GEOGRAPHICAL INFORMATION SYSTEMS FOR ENVIRONMENTAL IMPACT ASSESSMENT: A FEASIBILITY STUDY

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Thesis presented in partial fulfilment of the requirements for the degree of Master of Arts at Stellenbosch University

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DECLARATION

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SUMMARY

This study acknowledges the status quo in South Africa as a country in transformation. Leaders concur that people live under the spell of the evil triplets of poverty, inequality and unemployment amidst the need for development and economic growth. In order to initiate positive change, the 1996 Constitution of South Africa supports integrated environmental management (IEM) and sustainability principles towards ecological, economic and social compromise. Furthermore, the National Environmental Management Act (NEMA) was legislated in 1996 along with the mandatory environmental impact assessment (EIA) tool in 1998. Despite this legislation being of global standards, current discourse highlights the need for new strategies and tools to improve IEM. The constraint lies in the implementation of policy as the EIA process is limited by inconsistency and project specific focus. Fortuitously technology has developed to levels where web-based tools encourage spatial awareness and individual responsibility for the environment. Usage of participative GIS supported by best practice in governance has the potential to successfully drive IEM.

This research builds on the integration of a policy instrument (EIA), spatial technology (GIS), development and human factors (people) as pillars of transdisciplinary methodology to collaborate and gather new information to expand knowledge and augment existing processes. The study objectives required rigorous research and involved a wide range of participants in a feasibility study to provide details of the viability of integrating GIS usage into EIA conduct in South Africa. Participants in the research were selected from the geographical scope of Cape Town and represent involved parties in EIA and potential users of GIS in EIA. The legislative scope is the Western Cape Province. Triangulation, a mixed method approach, was employed to collect and collate qualitative and quantitative information based on the opinions of involved parties in the IEM, EIA and GIS domains. Primary data collection methods included observation, fieldwork, informal, formal and focus group discussions as well as an e-mail questionnaire and a Likert scale e-survey. The knowledge gained was evaluated using SWOT and graphics.

The findings indicated that the majority of participants agreed that technology and skills are available to design and develop a web-based application for GIS usage in EIA. However, from the outcome of the study the main challenge is not related to technical skills and capacity, but to align the EIA with IEM sustainability principles for effective decision making and self-regulation. It is therefore envisaged that web-based GIS usage in EIA based on IEM has the potential to reconnect the EIA process by uniting people in knowledge with easy access to information from a central data base repository to an on-line web-based platform that links time and space to inform decision making.

Keywords: environmental impact assessment, feasibility study, geographical information system, integrated environmental management, sustainability principles, transdisciplinarity, web-based tools.

OPSOMMING

Die uitgangspunt van hierdie studie is dat Suid-Afrika 'n land in transformasie is en die behoefte aan ontwikkeling en ekonomiese groei van kardinale belang is weens die armoede, ongelykheid en werkloosheid waaronder baie mense lei. Effektiewe omgewingsbestuur is uiters belangrik om omgewingsbesoedeling en agteruitgang te verhoed. Ten einde 'n positiewe verandering te inisieer, ondersteun die 1996 Grondwet van Suid-Afrika geïntegreerde omgewingsbestuur (GOB) en volhoubaarheidsbeginsels teenoor ekologiese, ekonomiese en sosiale kompromie. Die 1996 Nasionale Wet op Omgewingsbestuur (NEMA) het die omgewingsimpakstudie (OIS)-instrument in 1998 verpligtend verklaar. Die OIS wetgewing is gebaseer op hoë internasionale standaarde, maar ten spyte hiervan beklemtoon die huidige diskoers die behoefte aan nuwe strategieë om OIS in die praktyk effektief te belyn met die GOB beleid. Tans word die OIS proses beperk deur teenstrydigheid tussen gebruikers van die proses sowel as projekspesifieke fokus. Tegnologie het ontwikkel tot 'n vlak waar webgebaseerde GIS ruimtelike bewustheid aanmoedig en individuele verantwoordelikheid vir die omgewing aanbeveel en ondersteun word. Deelnemende GIS, ondersteun deur goeie regering, het die potensiaal om OIS en GOB suksesvol in die praktyk te implementer.

Hierdie navorsing bou voort op die integrasie van 'n beleidsinstrument (OIS), ruimtelike tegnologie (GIS) asook ontwikkeling en menslike faktore (mense) en ondersteun die transdissiplinêre metodologie om nuwe inligtig te versamel en vryelik te deel. Die studiedoelwitte het streng navorsingsmetodologie vereis deur 'n wye verskeidenheid van deelnemers te betrek in 'n ondersoek na die haalbaarheid van die integrasie van GIS gebruik in OIS in Suid-Afrika. Deelnemers aan die navorsing is gekies uit die geografiese domein van Kaapstad en was betrokke partye in omgewingsbestuur en potensiële gebruikers van GIS in OIS. Die wetgewende domein is die Wes-Kaap. 'n Gemengde-metode benadering is gevolg om kwalitatiewe en kwantitatiewe inligting te versamel en was gebaseer op die menings van die betrokke partye in die IEM, OIE en GIS terreine. Die kennis is geëvalueer met behulp van SWOT analise en grafika.

Die bevindinge dui aan dat die meerderheid van die deelnemers saamstem dat tegnologie en vaardigheid beskikbaar is om 'n program vir GIS-gebruik in OIS te ontwikkel. Die uitslag van die studie dui daarop dat die grootste uitdaging vir effektiewe besluitneming en self-regulering nie verband hou met tegniese vaardighede en kapasiteit nie, maar om die OIS te verenig met GOB-

volhoubaarheid beginsels. Die vooruitsig is dus dat web-gebaseerde GIS gebruik in OIS gebaseer op GOB die potensiaal het om mense met kennis te verenig en omgewingsbestuur effektief in te lig.

Trefwoorde: geïntegreerde omgewingsbestuur, geografiese inligtingstelsel, haalbaarheidstudie, omgewingsimpakbepaling, transdisiplinariteit, volhoubaarheidsbeginsels, webgebaseerde instrumente.

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ABBREVIATIONS AND ACRONYMS

APPEA	Australian Petroleum Production and Exploration Association
ATM	Automatic teller machine
BA	Basic assessment
BAR	Basic assessment report
CBA	Cost benefit analysis
CD	Compact disc
CEA	Cumulative environmental assessment
CLUES	Cape Land Use Expert System
COPES	Coordinated Observation and Prediction of Earth Systems
CSIR	Council for Scientific and Industrial Research
DANIDA	Danish International Development Agency
DDT	dichlorodiphenyltrichloroethane
DEA	Department of Environmental Affairs
DEA&DP	Department of Environmental Affairs and Development Planning
DEAT	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
EA	Environmental assessment
EAP	Environmental assessment practitioner
EAPSA	Environmental Assessment Practitioners of South Africa
EDM	Environmental decision making
EIA	Environmental impact assessment
EIAMS	Environmental impact assessment management strategy
EMF	Environmental management frameworks
EPA	Environmental Protection Agency
ERM	Environmental risk management
ESRI	Environmental Systems Research Institute
FSCP	Fine scale systematic conservation plans
GECCH	Global environmental change and human health
GEOSS	Global Earth Observation System of Systems
GIGO	Garbage in garbage out
GIS	Geographic information system
GPS	Global positioning systems
GUI	Graphic user interface
I&APs	Interested and affected parties
IAIASA	International Association for Impact Assessment South Africa
IEM	Integrated environmental management
ISIS	Integrated Spatial Information System
IT	Information technology

IUCN	International Union for Conservation of Nature
KM	Knowledge management
LCA	Life cycle analysis
LEG	Aspects of environmental legislation (course at Unisa)
LUDS	Land use decision support tool
LUPO	Land Use Planning Ordinance (provincial)
MCE	Multi-criteria evaluation
NEAS	National Environmental Assessment System
NEMA	National Environmental Management Act
NGO	Non-governmental organisation
PPP	Public participation process
PSDF	Provincial Spatial Development Framework
RoD	Record of decision
SAIEA	South African Institute for Environmental Assessment
SANBI	South African National Biodiversity Institute
SARS	South African Revenue Service
SAWS	South African Weather Service
SD	Sustainable development
SDCEA	South Durban Community Environmental Alliance
SDF	Spatial Development Frameworks
SDI	Spatial data infrastructure
SEA	Strategic environmental assessment
SI	Sustainability Institute
SIA	Social impact assessment
SMURF	System for managing urban and regional functionalities
SUN	Stellenbosch University
SWOT	Strengths, weaknesses, opportunities and threats
UEMP	Urban Environmental Management Programme
UDHR	Universal Declaration of Human Rights
UCT	University of Cape Town
UK	United Kingdom
UNDP	United Nations Development Program
UNEP	United Nations Environmental Policy
UNESCO	United Nations Educational, Scientific and Cultural organisation
UNFCCC	United Nations Framework Convention on Climate Change
UWC	University of the Western Cape
WESSA	Wildlife and Environment Society of South Africa
WWF	World Wildlife Fund (for Nature)

CHAPTER 1: EIA, GIS AND PEOPLE IN PLANNING FOR IEM

"I hate bullies:

I stand for simple justice, equal opportunity and human rights.

They are indispensable elements in a democratic society and well worth fighting for".

Helen Suzman

The intention of the research is to support and validate the current urgent call by EIA users for political will, tools and strategies to respond to ineffective and uninformed environmental management and impact assessment in a changing human and natural environment burdened by environmental pollution and degradation (Fredericksen 2010; IAIASA 2010; Margarum & Born 1995). The research is in itself a process and the potential outcome aims to justify and recommend integrated web-based GIS usage[1] in the EIA process towards effective EIA in the Western Cape.

The reasons for relating the research to a process is that the research approach relates to a funnelling process starting with the real world problem and research question regarding GIS in EIA and, through the process steps of the research design, end with a potential solution. In this study the initial aim was to design, develop and implement GIS in EIA, but through the process steps of data gathering it became obvious that the research in that format would not yet justify the potential costs involved.

This was due to the underlying problems in the EIA process within the scope of this study that was not based on the lack of skills and technology, but on the law being disconnected from the people due to the lack of adherence to IEM sustainability principles in practice. Malan in Barron (2011) concurs with this problem and suggests that ethics need to be reintroduced into decision making as the problems occurring have to do with the lapse of values, greed and dishonesty and lack of transparency and accountability. Therefore only the aim of the study was amended to reflect a feasibility study of GIS in IEM so that the research process would address the challenges encountered in the design, development and implementation of GIS in EIA.

And so the research process commences as it was based on an enquiry that originated from personal observation and practical problems experienced within the diverse world of integrated

[1] GIS is 'a system for capturing, storing, checking, integrating, manipulating, analysing and displaying data which are spatially referenced to the Earth'(Heywood et al 2007). The most important is the GIS spatial analysis functions that create models to aid informed spatial decision making and the ability to integrate data from more than one source using map overlay (Chang 2010; Vlok 2007). Web-based GIS usage are client server systems where servers (such as an Internet Map Server) hold GIS data and provides functions for desktop clients using GIS software to view and process the data (Heywood et al 2007).

environmental management (IEM) where environmental impact assessment (EIA) is the only mandatory legislation to regulate the impact of the activities related to project development. Chapter 1 introduces the research problem as it relates to challenges faced by parties involved in environmental management and impact assessment. The main challenge focused on in this study is to examine the feasibility of web-based GIS usage as a solution towards the lack of applied IEM and effective EIA decision making. In the final chapter the study concludes that the integration of policy, technology and people have the potential to raise the standard of EIA within the scope of this study.

As the EIA process was developed for people who are the custodians and consumers of environmental resources (Bourseiller 2005), the research process is an attempt to determine from the opinions of people whether usage of GIS technology has the potential to inform decision making and facilitate the re-connection between EIA and the people affected by the impacts of development projects. In order to make unbiased interpretations from the knowledge gained through data sourcing, an umbrella term "involved parties" was selected to represent EIA users and participants in this research as hypothetically independent EIA users with impartial opinions.

These parties include environmental assessment practitioners (EAPs), case officers and competent authorities (CA) who are the decision makers in government and interested and affected parties (I&APs) who represent civil society. The term 'stakeholders' is often used to refer to parties involved in EIA, but this could potentially lead to confusion as the only involved parties who should benefit financially from the project would be the proponent or client and investors (Van der Merwe S 2011, Pers com; Fortuyn 2011, Pers com).

In the following section of this chapter the environmentalists' dilemma is introduced as a threat to effective environmental management and it is summarised in the historical background to the research problem and the real world problem (Norton 1991). The research process is defined through the aim and objectives and supported by the methodology, methods and rationale of the study. The research process is approached as a funnelling progression which starts with the global environmentalist's dilemma, then examines local environmental management processes, identifies with challenges within the scope of this study towards potential local solutions such as GIS usage in EIA for effective decision making based on IEM. The inclusion of IEM and the sustainability principles based on values and ethics as a potential solution supports the funnelling process as the solution to this study becomes the key to potential universal challenges that lie beyond its scope

1.1 THE DILEMMA OF IMPROVING STANDARDS OF LIVING

The urgency for economic growth to improve society's standards of living is envisaged by environmentalists as a dilemma as they believe that decision makers often disregard important factors such as time and space within the constraints of the carrying capacity of the Earth (Gupta 1997; Norton 1994; Naidoo 2010). The origin of this dilemma goes back to the 1960s when the damage caused by the post-war culture of unregulated development projects became obvious (Lear 2007). Consequently, awareness of environmental management increased amongst people and a paradigm shift in ethics occurred when environmental awareness evolved into a new moral code that did not fit into existing philosophies. This discourse led to the development of the environmental movement.

Scientists and philosophers like Carson (1962) and Hardin (1968a; 1968b) were intent to align environmental value systems with potential ethical solutions to sustain the challenge of managing the carrying capacity of Earth. Hardin (1968a) referred to the combined effects of ruthless industrialisation, resource consumption and population growth as the tragedy of the commons. Furthermore, Hardin (1968b) claimed that unregulated freedom in an overpopulated world where everyone is entitled to an infinite share of the finite environmental resources would bring ruin to all as the carrying capacity of the land would be exceeded (Leonard 2007).

Carson (1962) is known for her contribution to environmental awareness through her book titled *Silent Spring* that was published in 1962. She wrote about the effect of the loss of biodiversity due to uninformed decision making. The book challenged industry for spreading misinformation and criticised governments for their apparent moral right to allow the indiscriminate release of toxic chemicals such as DDT into the environment without knowledge of its long term consequences. Due to her lobbying for effective environmental management and impact assessment, the use of DDT was banned in many parts of the world (Carson 1962; Lear 2007; Macleod 2011).

Fifty years later, leaders in the environmental management domain still confront the dilemma of a lack of knowledge of the impact of development practices on the environment and the consequential lack of informed decision making (Margarum & Hooper 2001). However, the heightened awareness of the need to enable effective environmental management raised consciousness and encouraged political will on local and international fronts. In South Africa the South African Constitution and Bill of Rights of 1996 support the individual's environmental rights along with improvement of living standards.

Furthermore, the South African National Environmental Management Act (NEMA) of 1998 is founded on the IEM principles of sustainability and the EIA process became mandatory in 1998 as a tool for effective environmental assessment in practice (DEAT 2004a; 2004b). Despite legislative

support, users of EIA concur that no framework or barometer has been available to effectively guide leaders, developers and other decision makers towards informed environmental management of development projects in practice (Groenewald 2004a). In theory, NEMA is based on IEM sustainability principles, but it seems as if users are unaware of the value of IEM in practice.

A decade later in 2008, a conference was held to evaluate the impact of the EIA tool on development projects in South Africa. As an outcome, the conference identified flaws and shortcomings in EIA in practice despite the fact that the policy meets global standards and is grounded on environmental ethics (EAPSA 2011; Mabudafhasi 2011). The conference proceedings highlighted the urgent need for discourse to find new strategies and tools to improve EIA (Hector 2009) and suggestions were made to raise awareness of IEM so that all people could understand the concept of the IEM sustainability principles for informed decision making practices (Lukey 2010).

Authorities responded to the outcome of the conference by appointing environmental strategists to find solutions to facilitate the EIA process in compliance with the intent of South Africa's environmental legislation. Experts in South Africa as well as global strategists have thus been seeking solutions such as technological advances and alternative forms of indigenous knowledge management and investigating new frameworks and change management for integrating and presenting technological processes to facilitate synergy between decision makers in development projects (Lear 2007; Hector 2009; Unisa 2009; Gontier et al 2010; Thomson 2010).

1.2 THE DILEMMA OF REGULATING DEVELOPMENT EFFECTIVELY

The real-world problem identified in this study highlights the dilemma faced by leaders in regulating development effectively. They are responsible for the implementation of strategies, policies and tools to minimise negative impacts like environmental pollution and degradation and maximise positive impacts of development projects on the environment. This problem is emphasised in the context of the pertinent issues that were identified at the 2008 DEAT EIA conference and the 2009 UEMP conference as concrete challenges that confront involved parties in the domain of environmental management and development planning in South Africa (Hector 2009; Lukey 2009). In the search for solutions for effective EIA, it was established that South African environmental policies meet global standards.

Despite this pronouncement, implementation of environmental legislation has been found to be disconnected from the people who are actually responsible for the activities that create negative impacts. Furthermore, the principal shortcomings of the EIA process were identified as a lack of knowledge management to inform decision making, the need for involved parties to commit and

comply with regulations, the need for the public to participate in knowledge sharing as well as the importance of good governance (Hector 2009).

In addition, the intent of certain involved parties was found to be unclear as many role players seem to seek profitability of the organisation rather than equity for all within the complex reality of science, politics, society and ethics (Steyn 2008; Hector 2009; Lukey 2009). Leaders and experts suggested that this dilemma could potentially be resolved through first, combining transdisciplinary knowledge with an understanding of IEM principles and, second, effective tools accepted and applied by all parties.

This practice must go beyond rhetoric to connect the basic EIA framework to all the people participating in a process towards self-regulation (Lovelock 2006; Grin et al 2008; EAPSA 2011; DEA 2012). Furthermore, reference was made to the value of GIS technology in combining spatial and non-spatial attributes for knowledge exchange to potentially drive environmental management and impact assessment processes successfully (Hector 2009).

1.3 THE POTENTIAL SOLUTION OF GIS TECHNOLOGY FOR EFFECTIVE EIA

The research problem focuses on GIS usage in EIA as a potential solution to address the lack of IEM in EIA. This problem is set in an era of increased technological and communication innovation. Preliminary research clearly shows that the technology to develop a GIS application to facilitate the EIA process in the context of this study are available, as operational stand-alone projects have been developed in Cape Town. Yet, no such system-wide application exists (Milner 2007; Hector 2009; Higgs 2009; Calaca 2010, Pers com; Chatfield 2010; Roos 2010, Pers com; Smith 2010, Pers com; Stipinovich 2010, Pers com; Van Dyk 2010, Pers com).

From knowledge gained during the preliminary phase of this study, experts in the domain of GIS and EIA agree that effective GIS usage in EIA would require several elements: suitable GIS software and web technology; combination with spatial tools such as Google Earth; the latest available land use and land cover data; spatial data with features and functionality related to the natural and built environment where proposed development projects take place.

The application should be able to function as an online or downloadable platform where all participants could engage simultaneously and share current information to make informed decisions. That is compared to often outdated desk top information currently available to decision makers. Such a GIS application could potentially simulate policy scenarios, transport and diffusion pathways as well as cumulative environmental impacts to solve complex problems involving policy, people and

proposed projects using multi-criteria evaluation (MCE) methods [2] (Martens et al s.a.; Longley et al 2006; Castells & Guardans 2008; Jager 2008; Van Niekerk 2008; Ralston 2009; Seto & Shepherd 2009; Chang 2010). In order to resolve the research problem, this study therefore motivates for an investigation into the feasibility of web-based GIS usage in the EIA process towards informed decision making and effective EIA in practice, based on IEM principles.

1.4 THE AIM OF THE STUDY

To recap, the initial aim of the study was to design, develop and implement a web-based GIS application to facilitate EIA decision making. However, during the preliminary data collection it became clear that the primary challenges faced by involved parties in the scope of this study were related to underlying factors such as the lack of IEM principles in the EIA process and to a lesser extent to technological or capacity limitations. Furthermore, the technology was potentially available, a database was being developed by local government and similar GIS applications had been implemented successfully in various municipal departments such as corporate GIS (Calaca 2010, Pers com; Roos 2010, Pers com; Smith 2010, Pers com).

As a result, the decision was made to adjust the research topic and to rather investigate the feasibility of web-based GIS usage for effective EIA based on the opinions of involved parties in the environmental management and impact assessment domain. Therefore, for the purpose of this study, the original research topic related to investigating the design and implementation of a web-based GIS application would rely on the outcome of this feasibility study in order to recommend the original topic for future research (Roos 2010, Pers com; Smith 2010, Pers com).

Consequently, the aim of the study was amended to a feasibility study of GIS in EIA with the purpose:

- To determine from the opinions of involved parties representing transdisciplinary roles and responsibilities in the EIA domain in Cape Town and the Western Cape, whether web-based GIS usage in EIA based on IEM principles is considered a feasible option to facilitate effective EIA in practice.

A secondary purpose was to identify from the opinions of the involved parties as participants in the research process whether the shortcomings in the current EIA process could effectively be facilitated through GIS usage in EIA. The outcome of this study would therefore recommend and

[2] Multi-criteria evaluation is a method of combining several, possibly conflicting, criteria maps such as land-use, zoning and property rights to derive suitability maps based on the trade-off functions and user-specified criteria preference weights. Implementing MCE in GIS requires selection of criteria such as the identification of data layers that are important to the problem followed by standardisation of criteria scores used by the data layers to enable meaningful comparisons between criteria such as population density and distance to the nearest railway line. Weights are allocated that reflect the importance of the data layers. The MCE algorithm is applied and a map is produced (Longley et al 2007).

inform future research in the design, development and interpretation of a web-based GIS application for EIA. In the section that follows the research objectives are viewed.

1.5 RESEARCH OBJECTIVES

To achieve the aim of a study, five objectives were set to be reached to accomplish the projected outcome, namely:

- To carefully choose the most suitable research methodology and data sourcing methods for saturation of information to understand and validate this research within the complex domain of policy, technology and people. This objective unfolds in Chapter 1 in the next section already;
- To conduct a scholarly literature review to evaluate the value of GIS usage for EIA. This objective is explored in Chapter 2;
- To investigate the shortcomings of the current EIA process in practice within the scope of this study as well as the functionality of GIS usage to inform EIA in line with the intent of IEM. The outcome of this dual investigation is examined in Chapter 3;
- To determine, from empirical data collected on the opinions of involved parties in the IEM domain, whether web-based GIS usage in EIA would be a feasible solution to facilitate EIA in practice. The outcome of this objective is presented and evaluated in Chapter 4;
- To conclude the feasibility study by highlighting the critical success factors that can potentially enable effective EIA practice based on IEM by uniting GIS, EIA and people and to make suggestions for future research. These factors and suggestions are presented in Chapter 5.

