbalance in expertise.

Appropriateness of the modelling approach for the domain

The knowledge that needs to be applied in the context of wildlife translocation is ill defined. For many of the criteria there is either no specific information available or the opportunity costs of precise information are a constraint although the information is theoretically available. Consequently there are information gaps. Although it may be possible to define objective, measurable criteria and indicators for the criteria these indicators cannot in themselves embody all that needs to be evaluated. Decisions about wildlife translocations require integrated knowledge, which cannot be fully captured in simple criteria and a crisp bivalent format. The literature review shows that rule-based systems are generally applied for well-defined information spaces in which precise statements about processes and relationships are possible and empirical data are available. The knowledge and expertise required for choosing a suitable wildlife translocation area is however not practical, procedural problem solving knowledge. The translocation of wildlife into communal conservancies is a unique problem scenario not an everyday exercise. Experts do not have explicit or implicit knowledge about "how this is normally done". They are likely to express their opinion

as “soft” rules such as *if x then probably y* rather than *if x then y*. Their expertise is a collection of information and past experiences concerning the criteria. Furthermore, rule-based knowledge representation based on bivalent logic requires large numbers of rules to account for shades of meaning such as *poor, fair, good, very good* etc (Rauscher & Reynolds 2003) which can easily lead to combinatorial explosion (Saunders & Miller 2004). Rule-based systems are therefore not well-suited for ill-defined problems.

ANNs have good predictive power, but provide little explanation about the causal relationships driving ecological phenomena. Olden & Jackson (2002) describe methods for clearer understanding of the mechanics of ANN and present an approach for statistically assessing the importance of weighted parameters. ANNs require a well-defined performance measure and a large amount of training data (Kiang 2003), neither of which are available for translocations into communal conservancies in Namibia.

As a statistical method, Bayesian inference is rooted in empirical observations and when applied to broad, ill-defined problems, requires a large amount of data to characterize conditional probabilities. An important feature of Bayesian inference is the ability to perform well in spite of missing data. If no data are available, as is the case for most of the parameters of the wildlife translocation model, the conditional possibilities have to be supplied solely by expert judgment thus defeating the value of a statistically based approach. Another possibility is to use proxies which can be measured and quantified, but a substitute may not adequately describe the parameter in its entirety. Statistical methods such as Bayesian inference describe the strength of belief that a proposition is true, e.g. “Mary is sure that Peter is tall”. Fuzzy logic on the other hand describes the truth value of the proposition “Peter is tall”.

Knowledge relevant to wildlife translocations and the identification of suitable areas is ill-defined and uncertain. Although it may be possible to identify all necessary criteria, the relative importance of the components are not completely determinable, nor is it possible to measure all criteria exactly. ANN and Bayesian inference are based on “hard” numerical data. Conservation managers however seldom base their decisions on scientific data, but rather use intuitive, heuristic decision making based

on experience (Pullin & Knight 2001, 2003; Pullin *et al.* 2004) and are likely to express knowledge in qualitative terms such as *very low*, *low*, *medium*, *high* and *very high*. Fuzzy logic provides a means for experts to express their opinion in “fuzzy” values which can be translated into linguistic terms and are better suited to represent the ill-defined and uncertain information space of wildlife translocations. The multivalent fuzzy logic reduces the risk of combinatorial explosion which often occurs in system relying on bivalent data interpretation (Saunders & Miller 2004). Fuzzy logic allows the combination of qualitative assessment with a rigorous mathematical method which makes it well-suited to deal with imprecise knowledge and knowledge gaps. It must be noted however that this approach requires that the fuzzy terms are represented as numerical values in order to be computed, and the use of a mathematical formula may evoke a false sense of correctness. Mathematically correct computation does not in itself produce the right solution for a given context. Expert input and careful modelling (and responsible interpretation) are required to situate the knowledge in the appropriate context.

Appropriateness of results

Some 433 out of 600 records differ by only two points or less. This difference is acceptable considering that the experts’ scores reflect opinion and cannot be assumed to be absolute.

Records of category E_{NEG} do not really seem to be cases where the expert rating and the model output differ. Both expert assessment and model output are negative, which means that a translocation is not recommended. The differences between model output and expert assessment suggest that experts are less likely to differentiate on the negative scale. When not in favour of translocating into an area they are more likely to rate 0. The more detailed differentiation on the negative side of the scale however provides useful information. There is a meaningful difference between stating that the proposition “It is strongly recommended to translocate springbuck into this area” is 100% false or that the proposition is 10 % false. In the former case it is implied that a translocation of this species may never be considered, perhaps due to ecological factors, whereas in the latter case it is implied, that when some necessary improvements have taken place, there will be a chance of future consideration for wildlife introduction. A closer look at the intermediate scores of the single parameters

will reveal, where these improvements need to be made. This is precisely why the fuzzy logic approach is advantageous.

Examining the E_{CONTRAST} cases, most of them show little discrepancy between expert rating and model output, they are simply close to undetermined on either side on the scale. For instance the experts rated 3 or 4, the model output is 5 or 6. Or the experts rated 0 the model output is 5 or 6. The model output is on the positive scale but still low enough as to not suggest the respective area for wildlife introduction. The experts may simply not have differentiated as much as the model does and summed up their verdict "Not recommended" as a 0 rating.

For 19 records out of a total of 600 records the difference between overall expert rating and model output is conspicuous. In these cases either the expert rating is extremely high whereas the model output is lower (E_{POS}) or the expert rating is very low (E_{CONTRAST}) and the model output is highly positive. In all these cases the input values support the model results and contradict the overall expert ratings. As the input values reflect assessments by the same experts this contrast suggests amongst other possibilities that either the experts' overall assessment was biased or that the experts did not take all parameters into account. It could also indicate that there may be an additional factor, which the model does not take into account.

In all 25 cases where the experts' overall assessment is 10, the input values for either ecological suitability or existing population size are 10 whereas at least two other parameters had been scored below 10 by the same experts. This contradiction suggests that the experts had difficulty taking all parameters into account. The two cases where expert overall assessment is 6 although the same experts had rated ecological suitability of these areas 0, i.e. 100% unsuitable, supports this notion. The results further suggest that Experts seem to have focused more strongly on ecological factors than on sociological factors.

Those records that show high discrepancy between model output and expert rating were discussed again with some of the domain experts. The discussion confirmed that there are biases influencing the expert's assessments. In the case of Uukwaluudhi conservancy, this area had previously accepted wildlife into a game camp in the core

area. The experts tend therefore to not consider this area again. Another problem is the fact that, with the exception of the wildlife core area, this conservancy has a high density of people and associated land uses. A problem arises for the expert, whether to assess the entire conservancy, or just the much smaller game camp. Shortly before the workshop, MET had decided to implement the planned enlargement of the Nyae Nyae conservancy game camp. This change influenced the expert's assessment towards favouring translocations into this area.

The consulted experts also confirmed that they are likely to overemphasise criteria that fall within their direct expertise and tend to disregard the remaining factors. The imbalance of expertise in favour of biological and wildlife management related knowledge may account for some of the discrepancies between expert assessment and model output. When considering each criterion separately, the experts were able to assess those factors that lie outside their technical expertise by pooling their experience in the group discussion. But in the case of overall assessment of a conservancy they tended to focus on the bio-physical factors. This assumption was confirmed by some of the experts themselves. One has to keep in mind that the expert overall ratings are not absolute. If the knowledge acquisition had been repeated with the same group of experts only a few days later, the expert ratings would most likely be slightly different. It is therefore safe to conclude, that the comparison of expert data and model output reveals no pattern of difference that suggests that there is a general fault in the model.

Comparing the expert recommendations with the model output there is enough overlap to suggest that the model is performing well.

Sensitivity analysis

The high values for parameter 1 in test series (i) and (iv) are caused by the records for areas which are outside the historic range for the species in question and can be ignored. Parameters 2 and 3 are the most sensitive towards changes in input.

Changing the input of two parameters has similar results. The parameter combinations which show the highest sensitivity to input changes are combinations with parameters 2 and 3. Parameter 2 is the assessment of the current population size, parameter 3

expresses to what degree there is enough water accessible to the species. These two criteria, existent population size and water availability can be backed up by empirical data and are straightforward to assess. Errors in input values are therefore less likely to occur than in the case of parameters such as those describing management capacity of the people of the area or the degree to which livelihoods need to be improved.