In the following section the first objective is expounded on in terms of the methodology, methods and data sourcing process.

1.6 THE TRANSDISCIPLINARY RESEARCH METHODOLOGY

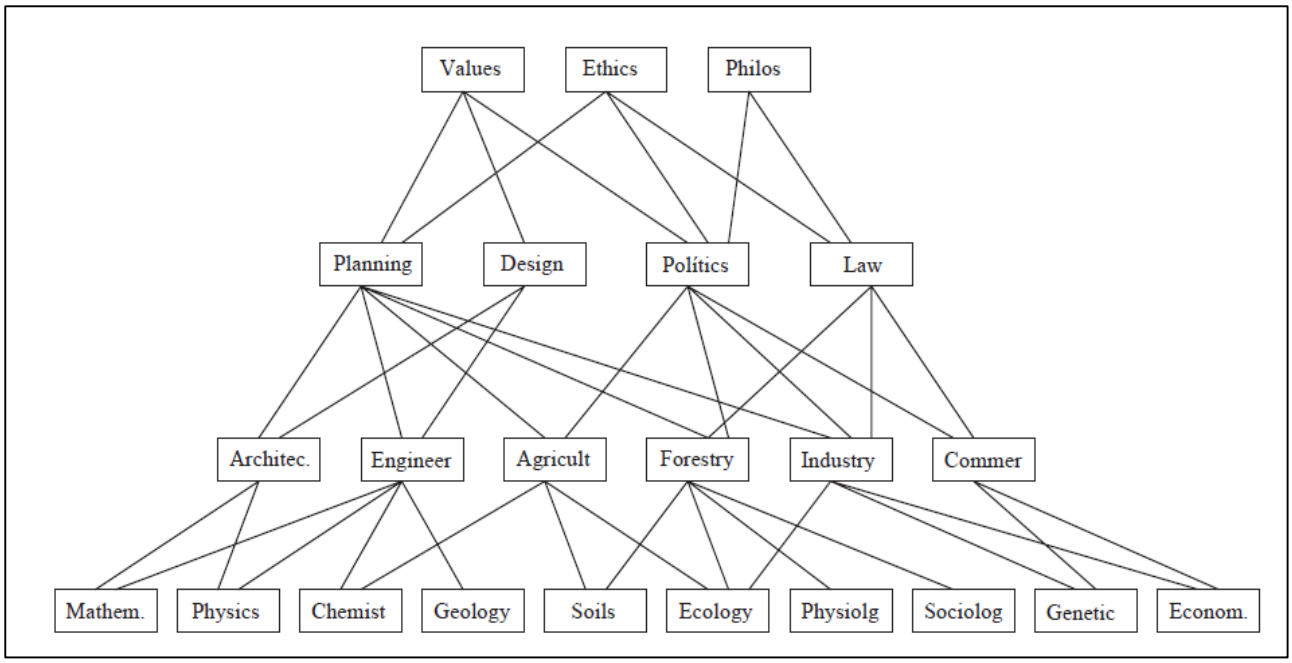
Transdisciplinary methodology or a multi-faceted approach was employed in this study in order to better understand the complex human-ecology-technology paradigm of the IEM and EIA domain (Grin et al 2008). IEM is a transdisciplinary field where involved parties represent all the disciplines relevant to the development project (Fuggle & Rabie in Mitchell 2001).

Transdisciplinarity in the context of this study focuses on the integration of technology, geographical information, socio-economic strategies, legislation and principles of equity and sustainability. To clarify the meaning of transdisciplinarity, Nicolescu (2002) explains that disciplinary research is concerned about one level of reality whereas transdisciplinarity concerns the

dynamic action of several levels of reality at once to support knowledge transformation amongst involved parties and improve existing processes. Furthermore, transdisciplinary collaboration creates a synergy of complementarity between participating parties that can potentially mitigate the impact of anthropocentric activities in development projects (Funtowicz & Ravetz 1999; Nicolescu 2002; Max-Neef 2006; Theron et al 2006; Hoffmann-Riem 2008).

According to Castells & Guardans (2008) the role of scientific expertise that supports policy decisions on salient environmental issues is a central tenet in transdisciplinary research. The same view is adopted in this study and provides the empirical grounding of the research approach which is based on epistemology in terms of knowledge management and ethno-methodology as it relates to the human element in EIA and GIS. The research approach is also based on normative theory (how the world ought to be) and descriptive theory (how the world is) (Judge, Stoker & Wolman 1995; Mouton 1996).

Environmentalists and scientists like Hardin (1968b), Max-Neef (2005) and Marsden (2005) endorsed multi-disciplinarity as a key enabler for effective process implementation. Pohl & Hirsch-Hadorn (2007) concur that the goal of transdisciplinary research is to respond to societal knowledge demands when attempting to solve complex problems for the common good. Max-Neef's (2005) transdisciplinary diagram is presented in Figure 1.1 to clarify the concept of transdisciplinarity by means of a visual illustration followed by a brief explanation.



Source: Max-Neef (2005: 9)

Figure 1.1: The transdisciplinary concept of processes and reality

This model offers a clear visual representation of transdisciplinarity and relates to the paradigm of people, ecology and technology identified in this study as a solution to the implementation of IEM and effective EIA. This transdisciplinary model starts with an empirical level of what exists with a focus on awareness of the world of human and natural science.

It moves to a second purposive or pragmatic level that represents what people are capable of doing by using the technological disciplines such as information technology (IT) and modern communication tools such as the Internet, web-based tools and GIS software. The third stage represents the normative level of what people do to influence their milieu using legislation (policy), governance (politics) and development (projects). Finally, the top level describes the complex reality of concerns for the human species and life in general, which includes values and beliefs like justice and transparency residing in the IEM sustainability principles (Max-Neef 2005).

1.7 RESEARCH METHODS COMPATIBLE WITH TRANSDISCIPLINARITY

Research methods compatible with the transdisciplinary approach were examined and a mixed methods approach termed triangulation was selected as it involves two or more research methods to enhance the validity and reliability of the information sources to support the findings and the research results (Neubert 2000; Leedy & Ormrod 2005). Repko (2008) defines triangulation as achieving balance in an interdisciplinary sense. He postulates that the complexities of the different realities of mixed methods enable qualitative and quantitative methods to combine towards a more holistic perspective on a given concept to emphasise the truth. Triangulation is especially relevant when dealing with complex interactions among multiple factors that affect social relations and human affairs (Creswell 2003; Pinson 2004; Steyn 2008).

The participants in the data collection processes in this study represent involved parties in the EIA process, IEM and GIS domain. Furthermore, these participants represent the opinions and perceptions of EIA and GIS users from the geographical Cape Town metropolitan area. The legislative scope of the study was identified as the Western Cape province as EIA decision making is entrusted to provincial level authority and in this case the Department of Environmental Affairs and Development Planning (DEA&DP) of the Western Cape Provincial Government. In line with triangulation, qualitative and quantitative methods were employed for data sourcing and deemed sufficient to provide adequate mixed-method breadth, depth and integration of information to understand the topic matter (Repko 2008) and to reach a viable conclusion regarding the feasibility of GIS usage in EIA.

1.7.1 Qualitative data sourcing

Qualitative research is a generic term for investigative methodologies described as ethnographic, naturalistic, anthropological, field or participant observer research and emphasises the importance of engaging subjects in a natural setting. Interaction between variables is important and detailed data is usually gathered through open-ended questions that provide direct quotations. The interviewer is an integral part of the investigation (Jacob 1988). A number of methods for data sourcing were used as are discussed below.

The initial inductive method of data sourcing included fairly structured observation and participative discussions performed during conference proceedings and workshops, as well as less structured individual interviews and discussions using descriptive and causal questions (Mouton 2001; Leedy & Ormrod 2005). Le Roux (2004) postulates that observation and field studies are normally used to examine social processes in a specific situation at a particular point in time or over a period of time. The inductive approach helps the researcher to observe patterns and denote conclusions about the acquired information.

The initial idea for this research was formulated during observation of participants while attending the DEAT Ten years of EIA conference in 2008 and subsequent interacting with experts in the diverse field of environmental management and impact assessment. Other conference proceedings that influenced the research included the Urban Environment Management Programme (UEMP) conference in 2009. The UEMP is an organisation that facilitates collaboration between South Africa and Denmark and is funded by the Danish government to build the institutional capacity of local environmentally sustainable services.

The programme partners are DEAT, the Department of Health, the Western Cape Provincial Government as well as the Gauteng and KwaZulu-Natal Provincial Governments. The UEMP focuses on matters related to air quality, environmental health, sustainable planning, sustainable energy and waste management (UEMP 2009). Other conferences and workshops attended by the researcher include the Green Building conference (2010 and 2011), Climate Change Green paper discussion workshop (2011) as well as GIS workshops at the University of the Western Cape (UWC) and Stellenbosch University (SUN) in 2011.

The next method for data sourcing was a structured e-mail questionnaire involving a group of experts in fields related to IEM that was used as a pilot study to seek advice and explore the opinions of the participants regarding the feasibility of the proposed research problem. The question that was posed asked experts for their opinions on whether participants in EIA would benefit from GIS usage

for knowledge exchange. This stage of the data sourcing took place as a topic for research methodology in an honours course before this research formally commenced.

Critical thinking and argument analysis supported interpretation of the results and decision making (Mouton 2001; Hesse-Biber & Leavy in Le Roux 2005; Leedy & Ormrod 2005). The participants were all known to the researcher and consisted of a sample of fifteen people who represent parties to the multi-disciplinary domain of environmental decision making (EDM) in a development project as reported in Table 1.1 below. All participants responded positively towards the rationale behind the research topic and hence encouraged the researcher to commence with this study. Analysis and interpretation of the outcome of this method of data sourcing is presented in Chapter 4.

Table 1.1: List of respondents involved in the e-questionnaire

Data sourcing method: E-questionnaire Recipients: Experts from multi-disciplinary domains in environmental decision making (EDM)				
Business	Ecology/Environmental management (EM)	Industry	Technology	Government
Economist Commerce Industrial psychologist Knowledge manager	Two EM honours students M.Phil. student at the Sustainability Institute Water quality scientist	Engineer Metallurgist Manager at CSIR	IT expert GIS lecturer at Unisa	Disaster management expert Rural development expert

Table 1.1 records the origin of participants involved in the initial e-questionnaire sent by email. Specifically, the table distinguishes five different disciplines that this sample of fourteen subjects represents. The details of this method of data sourcing is described in the section below and the findings are discussed in Chapter 4.

The next mode of data sourcing consisted of two sets of separate semi-structured interviews to seek the opinions and advice of a larger sample of experts involved in IEM, EIA and GIS within the geographic scope of this study (Mouton 2001; Leedy & Ormrod 2005). Table 1.2 lists the first group of participants in semi-structured inteviews which represented different departments within local government, together with the second group of participants who represent tertiary institutions, I&APs and industry. All participants were aware of the value of GIS usage in informed decision making. Even though the participants are divided into two groups, the interviews were held with individual members of each group. The grouping stems from dividing the groups into participants representing local government and the second group representing other parties involved in GIS, EIA and EDM for

comparison. Details of the data sourcing methods are described under the respective headings below and the outcome of the findings are presented in table format in Chapter 4.

Table 1.2: List of participants involved in semi-structured interviews

Data sourcing method: Semi-structured interviews Recipients: Experts in the GIS, EIA and environmental decision making (EDM) domain			
Local government	GIS and EDM experts at tertiary institutions	Industry	I&APs
EIA-GIS technician Corporate GIS technician IT systems integration Strategic development management Environmental risk management	Senior lecturers at SUN (EDM and GIS) Senior lecturer at UCT (EDM) GIS expert at UWC Senior lecturer at Stellenbosch University Sustainability Institute (SSI)	GIS, EDM and EIA expert at CSIR	Senior manager at NGO World Wildlife Fund (WWF)

The first group involved respondents from within the different disciplines of the City of Cape Town and Western Cape municipal and provincial governments respectively. Robust interactive discussions convinced the researcher to sustain interest in the research line of inquiry and to adopt a multi-facetted approach towards the many variables, disciplines and perspectives related to the respondents. The respondents furthermore recommended a review of the costs and skills required to design and develop a web-based GIS application linked to a database and to consider the current construction of integrated data base development at City level to avoid duplication.

At this time the process of information and data integration onto GIS called Integrated Spatial Information System (ISIS) to assist in land use management was actively being implemented by local government. The researcher then recognised the too limited capacity in available human and financial resources to fund and conduct the complex and expensive process to design and develop a GIS application to facilitate EIA. Hence, the focus of this study was altered to one exploring the feasibility of GIS usage to inform effective EIA that could potentially lead to future research based on the conclusion of this study.

The second set of participants listed in Table 1.2 hosted discussions with tertiary education institutions and encouraged continued examination of web-based GIS usage in EIA. Industry showed interest in the study and highlighted the value of GIS software combined with spatial communication

networks such as Google Earth and the NGO representative valued the opportunities that would be potentially created for I&APs to engage in and support informed decision making. Different views regarding the feasibility of web-based GIS usage in EIA came to light and fuelled the decision to formulate the final phase of data sourcing around the culmination of a sample of all the different views through interactive participation with focus groups representing the disciplines practically involved in the EIA process.

According to Le Roux (2005), focus group discussions are the best known qualitative research method, as the group interaction leads to greater insight into the topic. To ensure high construct validity to the method (Mouton 2001), six focus group discussions with participants were held in order to collate and compare the views of the majority of involved parties in GIS, EIA and IEM within the scope of this study.

Focus group data sourcing and analysis was very time consuming. Participants in the focus group discussions represented involved parties in EIA who use GIS for informed decision making in practice as well as GIS experts from a tertiary academic institution as shown in Table 1.3.

Table 1.3: List of participants involved in the focus group discussions

Data sourcing method: Focus group discussions Recipients: Involved parties in EIA, IEM, GIS and EDM					
CSIR EAPS using GIS	Environmental consultants using GIS	GIS experts at tertiary institution involved in geographical analysis	I&APs at established NGO Wildlife and Environment Society of South Africa (WESSA)	Government officials representing case officers from DEA&DP, environmental framework managers (EMF) and GIS technicians	Self-employed EAP involved in specialist studies for EIA and EDM using GIS

Structured, themed questions were emailed to recipients for preparation or perusal several days before discussions took place. The interviews were semi-structured with a low degree of control in the sense that the questions were structured, but invoked open-ended responses from participants. The discussions were emotive as all the participants were experts in their field and this led to authentic contributions in terms of the critical issues, challenges and opportunities in the EIA and IEM domain.

The questions were formulated according to the main and sub-themes of this study and the discussions and responses were recorded and transcribed for argument analysis and expressed as direct quotes in Chapter 4.

In the data sourcing process, participants in every focus group were asked to respond to questions which led to discussions that generated meaningful information on the research problem and the feasibility of the proposed solution. Interactions with the focus group participants were dynamic and aimed to provide adequate breadth and depth as well as integration of information. Discussions continued until saturation of data was achieved so that follow-up deliberations were not deemed necessary (Le Roux 2005). This information was recorded and transcribed with approval of the participants and the findings were categorised according to the matrix of strengths, weaknesses, opportunities and threats (SWOT) to find the competitive advantage of the topic analysed. The concept behind the acronym SWOT in terms of its application toward project analysis is briefly summarised in bulleted format as:

- Strengths represent the characteristics of the project that give it an advantage over others.
- Weaknesses represent characteristics that place the project at a disadvantage to others.
- Opportunities represent elements that the project could exploit to its advantage.
- Threats represent elements in the environment that could cause problems for the project.

In Chapter 4 a summary of the qualitative and quantitative trends are presented as direct quotes in table format to provide a framework for evaluating the feasibility of web-based GIS usage in EIA according to the opinions of the respondents. A copy of the focus group discussion document appear in Appendix A for further perusal. In the following section the use of quantitative data sourcing in this study is presented.

1.7.2 Quantitative data sourcing

According to Smith (1983) a mixed methods approach to data sourcing combining quantitative and qualitative methods produce alternative versions of reality. He further postulates that quantitative research attempts to gather data by objective methods to provide information about relationships, comparisons and predictions. Instruments such as the Likert scale are used to achieve an accurate reflection on measurement of an independently existing object. Furthermore, during the process the researcher or investigator is removed from the investigation so that the results are unbiased by the situation surrounding the researcher. This is crucial to the scientific process to ensure the findings can be replicated by anyone using the same instrument (Smith 1983).

An e-questionnaire eliciting question responses according to a 5-point Likert scale was used for quantitative data sourcing. The format expedited analysis and determined from the remotely collected

opinions of respondents whether it would be feasible to implement web-based GIS usage for effective EIA decision making. Questionnaire statements were formulated about the key concepts that emerged from the outcome of the focus group discussions and were structured according to the main and sub-themes of this research. The questionnaire did not require 'yes/no' answers, but were statements that required scaled evaluation. The five points along the Likert scale are descriptive labels to help participants determine how they should rate their opinions and the digital scales of measurement in numeric form allow for a user-friendly method for statistical analysis (Babbie & Mouton 2001; Theron & Saunders 2009).

Originally the sample population was a simple random selection from DEA&DP case officers as the researcher was promised access to and counted on a large probability sample within the sampling frame of case officers who represent the EIA decision makers in government. A senior manager at DEA&DP offered to be the focal point to ensure that all case officers received and responded to the survey. The researcher had no control over the sample universe apart from the verbal agreement and after only receiving six responses it became obvious that the envisaged large sample population was not responding to the survey. Direct contact with case officers proved futile as did attempts to access the manager. Even though the case officers were not known to the researcher, it was inferred that the content of the survey may have been perceived to be too transpicuous and the subjects may have felt they or their positions were under scrutiny and hence the few responses to the survey. To increase the sample universe under time constraint, the researcher approached a convenience sample of EAPs to participate in the survey and received another six responses that brought the total responses to 12.

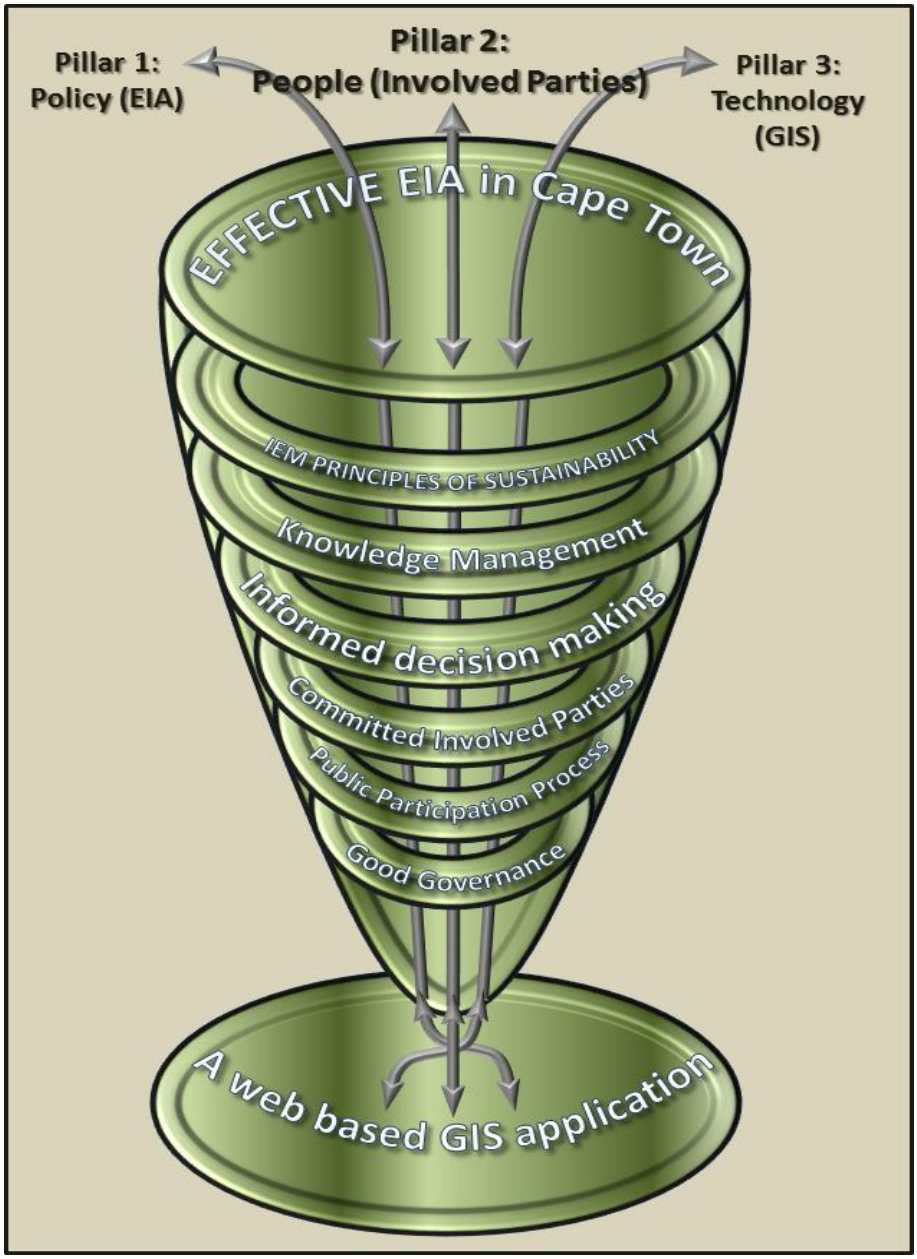
Even though the sample universe was small, the outcome of the e-survey was not insignificant as the trends in quantitative research followed that of the qualitative research findings. The majority of the respondents supported web-based GIS usage in EIA as a potential tool to align the EIA in practice with IEM in terms of knowledge management, informed decision making, encouraging commitment from involved parties and effective public participation as well as good governance. The summary of all the sections of the e-survey for quantitative results are presented as graphics in Chapter 4 and the original of the graphics, along with a copy of the Likert-scale e-survey, is displayed in Appendix A.

In concluding this section, Barron (2011) suggests that ethics need to be reintroduced into decision making as the problems we face have to do with the lapse of values, with greed and dishonesty and lack of transparency and accountability. Max-Neef (2005) concurs and postulates that the transdisciplinarity leads to an altered and improved state of understanding and reframing of mind sets. This concept reflects on a model that was generated from insights gained through the funnelling process that the research design followed since the initial planning phase. The model aims to clarify

the concept of GIS usage in EIA as well as the main themes and sub-themes that represent vertical pillars and horizontal tiered steps towards effective EIA based on IEM. The model appears next here in Chapter 1 and is revisited in Chapter 5 for the dual purpose of visually illustrating the framework of the construct of the study and to demonstrate the funnelling concept of the research.

1.8 A GIS FOR EIA MODEL

In this chapter, in Figure 1.2, the model is referred to as the 'GIS for EIA model'. It symbolises the current EIA process as well as the transdisciplinary interconnecting of GIS, EIA and people under an umbrella of IEM sustainability principles that leads to effective EIA within the scope of this study.



Source: Adapted from Van der Merwe (2011)

Figure 1.2: A visual presentation of the GIS for EIA model

The GIS for EIA model represents the opportunity for web-based GIS usage in EIA in practice and it also presents the essence and transdisciplinary concept. It intends to clarify the aim and objectives of this study. The base of the model symbolises a web-based GIS application as the potential means to enable effective EIA at the top of the model. The vertical pillars represent the three main themes of EIA, GIS and People. Together, the pillars represent the complex transdisciplinary relationship of policy, technology and people. There are six horizontal tiers or tiered steps between the base and the top that are used to represent a 'step-up' in the standards of behaviour of the participating involved parties in EIA towards an understanding of IEM.

The concept of the tiered steps also reflect on opportunities to turn weaknesses and threats into opportunities and strengths and is linked to the section in Chapter 3 where the sub-themes are presented as they relate to the IEM sustainability principles and also connect to the model displayed in Chapter 5 that symbolises the mind-sets of EIA users to change towards a more holistic view. Five of these tiers represent the five sub-themes that are presented concurrently throughout this study. The sixth tier represents the umbrella of IEM as an overarching concept of sustainability principles that unites all the themes of this study.

In the following section the pillars and tiered steps of the model are described in the context of the themes in this study.

1.8.1 IEM as the overarching concept for sustainable solutions

One of the key challenges in the implementation of EIA is to attain awareness of IEM (SDCEA 2008). EIA is based on the holistic philosophy of integrated environmental management (IEM) that includes a duty to provide involved parties with the means to identify possible environmental impacts of their actions and to assist authorities in deciding whether the benefits of the proposed project outweighs the costs and whether it is a sustainable option (Sowman et al 1995; DEAT 2004b).

Recent research (CSIR 2007) claimed that the need for IEM for decision making purposes increased as political commitment for sustainability increased. In the context of this study the EIA process as a concept is aligned with the intent of NEMA and IEM in order to support the need for EIA to be founded on the IEM principles of sustainability. This study supports local to global IEM as well as a holistic approach to inform decision making and to encourage all involved parties to participate in projects in order to improve processes (DEAT 2004c; ERM 2008). Lukey (2008) concurs with the need for IEM and suggests that the entire nation's capacity be built around knowledge sharing and understanding IEM.

1.8.2 The main themes as pillars in the model

The EIA process focuses on the coordination of human activities, ecological systems and regulatory disciplines (DEAT 2004b) and is presented as the first pillar in the model. The shortcomings in the EIA process need to be overcome through a step-up (raising) in standards towards effective EIA by uniting EIA and people.

The second pillar represents technology such as modern communication networks and web-based tools including the Internet, Google Earth and GIS to manage knowledge in order to inform the needs, roles and responsibilities of involved parties in project and policy processes (Longley et al 2005). People are placed at the core of legal processes in the South African Constitution, Act 108 of 1996 and the Bill of Rights (DEA&DP 2011) as well as Agenda 21 (UNCED 1992) and therefore people as involved parties in the context of EIA and IEM are presented as the third pillar in the model.

1.8.3 Research sub-themes as tiered steps in the model

The transdisciplinary approach adopted in this study supports the need to create opportunities that can raise the professional standard of the EIA process. Such opportunities include critical success factors such as effective knowledge management; information exchange for decision making; stakeholder engagement; public participation and responsible governance (Pandor 2010; Patel 2010). These factors relate to IEM sustainability principles and also highlight the areas where shortcomings of the current EIA process manifest. As these opportunities and shortcomings have to be examined in detail, they have been selected as the sub-themes of this study. Consequently, these sub-themes are examined in the section below as potential opportunities and strategies to encourage a step-up in the current EIA standards.

1.8.3.1 A step-up to effective knowledge management

Knowledge management is defined as a discipline of enabling people to collectively and systematically create, share and apply knowledge to better achieve their objectives (Young 1996). Tobin & Volavsek (2006) furthermore propose that knowledge management enables competitive advantage and needs a platform for the practical implementation of knowledge exchange. In the context of this study, knowledge management ensures that information exchange is continuous, fluid and accessible to all involved parties in the EIA process in order to inform decision making. A web-based GIS platform could potentially enable effective knowledge exchange and knowledge management towards informed EIA.

1.8.3.2 A step-up to informed decision making

DEAT (2004a) defines decision making as a sequence of steps, actions or procedures that result in decisions at any stage of a proposal deployment. Informed decision making refers to having access to the relevant information to make such decisions. However, access to information is not the only requirement of informed decision making. Decision makers also need to understand the aims and objectives of the project and need to have the capacity to make good judgement decisions based on relevant, reliable and current information (Rashmin 2004). Throughout the EIA process opportunities exist where GIS usage could be integrated into EIA to analyse the costs and benefits of social, environmental and economic impacts to inform decision making so that the project can proceed.

1.8.3.3 A step-up to committed involved parties

Lack of collaboration by involved parties is one of the shortcomings of the current EIA process (DEAT 2004b) as it undermines transparency in participation and knowledge exchange (Bulman 2011). Commitment by involved parties is a process leading to a joint effort by stakeholders, technical specialists, the authorities and the proponent (CSIR 2007).

All involved parties should commit to be part of the evaluation process to ensure optimal operations to create greater interdisciplinary linkages and raise awareness of IEM (CSIR 2007; Bishop 2001). Web-based GIS usage linked to the EIA process as a platform for collaboration and knowledge sharing has the potential to encourage involved parties to commit to their roles and responsibilities in EIA.

1.8.3.4 A step-up to authentic public participation

Ever since the informal beginning of environmental assessment in South Africa in the 1970's, national laws and regulations contained procedures for public participation. Public participation is a mechanism whereby the public is not only heard before the decision, but where they have an opportunity to potentially influence the decision from the beginning until the end of the process.

Effective public participation enhances transparency and accountability towards responsible decision making (Bulman 2011). Bredell (2009) concurs and noted in a DEA&DP budget speech that it is crucial for cooperative government to communicate and interact with the public so that everyone understands that they have an important role to play. Furthermore, since the inception of this study the need for strategies such as web-based GIS usage have been highlighted to effectively engage interested and affected parties (I&APs) in the EIA process.

1.8.3.5 A step-up to good governance

Good governance is based on discipline, transparency, independence, accountability, responsibility, fairness and social responsibility as prescribed by the King Report (SAICA 2010). EIA does not take place in a vacuum where all things stay the same, but within the challenges offered by such processes as governance, waste management, national development strategies, spatial planning, land use and zoning laws, public participation, decision making and the integrity of EIA in practice (DEAT 2004a; Enviroworks 2008).

As a result it is crucial that the EIA process operates effectively and political support for EIA enhancing strategies and tools is vital to the credibility and administrative efficiency of the EIA in practice. Web-based GIS usage in EIA would potentially encourage alignment between involved parties and within government departments. The themes that represent the pillars and tiered steps in the GIS for EIA model relate to the different phases of the research design of this study as presented in the following section.

1.9 THE RESEARCH DESIGN

The research design is the diagrammatical version of the research plan and sets out step by step "what was done" (Van der Merwe & De Necker 2012). Twelve phases are diagrammatically displayed in Figure 1.7 and described to follow the practical research process step-by-step. All the phases are explained ahead of the research design diagram.

In Phase 1 knowledge was gained concerning the concept of web-based GIS usage in EIA, generated through practical observation and field experience. Phase 2 followed the development of the GIS for EIA model since the onset of the research process and clarified the research problem. In Phase 3 remote e-data sourcing was performed which encouraged and enabled the researcher to continue and refine the investigation.

Phase 4 consisted of formal interviews with City of Cape Town municipal managers that aided the endorsement of the aim of the study and provided legitimacy to the surveys. During Phase 5 formal interviews and semi-formal discussions were conducted with involved parties in the IEM domain to invite critique and solutions regarding the rationale of the research. Phase 6 presented a broad scholarly and literature review of the themes of the research problem, including relevant case studies.

In Phase 7 appropriate research methodologies and methods were investigated and defined, leading to the adoption of transdisciplinarity and triangulation as the research approach. During Phase 8 additional qualitative data collection through focus group discussions with involved parties in EIA were planned and executed.

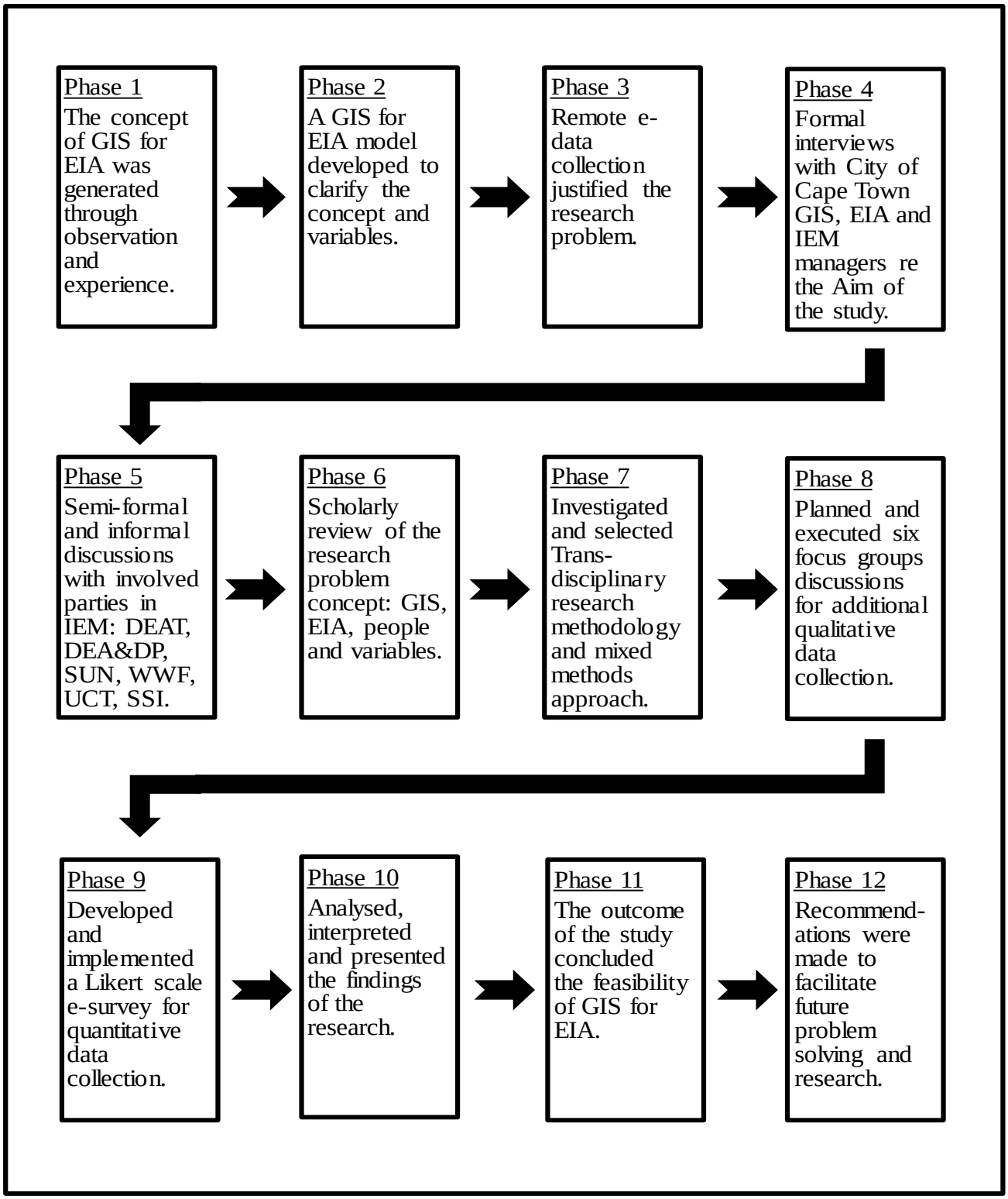


Figure 1.3: The research design

The research design provided the plan or blue-print to the research process and its graphical display facilitated understanding and interpretation at a glance of 'what, when, why and how' the research was conducted. The aim and objectives, research methodology, methods, data collection, presentation

of findings, conclusion and recommendations for future research are all emplaced in some way in this sequential schema.

During Phase 9 quantitative empirical data were collected through the development of a 5-point Likert scale e-survey that was sent to case officers and EAPs. Phase 10 represented a stage to collate, analyse, interpret and present the research findings in comparative tables, SWOT analyses as well as graphics. Finally, in Phase 11 the outcome of the feasibility study was concluded and in Phase 12 recommendations for future research related to critical factors that were generated from the outcome of the research were formulated.

In the following section the report structure summarises the complete research project by chapter.

1.10 REPORT STRUCTURE

This section concludes the chapter as it summarises the structure of the research by chapter in line with the aim and objectives of this study as well as the research design. This first chapter introduces the topic and problem approach, the aims and objectives, methodology and methods as well as a model that developed out of the research of the problem and transdisciplinary approach to problem solving. The model clarifies the construct of the study as well as its directing aim and objectives and helps to unpack the research design.

Chapter 2 introduces theories and expert knowledge underpinning the research as well as case studies related to the research problem that focus on challenges and opportunities encountered in the EIA and GIS domains. Example GIS maps are presented to validate GIS for EIA in practice.

Chapter 3 represents a dual study of EIA and GIS as spatial management tools. The shortcomings of the current EIA process are linked to IEM sustainability principles that reflect on opportunities to step-up standards and integrate technology such as GIS usage in EIA for improved standards in practice.

Chapter 4 collates, analyses, interprets and presents the findings of the qualitative and quantitative data collection and meets the set objective to support the validity of web-based GIS usage in EIA. Furthermore, in agreement with the research design, the chapter concludes by summarising the findings as it correlates with the sub-themes of the study to evaluate GIS usage as a potential solution to the shortcomings of the EIA within the scope of this study.

Chapter 5 encapsulates the outcome of the original aims and objectives of this study. The model introducing the themes and sub-themes of the study diagrammatically in Chapter 1 reappears here in amended format as a visual demonstration of the conclusion of this study. Finally, challenges and limitations encountered during the study are described followed by suggestions for future research

based on the outcome of results of this research. In Appendix A an example of a working document used in the focus group discussions is presented as well as copy of the e-survey based on a 5-point Likert scale. In Appendix B a short description of GIS anatomy is offered for perusal.

The next chapter examines existing scholarly knowledge and contributions related to the concept of effective EIA, GIS usage and people unified with the sub-themes of knowledge management, informed decision making, and commitment by involved parties, public participation and good governance.

CHAPTER 2: SCHOLARLY KNOWLEDGE TO SUPPORT IEM

ISAIAH 40:6 "All flesh is grass, and all the goodliness thereof is as the flower of the field"

Unregulated land use development and collective mismanagement by people have degraded the environment and its ecological systems. Only a few benefit from unscrupulous profit-focused development projects, but everyone shares in the costs. These costs have complex geographical, spatial and socio-economic impacts. Evidence of these impacts is obvious in examples of urban sprawl, water, air and soil pollution and social injustice. A practical approach is needed to mitigate these impacts. This literature review was approached with vigour to gain knowledge and learn from the written perceptions and opinions of experts and leaders in previous and current publications as well as from visually displayed maps regarding the strategies and tools required to manage the natural environment as temporary consumers and custodians of the finite natural resources.

A scholarly review is the process of studying the current state of knowledge on a limited topic found in academic books and journal articles. Reflecting on the subject for scholarly review of this research emphasises the need for integration of principles of sustainability into policies and programs to attempt to reverse the loss of environmental resources (Mbeki 2008). In this chapter, current scholarly knowledge on the feasibility of web-based GIS usage in EIA in terms of definitions, theories and measuring instruments, books, conference proceedings, speeches, reference material, journal articles, newspapers, magazines, maps, websites and reports were reviewed, examined and reported on. Knowledge presented in recent theses and dissertations related to the research paradigm were considered and recent web-based projects were summarised as case studies to reflect on critical issues potentially encountered in the environmental management and impact assessment industry to guide the research process. On occasion the published knowledge is supported by discussions or critique to clarify and gain further insight into this fairly new research topic that is still under development. In the following section a summary of the current state of knowledge on the research within the scope of this study is explained.

2.1 THE FOCUS AND IMPORTANCE OF EXAMINING GIS IN EIA

From knowledge gained, it is evident that web-based communication techniques based on electronic and digital tools have the potential to inform interactive decision making across disciplines such as governments, the media, political groups and the public. The benefits of web-based GIS usage

in EIA include easy access to information, education in citizen illiteracy, knowledge exchange, education, stakeholder engagement, effective public participation and informed decision making (Milner 2007). Van Niekerk (2008) concurs and has proven in his research on CLUES (A web-based land use expert system) that web technology has the capacity mentioned above. However, there are challenges that need to be addressed, such as lack of capacity and skills as well as dubious intent by certain EIA users and problems of corruption and lack of transparency perceived to occur in countries in transformation, but it is evident from the literature studied that these challenges could potentially be successfully addressed (Maathai 2005; Repetti et al 2006; Gower 2009; DEA 2011). In Table 2.1 below GIS projects that were examined to initially inform the research question of this study are presented.

Table 2.1: GIS projects that informed the preliminary research

Project	GIS for decision making	Source and date
Intranet based corporate GIS application for zoning and property valuations.	Cape Town District Spatial Development Plans (SDF), EMF and Urban Restructuring Plans.	www.capetown.gov.za/en/sdf Accessed 2010
DEA&DP	DEA&DP recommends that consultants and EAPS use GIS for visual impact assessment.	www.capegateway.gov.za Accessed 2010
MAPA	Mapped protected areas for biodiversity conservation using GIS and GPS with an online database and a map that is available on Google Earth.	www.mapaproject.org Accessed 2010

The content of Table 2.1 is a summary of the GIS projects examined during the preliminary stage of this research. These projects encouraged the research process as it provided evidence of the value added by GIS to manage knowledge and inform decision making.

In this chapter literature related to the main themes, namely EIA, GIS and people, are reviewed, followed by a scholarly examination of the sub-themes in the domain of EIA, GIS and people. To recap, the sub-themes are based on IEM sustainability principles and include knowledge management, informed decision making, committed involved parties, effective public participation and good governance. In the following sections, literature related to EIA, GIS and people support the need for change in terms of new strategies and tools required in the current EIA process.

2.2 LITERATURE RELATED TO THE MAIN THEMES: EIA, GIS AND PEOPLE

There is a call for unified environmental management in South Africa. This emphasises the need to step beyond business-as-usual and to step up to embrace change by using tools, techniques and strategies for informed decision making (Thomson 2010; IAIASA 2011). To recap, in the context of this study the EIA process represents policy. GIS represents technology and people represent involved parties in EIA and IEM. Stepping out of business-as-usual refers to the need to raise EIA standards in South Africa such as integrating web-based GIS usage in EIA for informed decision making.

Furthermore, suggestions were made that innovative and effective problem solving requires that values and ethics be reintroduced into decision making as the problems we face relate to the lapse of values showcased as greed, dishonesty, lack of transparency and lack of accountability. Subsequently, the discourse between the scientific community, policy makers and stakeholders should be strengthened to develop synergies from various knowledge sources to unify the development of social upliftment, economic growth and environmental management (Castells & Guardans 2008; Grin et al 2008; Barron 2011). Robinson & Schroeder (2009) suggests that EIA should change from the need to clean up, to creating less mess to begin with. In the next section the EIA legislation is introduced, followed by comments on the shortcomings of the current EIA process within the scope of this study and potential opportunities for effective EIA.

2.2.1 Literature related to EIA shortcomings

This section of the chapter supports the justification of the research problem that aims to improve the current EIA process by gleaning insight into the discourse amongst involved parties in the domain of environmental management and impact assessment related to the shortcomings of the current EIA process. EIA fits into the purpose of environmental decision making and includes the functioning of planning, design and decision making based on information gathered about the current situation to forecast the impacts, choices and actions over time in terms of biophysical, social and economic opportunities and constraints if certain actions are undertaken (Wright & Burns 2007; Bulman 2011).

In South Africa, NEMA (Act 107 of 1998 as amended) is the legal framework for environmental decision making. NEMA has been amended four times since its inception in 1998 and is now referred to as NEMA Act 62 of 2008. The amendments were deemed necessary in order to meet the requirements of the EIA process in practice. NEMA is based on IEM sustainability principles endorsed by Agenda 21 to ensure development is socially, environmentally and economically sustainable. The 1996 South African Constitution and Bill of Rights also encourage a triple bottom line of compromise between environmental management, economic growth and social upliftment.

The Department of Environmental Affairs (DEA) is currently responsible for environmental affairs and national environmental management legislation in South Africa (Bulman 2011). The Department of Environmental Affairs and Development Planning (DEA&DP) is responsible for provincial environmental affairs in the Western Cape. EIA is the responsibility of both national and provincial government institutions.

Shortcomings in the EIA process caused involved parties to become "fatigued" with perceived lack of alignment between government departments (Hector 2009). Furthermore, the lack of transparency in the EIA process manifests through political positioning of officials, tolerance towards pollution and delays in decision making that leads to appeals. The requirements of various legislative processes such as EIA and development planning are not aligned and cause conflict between involved parties to the extent that the media commented on investors allegedly leaving the Western Cape to develop projects elsewhere due to the controversy involving EIA decision making under DEA&DP (Kloppers 2011).

The South African environmental policy meets global standards. However, involved parties in environmental management reason that although the legal framework is intact and methods have been developed to manage the environment, the practical application of the process and integration of all disciplines do not meet the global standard of the framework (DEAT 2005; Mabudafhasi 2011; Barron 2011).

Environmental strategists in the DEA (Mabudafhasi 2011) and the IAIA in South Africa agreed that a practical approach is needed and that change initiatives need to be introduced so that new strategies and tools are implemented to facilitate the current EIA process. The DEA supports the call for new strategies and renewed governmental commitment to IEM centred on sustainability principles and alternative tools (EAPSA launch 2011). The following section reviews literature specific to the potential value GIS usage could add in EIA.

2.2.2 Literature related to GIS technology for EIA

Lee & George (2000) suggested that although EIA may be limited as a separate, standalone technique to sanction project level assessments, it is a crucial part of project planning as it offers a basic framework which can be expanded by technology to create a powerful tool for involved parties to consider trade-offs in a balanced approach to development. Furthermore, Rashmin (2004) recommends GIS as a useful approach in systematic identification and evaluation of potential impacts of proposed projects in site selection, evaluating the trade-offs and mitigation in EIA. He suggests that even if initial GIS studies identified major environmental impacts during the EIA process, using GIS to evaluate the implementation of sustainable mitigation measures alleviates such concerns.