The input interval for all parameters other than 1 is [0,10]. The output interval is [-1.0, 1.0]. One point on the input scale [0,10] is equivalent to an apparent 0.200 on the output scale [-1.0, 1.0]. Changes in input value for any of the parameters other than 2 and 3 by up to 10 points on the input scale did not result in changes of output higher than 0.2 points on the output scale. The only exception is parameter 10, which showed a difference of maximum 0.228 on the output scale, a minor difference, after changing input values by 10 points on the input scale.

The highest average change between out_1 and out_2 for each parameter after increasing each parameter separately until the upper limit for the input value is reached is 0.29. For all other parameters the average change is below 0.2.

A change of input values by 1 on the input scale for all parameters resulted in output changes between 0.317 and 0.441 on the output scale. In terms of the input scale this change corresponds to an apparent 1.5 to 2.5 points, which is a small change considering that all 16 input values have been increased by 1 point. The average difference between output values after incrementing all parameters by 1 is below or close to 0.200 with the highest average being 0.24 for Roan which is equivalent to 1 unit on the input scale.

Because one point on the input scale is equivalent to 0.200 on the output scale one would expect that increasing the input by 1 to 10 points would result in output values increasing by at least 0.200 each time. This rate of increase however only occurs for increments from 1 to 4. For increments higher than 4 the output grows much slower. As input values are increased, more and more parameters reach the upper limit of the input range, which explains why the output increase levels out. The average output increase remains below the equivalent of one point on the input scale, for oryx, and below two points for roan, although the input is changed by up to 10 points.

All five tests suggest that the wildlife translocation model is robust towards changes in input. A main point of critique against the model is that the input values are based on expert's opinion rather than "hard" data and that it is therefore highly subjective and susceptible to human (expert) error. The sensitivity analysis shows that the only two parameters for which input errors are significant are parameters for which "hard", empirical data are available. All other parameters, some of which rely strongly on opinion and expert's experience are not sensitive to input errors.

Appropriateness of output formats

The cartographic output summarizes outputs across all conservancies. This spatial overview of all conservancies is useful for selecting a suitable translocation area. The bar charts provide summaries of the results for a specific area. Both output formats communicate the model's results well. The traffic-light concept of red=unsuitable and green=suitable is intuitive. The colour scheme can however be adjusted to support colour blindness. However as the results of the literature survey show, visualisation techniques, especially GIS are not wholly unproblematic. It is therefore critical to ask why a particular technique was used, what truths claims are made, whose knowledges are being excluded, how the image will be received and how objectification can be counteracted (Rose 2001, p. 16).

A mimetic model of the world

The KBDSS reads input data via the GIS extension GeoNetweaver from shape files. Each model parameter is associated with a data field in the shape file. If more than one shape file is used GeoNetweaver creates an overlay based on the information of the shape files and the truth values generated by the knowledge base. Originally it was intended that empirical data be input in the translocation KBDSS via several shape files which represent the historic range of the species and the vegetation type as polygons and water as point data. Problems were encountered because a previous version of the software did not calculate the overlay correctly, representing truth values in the wrong colour.

One problematic aspect of GIS, which is inherent to all computer representation, is that data are represented in fixed data types. Yet local knowledges are geographically

imprecise and do not fit well into the point-line-polygon paradigm. The experience of developing the wildlife translocation KBDSS confirms this problem.

The data type representing vegetation type was very coarse and therefore strongly scale dependent. The resulting map divided each conservancy into smaller pockets of suitable and unsuitable areas, which did not correspond with the reality. Moreover, water point data only reflect the location where a water point has previously been recorded, but says little about the availability of or the access to the water.

It was therefore decided to reduce spatial representation to the outline of the conservancy border and to base all other inputs on assessments of experts, who are familiar with either the area or the species. All results of the KBDSS are truth values associated with a polygon representing a conservancy. But not all criteria apply equally for an entire area. Ecological suitability or access to water may be adequate for the focal species in specifiable areas of a conservancy, but not in others. Similarly, not all households in a conservancy may be equally supportive or unsupportive of the conservancy's management goals. The model however represents a conservancy as a homogenous entity. When eliciting expert knowledge for data input the experts are required to take this heterogeneity into account. But it is not reflected in the graphical outputs, which only convey the overall truth value.