According to Lee & George (2000), EIA regulations imply that the EIA process is only linked to one decision making point in the project cycle and that the EIA evolved as an aid to project decision making rather than as a planning and management tool. Yet, good international practice suggests that EIA should proceed together with the project cycle and link into decision points at different stages in that cycle, such as planning, authorisation and implementation. Throughout the EIA process opportunities exist where GIS usage could be integrated to account for social, environmental and economic costs and benefits to inform decision makers so that the project can proceed (DEAT 2004a). In Table 2.2 journal articles accessed from SUN library databases related to the use of GIS in EIA and that were used to inform the research are listed.

Table 2.2: Journal articles related to EIA, EDM and GIS integration

Journals accessed from SUN library databases: 2010-2011	
Journal topic	Source
GIS habitat models for applications in EIA and SEA.	Gontier et al 2010
Application of remote sensing and GIS to EIA for SD.	Abbas & Ukoje 2009
GIS approach is useful in site selection.	Rashmin 2004
An assessment of land degradation in Zimbabwe.	Mambo & Archer 2007
Qualitative method of visual landscape EIA based on GIS.	Zhang et al 2008
Knowledge management for improving EIA in a government agency.	Sanches & Morrison-Saunders 2011
Assessing the cumulative effects of projects using GIS.	Atkinson & Canter 2011

These articles provided some insight into the rationale of the study for validating web-based GIS usage in EIA, but its relatively low numbers also emphasises the dearth of such enquiry reported in literature. The work of Rashmin (2004) and Sanches & Morrison-Saunders (2011) are specifically referred to in the text.

Stotko (2011) states that web-based GIS tools are capable of highlighting areas of environment-development concern, but does not make the work of environmental practitioners or specialists obsolete, as it functions as a screening-level assessment tool. Specialists will still be required to ground-truth the baseline information. He suggests that web-based GIS usage encourages cognisance on a broad scale so that sustainability principles will subsequently be upheld and drawn into the project level assessment.

GIS usage has gained global support as it successfully informs interactive decision making as GIS provides a framework for spatial decision making. Climate change, locating nuclear waste storage facilities and disaster preparedness create new challenges and opportunities for GIS. Areas prone to flooding when sea levels rise in response to global warming and spatial changes in ecosystems as regional climatic zones shift need to be identified. GIS applications can predict changes to critical environmental cycles such as the hydrological, carbon and nitrogen cycles to monitor extreme natural events as well as land use changes in compliance with the United Nations Framework Convention on Climate Change (UNFCCC). Optical data from satellite images are used in GIS to create multi-layered models combined with process based descriptions and landscape knowledge to produce detail of the real world with matching temporal and spatial characteristics (Heywood et al 2008; Lovett & Appleton 2008; ESRI 2011).

GIS software such as ArcGIS integrates data as a map by using thematic overlays from different sources, but of the same area, to form a new layer as a (Arc) map (Heywood et al 2008). In other words, advanced technology, modern communication networks and transdisciplinary knowledge are combined with real-world information to enable visual and textual literacy across time and space (Milner 2007; Brown 2009). The research revealed current projects based on GIS, web and communication technology such as the Coordinated Observation and Prediction of Earth Systems (COPES), the System for Monitoring Urban Functionalities (SMURF) that is presented as a case study later in this chapter, Global Earth Observation System of Systems (GEOSS) and Global Environmental Change and Human Health (GECHH).

These projects were examined in depth by the researcher to inform this study and is presented to focus on the value added by web-based GIS in terms of multi-criteria decision making, modelling, predicting and forecasting tools used to inform EDM. These GIS applications, operations and projects were explored as opportunities to harness the Internet and Google Earth in the operationalising of web-technology for informed decision making.

The Internet plays an important role in information exchange and it supports GIS applications in many ways. The Internet is interactive, links users, has powerful search abilities, is a medium for data collection and is portable. As a result, GIS is no longer restricted to desk top applications. The integration between GIS and the Internet as well as GPS and web services creates new opportunities for GIS such as interactive mapping and navigation systems.

Table 2.3: List of projects where web-based GIS usage informed decision making

Web-based GIS projects	Brief description of project	Source
Coordinated Observation and Prediction of Earth Systems (COPES) now called CIRUN (Climate information: Responding to user needs)	Brings data, modelling and prediction into government and business decision making. Also developing forecast tools.	www.climateneeds.umd.edu Originally accessed in 2010 Accessed again in August 2014
CLUES (Cape Land use Expert system)	Multi-criteria evaluation (MCE) in GIS to support decision making for suitable land use analysis and management.	www.academia.sun.ac.za/cga
GEOSS (Global Earth Observing System of Systems)	Aims to connect producers of environmental data and decision support tools with end users of these products in order to enhance the relevance of earth observations on global issues to generate comprehensive near real-time environmental data.	www.earthobservation.org

In Table 2.3 below projects are listed in tabled format to focus on projects based on similar concepts where web-based GIS is used for knowledge management and informed decision making In concluding this section, it can be declared that the literature reviewed overwhelmingly supports the benefits of web-based GIS usage in EIA. The final theme of people as involved parties in the EIA process is examined and reviewed in the section that follows.

2.2.3 Literature related to people as involved parties in EIA

People are expected to be part of the solution to mitigate environmental impacts as they are the primary custodians and beneficiaries of the environment that sustains them. The law and technology is there for the benefit of people and current discourse on the need to unite these three concepts to bring the law closer to the people and to improve current processes are discussed in this section. The role of people as participating parties in EIA is reviewed as well as the role of people as GIS users in the EIA process. Users include governments, the media, industry and business as well as political groups and the public (Repetti et al 2006; Gowa 2009; Higgs 2009).

As environmental awareness increases, involved parties need to realise that in their professional careers and as members of society, they are the actual ones impacting on the environment. It is therefore crucial that involved parties be committed to development that is compliant with policy, strategies and tools to address complex environmental issues such as pollution and mitigation of the impact of anthropocentric activities (IAIASA 2011). These impacts include ecological and environmental impacts, sustainability, urban design and development challenges (DEAT 2004a; Max-Neef 2005; Repetti et al 2006; Hirsch-Hadorn et al 2008). As mentioned in Chapter 1, the umbrella term 'involved parties' is used to describe people in the context of this study and refers to all the independent role players involved in the EIA process.

DEAT (2002) refers to the people involved in the EIA process as the proponent, authorities and interested and affected parties (I&APs) and speaks of them as the stakeholders in the environmental decision making process. DEA (2010) refers to people involved in the public participation process as I&APs to include any person interested in and affected by an activity and any organ of state that may have jurisdiction over any aspect of the activity. I&APs represent a sub-group of the public who participate in the EIA process due to a potential interest in the proposed project. The term involved parties also captures the collective opinions of people as potential GIS users to facilitate the EIA process (Fortuyn 2011, Pers com).

Involved parties represent multidisciplinary areas of knowledge and need to share a common platform for knowledge exchange to inform decision making to effectively assess the complex and dynamic human-environment relationship reflected in the EIA process (Dvir & Pasher 2004). Strategies and tools for knowledge exchange need to be appropriately transmitted to be understood by all the parties in the process (Morin 1999). Fortunately, opportunities exist for involved parties to join forces to better understand how to incorporate environmental concerns into development in compliance with EIA (Lee & George 2000). Opportunities include the development, implementation and maintenance of information technology (IT) and web technology tools.

In the following section literature is reviewed to support methods to transform the critical issues that challenge and limit the current EIA process within the scope of this study into opportunities by integrating technology to reconnect the EIA process with people. These shortcomings in EIA reflect on the IEM principles of sustainability and are presented as the sub-themes in this study.

2.3 THE SUB-THEMES AS OPPORTUNITIES FOR EFFECTIVE EIA

During this phase of the study literature was reviewed in order to justify the rationale for selecting specific critical issues as shortcomings that limit the current EIA process in the scope of this study. These shortcomings are presented as sub-themes as they potentially offer opportunities to unite the main themes of EIA, GIS and people. In other words, this study proposes that the selected sub-themes have the potential to transform the shortcomings in the EIA process through web-based GIS usage in EIA toward effective EIA aligned with IEM.

In order to clarify web-based GIS usage in EIA, it is explained in the context of web-based tools where everything in the present world is connected and current business discourse illuminates an emerging shift in the conceptualisation of value creation in all industries. The leading sectors are IT industries, film, TV, computer games and e-business that encapsulate much of what is digital and creative.

Modern communication tools and IT are described as the 'canaries in the mines' that set the scene for change in the business and civil domain towards economic sustainability as well as sustainable social and cultural life (Hearn & Pace 2006). Furthermore, web-based GIS technology is able to combine visual and textual literacy to enable people to communicate and exchange knowledge to better understand the complexity of the human-environment relationship as well as sustainable mitigation measures (Marsden 2005; Repetti et al 2006; Van Niekerk 2008; Brown 2009).

In Table 2.4 below case studies selected from publications that focus on the benefits of GIS usage and web-based GIS usage in decision making and more specifically EDM are presented. These case studies are listed in tabled format and included in the text as a reference to additional case studies that informed the research and to highlight the correlation between the sub-themes of this study and the published case studies by experts in the EA and GIS domain.

The case studies listed in Table 2.4 are significant as the content of these case studies were thoroughly scrutinised by the researcher to gain knowledge of the practice of GIS usage in EDM. The format of the table sets out to focus on the correlation between the published case studies and the sub-themes selected in this research.

The concepts of the sub-themes are specific to IEM and EIA and have been justified through published expert views as factors common to multidisciplinary discourse and processes as follows: knowledge management (Max-Neef 2005; Brown 2009), informed decision making (Castells & Guardans 2008), involved parties (Norris 2001; Milner 2007; Seto & Shepherd 2009), public participation (Higgs 2009; Chatfield 2010) and governance (Repetti et al 2006).

In the following sections a literary review of these sub-themes are presented in terms of the potential value of web-based GIS usage to enable effective EIA.

Table 2.4: A compilation of published case studies where GIS usage informed EDM

Source: Lovett & Appleton (2006)	
Case study	Source
The application of visual technology for coastal zone management.	Jude et al 2001
Developing a virtual reality user interface for GI retrieval on the Internet.	Brown 1999
Using games software for interactive landscape visualisation in landscape and environmental planning.	Bishop & Lange 2005
Visualisation techniques for planning renewable energy development.	Miller et al 2006
GIS and environmental decision making.	MacFarlane & Dunsford 2006
A GIS based visualisation of development projects.	Appleton & Lovett 2005
Using virtual reality to stimulate coastal erosion.	Brown et al (2006)
A GIS based visualisation of development proposals.	Appleton & Lovett 2005
GIS based land use suitability analysis.	Malezewski 2004
Using games software for interactive landscape visualisation.	Bishop I & Lange 2005
GRID enabled GIS.	Jarvis 2007
Applying and Evaluating techniques for stakeholder participation in land use planning.	Shutidamrong & Lovett 2007

2.3.1 Knowledge management (KM) for effective EIA

The importance of knowledge management for EIA is reinforced by its inclusion in the NEMA (Act 108 of 1998) recommendation in the Environmental Impact Assessment and Management Strategy (EIAMS 2011). Young (1996) defines KM as the discipline of enabling individuals, teams and entire organisations to collectively and systematically create, share and apply knowledge to better obtain their objectives. Knowledge management has been advocated as the only way to maintain

competitive advantage in the global economy together with a platform for practical implementation (Tobin & Volavsek 2006). Furthermore, KM connects knowledge production and the demand for relevant and current information to solve societal problems. Knowledge source integration will create a platform for collaboration of specialist knowledge, legislated regulations, stakeholder input, geographic and spatial information, advanced communication networks, web technology and GIS (Jager 2008; Repetti et al 2006). Technology can potentially facilitate KM to support sustainable economic rationality (Tobin & Snyman 2004).

In defining GIS, Chang (2008) and Rashmin (2004) refers to it as a powerful set of tools for collecting, storing, retrieving, transferring and displaying spatial data as well as a decision support system that involves the integration of spatially referenced data in a problem solving environment. Web-based GIS usage will allow for data availability at international, national and provincial level to inform effective EIA in practice (DEA 2011; SANBI 2011; UNESCO 2011). Knowledge management ensures that information is continuous, fluid and accessible to all involved parties in the EIA process to inform decision making.

Furthermore, user friendly technology that combines a database of current and relevant information with analytical potential such as GIS ensures that knowledge is retained and adds continuity in the study of the rapidly changing environment (Longley et al 2005; Sanchez & Morrison-Saunders 2011). The media is a potential platform for effective knowledge exchange. Despite critical issues such as trust and cost, opportunities exist for the media and environmental authorities to jointly participate in projects geared to future sustainability (Groenewald 2004b; Lukey 2009, Pers com; Mabudafhasi 2011, Pers com).

In concluding this section, it is reiterated that scholarly knowledge supports the importance of KM to unite GIS technology with processes such as EIA to ensure effective IEM implementation. In the following section literature on the sub-theme of informed decision making is reviewed and presented in terms of the need for GIS usage to enable effective EIA through informed decision making by all involved parties.

2.3.2 Informed decision making for effective EIA

Literature in the domain of environmental management highlights the need for new tools and strategies such as GIS usage to inform decision making for effective EIA. The purpose of EIA is to identify, predict and assess potential environmental impacts and to provide information for decision making. However, currently EIA is project centred, lacks strategic planning and is unable to assess cumulative impacts. IEM strategists have developed other tools such as strategic environmental assessment (SEA) and cumulative environmental assessment (CEA), but these are not mandatory

applications by regulation. New legislation could be created to make SEA and CEA mandatory. However, it has been recommended that SEA and CEA principles should rather be integrated in existing EIA legislation to enhance the current EIA (Mitchell 2001; DEAT 2007a; DEAT 2007b; Bredell 2009; Gonteir et al 2010).

Decision making relies on access to reliable and relevant information to improve management practices. In addition, decision making authorities rely on their own learning and experience to assess impacts on the environment and to adjust policy for effective decision making regarding the best investment of available resources (DEAT 2007). Informed decision making will lead to more sustainable management of natural resource use and towards a global culture of responsible behaviour (Max-Neef 2005).

Screening of the project location formed part of informed decision making in the original EIA process legislated in 1998, but was later excluded from the regulations to expedite the process. However, as a result of the exclusion of the screening process, baseline information from early onset in the planning process was no longer available (Lee & George 2000; Rashmin 2004; Rossouw et al 2004; DEAT 2007; Oosthuizen et al 2011). Web-based GIS usage can provide relevant baseline information to all involved parties to inform decision making. In the following section a review of literature regarding the potential for GIS to encourage committed participation by involved parties is presented.

2.3.3 Committed involvement by parties for effective EIA

Literature related to uniting involved parties such as stakeholders, technical specialists, authorities and the proponent to commit to a joint effort towards an effective EIA process is reviewed in this phase of the study (CSIR 2007). DEAT (2004b) recommends meaningful and timely engagement by all parties for effective EIA. Lee & George (2000) concurs and suggests that decision making throughout the project cycle should involve the participation of all parties such as developers, authorities and financial institutions who function in different decision making settings.

A challenge for EIA is to ensure that involved parties understand that the growth in economic activity is achieved by consuming the value of ecosystem goods as well as the associated social costs that may prejudice future economic growth and development. Involved parties need to realise that in their professional careers, as members of society, as primary custodians and beneficiaries of the environment that sustains them, they are the actual ones impacting on the environment and they are therefore partly responsible to find solutions to mitigate impacts on the natural environment (Higgens & Morgan 2000).

Effective practical collaboration between involved parties is often prevented by time and location factors. However, web-based GIS usage has the potential to unite involved parties to collaborate across time and location limitations by providing the platform for synergy between involved parties and legislation and to reduce conflict. To conclude this section, it is recognised that scholarly knowledge supports the notion that all involved parties should commit and participate in the evaluation process to ensure optimal procedures, create greater interdisciplinary linkages and raise awareness of IEM (Bishop 2001; CSIR 2007). In the following section the need for cooperation in the public participation process is addressed.

2.3.4 Authentic public participation for effective EIA

There is a need for strategies to effectively engage interested and affected parties (I&APs) in the EIA process. Public participation is described as the engagement of I&APs in the decision making process and is a mechanism by which the public is not only heard before the decision is made, but have an opportunity to potentially influence the decision throughout the process (CSIR 2007). The South Durban Community Environmental Alliance (SDCEA) (2008) recommends that participation takes place from an approach of wanting to understand the South African public. Rossouw et al (2004) concurs and suggests a new approach to public participation as a challenge to the process to engage people in South Africa, rather than a top-down Eurocentric approach that has proven to be less effective.

Public participation GIS is widely recognised as a potential means of empowering marginalised people and communities engaged in social change. Bishop (2008) believes that opportunities exist to develop public participation and collaborative environmental decision making through web-based GIS usage. Visual communication such as web-based GIS maps for clear interpretation of information to illiterate members of the target population is able to alert people of risks along with providing guidelines for avoiding potential hazardous activities (Lee & George 2000; Appleton & Lovett 2008; Bulman 2011).

The I&AP code of ethics supports public participation as a process to make better decisions that incorporate the interests and concerns of all involved parties and meet the needs of the decision making authorities to obtain clear and accurate information about the proposed activity. Furthermore, in plain language, effective public participation enhances transparency and accountability towards responsible decision making (Bulman 2011). This review of literature concerning the public participation process supports the need for tools such as web-based GIS technology towards a more effective EIA process. In the next section the need for strategies and tools such as the potential of web-based GIS usage to empower governance is explored through literature review.

2.3.5 Good governance for effective EIA

The potential of a step-up in governance towards IEM related EIA is scrutinised in this section. In terms of Regulation 1184, DEAT entrusted the approval of EIAs for development proposals to the provinces as competent authorities (DEAT 2004). In the Western Cape it is the responsibility of the DEA&DP to approve or reject proposals (Rossouw et al 2004). DEA&DP follow the EIA requirements and also enforce the Land Use Planning Ordinance (LUPO) that impacts on the EIA process. This is a cause for concern for many involved parties as the outcome of the EIA procedure may approve the project, but then replication of requirements are called for or the proposal gets rejected due to LUPO zoning requirements (Kloppers 2011).

Many applications end at the appeals stage as the only opportunity in the EIA process to resolve conflict. Competent authorities need to be equipped in training, skills and experience to ensure the EIA process does not result in delays, inappropriate decisions or costly and time-consuming appeals. A recent report suggested that, for the EIA to be credible, the capacity of the authorities, in terms of numbers and skills, needs to improve (Bulman 2011). Should web-based GIS usage in EIA be designed and developed concurrently with business needs from an organisation such as the International Association for Impact Assessment (IAIA) and aligned with government strategies, it could be implemented as a mandatory requirement for EIA decision making and could be funded from state coffers. Provincial government, local government, EAPs, industry and I&APs could have access to the same information that could lead to involved parties recognising trends and thresholds of positive and negative impacts of development. Also, opportunities for learning, awareness raising of cumulative impacts, planning and decision making for current and future development projects could be raised (Repetti et al 2007).

In conclusion, this section shows that literature supports the need for new strategies and tools within the EA process in terms of good governance. Along with the sub-themes that have been presented, a feasible deduction is made that the shortcomings in the current EIA process could be converted into a step-up towards effective EIA and that web-based GIS usage has the potential to enable effective EIA. The next section reviews case studies of web-based GIS tools that have been developed and implemented with beneficial results in South Africa and other African countries to highlight challenges, opportunities and critical issues pertinent to the integration of policy, technology and people in countries in transition. Also, government initiated projects are described, and to conclude this chapter, a selection of GIS maps are presented to add validity to the feasibility of web-based GIS usage as a solution for effective EIA based on IEM.

2.4 CASE STUDIES THAT HIGHLIGHT THE BENEFITS OF GIS USAGE IN EIA

During the literature review phase of data collection, case studies that conformed to required criteria were selected. All three case studies originate from countries in transition, namely Uganda, Senegal and South Africa. Each case study utilised a computerised mapping system that employs spatial technology such as remotely sensed satellite images and georeferenced information for policy development and environmental management. Furthermore, they represent application ownership and management by high-level decision makers such as industry, international aid organisations, non-profit organisations and government.

Lastly, information from the systems was made available using different mediums such as GIS and Internet connectivity, the Internet, desktop information at Internet cafés and on portable computer discs (CD) to highlight other opportunities for GIS usage apart from a web-based platform. These case studies were selected from different sources and from many case studies that were examined as examples of projects that employed web-based GIS usage specifically for environmental assessment in countries in transition to highlight opportunities and challenges that may compare with the state of affairs in the scope of this research.

Matomela (2011) contends that web-based GIS usage have had beneficial results for user friendly interaction with geographical and spatial information in various disciplines such as industry, health and social domains to streamline administrative processes, increase transparency and limit human tampering in projects. He then mentions specific challenges that exist in South Africa and other parts of Africa. Examples are the need for Internet access, credit card facilities to access web sites, limited bandwidth, the lack of capacity at call centres and transdisciplinary conflict (Cokayne 2011; Matomela 2011). These challenges are related to changes in systems undergoing transformation, but according to Funtowiczs & Ravetz (1999) it should not be a reason for concern as contradictory aspects of knowledge can be complementary. Furthermore, MacFarlane & Dunsford (2004) postulate that initial problems can be eliminated and the system can improve as the views of users representing different disciplines potentially create a larger resource base for informed decision making (Thompson 2010).

The first case study described by Gowa (2009) relates to a project that has been operational in Uganda since 1994 and is driven by UNEP and the World Bank to focus on training, data capture and capacity building in skills training for data capture, equipment usage and maintenance. The project supports the need to collect, update and transform data into useful formats for environmental analysis to produce national state of the environment reports and environmental atlases in Uganda. The second case study is set in Senegal for monitoring urban functionalities and the third case study relates to the

SANBI (South African National Biodiversity Institute) Biodiversity GIS project in the Western Cape, South Africa (Repetti et al 2007; SANBI 2011). Each case study is set out in the same format of introductory paragraphs, a section on challenges relating to the case study that coincides with the challenges that emerged from this thesis and concludes with pertinent critical issues that could be relevant in future reflections on web-based GIS usage.

2.4.1 Case study: Uganda

The Uganda case study is based on a GRID Arendal publication in collaboration with UNEP. The Uganda National Environmental Information Centre's (NEIC) project to build capacity with the use of remote sensing tools and GIS and most of the subsequent deductions were derived from a report by Gowa (2009). In 1994, environmental information systems (EIS) were developed and GIS maps were used in a government audit of the environmental goods and services in Uganda to provide a baseline assessment and economic cost benefit analysis of environmental resources. In 1996 a metadata tool was developed for producing and storing data and to encourage sustainable land management initiatives and commitment to joint participation. This project operated and supported development goals at national and district level from 1996 to 2000 and improved public awareness.

The Ugandan National Environmental Management Act (NEMA) affirmed the vital requirement for GIS usage and Internet connectivity for rural transformation and national development as well as for communication with local and global audiences through the website. GIS and GPS were used in awareness raising, research, education, decision making, remote sensing and analysis. GIS usage supported the inventory work of wetlands, trans-boundary issues and added value in planning at national level. The following section is a summary of the challenges encountered during the first case study that relate to the shortcomings in the current EIA process within the scope of this research. The main topic in each paragraph is printed in italics to highlight the focus of the discussion.

2.4.1.1 Challenges and opportunities encountered during the Uganda case study

The challenges and opportunities reported on by Gowa (2009) relate strongly to the subthemes of this study. In terms of *knowledge management*, an effective monitoring and evaluation system was needed to improve access and use of environmental information by the public. The need for education and research for cultural, social and economic development emerged along with the requirement to develop and implement an outreach strategy to encourage awareness and knowledge exchange.

Regarding *informed decision making*, the need for consistent, current and relevant information availability was a prerequisite for rational and cost effective environmental decision making. The use of remote sensing technology increased availability of information for environmental decision making, education and research. Standards were set for geo-coding, geo-referencing and data

collection methodologies to expedite data exchange. Access to environmental information was not only a philosophical entitlement of a theoretical achievement, but a practical vehicle for realising sustainable development.

Project leaders realised that *commitment by involved parties* would empower the community to exchange knowledge of potential development impacts and participate in monitoring and management of the environment. Consequently, efforts were made to include all involved parties and encourage collaboration between people, resources, environment and development. Language and geographical barriers limited many people from access to information. As a result a resource centre was started at the Ugandan NEMA offices in Kampala to encourage education, individual responsibility for the protection of the environment and public awareness. A directory and meta-database of experts in the environmental domain and national institutes involved in environmental management was developed. Information was donated by UNEP, UNDP and world resource institutions and consequently usage of the centre grew.

The UNEP noted that environmental issues were best handled through *public participation* and access to information was considered a critical empowering factor in efforts to eradicate poverty and improve management and governance of the environment. Project leaders encouraged problem solving participation and decision making based on sustainability and environmental justice. Television and radio coverage of the system improved the knowledge base of the public by broadcasting in local languages, but employing the media was often a financial impediment. Thematic maps with answers to frequently asked questions were created to enhance public awareness. Yet, users still alleged that the information at resource centres was aimed at literary levels higher than their own.

Good governance at national level through the Ugandan NEMA implementation supported and orchestrated the project together with financial and technological assistance. The UNEP**,** UNDP and the World Bank provided the necessary data. However, it was found that authorities at district level had an autonomous approach and were reluctant to support the collation of environmental information as they were sceptical of the dividends at local level. They were sceptical that costs were felt at local level, but benefits at national level. To ensure long term sustainability, users of the project had to collaborate with policy makers. The following section highlights critical issues that were faced during the Uganda project.

2.4.1.2 Critical issues encountered during the Uganda project

This section highlights critical issues encountered during the Uganda project that was obtained from the project report by Gowa (2009) and that should be considered in future implementation of

GIS usage to support and monitor environmental policy development. One of the main challenges was that involved parties in the environmental domain assumed that the public understood the usefulness, relevance and applications of their work, whereas the public felt excluded.

Furthermore, at local level there was a lack of capacity, lack of software and non-functional equipment. Capacity of computer disc space was too limited for analysis and there was a lack of output devices such as plotters, printers and software. Heavy duty programs needed for image analysis and other GIS work could not be installed or ran very slowly. Staff turnover was high and skills gaps were created due to lack of training. In conclusion, due to the lack of knowledge management, recommendations were made to employ a committed GIS manager in future and to develop an action plan for financial sustainability. In the following section the second case study is examined.

2.4.2 Case study: Senegal

The report on the Senegal case study is an Elsevier publication supported by the United Nations Educational Scientific and Cultural Organisation (UNESCO) and the Ecole Polytechnique Federale de Lausanne in Switserland. This case study is introduced by Repetti et al (2006) as a 'software system monitoring urban functionalities' (SMURF). SMURF supports participatory planning and management in African cities using participative GIS models and communication technologies to support public participation. It is a software instrument that consists of a geographic database and spatial indicators for sharing information, editing information and evaluating city development. In this section the SMURF case study is introduced, followed by discussions of challenges and opportunities that emerged during the project in Senegal that relates to the sub-themes of this thesis. In conclusion, critical issues encountered during the SMURF project are highlighted to potentially consider in future GIS usage for projects in countries in transformation.

This case study involves a specific computerised GIS application with indicators for monitoring urban functionalities and supporting participatory strategic planning in African cities with scarce financial resources. The project was set in Thies, Senegal against the background of urban sprawl in underdeveloped nations where local governments often lack the resources to manage the complexities of socio-political behaviour. Participative GIS models with indicators for land auditing and monitoring was used to unite technology, information, knowledge and participatory decision making.

The SMURF project is web-based and complements collaborative and participatory strategic planning approaches to urban management as maps in which multiple layers for information integration and multi-criteria analysis are presented. It was created to evaluate development suitability of the geo-environment for land-use categories including buildings, waste disposal and nature conservation. The software instrument consisted of a geographic database and spatial indicators for

sharing and editing information and evaluating city development. Data on current projects in the land use related database was structured into digital images, land information, urban development projects as well as data on local stakeholders and GIS users. The interactive GIS mapper was aligned to the users' needs, their level of computer skills, local infrastructure and data quality.

The SMURF application was installed in thirty computers in the urban area including the local and regional administrative services, NGOs and a cyber café for public access. Basic viewing and editing as well as interactive indicators were constantly improved by simplifying the interface functions to ensure that it was user-friendly and it was also supplied with a user manual. Data updates were collected from SMURF users, errors were controlled and the data modification information was presented once or twice a year. The aim of the application was not to reduce the complexity of urban management, but to offer an interactive tool to provide assessment monitoring, comparisons, communication and knowledge to decision makers.

The SMURF interface offered visual elements such as a graphic window for displaying maps, aerial images and spatial data, tools for handling the graphic window and information display, a menu for digital image management and spatial indicators for land use, property ownership and zoning for land auditing and monitoring. In the next section challenges faced during the Senegal project are summarised and highlighted by displaying the topic in italics. As mentioned before, these topics reflect on the subthemes of this research study.

2.4.2.1 Challenges and opportunities encountered during the SMURF project

SMURF was designed as a platform for *knowledge management* and information exchange as well as a decision-support tool that uses measuring elements to help users locate themselves in the environment (aerial images, maps, roads, squares and waterways). A participative forum of consultants managed the knowledge exchange platform at local scale.

The SMURF GIS application provided powerful tools for facilitating *informed decision making* as data storage, consultation, editing and structuring. However, decision makers and stakeholders had to create and update the data. The outcome of the project demonstrated that the potential for sharing information about land-use exchange resulted in improved and coordinated decision making and motivated users to update the database.

The SMURF application encouraged *commitment by involved parties* by designing the application for users with limited computer skills. A user guide and training sessions contributed to its usability. Through analysing the users' reaction, the application was constantly improved by simplifying the interface buttons and functions.

Public participation included participative appraisal, participative information collection, participative mapping, development forums, participative scenarios evaluation and public meetings on and through the system. Participative engagement between stakeholders, assessment, monitoring and controlling functionalities lead to continuous improvement of this project as well as other development projects.

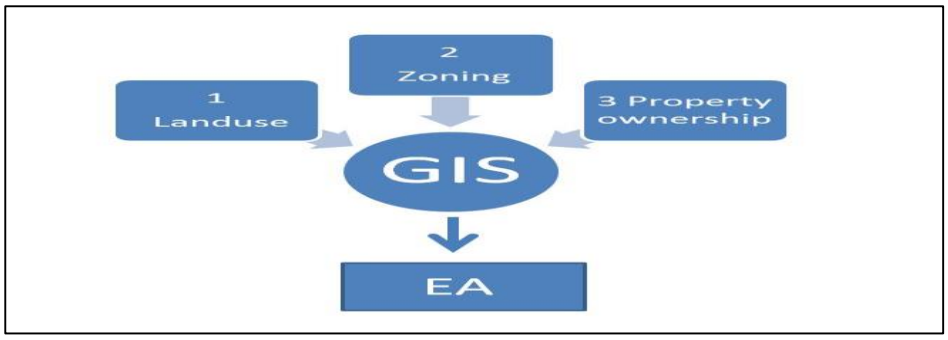
Good governance was encouraged to empower users to increase their political influence on urban management in the city. The forum management was chaired and supervised by the city mayor who also managed the data update. Management at district level responsible for urban planning and management were technically competent; however, local governments struggled with their leadership role due to their reluctance to share decision making responsibilities, lack of technical skills and lack of human resource capacity. The following section highlights critical issues encountered.

2.4.2.2 Critical issues encountered during the SMURF project

The following critical issues encountered during the SMURF project are deemed relevant by this research to be considered in future development and implementation of web-based GIS usage in EIA. Firstly, it was found that the interactive data viewer was the most frequently used mode of information and served as support for *knowledge management* to inform stakeholder discussions and decision making and was also used for the design of ground-projects.

Furthermore, usage by unskilled GIS users was limited to data viewing functionalities. However, some technicians who had a good understanding of the situation, analytical skills and knowledge of urban planning successfully used the statistical values and thematic map indicator functionality. As in the Uganda case study, local priorities took preference with the result that forums were organised infrequently or truncated and there was a need for alternative GIS solutions adapted to developing countries where there is often a shortage of resources, lack of computer skills and low quality of available information. Furthermore, some officials retained information and were reluctant to allow and share easy access of official data with the public for fear of loss of political leverage and the apparent need to retain information about informal or illegal activities.

In conclusion, the success of this project was found to be dependent on the political willingness to implement collaborative management processes between authorities and other involved parties. Figure 2.1 below presents the three most important variables that emerged as the frequently used mode for knowledge exchange in the interactive data viewer of the SMURF project.



Source: Rashmin (2004)

Figure 2.1: The most important GIS variables used for evaluation during the SMURF project

The most frequently used mode for knowledge exchange in the interactive viewer was land use and administrative limits (zoning) as well as property ownership. This is significant as it means that when involved parties share information about only three variables there is already beneficial impacts on informed decision making. As specified in Figure 2.1, the information from these indicators are made available through GIS usage to decision makers for informed environmental management and impact assessment decision making. In the following section a case study of the SANBI project is presented.

2.4.3 Case study: SANBI Biodiversity GIS

The SANBI Biodiversity GIS (BGIS) is a web-based project hosted by the Department of Biodiversity and Conservation Biology at the University of the Western Cape (UWC) and managed in collaboration with Cape Nature, the Botanical society of South Africa, DEA&DP and the city of Cape Town, the Department of Water and Forestry (DWAF) as well as the Western Cape Department of Agriculture. In this section SANBI's Biodiversity GIS project is presented together with challenges and opportunities and critical issues that have been encountered during this project. The reason for selecting this case study to present the benefits of GIS usage in EIA is that it relates to this thesis as it was also developed to bridge the gap between science, policy and decision making (SANBI 2011).

The BGIS project has been operational for eight years and is regarded as an international flagship in the GIS domain (Terrapon 2011, Pers com). BGIS assists biodiversity planning and decision making through accessible and comprehensive spatial biodiversity information. Tools are provided for interactive mapping and analysis of available biodiversity data. The map component provides users with quick access to the interactive GIS project maps available on the BGIS website. The web site is compatible with Internet Explorer and interactive map viewers are available at www.bgis.sanbi.org (SANBI 2011).

The BGIS Advisor tool was developed as an aid to the decision making process at early onset in the development project during the screening process as well as during the orientation, contextualisation and investigation stages of EIA. It aims to provide information on defining and describing the EIA process and how to go about undertaking an EIA. It is said that this tool currently holds 11 million biodiversity records which can be used in the EIA process by channelling the user to comprehensive and effective information that is relevant to the particular development project (SANBI 2011).

A Species Distribution Modelling Tool is part of the BGIS Advisor. Users are mainly EAPs and biodiversity specialists and all information is said to be peer reviewed to improve the quality of data available on biodiversity records. This system facilitates the development of a comprehensive set of biodiversity datasets for South Africa and allows for pattern and process identification where EIA is undertaken to facilitate cumulative impact monitoring.

Critical Biodiversity Areas (CBA) maps aim to guide sustainable development by providing a synthesis of biodiversity information to decision makers. CBA maps available from www.biodiversityadvisor.sanbi.org are designed to indicate efficient election and classification of land for safeguarding of national biodiversity thresholds (SANBI 2011). The next section summarises challenges and opportunities faced during the SANBI project.

2.4.3.1 Challenges and opportunities encountered during the SANBI project

Brief descriptions of the challenges and opportunities that emerged from the SANBI project that are pertinent to the sub-themes of this thesis are presented in this section. In terms of *knowledge management* BGIS allows users to perform basic spatial analysis. Standard as well as advanced tools and tabs allow users to interact, draw, add text, add grids and email manipulated maps to other users, save maps, extract data from shape files and upload data. The website also allows users to contact SANBI online at bgishelp@sanbi.org.

SANBI's web-based tools were designed to exchange information about the biodiversity of South Africa and SANBI's constraints maps are used by EAPS, NGOs, specialists, case officers and competent authorities to *inform decision making*. SANBI holds workshops to gain understanding of the format, presentation and type of information BGIS users require.

SANBI works closely with DEA&DP and DEA to create a platform for *commitment by involved parties*. The BGIS website is available online and developers designed the tools to be user friendly. BGIS courses are held at the University of the Western Cape (UWC) to educate involved parties in the environmental management and GIS domain of Google, BGIS and GIS applications. Furthermore, the SANBI BGIS projects are often exhibited at conferences to raise awareness of environmental

management and all information is available online and on the interactive web-base for easy access by I&APs for authentic *public participation*.

In terms of *good governance*, SANBI's GIS tools are aligned with local, regional and national government requesting new strategies and tools to assist the current EIA process. SANBI's CBA maps are used by many parties in EA. The BGIS project was introduced at the 2011 International Association for Impact Assessment (IAIA) conference in Mexico and representatives from India showed interest in acquiring BGIS information and knowledge to implement similar projects in India and South East Asia (Terrapon 2011, Pers com). A summary of critical issues are follows.

2.4.3.2 Critical issues encountered during the SANBI project

This section highlights critical factors encountered during the SANBI project that should be considered in future development and implementation of GIS usage in EIA. The information that follows was collected during numerous conversations at the time of gaining insight for the secondary data sourcing phase of the study and it is included as part of the scholarly review in this chapter although it correlates with the findings of the primary data collection.

A primary concern is that users say that maps of critical biodiversity areas (CBA) are not always compatible with non-SANBI maps and the CBA maps and land use change maps have not been updated regularly since it was developed in 2009. Updating CBA maps is very costly and time consuming, so all information cannot be expected to be current all the time. However, the problem is that BGIS is a desk-top application and supporters in government positions have been known to insist on making use of CBA maps in the EIA process and users who are often in positions of decision making such as case officers, are less likely to go to the site of the development project if they can use the virtual application.

Should land-use information not be current, decisions could be made on incorrect information and a development project could wrongly be approved or rejected. A disclaimer is added to the website stating that the CBA maps and handbook is not guaranteed to be free from error and omission. Users are recommended to do site inspection as part of the screening process to ground truth data. Additionally, limited bandwidth slows down the user friendliness of the application.

Ralston et al (2009) presented a paper on fine-scale systematic conservation plans (FSCP) and its contribution to EA in order to demonstrate the benefits and challenges of FSCP or CBA maps for EA based on recent experience in the Western Cape. CBA maps are used for Spatial Development Frameworks (SDF) and Environmental Management Frameworks (EMF) as well as environmental authorisations.

A red-flagging option provides a strategic overview of the biodiversity of the proposed project for ecosystem scale assessment and potential impacts. In the following section government initiated projects that deploy the collaboration of GIS usage in EIA are presented, in particular the DEA EIA-GIS system, the DEA NEAS and the EIAMS knowledge and information project.

2.5 GOVERNMENT INITIATED PROJECTS RELATED TO GIS FOR EIA

At commencement of the research, literature on GIS usage in EIA decision making in practice was limited. However, concurrently to this research process there are many research and development projects that deploy the collaboration of GIS and environmental decision making in South Africa and globally. In this section, the DEA EIA-GIS system; the DEA NEAS system and the EIAMS knowledge and information project are briefly described.

2.5.1 The DEA EIA-GIS system

The Department of Environmental Affairs (DEA) is currently developing an EIA-GIS decision support system in South Africa. Its purpose is to visualise useful information and identify geographical areas of national importance particularly focussing on current EIA regulations (Government Notice (GN) no. R.543) that released as draft versions by DEA&DP in 2010 and 2011 and formally published with the concurrence of the national Minister responsible for environmental affairs in terms of Section 24J of NEMA (Act 107 of 1998). Listing Notice 1 (GN No. R.544), Listing Notice 2 (GN No. R.545) and Listing Notice 3 (GN No. R.547) are also included in the DEA EIA-GIS system in the Listing of Activities and Competent Authorities identified in terms of Section 24(2) and 24(d) in Listing Notice 3 (Western Cape Government DEA&DP 2013). According to the DEA (2011) and Oosthuizen et al (2011) spatial information related to proposed development projects can be collected and displayed on the DEA EIA-GIS system featuring environmental attributes, spatial and non-spatial attributes as well as relevant policies and guidelines. One of the main challenges in implementing such an EIA-GIS support system is to augment an effective GIS Viewer. A viewer needs to be easy to use, have good information that is current and relevant, be linked to metadata and have the required IT capacity including bandwidth. Furthermore, all users would not need access to ArcGIS (GIS software) to access information from maps (Anonymous GIS expert involved in EIA 2011, Pers com).[3]

[3] A GIS Viewer allows users without GIS software on their computer to view and print maps created in GIS formats. Some types of these Viewers can also contain tools for map editing and spatial analysis. A Viewer is useful for people to view, print and share maps, but not generally responsible for editing them (Wisegeek.com 2014).

2.5.2 The National Environmental Assessment System

The National Environmental Assessment System (NEAS) is an electronic system that was initiated by DEAT in 2004 to be used to capture and process EIA applications, generate environmental reports and Record of Decisions (RoDs). It serves as an e-government solution to provide involved parties with access to track the progress and status of environmental applications submitted. The latest version, NEAS III, captures EIAs for NEMA 2010 Regulations. Currently it serves as a database. However, functionalities such as status reports and decision support applications still need to be finalised (SANBI 2011; Oosthuizen et al 2011).

2.5.3 Environmental impact assessment and management strategy

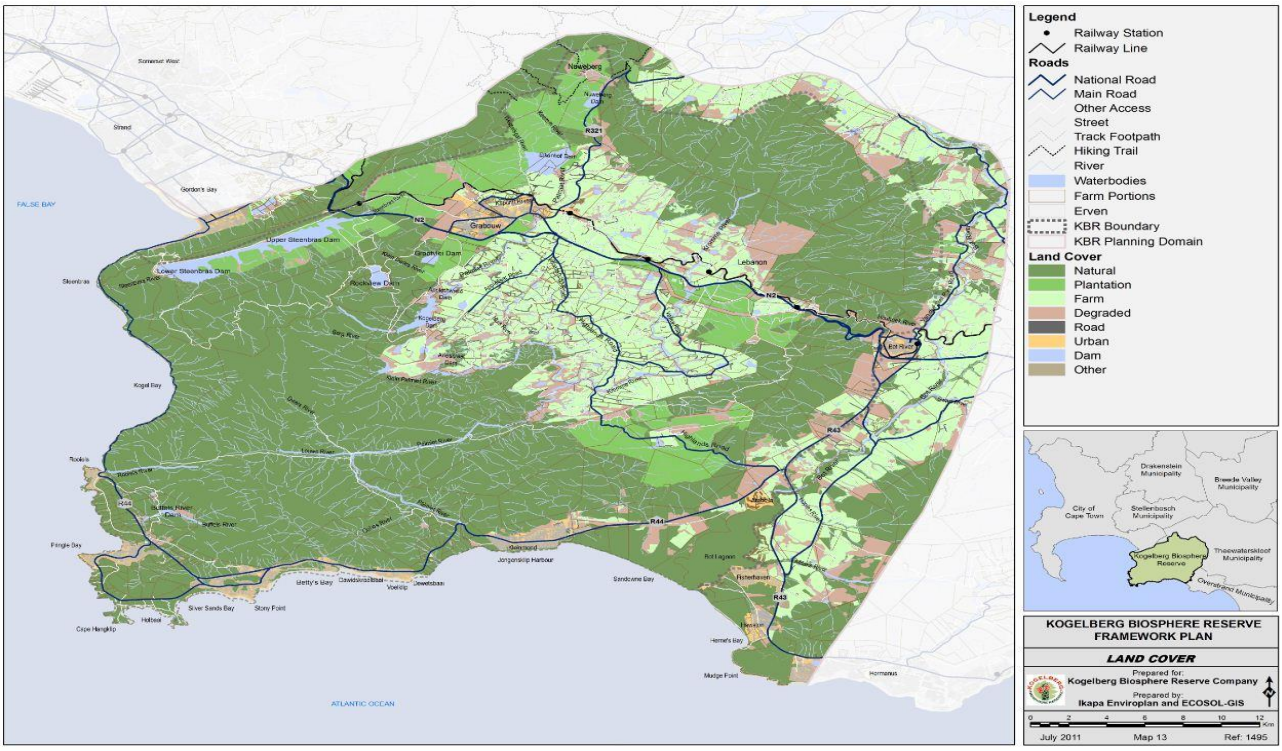
The Environmental Impact Assessment and Management Strategy (EIAMS) project was initiated by the DEAT steering committee based on the outcome of workshops related to EIA shortcomings at the EIA conference in 2008. The DEA employed EIAMS consultants to investigate the role of knowledge and information in EDM in South Africa to ensure information is effectively managed and disseminated, data is efficiently stored and accessible, knowledge is advanced and capacity is available to competent authorities (Oosthuizen et al 2011).

In the DEA, the requirement for GIS usage is to firstly manage spatial data for sectors for which DEA is the custodian, such as waste, heritage site and tourism management. Secondly, GIS usage is required to support strategic business such as maintaining the vegetation maps of South Africa, Lesotho and Swaziland and related SANBI maps. Thirdly, GIS usage is to provide spatial analysis and map production facilities for state of the environment reports, the 'environment' being an area of concurrent national and provincial competence (DEA&DP 2010). The GIS function provides spatial data through Internet and intranet portals (Oosthuizen et al 2011). In concluding this chapter, maps are graphically displayed in the next section to support the value of GIS usage for EDM.

2.6 GIS MAPS TO SUPPORT THE FEASIBILITY OF GIS USAGE IN EIA

All involved parties should have access to maps using GIS to facilitate visual knowledge of relevant information to inform decision making. GIS maps of the Kogelberg Reserve were recently produced with updated and groundtruthed information that includes detailed images of CBA, land cover, cadastral and municipal areas as well as land use. In Figure 2.2 an example of a GIS map focusing on land cover variables is presented. The variables visible on this map include the following land cover options: natural veld, commercial plantations, farmlands, degraded land, roads, urban uses, dams and an open 'other' class to inform decision making. The figure indicates that the technology, skills and capacity exist among geospecialists within the geographical scope of this study to produce GIS

mapping to present the relevant information, such as this map showing land cover to a fair level of detail, to authorities for informed decision making.