The elements listed in the bar charts may seem to be of equal importance, but such equivalence is not the case. There is no indication of the actual influence a particular element has on the overall result. The bar chart Roan Overview for the Mashi conservancy gives the impression that the main reason why the truth value for introducing Roan is low, is because of the *High Cultural Value* parameter, as this parameter has the lowest input score. However, *High Cultural Value* is part of the *Good Rationale for Species* goal, which is 100% true due to *Roan Strong National Strategy Contribution*, overruling *High Cultural Value* because of the logical OR connection. The real constraints are *Low Population Numbers* and *Access to Water*. It is the responsibility of the developer to either make this discrepancy explicit or, better, to carefully select elements of bar charts so that they are all equal in their influence. This is important to avoid misinterpretation.

Democracy

In the community-based environmental management context GIS provides possibilities for enhancing knowledge of resources and utilisation potentials. But use of GIS technology can only lead to community empowerment if these processes are driven by the people themselves. Harris *et al.* (1995) stress that, if data are created from the top-down, GIS empowers the powerful and disenfranchises the weak via selective participation. This claim is particularly pertinent in the light of South Africa's and Namibia's apartheid legacy. Participation in GIS has to be broad based, inclusive, gender sensitive and biased toward the interests of marginalised people. This set of objectives requires education of local people in GIS which is a considerable hurdle in countries like Namibia and South Africa, where access to education was withheld from the majority of the people. Moving beyond the top-down elitist process thus constitutes a considerable challenge (Harris *et al.* 1995).

It is expected that access to information technologies will level the imbalances between rural communities and other agents (Tagg *et al.* 1996). However, adoption also implies non-adoption or inability to adopt, which results in the polarisation of users and non-users (Pickles 1995). Communities are not homogeneous and there is the danger that GIS, like any technology, empowers only the technologically adapt and disempowers others. This polarisation is problematic in terms of capacity raising within the MET, but also in terms of stakeholder participation in the modelling process and the relationship between MET and the rural communities who are the potential receivers of the animals that are to be translocated. Whose knowledge is to be included into the KBDSS and hence put on the map and whose knowledge is left out? MET has the means to exercise power by setting the criteria and choosing the experts whose knowledge is included into the system.

It is therefore vital that the knowledge acquisition process involves all stakeholders and allows community participation. The model parameters describe ecological factors but also assess a conservancy's management capacity. This assessment must not only be considered by outside experts but the community members should have a voice here, too. As with any decision situation there will be conflicting interest groups and conflicting priorities. But the sensitivity analysis suggests that the model

underlying the KBDSS is robust towards biased inputs. There is therefore no reason why the knowledge elicitation process could not be broadened towards conservancy participation.

MET's mandate in the process of wildlife translocation and the adoption of the KBDSS must be clearly stated. The KBDSS is intended as a selection tool to find the best translocation site in the best interest of the people, to select the best species for a given area and to monitor the environmental management capacity of the potential receivers of species population. Unless the MET's mandate is clarified, also from the point of view of the conservancies, and the communities are integrated into a participatory process, the KBDSS can be misunderstood as a surveillance or control tool. The assumption that technology like the KBDSS make it possible to gather, manage and compare measurable data about people and their living space is not value free. How much data collection is necessary for environmental decision making and when does surveillance begin? The danger needs to be unveiled and the processes must be critiqued to avoid unnecessary and unasked for government control.

Veregin (1995) raised the question whether decision makers are disengaged by technological tools such as the KBDSS. Are they less likely to incorporate subjective values and humanistic concerns when the decision making process is supported by a DSS?

For any model it is necessary to clarify what the model can and cannot do. The KBDSS is a tool to integrate environmental, socio-economic and cultural factors into the selection process for wildlife translocation. It is not a tool for measuring and representing the bio-physical, sociological and economic realities. Many of the input values are based on expert opinion. From a strictly empiricist point of view the KBDSS may seem too subjective. But from a critical theory or constructivist point of view it may seem that the model assumes objective reality and needs to be further contextualised.