Source: Ikapa Enviroplan and ECOSOL-GIS (2011)

Figure 2.2: GIS map of land cover for the Kogelberg Biosphere Reserve Framework plan

Source: Dennis Moss Partnership (2011)

Figure 2.3 GIS map showing alternatives in site selection of a proposed project

The map presented in Figure 2.3 is used by consultants for in-house screening, constraints delineation, alternative site selection and compliance with mitigation planning to inform effective decision making. Maps such as these, together with Google images of site specific information, provides a platform to enhance users' visual environmental intelligence and potentially ensures that everyone has access to the same information.

In concluding this chapter web-based communication techniques based on electronic and digital tools were found to have the potential to inform interactive decision making and the benefits of web-based GIS usage in EIA include easy access to information, education in citizen literacy, knowledge exchange, education, stakeholder engagement, effective public participation and informed decision making. Challenges were also presented such as lack of capacity and skills as well as dubious intent by certain EIA uses and problems of corruption and lack of transparency perceived to occur in countries in transformation.

However, it is evident from the literature studied that these challenges could potentially be successfully addressed and that the skills and technology are available for GIS usage in EIA, as proven by the GIS maps displayed above. GIS usage was recommended as a useful approach in informed EIA in terms of systematic identification and evaluation of potential impacts in site selection, evaluating of trade-offs and mitigation of negative impacts. In the light of the outcome of this scholarly review, web-based GIS usage in IEM was deemed a feasible solution to facilitate the disconnection between theory and practice in the EIA process. Chapter 3 follows as a dual study of EIA and GIS as spatial management tools and the feasibility of GIS in EIA is examined against the background of the origin of the EIA and environmental legislation based on IEM sustainability principles.

CHAPTER 3: UNITING EIA AND GIS AS SPATIAL MANAGEMENT TOOLS

"Information technology is the canary in the mine and is setting the scene for change. It is very relevant to economic sustainability as well as social and cultural life"

Hearn & Pace (2006)

Current discourse in the integrated environmental management (IEM) domain recommend that the environmental impact assessment (EIA) process be made applicable to a broader context of non-project activities and focus on a more holistic emphasis of impacts and trade-offs so that development projects would profit a wider spectrum of beneficiaries. This is due to opinions that the current EIA process is constrained by analytical and administrative shortcomings and limited by spatial as well as temporal dimensions that impede its ability to analyse impacts beyond project specific and simple cause-effect relationships. In this chapter GIS technology is examined as it sets the scene for change in environmental decision making (EDM).

This chapter presents a dual study of EIA and GIS. The EIA concept along with a diagram of the timeline of the origin and development of EIA in South Africa is presented together with a graphic illustration of the current EIA process and the role of EIA as it relates to the IEM sustainability principles. In addition, the characteristics and functionality of GIS and web-based GIS usage is presented as part of a feasibility investigation to find solutions to EIA shortcomings and to inform EDM in the IEM domain.

3.1 EXPLORING A DUAL STUDY OF EIA AND GIS

EIA and GIS are the main themes of this study and are also symbolic of the vertical pillars in the GIS for EIA model that is presented in Figure 1.2 in Chapter 1 and in Figure 5.1 in Chapter 5. EIA represents policy and people represent the involved parties that participate in the EIA process and in IEM. GIS represents technology as the potential solution for effective EIA. Both EIA and GIS are innovative tools developed for the critical analysis of the spatial and non-spatial attributes of environmental management as well as for monitoring the interrelationships between human behaviour and natural resources (Marsden 2005; Jarvis 2007).

During the research process it became obvious that involved parties participating in mandatory processes such as Basic Assessment (BA) and Environmental Impact Assessment (EIA) need the capacity to evaluate and monitor risk as well as the capability to effectively use and understand spatial

information needs. In addition, regulatory processes need to be integrated and coordinated between organs of state. Moreover, participants in the business world need to make decisions under time and financial constraints and decision makers should have access to information that do not generally require reading lengthy documents (DEAT 2004a; IAIASA 2011; Mabudaphasi 2011; Theron 2011, Pers com).

The aim of seeking solutions to shortcomings in the EIA process is therefore not necessarily to approve more project development proposals, but to inform EIA decision making towards effective, efficient, timely and consistent EIA processes in practice (DEAT 2004a). Concurrently to the challenges experienced by users of EIA, the role of scientific expertise such as web technology and modern communication systems to support salient environmental issues are at the centre point of transdisciplinary research and features prominently in strategic planning for effective IEM and EIA (Van der Merwe 2009).

Through transdisciplinary integration, platforms for knowledge exchange has been developed and institutionalised. Examples of such applications include Google Earth technology and comprehensive observational networks that can predict, pre-empt and personalise earth system information for the sustainable use of environmental resources. GIS usage integrates science and modern technology to provide a platform to develop environmental management and compliance monitoring capacity. Such a platform could function as a one-stop stage for knowledge management of relevant information for multi-criteria evaluation (MCE) to be communicated to involved parties during the full life cycle of the EIA process related to a proposed project as well as for strategic development framework plans and environmental management plans. GIS has the potential to communicate relevant information related to georeferenced locations such as site maps, land use and land cover data as well as baseline information of the project to all involved parties (Van Niekerk 2008; Chang 2010).

According to the IAIASA (2011) implementation of new procedures such as a GIS usage in EIA decision making would require involved parties to be committed to meet the accelerated pace of change in the IEM domain to enhance and complement the current EIA process. Change in this context refers to transformation in the natural environment, planning for environmental risks and global environmental change, changing legislation and new policies. To effect change management, effective knowledge management and technology need to be incorporated into current frameworks and processes.

GIS consists of three concepts, namely the individual (cognitive science), the computer (representation, computation and visualization) and society (societal impacts). Non-professionals use GIS in everyday life to find a location and for navigation. Many professions uses GIS applications

for decision making, but to become a GIS professional the basic concepts of the technology needs to be understood.

GIS is used in natural resource management such as land use planning, environmental impact assessments, risk management, weather service provision, community mapping, crime related spatial pattern analysis, site specific agricultural planning and practice, site selection for infrastructure development, interactive mapping and many more industrial applications (Longley et al 2005). Therefore involved parties in EIA using GIS would be exposed to the practical collaboration of relevant transdisciplinary information that would potentially lead to increased literacy, learning and better understanding of environmental management and impact assessment (Marsden 2005; Walmsley & Thipala 2007; Brown 2009; Murtugudde 2009; Seto & Shepherd 2009).

3.2 INVESTIGATING THE ORIGIN AND INITIAL DEVELOPMENT OF EIA

Lee & George (2000) suggested that the origins of the EIA have come back to haunt its present day proponents in developing and transitional countries where bureaucracy often slows down the purpose of the process. To investigate the reasoning behind that statement, this study explored the origins of the EIA process.

Initially EIA was designed to warn involved parties of impending environmental effects such as pollution and was applied relatively late in the project cycle after design decisions had been made. In the context of development projects in developing countries in the 1980s, the process was mostly donor driven and conducted by expatriate consultants. Despite constraints due to the absence of general environmental policy, lack of political will and authoritarian political systems, individuals fought for suitable and sustainable management methods and the mitigation of negative impacts (Sowman et al 1995; Sadler 1996 in DEAT 2004b; Max-Neef 2005).

It emerged that EIA originated out of awareness and planning surrounding the environmental movement in the 1970s. At the time, the EIA discourse was raised to global prominence with the Stockholm conference, the enactment of the United States Environmental Protection Act (EPA), the Brundtland report in 1987 as well as Agenda 21 and its sustainability principles in 1992 (Lee & George 2000). A timeline of the evolution of the South African EIA process is presented in Table 3.1 to explain the development of EIA followed by discussions related to the theory and practice of EIA.

Table 3.1 simplifies the development, evolution and implementation of EIA in South Africa. It shows progress from initial recognition of biophysical impacts of development to the steady practical and enforced implementation of rigorous and eventually legal prescriptive measures and methods to

ensure the professional assessment of development and that negative impacts are forestalled before development takes place.

Table 3.1: A timeline of the EIA development process in South Africa

PERIOD	INTEGRATED ENVIRONMENTAL MANAGEMENT (IEM) TOOLS: EIA
1970s	EA focussed on biophysical impacts and cumulative impact research.
1980s	EIA a voluntary tool in South Africa; included social assessment, economic analysis and risk analysis.
1990s	EIA became part of initial efforts to address cumulative effects. Sustainability principles received attention. SEA emerged as a tool for addressing environmental management issues in policies and plans. South Africa received international recognition as EA expanded to include cumulative effects. NEMA (Act 107 of 1998) came into effect as South Africa's national environmental legislation 1/1999 and the EIA process became a mandatory tool of impact assessment.
2000s	In 2004 and 2006 NEMA amended with new EIA regulations. Basic assessment introduced to streamline and fine-tune the process (provincial departments under-resourced). Under the new regulations small non-destructive projects fast-tracked and big projects given more attention. EAPs to prove their independence in the process. Activities with potential impact on the environment listed in Regulation 386 and 387 in NEMA (Groenewald 2004a).
2010	NEMA amended for seventh time (NEMA 14 of 2009) and EIA regulations updated in 2010. EAPs given more responsibility, for instance to decide whether a project requires BA or EIR. Listing notices changed to Listing 1, 2, 3. Any I&AP may register to take part in public participation process as constitutional right and *locus standi* no longer required. Time frames for I&APs to respond increased. Call for new strategies and tools to facilitate the process.
2011	GIS maps increasingly considered in practical implementation of EIA process. In terms of integration in IEM, the Waste Act (Act 58 of 2008); Air Quality Act (Act 39 of 2004); Integrated Coastal Management Act (Act 24 of 2008) and Biodiversity Act (Act 10 of 2004) all use the same EIA process for decision making purposes (DEA&DP 2013).

Source: Adapted from Mitchell 2001 (2001)

In the 1990s environmental issues took centre stage in the sustainable development debate and highlighted the need to incorporate environmental concerns into development processes. As a result the public became more environmentally conscious, governments reacted by developing environmental policy and EIA became the mandatory tool of the National Environmental Management Act 107 of 1998 in South Africa. Environmentalists finally felt they had the means to not only suggest constraint, but a tool to keep developers in check and to encourage environmentally suitable development (Groenewald 2004a).

Mitchell (2001) and Lee & George (2000) recommend that the EIA process should be allowed to develop through a process of evolutionary maturation or else as a reaction to the shortcomings of EIA theory and practice. Furthermore, Mitchell (2001) suggested that EIA should incorporate more social, economic and cultural considerations into projects, programs, plans and policies towards a balanced approach to strengthen EIA.

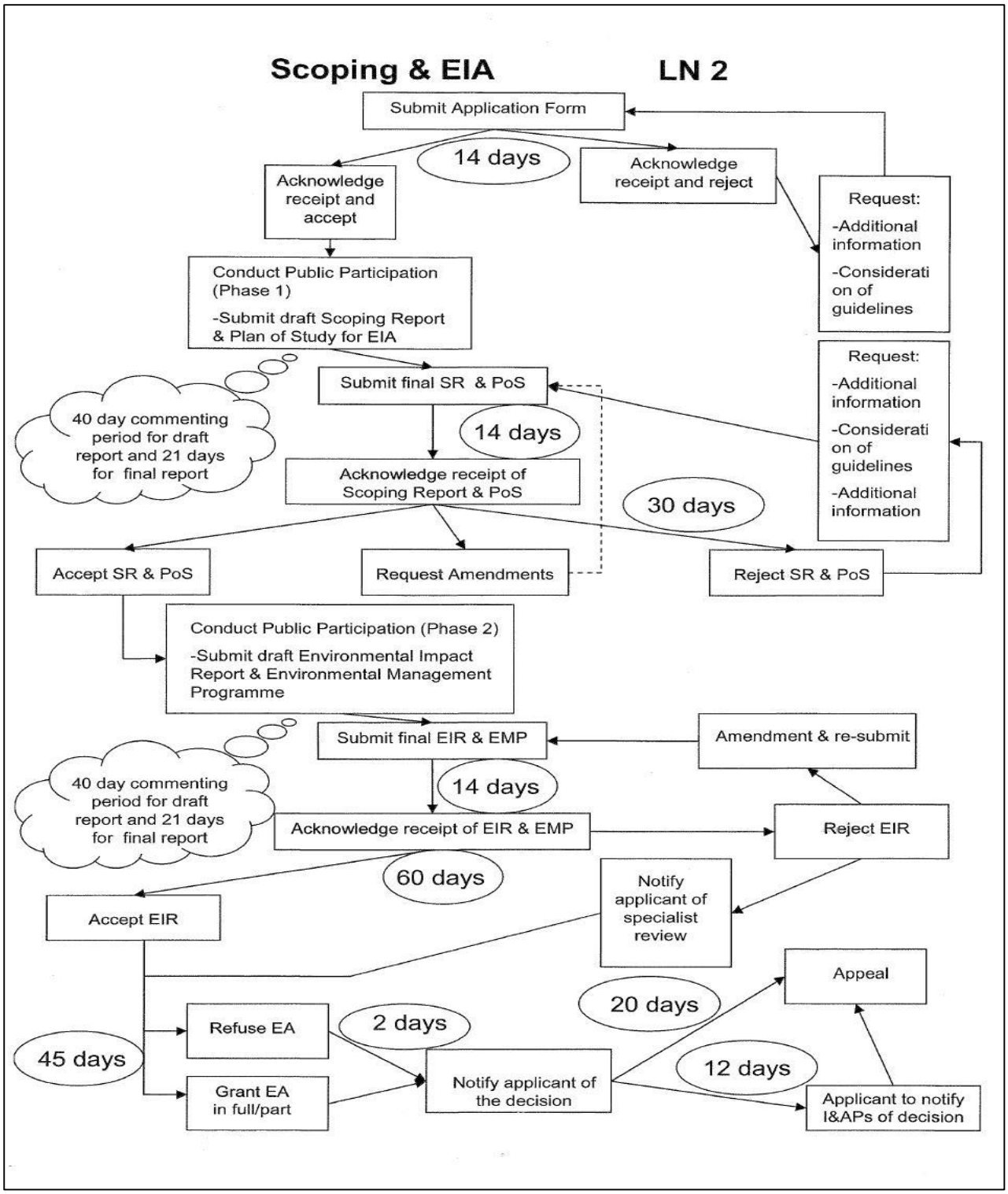
3.3 INSPECTING THE CURRENT EIA PROCESS

EIA is a public process that was initially developed as an approach to bring the law closer to the people and to give effect to the environmental right enshrined in Section 24 of the South African Constitution of 1996. Therefore the original purpose of EIA was to aid policy formulation and planning. It was not to be a technical process divorced from the needs and priorities of communities, but to provide a positive, interactive approach that could easily be understood by non-specialists as a guide for the development process (LEG201 2006; CSIR 2007; UEMP 2009).

However, from expert opinions it is apparent that the current EIA process in South Africa focuses almost entirely on the bio-physical environment. It should rather maximise socio-economic outcomes while ensuring ecological integrity and addressing the triple bottom line of ecological, economic and social issues (Lee & George 2000; Mitchell 2001; UEMP 2009; Zille 2009; Mabudhafhasi 2011; DEA&DP 2013).

Certain involved parties benefit from the process, but for others the EIA is still limited by its image as a separate, stand-alone technique to sanction growth at project level that is only vaguely connected to the project cycle. On the other hand, the EIA has become an accepted part of project planning and can be a framework for implementation of sustainability principles. Furthermore, EIA has the potential to help involved parties consider the real trade-offs and best practicable environmental option involved in the practical implementation of sustainable development practices (Sowman et al 1995; Lee & George 2000; Mitchell 2001; DEA&DP 2013).

The current EIA process, in compliance with the latest amended version of NEMA, is diagrammatically portrayed in Figure 3.1, upon which this narrative elaborates. EAPs have to declare their independence and decide whether the proposed project requires Basic Assessment or EIA authorisation according to listed activities.



Source: DEA&DP (2013)

Figure 3.1 Diagrammatic portrayal of the current EIA process

Figure 3.1 demonstrates the opportunities where the EIA process in practice could be facilitated by GIS usage to enable more effective EIA. The process is presented as a systematic sequence of steps involving interrelated stages in completing the entire process and operates within the limits of time, cost, information and resources (IAIASA 2011).

The decision whether an EIA should be done needs to happen at pre-feasibility and feasibility stages to avoid delays and wasted expenditure as the EIA process takes time. Listed activities appear in regulations referred to as Listing Notice 1, 2 and 3 and also apply to applications for environmental authorisation in terms of Section 24G of NEMA (Act 107 of 1998). If the activity falls within Listing Notice 1 and 3, the activities are subjected to a basic assessment (BAR). Should the activities fall within Listing Notice 2, the project activities are subjected to scoping and EIA (DEA&DP 2013).

Environmental impacts are assessed in advance by focusing on prediction and prevention of adverse impacts before permission is granted for the project to proceed (Rampedi & Joubert 2007). Lee & George (2000) suggest that the EIA process needs an institutional framework to suite the specific conditions in South Africa. Amendments, suspensions, withdrawals, exemptions and deviations to the EIA process may be applied for according to the policy requirements. There are 8 basic stages of the EIA process. In accordance with DEA&DP (2013) these stages are mentioned and briefly explained below:

- Screening: decision making related to level of assessment, i.e. BAR or EIR.
- Scoping: decision making regarding issues that need to be addressed, consideration of alternatives and the terms of reference for specialist studies.
- Specialist studies: assessment of potential impact significance and recommended mitigation.
- Integration and assessment: a report of recommendations made including input from I&APs.
- Public participation: occurs throughout the process where the public presents their views.
- Authority review and decision making: the competent authority reviews the final report and grants or refuses authorisation with conditions and reasons.
- Monitoring: compliance with EA conditions to assure assumptions made in EIA were correct.

In compliance with the intent of EIA legislation, time frames need to be strictly adhered to by involved parties such as EAPs and consultants and should a time period of six months pass due to delays, the application becomes redundant. It is assumed that case officers generally attempt to stick

to time frames to give applications the approval to proceed. However, it has been reported that during the EIA process in practice such as the stage of approval of the draft scoping report, lack of decision making causes delays and compliance with the time frames have been known to be neglected (Anonymous involved parties 2011, Pers com).

3.4 EXAMINING THE SPATIAL FUNCTIONALITY OF GIS

In defining GIS and GI science the holistic objectives of GIS are presented as a solution to real-world problems. Longley (2005) suggests that science and practical problem solving has merged in the GIS discipline and consequently in the application of solution centred interdisciplinary teamwork. GIS is a combination of computerised cartographic systems that store map data as well as a database management system for attribute data. Inter alia, GIS facilitates calculation of areas and distances, construction of buffer zones, drawing of contour lines, superimposition of maps and identification of sensitive sites and constraints (Longley 2005; DEAT 2011). General knowledge and specific knowledge are combined in GIS to assist problem solving.

GIS applications are able to be both normative in assisting site selection and positive in forecasting the outcome of behavioural patterns. Forecasting involves predicting, analysing and modelling the spatial outcomes when consumers adapt to locational eventualities, like alternative retail sites or the erection of a nuclear waste storage facility nearby. Longley (2005) promotes GIS as it can assist in positive management decision making. Risk managers, for instance, analyse and compare annual flood predictions, archaeologists consider spatial events along time scales longer than the human lifetime and business managers may consider time-and-space factors for the operational and strategic direction of the organisation.

Longley (2005) also claims that GIS is in line with Newton's law of motion and Einstein's law of relativity. The law of motion states that all matter behaves in predictable ways. GIS assists land use decision making such as preferred transport routes by looking at behavioural habits of people. The law of relativity is applied in the sense that uncertainty exists and all predictions cannot be controlled even though GIS could be employed to anticipate flood risk and the efficacy of flood controls. Furthermore, the integration of knowledge and ongoing development of a database will allow for comparative re-evaluation of data to ensure results are sufficiently accurate to support informed decision making in a scientific manner (Heywood et al 2006). In the following section EIA and GIS are viewed in terms of the IEM principles that prescribe the code of practice for EDM. In the interest of readability, diagrams and brief descriptions of the anatomy and functionality of GIS usage are displayed in Appendix B for perusal.

3.5 REVIEWING EIA AND GIS IN IEM

According to Mosakong (2008) the primary purpose of IEM and EIA in South Africa is to focus more on implementing sustainable development by anticipating, avoiding, minimising and mitigating significant negative impacts on the environment and to focus less on the administration process. To enable better understanding of IEM and the current EIA process in South Africa, some important terms and concepts in environmental management and impact assessment are briefly explained. Environmental assessment (EA) is the broad global term for all forms of environmental assessment of the potential or manifested impacts related to development projects, plans, programs or policies. Proponents are required to comply with the top-down prescribed, legal requirements of assessments. Integrated environmental management (IEM) is the term comparable with the globally accepted term EA and was developed as a holistic bottom-up philosophy with principles that prescribe a code of practice for ensuring that environmental considerations are fully integrated by all sectors of society at local, national and global level for the full life cycle of the activity (Sowman et al 1995; DEAT 2004c).

The NEMA and IEM toolkit consists of the mandatory EIA as well as non-mandatory procedures such as the Cost Benefit Analysis (CBA); Social Environmental Assessment (SEA) and Cumulative Impact Assessment (CIA) that aim to integrate and implement the IEM sustainability targets effectively across all sectors of operations to facilitate responsible behaviour (Lukey 2008). In theory, South Africa's NEMA and IEM legislation is sound, in line with international best practice and supported by standards such as ISO9001 and ISO14001. However, there are weaknesses that require attention in the interest of sustaining ecosystems, natural resources, land-use and land development.

The key issue and challenge that leaders in IEM face is to regulate and guide human behaviour in the implementation of the EIA process in a way that promotes the achievement of the IEM sustainability principles (Rampedi & Joubert 2007). In the following section the IEM principles are presented in bullet point format to highlight how it relates to the EIA process in practice as well as its importance at the forefront of effective environmental management. In the bulleted paragraphs that follow, GIS characteristics are presented as a potential solution aligned to the shortcomings of EIA as it relates to IEM.

- The principle of *adaptive response* supports a flexible process and adjusts to the circumstances of the activities without compromising the process (DEAT 2004a).
- The principle of *rigour* can be linked to the standard of IEM tools and techniques available to industry as well as the best available technology used in industry (Lee & George 2000; Mitchell 2001; DEAT 2004a; LEG201 2006; CSIR 2007).

- The principle of *informed decision making* recommends appropriate methods and techniques to address crucial matters and provide relevant and current information for decision making. All involved parties should participate in the evaluation process to ensure optimal operations, greater interdisciplinary linkages and awareness of IEM to trade off the environmental, social and economic costs and benefits of development impacts (DEAT 2004a; CSIR 2007; Van der Merwe 2011, Pers com; Volschenk 2011, Pers com).
- The SA Constitution and NEMA are aligned with the *equity* principle as it stresses resource use efficiency, pollution control and international equity (DEAT 2004b).
- The intent of the *sustainability* principle is to support a standard of living where everyone has the right to an environment not harmful to their health or well-being and to have the environment protected for the benefit of present and future generations through reasonable legislative measures (DEAT 2008).
- The principle of *global responsibility* recommends due consideration for global and transboundary environmental issues.
- The principle of *holistic decision making* suggests engagement with people so that the needs and values of I&APs as well as all relevant forms of knowledge, including traditional knowledge, be considered.
- The principle of *environmental justice* implies that adverse environmental impacts should not unfairly discriminate against vulnerable and disadvantaged people (DEAT 2004b).
- The *precautionary* principle advocates that environmental risks require a cautious approach.
- All involved parties should be committed to the principle of *accountability* that applies throughout the EIA process and focuses on information, decision making and implementation. The information presented needs to be correct, accessible and comprehensible by a wide range of involved parties (DEAT 2004b; DEAT 2008).
- The *transparency* principle states that decisions should be made in a transparent manner, information must be provided according to the law and the public must participate in decision making to encourage trust and acceptance.
- The principle of *alternative options* recommends a decision making process of trading off environmental, social and economic costs and benefits of proposed developments where all involved parties participate in evaluating and exploring alternatives to minimise negative impacts of operations in order to ensure the best practicable environmental options (DEAT 2004b; CSIR 2007; DEAT 2008).

- The principle of *alternative options* also refers to suggested alternatives (including no-go areas) to the main proposal such as alternative locations, layouts and design so the public and authorities are not confronted by singular options.
- It is imperative for decision makers to have the capacity to make informed decisions as presented by the principle of an *integrated approach* where all environmental elements are inter-related and decision affect all components of the environment including all affected people.
- The *institutional coordination* principle supports synergy between environmental laws for pollution control, waste management, natural resource protection and land development (LEG201 2006; MacFarlane & Dunsford 2006; Bulman 2011).
- The principle of *stakeholder engagement* proposes meaningful and timely engagement between all stakeholders to contribute effectively towards the process of decision making.
- The principle of *dispute resolution* aims to reduce dysfunctional conflict and manage functional conflict.
- The principle of *continual improvement* of the environmental performance of an organisation relates to the commitment of involved parties in the EIA process.
- The principle of *community empowerment* promotes knowledge sharing and awareness raising of IEM. Involved parties need to participate at every step of the EIA process since the input of the whole community is needed when government cannot cope with all the environmental management and impact assessment challenges.
- The *polluter pays* principle requires suitable measures to calculate environmental costs of economic activity and the polluter bears the costs (DEAT 2008).

In comparison to the holistic view of the IEM sustainability principles, Mitchell (2001) describes the key limitations of the EIA process as its inconsistent application to development proposals by omitting sectors and activities as well as its operation as a stand-alone process and its inability to address cumulative risk factors. Solutions to these shortcomings in EIA include the need for effective strategic decision making frameworks to ensure effective screening of projects, less non-compliance and co-operative governance (Lee & George 2000; Rossouw et al 2004; UEMP 2009). Furthermore, users of the EIA process reported on the critical issues that emerged from the practical implementation of EIA. These issues were investigated and presented in the South African Country Report (DEAT 2005) as the need for development of a shared database for collecting, managing and tracking EIA applications.

Other requirements include the need for effective strategic decision making frameworks to ensure effective screening of projects, less non-compliance and cooperative governance (Lee & George 2000; Rossouw et al 2004; UEMP 2009; City of Cape Town 2010). In the following section the challenges and benefits of GIS applications are presented as it relates to the shortcomings of the EIA process in practice within the scope of this study.

3.6 EXAMINING GIS AS A SOLUTION TO ALLIGN EIA WITH IEM

Published research by experts on effective GIS usage and related literature is integrated with the sub-themes of this study to highlight opportunities offered by GIS to facilitate the EIA process in compliance with NEMA and aligned with the IEM sustainability principles. To recap, the sub-themes of this study have been selected as they are aligned with the shortcomings in the EIA process within the scope of this study and with IEM sustainability principles, so that effective use of them create opportunities for effective processes such as the EIA process.

A shared platform for information exchange is recommended for interrogation, analysis, forecasting and informed decision making with the potential to increase transparency of project activities and public awareness of impacts (Oosthuizen et al 2011). In the section below GIS usage is examined as a potential solution to the sub-themes of this study towards an EIA process.

3.6.1 GIS as a solution for knowledge management in EIA

GIS usage could encourage transdisciplinary knowledge exchange of salient environmental issues for just-in-time (JIT) solutions[4] in order to reduce negative impacts and increase positive impacts of the development on the environment and *vice versa*. According to Jarvis (2005) GIS data is based on formal information as well as entries in knowledge repositories. Information is all-important for GIS and more accurate information could provide the capacity to make better decisions. However, it is crucial that knowledge managers are aware of the meaning of the acronym GIGO (garbage in and garbage out) in the context of the profile of data quality and that too much information could cause data overload for the effective operation of information systems. Longley et al (2005) warn users of GIS mapping and geo-visualisation of the need to understand and manage the aims, objectives and strategies of the projects they are working on in order to reduce superfluous information.

[4] JIT is a strategy that strives to improve a business' return on investment by reducing in-process inventory and production costs, for instance through mitigation of negative impacts. JIT focuses on continuous improvement in quality and efficiency (Steyn 2008).

3.6.2 GIS as a solution for informed decision making in EIA

GIS technology for the management of environmental resources require increased bandwidth to enable greater diversity of data, since visual colour images, graphics and videos assist learning as visual and textual stimuli enhance better understanding of environmental impacts and optimal land use options (Marsden 2005; Brown 2009; Murthugudde 2009; Seto & Shepherd 2009). King & Stimson (2010) and Longley (2005) recommend GIS as the most significant contribution that geography can make to integrate human and physical science through cognition.

Therefore, web-based GIS usage could inform EIA by making it easy for all parties involved in the EIA process in practice to access information as well as organise, store, retrieve and apply knowledge. Furthermore, Van Niekerk (2008) postulates that Google Earth has the potential to create opportunities for users to interact with geo-technology in an intuitive way and that web-mapping tools allow users to visualise and learn about the environment in a user-friendly way that will lead to informed decision making. Together, users of EIA and GIS should promote the development of web-based GIS usage with the potential to comply with the IEM principles and inform the current EIA process as a platform for transmitting the relevant transdisciplinary information to support environmental decision making (EDM) in a problem solving environment.

3.6.3 GIS as a solution for commitment by involved parties in EIA

According to Engel-Cox & Hoff (2005), a visual image that retains its scientific integrity and clearly communicates a relevant and timely message may be the ultimate expression of the translation of data to information, knowledge and policy. GIS usage on an e-platform will allow stakeholders to commit to one overall process where all disciplines collaborate and work together rather than eclipse each other (Repetti et al 2006; Ralston 2009; Seto & Shepherd 2009).

The Internet and Google Earth operates as a platform for environmental education and spatial analysis of land use options to a wide audience including governments, the media, political organisations and the public. Consequently, expert knowledge in a well-defined field can become accessible to all involved parties if user-friendly tools are used to facilitate communication (Seto & Shepherd 2009). Furthermore, literature in the domain of spatial planning suggests that improved means of engagement between involved parties potentially raise the parity to which people participate in decisions which have a direct effect on their local environment and lifestyle. Web-based communication techniques with variables and attributes created by GIS effect benefits such as ease of access, citizen literacy, education, debate and participation to encourage commitment by involved parties (Foody & Curren 1994; Milner 2007).

3.6.4 GIS as a solution for authentic public participation

Longley et al (2005) claim that on global as well as local level, science and practical problem solving methods merge as a solution-centred discipline through interdisciplinary team work and interactive decision making. Authentic public participation requires communication technology that transcends time and space to allow for easy access with geographically dispersed participants to effectively address public challenges. Web-based GIS usage would provide users with access to project information, legislated regulations and potential impacts to ensure that all involved parties adhere to the process requirements (Bulman 2011).

GIS is also capable of comparative re-evaluation to enable the decision maker to evaluate options in a detailed and scientific manner such as finding a suitable site for the disposal of radioactive waste and evaluating the acceptability of opportunities for mitigation of negative impacts where many factors or multiple criteria have to be taken into account. These criteria include important citing factors, such as the storage facility that has to suite the local environmental factors, hydrology, population distribution and accessibility to the site. Comparative suitability maps informed by GIS can then be used for public participation, public enquiries and informed decision making (Rashmin 2004; Heywood et al 2008). Furthermore, authentic means of effective public participation could be provided by communicating and engaging in local languages, through visual images and ethnographic maps[5] that the public can relate to (Norris 2001; SDCEA 2008; Van Niekerk 2008; Bulman 2011).

3.6.5 GIS as a solution to encourage good governance

GIS usage encourages authentic public participation to deploy political will, mutual understanding and knowledge exchange to facilitate the EIA process and support the current urgency for tools and strategies to respond to a changing environment (IAIASA 2010). In most countries the bulk of geographic information is owned by governments as they are the major data providers and custodians. According to Functowicz & Ravetz (2008) there is often a crisis of trust and involved parties may be sceptical to engage in practices where official science and governance is revealed as incompetent or corrupt.

GIS usage has the potential to produce maps of relevant knowledge aligned with government policies and strategies and this platform of collaboration between involved parties such as government

[5] Ethnographic maps show the geographic distribution and spatial relationships between phenomena and objects of a local area identifying familiar features to local inhabitants that they can relate to. There are two types of ethnographic maps, namely ethnic and historical-ethnic maps. Ethnic maps provide a picture of settlement patterns of peoples in the present and past and historical-ethnic maps reflect various aspects of the life of peoples and characteristic features of their traditional material and non-material culture in a particular period. An EIA public participation process could focus on these facts to engage authentic public participation in South Africa (Bruk 1979).

and industry is an opportunity for cooperation and good governance. A good example of good governance was the data resource sharing and collaboration between the government of Western Australia, Geoscience Australia and industry at the 2010 Australian Petroleum Production and Exploration Association (APPEA) conference to share specialist knowledge of Hurricane Katrina and the BP oil spill in the US to study the impacts of these disasters for future risk preparedness (Hazell 2011, Pers com).In the following section, current projects that employ GIS applications globally and in South Africa are reviewed. The projects were based on criteria such as current literature and the collaboration of policy, technology, ecology, economics and impact assessment as well as examples where civil society endeavours to inform effective and timely decision making (Marsden 2005).

3.7 EXAMPLES OF PROJECTS EMPLOYING GIS FOR SPATIAL DECISIONS

In the final section of this chapter textual and visual examples are presented of the development of GIS usage that encourages and informs decision making in practice. Technology has moved into virtual worlds to provide new opportunities to involve people in spatial decision making. Developers of virtual reality models propose that these real world simulations combined with GIS give users a sense of experiencing a place first-hand and Vaughan (2010) claims that it gives users a certain sense of place[6].

3.7.1 GIS usage for computer games

Computer games and animation has entered the domain of global environmental management too. ‘Fate of the world’ is such a computer game that features data from real world climate models and input from scientists and economists in the US and UK. The game allows users to experience sustainability and pollution issues with no easy answers to which they have to make moral and ethical decisions (Vaughan 2010).

This author pursues the matter further in the geographical domain and suggests that enhancing GIS with virtual reality software has the potential to influence involved parties to interact as avatars[7] with virtual environments to explore particular issues at specific locations. Climate change experts concur

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[6] Sense of place is a combination of characteristics that make a place unique. It involves human experience in a landscape, local knowledge and folklore and from identifying oneself in relation to a particular piece of land. Some of the tools for recording facets of the sense of place include maps, photographs, virtual reality, neo-geographic knowledge such as stories and interpretive displays and other evidence of human experience in a landscape combined with a persona experience (www.artofgeography.com).

[7] Avatar is the geographical representation of the user or the user’s alter ego. Richard Garriot coined the term in 1985 for the game Ultima IV: Quest of the Avatar. He took the Hindu word associated with a deities manifestation on earth in physical form and applied it to the players characters as their earth self-manifesting in the virtual game world so players had to be responsible for the actions of the character in the game in other words a form of self-regulation where you played yourself to be judged on your characters’ ethically nuanced actions (Grant AE & Meadows J 2009).

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and suggest that the fight against global warming has inspired computer games that mimic real-world scenarios and will potentially encourage people to smarten up by tackling complex real-world scenarios (Lovett & Appleton 2006; Castells & Guardans 2008).

3.7.2 GIS usage in prediction and monitoring tools

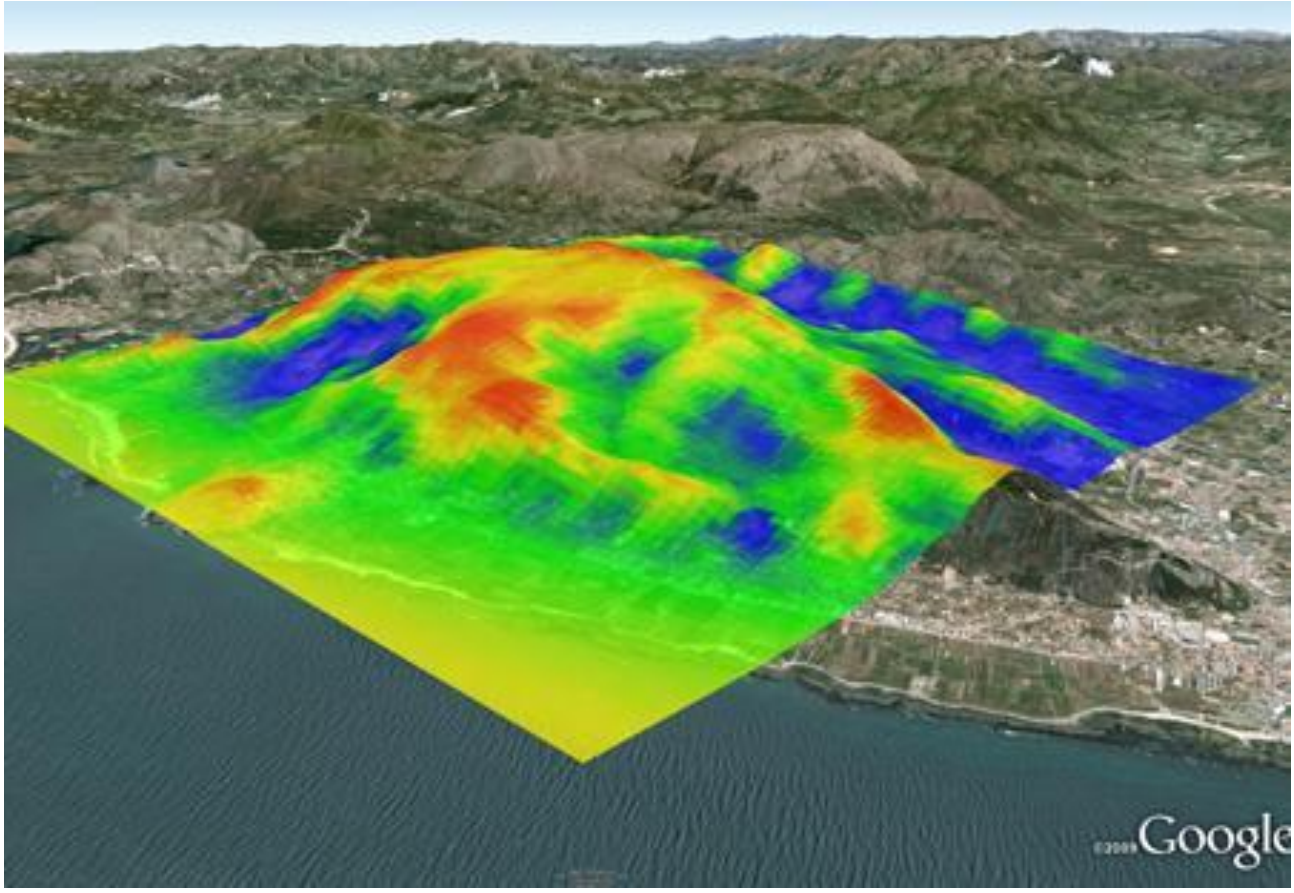
Salient issues such as climate change, nuclear waste storage facility location and disaster preparedness create new challenges and opportunities for GIS usage. GIS usage potentially predicts changes to critical environmental cycles in order to monitor extreme natural events and land use change. Spectral and optical data from satellite images are used to create multi-layered models combined with process based descriptions and landscape knowledge in GIS to produce detail of the real world with matching temporal and spatial characteristics. Comparative suitability maps are used for public participation, public enquiries and impact assessment decision making (Rashmin 2004; Lovett & Appleton 2006; Heywood et al 2008; ESRI 2011).

Rashmin (2005) encourages all involved parties to obtain access to maps using GIS to facilitate visual intelligence and visual knowledge of relevant information to inform spatial decision making. The functionality of GIS as a location suitability layer on a Google Earth background is displayed in Figure 3.2 as an example of map screening to illustrate most suitable site selection for wind farming. The image illustrates the graded location suitability layer on a Google Earth background using GIS for map screening. Colours closer to red on the colour spectrum denote the more suitable locations for wind farming. An example of GIS maps for EDM is presented in the following section.

3.7.3 Examples of GIS maps for environmental decision making (EDM).

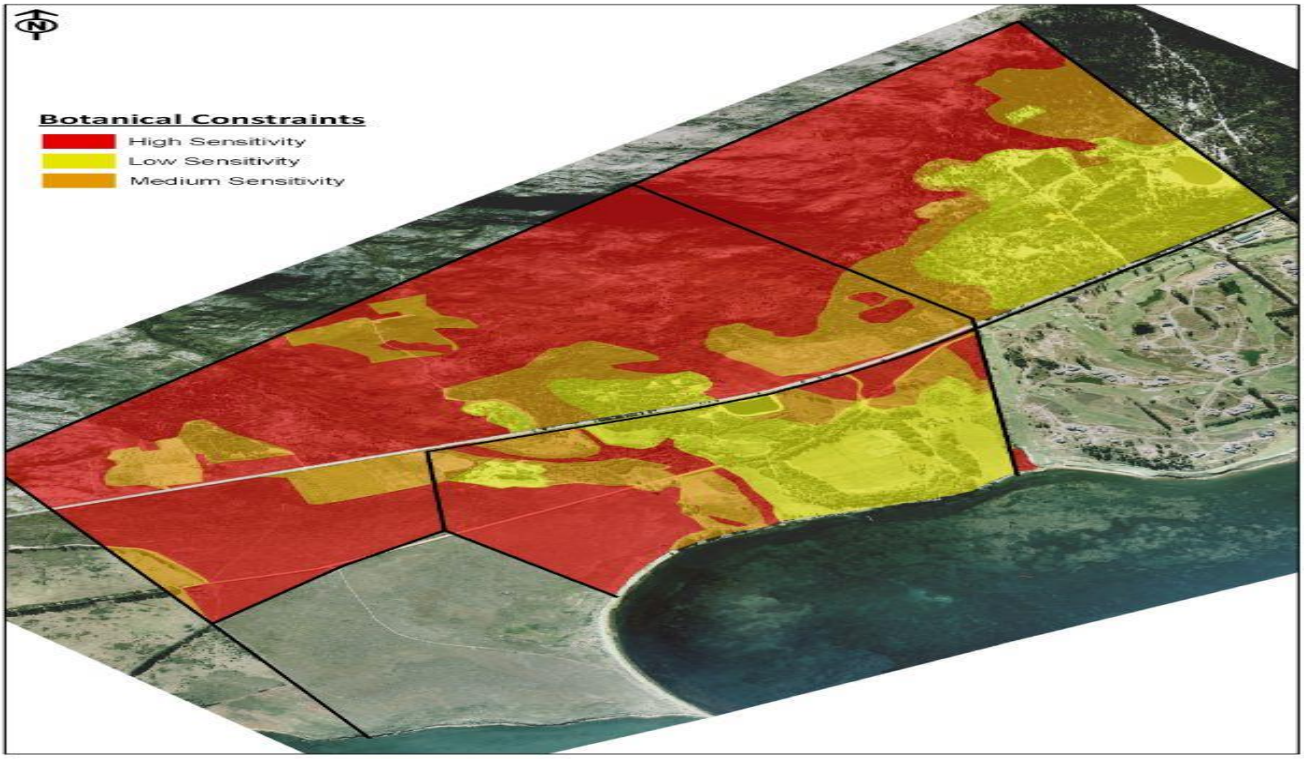
The GIS maps featured below are not used as working maps but as examples of maps designed and developed by a consulting firm for in-house screening, constraints delineation, alternative site selection as well as compliance and mitigation planning to inform effective EIA decision making.

This particular map in Figure 3.3 displays various degrees of critical biodiversity areas on and around the site selected for development to inform decision making regarding alternative site selection and no-go areas. High-, medium- and low-sensitivity weighting is colour coded for the level of botanical constraints delimiting the activities of the proposed development project to ensure negative impacts are minimised and strategies for mitigation are foreseen. Botanical constraints will also inform the decision makers of potential cumulative impacts from the surrounding area on the development and from the development on the botanical sensitivity of the area.