GIS software packages ship with detailed spatial data sets, such as zip codes and street maps of the USA or Europe. But until recently little GIS data were freely available for Namibia. The data used in Namibian environmental management are

being generated by government agencies and NGOs. These data are created for management purposes and little economic value has been attached to it. This attitude however is changing rapidly. Foreign plant collectors are locating rare plants via GPS coordinates and guidebooks and maps are marketed with coordinates and routes through “untamed wilderness areas”. Wildlife as land use is just one facet of the increasingly economic market forces at play. It is therefore important to highlight and raise awareness of the exploitative elements of GIS and its role in the exploitation of resources around the globe. There is no such thing as a value free tool. Any tool can be used for positive as well as for negative ends. The negative implications have to be made explicit; only if downsides are known can they be avoided and can a tool be used for positive ends.

CONCLUSION

Successful game introductions offer large benefits to communal conservancies. When wildlife on state land becomes available for translocation MET is confronted with the difficult situation of having to decide which areas will get wildlife and which do not. This complex task requires the pooling of interdisciplinary expertise as ecological as well as socio-cultural and socio-economic factors have to be taken into account. This multifaceted knowledge is unlikely to reside in any one expert. Time and money constraints make it unfeasible for a group of experts to meet and carefully discuss each translocation. A national game introduction approach, based on pre-defined criteria, will therefore go a long way to reduce the conflict and misunderstandings that often arise during ad hoc introduction exercises. But even in the case of working with a pre-defined set of criteria, human experts are unlikely to be able to take the whole array of relevant factors into account by giving each criterion equal and unbiased attention. The wildlife translocation KBDSS provides appropriate tools to facilitate the selection processes, communicate the results and open up explicit participatory debate so as to enable equitable sharing of the potential benefits among the different conservancies.

In a multicriteria framework the concept of an optimum does not exist (Belton & Stewart 2002). The KBDSS thus does not provide an “objective” analysis resulting in the “right” answer to the problem of choosing an appropriate area for translocation.

The system operates with a set of criteria, which have been defined by a group of experts and thus represent the experts' subjective perspectives on what is relevant.

The visualised output formats provide powerful communication tools and have the potential to enhance the transparency of the decision making processes. Visualised output can allow more interpretive modes of analysis than conventional quantitative analysis. Because of the potential downsides of visualisation techniques such as GIS it is critical to understand how these techniques work as knowledge systems and how visualisation produces truths. MET should strive to broaden participation in the knowledge acquisition process and ensure that the KBDSS maps and charts are embedded in the context of the discourse of planning, and not understood as the decision itself. The truth values embedded in the graphical displays should be seen not as factual statements but as expressing directions of development and scope for improvement. They should be seen as tools of communication providing context rich information to the human decision makers.

The KBDSS helps the decision maker to structure the problem of choosing an appropriate communal conservancy for wildlife translocation. The system and its outputs provide a focus for both decision makers and stakeholders and offer a language for communication and discussion. The wildlife translocation KBDSS is a tool aimed towards better considered, justifiable and explainable decisions.

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Table 1 Propositions associated with networks and data links antecedent to translocation area network. Names of networks are displayed in italics, names of data links in bold.

Network name	Proposition
<i>High management capacity</i>	The management capacity of this conservancy is exceptional
Strong management capacity	The management capacity of this conservancy is strong
Good track record	This conservancy has an exceptional track-record
<i>Low threats</i>	There are no threats to wildlife
Low external threats	There are absolutely no threats to wildlife and the conservancy from external sources
Low internal threats	There are absolutely no internal threats to wildlife in this conservancy
<i>Good rationale</i>	there are good reasons for putting wildlife into this conservancy
<i>High Social Development Needs</i>	The social development needs of this conservancy are high
High impact on livelihoods	Livelihoods are very low and need to be improved
High Own Use Need	'Own use' is a critical source of protein
<i>High Wildlife Use Potential</i>	There is high potential for wildlife utilisation in this conservancy
High Trophy Hunting Potential	The Trophy Hunting potential of this area is exceptional
High tourism potential	The Tourism potential of this area is exceptional
<i>High wildlife breeding potential</i>	There is high wildlife breeding potential
Good utilisation potential	Harvesting and marketing of wildlife/venison are extremely easy for this conservancy
High Ecological Productivity	The productivity of this area is very high
<i>Key Area for National Strategy</i>	This area is critical to national conservation objectives
National strategy	This area is critical to national conservation objectives
<i>Compatible land use</i>	The land uses in this area are compatible with wildlife
Land use	There is no impact from other forms of land use or the conservancy has set aside an exclusive wildlife area and it will be maintained

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