Source: Riso National Laboratory for Sustainable Energy (2009)

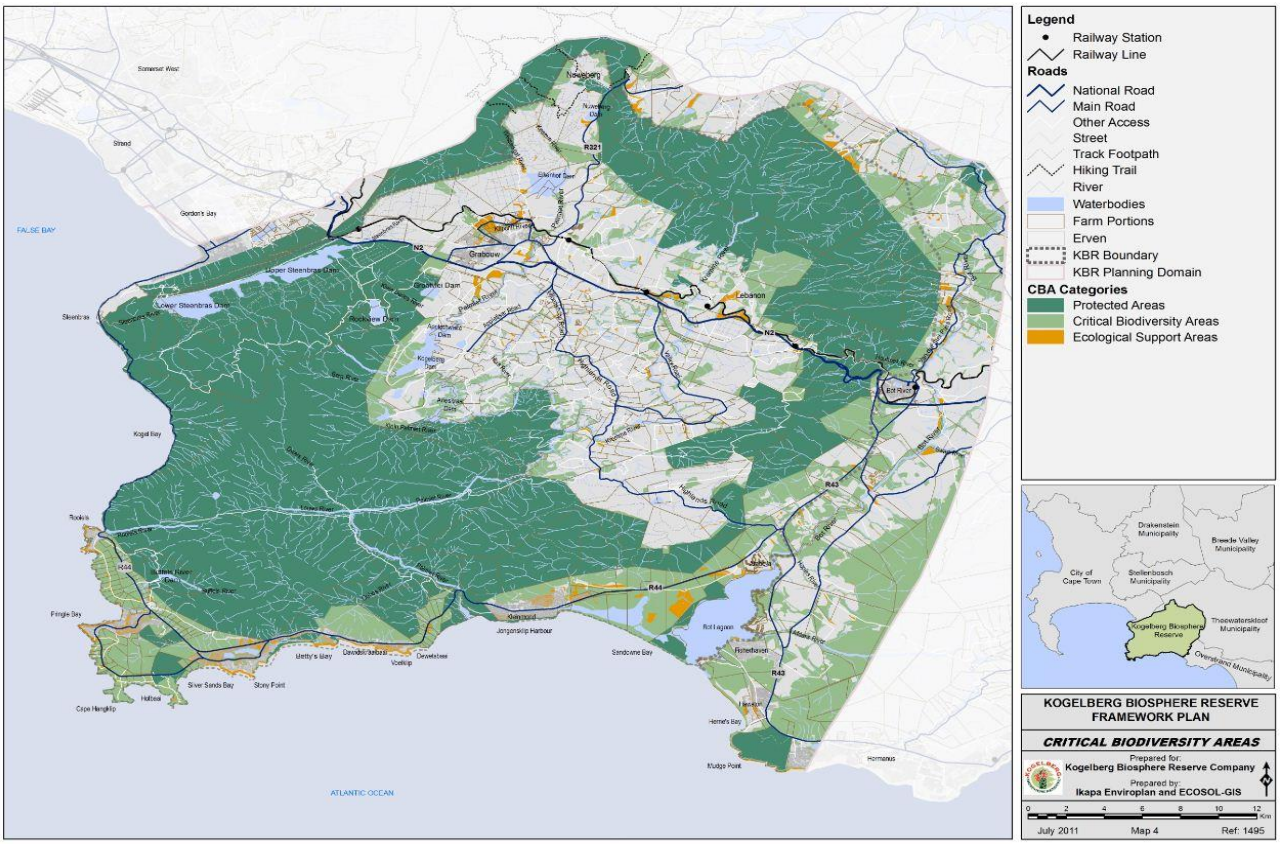
Figure 3.2: A location suitability layer for wind farming using Google Earth



Source: (Dennis Moss Partnership 2011)

Figure 3.3 Botanical constraints considered in the EIA of a proposed project near Kleinmond

Further interpretation of Figures 3.2 and 3.3 indicates that GIS usage has the potential to facilitate EIA and spatial development decision making such as site selection as well as consideration of alternative sites. On these particular maps varying grades of site suitability or vulnerability are clearly presented to be considered at feasibility and planning stage of the development process to ensure that the proposed activities take place at the most appropriate locations on the site (Riso National Laboratory for Sustainable Energy 2009). The map in Figure 3.4 was selected from a series of maps developed for the Kogelberg Biosphere Reserve to display critical biodiversity areas of a development constraints framework plan for this conservancy in the Overberg area of the Western Cape.



Source: ECOSOL-GIS and Ikapa Environplan (2011)

Figure 3.4 A GIS map locating critical biodiversity areas for the Kogelberg Biosphere Reserve

Developers of these maps ensured that the visual content of the map was groundtruthed and updated The series of maps were produced by ecological consulting firms iKapa Enviroplan and Ecosol-GIS as working maps for strategic planning and decision making (ECOSOL-GIS and Ikapa Environplan 2011). Web-based availability of these maps will potentially encourage participation by all and including, non-expert involved parties participating in decision making as they will have access to correct and relevant information.

Although the map in Figure 3.4 is not presented as a working map as such, but as an example of the potential of GIS maps for informed and effective EIA aligned with IEM, the salient features of the map presented focuses on displaying critical biodiversity areas. It also shows protected areas and ecological support areas in a region rich in biodiversity, but threatened by direct and cumulative impacts of development and other anthropogenic activities such as the risks related to land claims and the impact of agricultural activities. As presented in the legend, the focus of this map is on safeguarding critical biodiversity areas by delimiting reserve boundaries, water bodies and current land use.

In concluding Chapter 3, the postulate by Longley et al (2005), namely that the objective of science is to solve real-world problems, is introduced as a reminder. Science and practical problem solving methodology has merged in the GIS discipline and consequently in the application of solution centred, interdisciplinary teamwork where general knowledge and specific knowledge is combined in GIS to assist problem solving. Web-based GIS usage could potentially be the key to ongoing learning and sharing of knowledge that will diffuse into other areas like politics, economics and education and lead to actions, processes and systems aligned with the sustainability principles of IEM based on responsible and accountable behaviour towards effective self-regulation. Chapter 4 presents the findings of primary data sourcing for evaluation.

CHAPTER 4: EXPRESSED INDUSTRY OPINIONS ON THE USAGE OF GIS IN EIA

"Nature will bear the closest inspection. She invites us to lay our eye level with her smallest leaf, and take an insect view of its plain".

Thoreau H.D. 1817-1862

This study set out to present a close and in-depth inspection and investigation of the feasibility of an idea and the validity of it being converted into a business solution. In other words, the purpose of this study is to assess the feasibility of the value added by web-based GIS usage to facilitate effective EIA towards IEM in practice. If the findings of this study can prove the validity of the value of web-based GIS usage in EIA beyond reasonable doubt, the ground work is done for recommended future research into the development, design and implementation of a web-based GIS application for EIA as a business solution for effective EIA in practice.

A wide sample of involved parties across the transdisciplinary domain of environmental management and GIS was targeted using a mixed method approach called triangulation to ensure saturation of data sourcing during the time-frame from 2009 to 2012. Opinions and perceptions of participants and respondents were collated and assessed in detail so that dependable results and findings from primary data could be analysed, interpreted and presented in this chapter. In the section that follows the findings and interpretation of the qualitative and then quantitative data sourcing methods are presented chronologically as it follows the research design diagram in Chapter 1 and in lieu of Objective 4 to determine, from empirical data collected on the opinions of involved parties in the IEM domain, whether web-based GIS usage in EIA would be a feasible solution to facilitate EIA in practice.

The motivation for employing transdisciplinarity as the methodology in the light of the complexity of the integration of policy, technology and people in this study is evaluated in Chapter 1, along with the rationale of selecting the mixed method approach of triangulation that enables qualitative and quantitative methods to combine towards a more holistic concept to emphasize the truth. Details of data sourcing methods are presented in Chapter 1 along with tabled lists of the participants and respondents targeted for data collection. In the following section the outcome of qualitative and quantitative data collection is presented for measurement in table format followed by textual interpreting and highlighting of salient issues arising from it.

4.1 THE QUALITATIVE FINDINGS

The presentation of the research findings purposes to track a chronological sequence related to the order of the data sourcing procedure followed in this study. Through the selected measurement instruments the researcher aimed to provide a detailed interpretation of the critical challenges and opportunities experienced during the data collection that relates to the current EIA process and GIS usage in practice based on the opinions of involved parties participating in the research. Analysis and interpretation of the findings from the qualitative data sources are sequentially presented below. Qualitative findings are presented in three types of tables formatted to represent the phases of the qualitative data sourcing where large groups of participants were involved in a social inquiry regarding the validity of the research question.

The first opportunity for data sourcing occurred when DEAT facilitated a conference in 2008 to review the EIA process implementation after ten years. A large group of involved parties attended and participants represented a broad spectrum of involved parties such as government, industry and academia (SUN, UCT, UWC), municipal managers, town planners, NGOs, business representatives, environmental lawyers, international environmental dignitaries, South African Weather Services (SAWS), SANBI and IAIASA.

A few months later, in 2009, the researcher attended the Urban Environmental Management Programme (UEMP) knowledge management conference that was held to review projects and share information among the program partners. Participants included dignitaries representing the Danish and South African governments as well as local and international experts in the domain of environmental management, health, waste management as well as local municipalities. Through recording of observation and discussions as well as participation in the conference proceedings, knowledge was gleaned that is presented in this chapter.

Tables 4.1 to 4.7 in the following section present the findings gathered from the DEAT (2008) and UEMP (2009) conference proceedings. The text in the tables have been formatted to single spacing and the content of the tables are mostly verbatim quotations from participants recorded during the research to accurately reflect their opinions as expressed. The tables support data analysis by grouping the findings into manageable categories according to ‘promotional’, ‘non-promotional’ and ‘related projects’. For the purpose of this study ‘promotional’ factors refer to findings that reflect on potential opportunities, strategies and tools to facilitate EIA. ‘Non-promotional’ factors focus on weaknesses and threats in the process that need urgent attention and ‘related’ factors refer to critical issues that need to be considered in the feasibility study.

4.1.1 Conference proceedings: The shortcomings of EIA in practice

At this initial stage of data sourcing the researcher endeavoured to establish the status quo of environmental management and environmental decision making (EDM) practice. Being familiar with the theory of EIA and environmental legislation through undergraduate and post-graduate studies, the aim was also to gain more knowledge regarding the EIA process in practice. Data sourcing was non-specific at the time, as the scope of the study had not been delimited and data gathered from the DEAT (2008) and UEMP (2009) conferences consisted of observation and notes taken of comments by participants in discussions during the proceedings that were of interest and relevance to the research area. Furthermore, data was also collated from the electronic and hard copies of the conference proceedings that were sent to conference attendants from the conference organisers (Hector 2009; South African Cities Network 2009).

Some of the comments made by anonymous participants are presented as verbatim quotations in the content of the tables below to reflect the authenticity of the data. The tone and slant of the quotations differ as it reflects the opinions of involved parties in the EIA process who are a heterogeneous group with different perceptions on EDM.

Table 4.1 Evidence of a static approach to EIA from conference proceedings

Promotional	Non-Promotional	Related issues
The event was planned due to a need to evaluate ten years of EIA in South Africa.	There was a noticeable lack of integration and knowledge exchange between involved parties.	There seemed to be a gap between environmental management and development planning.
A large sample of involved parties (500 attendees) was present at the conference.	A lack of trust and an amount of scepticism was observed between involved parties and decision making authorities in government.	Participants complained about the project specific focus of the EIA and seemed to be uninformed of the need for sustainability (ecological, economic, social compromise).

The summary of observations from conference proceedings in Table 4.1 indicates a compartmentalisation of knowledge rather than networking and integrating knowledge across disciplines. The need for consistency, transparency and trust between involved parties is evident. There seems to be a static approach to environmental management and impact assessment by EIA users rather than a holistic view based on IEM. This indicates an awareness of the need to evaluate the process and to explore opportunities for knowledge management, transparency in processes, trust between involved parties and a bona fides platform where all parties could collaborate.

Table 4.2 Comments regarding EIA approaches during conference break-away sessions

Promotional factors	Non-promotional factors	Related issues
"The EIA needs to focus on key issues in terms of decision making."	"What gets created stays and impacts long after the developer is gone."	"Tools are needed that consider the receiving environment such as a screening to highlight the needs and desirability of the project."
"It is essential to develop an effective decision making framework that can be consistently applied to improve effective EIA."	"The public should be included in screening and mediation as intervention may prevent litigation."	"A platform is suggested on the DEAT website to advertise projects for public participation purposes."
"We look at 'what will the impact be' instead of 'what will the benefits of the project be'."	"Best practice includes the transfer of information and the institutionalisation of sustainable development."	"Integration of LUPO with NEMA is needed so that these two systems can talk to each other [collaborate]."

Table 4.2 presents comments made by conference participants that relate to their perceptions of the EIA process as it occurred in practice. It indicates that EIA needs consistency and effectiveness as well as the need to move away from linear thinking of what the impact will be to dynamic processes of how the development will benefit present and future environmental sustainability. Furthermore, knowledge management and decision making need to include screening of relevant baseline information.

Table 4.3: Conference participant requests for strategies and tools to facilitate effective EIA

Promotional factors	Non-promotional factors	Related issues
"All information resources needs to be put together, work with SANBI and employ GIS so that information for EA of the region or country is available for planning."	"We should question why NEAS and its ability to address critical issues such as sharing information, consistency in decision making and decision making criteria does not feature more in the options available."	"Despite the best EIA and the best laws and the best certified consultants and the most qualified authorities, without proper implementation on the ground EIA is meaningless."
"Legislation and consequent planning instruments need to actually speak to one another [integrate and collaborate]."	"Provinces say they cannot roll out [implement] NEAS, because their capacity will not allow for it."	"Tools are discussed as if they are de-linked from one another. Use risk assessment, CBA and EIA and integrate tools from different departments."

"Link the purposes of the tools to implement the policy. Integrate licencing and approval tools to create a regulatory, statutory, structural tool."	"We should start thinking about what triggers an EIA."	"For sustainability the ecological footprint, the carbon footprint and the social need for the proposed development should be considered and all data belongs in a common database."

Examination of the observations in Table 4.3 indicate a consistent expressed need for effective communication between involved parties and knowledge management to collaboratively lodge baseline information and triggers of cumulative impacts through GIS usage in EIA and IEM. Tables 4.4 to 4.7 present the opinions of participants at the conferences under the specific disciplines that they represent as involved parties in the EIA process followed by brief summarised interpretations

Table 4.4: Conference participant comments related to industry self-regulation

Promotional factors	Non-promotional factors	Related issues
"More authority needs to be assigned to environmental managers in industry."	"Industry does not provide their environmental managers adequate authority to influence decision making in the industry."	"Contractors and builders must be represented on task teams as they are the actual ones impacting on the environment."

Specifically, Table 4.4 highlights a need to prioritise ecological, economic and social compromise in industry and commitment from involved parties based on self-regulation and transparency.

Table 4.5: Conference participant comments on the need to bring the law closer to the people

Promotional factors	Non-promotional factors	Related issues
"Environmental education is imperative on local level. More interaction between government, industry, communities and schools is needed."	"There is no public awareness. Communities do not adequately participate in EIA processes and the public do not understand the basics of EA."	"Existing environmental training and education facilities must be better utilised. The specific needs of the community including transport should be taken into account."
"A process is needed where the public can seek representation and access information and legal assistance."	"Laymen do not understand EIA processes. The issue of language, culture and literacy barriers are often overlooked."	"Advertisements in the media should subscribe to a DEAT standardised format to eliminate vague and non-specific portrayal of developments."
"EIA documents must be translated into a minimum of three languages most used in the affected areas."	"Engagement of community leaders must show inclusion of a wide spectrum of people."	"Public participation needs to be independent with a real attempt to understand people and opportunities to resolve conflict."

The comments in Table 4.5 regarding the public sector as involved parties in the EIA process indicates that the public need environmental education and do not generally understand legal processes although they are expected to participate in the EIA process.

Table 4.6: Conference participant comments on the need for government transparency and trust

Promotional factors	Non-promotional factors	Related issues
"Adequate infrastructure, capital and tools are needed for effective and efficient decision making."	"Environmental impact management authorities do not provide adequate assistance and training to municipalities."	"A representative democracy is needed in this country; we don't trust our representatives to represent us accurately."
"Synergy is needed between all the stakeholders to drive the message of an eco-friendly sustainable society to the masses."	"DEAT relies on old information when making decisions. They do not keep up with the current situation of the area."	"Government decision making authorities should have regular forums or group meetings with other authorities i.e. health and waste management departments."
"There is a need for better corporate governance."	"There are concerns regarding the retention of competent officials."	"Government should be aware of the costs of EIAs and BAR and case officers should keep to timeframes."

There is a need for trust, transparency and retention of competent staff potentially be enabled by synergistic, efficient and responsible conduct.

Table 4.7: Conference participant comments on the need for EAPs' practical experience

Promotional factors	Non-promotional factors	Related issues
"Government should be responsible for the training of EAPS – potentially through mandatory internship programs."	"It is time consuming to find the correct person at the government departments and municipalities."	"Graduates need theoretical and practical experience."
A relationship of trust and collaboration between EAPs and decision making authorities will enhance effective processes.	EAPs need help in public participation and especially on whom to contact at various departments in government.	The certification process should be finalised [completed].

As Table 4.7 indicates, EAPs need to operate not only from an objective and independent approach, but also have the necessary experience and knowledge and ability to network and manage knowledge for informed decision making. There is a lack of opportunities for newly qualified EAPs to gain experience. Furthermore the need for practical internship was highlighted including acquiring

the skills to handle and innovatively apply spatial analytical techniques. The summary of conference attendees' impressions provided a consistent confirmation of a fair amount of discontent with current EIA practice. These views were further tested by an e-mailed questionnaire of which the responses are reported on in the next sections.

4.1.2 E-questionnaire: Benefits of GIS for effective EIA in practice

The next phase of the data sourcing procedure took place while investigating the viability of the research problem, but the data acquired were suitable for use in the final analysis. An e-mail questionnaire (see Appendix A2) was employed and a convenience sample of a group of fifteen experts engaged in transdisciplinary fields related to the concept of IEM were targeted to participate. The opinions of the respondents were collated and are presented verbatim as direct quotes in Table 4.8. A short interpretation follows.

Table 4.8: E-questionnaire responses on the value of the visual impact of GIS

Promotional factors	Non-promotional factors	Related issues
"A visual image of development impact over space and time!" "If it works it can have notable impact." "A picture is worth a thousand words!"	"Organisations do not see communication as a strategic tool." "Sustainability criteria are not fully taken into account in practice." "Some stakeholders are fixated on a purely capitalistic driven view of development and unaware of the impact caused by unsustainable development."	"Good idea. Demarcation of no-go areas would be useful in disaster management mitigation." "There is a lack of two-way communication between systems." "It would require understanding of various GIS tools and methodologies that organisations employ to assist their decision making."
"GIS could present cumulative impacts and changes in ecological processes."	"Often the government provides a green light before the assessment has been done."	"Project specific focus on environmental impacts needs to be resolved as it causes 'death by a thousand cuts' [a linear approach]."
"I like the GIS space and time link."	"It would require understanding of various GIS tools and methodologies that organisations employ to assist their decision making."	"Lack of knowledge exchange and lack of involvement by all stakeholders could be due to the fact that the developer pays for impact assessment and employs a consultant."

An interpretation of the direct quotes from the e-questionnaire in Table 4.8 highlights the benefits of spatial tools such as GIS that have the potential to encourage transparency and to present the

evidence for potential visual impact of cumulative changes and ecological impacts as well as baseline information of the receiving environment. The benefits of GIS usage for knowledge exchange was highlighted. These included communication between parties and education of involved parties that will in turn inform effective decision making and encourage good governance and knowledge management based on IEM.

As explained in Chapter 1, the participants represented disciplinary knowledge fields such as tertiary education, environmental management, business, industry, IT, disaster management and government. The participants were all professionally known to the researcher who consider their opinions knowledgeable to add value to the feasibility of the selected research problem. The survey represented a pilot study in order to explore participants' perceptions regarding the feasibility of the usage of a GIS application to inform EIA. The question that was posed in the email questionnaire requested experts to provide their opinions on whether involved parties in EIA would benefit from a GIS application for knowledge exchange.

4.1.3 Individual interviews: Validity of the research problem

As mentioned previously, the study at this stage still focused on gathering information to validate the design, development and implementation of a web-based GIS application. Data sourcing involved two groups of individuals who were interviewed to seek the advice and opinions of a larger sample of experts involved in IEM, EIA and GIS within the geographic scope of this study. For ethical considerations the participants requested to remain anonymous. Interviews took place in 2010 and 2011.

The first group of participants represented the transdisciplinary domain of IEM, EIA and GIS in the City of Cape Town Municipality and Western Cape Provincial Government. The second group involved individuals from academic institutions, such as Stellenbosch University (SUN), University of Cape Town (UCT), University of the Western Cape (UWC), the Sustainability Institute (SI), the CSIR as EIA and GIS consultants to industry, and I&APs represented by the World Wildlife Fund (WWF) as a representative NGO and relevant to both GIS and EIA.

Interviews and discussions were centred on investigating the same research problem, but questions were adapted to relate to the specific area of knowledge and expertise of the participants. The main focus of the interviews was to critique the validity of developing a web-based GIS application to facilitate and expedite EIA decision making and IEM in practice. Conversations were not voice-recorded, but written notes were taken. Learning took place and increased understanding of the critical issues related to the various disciplines associated with environmental management and

impact assessment as well as the GIS domain. The knowledge outcomes of these interviews are summarised in Table 4.9.

Table 4.9: Interview response outcomes

Promotional factors	Non-promotional factors	Related issues
During the time of the interviews the City was in the process of integrating data into the Integrated Spatial Information System (ISIS) that assists in land use management.	The discussions highlighted the costs of resources needed to design, develop, implement, maintain and monitor the application. There are major financial implications involved in these processes.	New insight gained guided the researcher to the realisation that research on database development was too complex and extensive for the scope of this study.
Cape Town City is currently busy with database development.	The impact of incompatible tools, old hardware and incompatible software is a critical issue that needs to be addressed. A GIS viewer is available at City level but it is not reliable or effective.	Constraints relate to a country in transition. There seemed to be a gap between environmental management and development planning.
Technology is available.	Data is not standardised and bandwidth problems hamper functionality at different levels by users.	Intellectual property can be a constraint as well as the lack of integration between different spheres of government at national, provincial and local level.

In interpreting the data gathered and presented in this table the major financial implications of resources to design, develop and implement a GIS application for EIA was highlighted. However, sustained interest in the research problem was encouraged as government is involved in database development that could support GIS usage and even though the capacity in terms of software and hardware is lacking, the technology is available. Furthermore, the need for collaboration and integration between government as the competent authority in EIA decision making, and other parties involved in EIM, EIA and GIS validates the requirement of GIS usage as a platform for knowledge exchange and potential solution to inform decision making.

The outcome of these interviews increased awareness of the impact of unsuitable data management tools, dated hardware, incompatible software, as well as bandwidth problems experienced by GIS users. The researcher realised that there were many different and differing views regarding the feasibility of the implementation of web-based GIS usage for effective EIA, and decided to arrange a final phase of qualitative data sourcing of group interviews through in-depth focus group

discussions to generate interplay of responses to yield advanced insight. The participating sample groups hypothetically represent the different views of involved parties in EIA and the outcome of these discussions would potentially be a viable and valid measurement of the opinions of parties participating in EIA and the change initiative involving GIS usage in EIA towards IEM.

In the next section the outcome of the interview discussions with six focus groups are presented and tabled, based on the audio-taped opinions of participants involved in the domain of EIA and GIS.

4.1.4 Focus group discussions: IEM deficiency in EIA and need for GIS

A series of six focus group discussions were held with involved parties in the domain of EIA and GIS. Participants represented multi-disciplines such as GIS technicians at local and provincial government, GIS experts from an academic institution, EAPs using GIS, EA consultants using GIS as well as representatives from an NGO and Specialists who are familiar with GIS technology. The list of participants appear in Chapter 1 as representative samples of participants in EIA, GIS and IEM, but they remain anonymous to protect confidentiality. The discussions were emotive rather than neutrally descriptive as all the participants are experts in their field. This mode of enquiry further supports the authenticity of the contributions regarding critical issues, challenges and opportunities in the EIA and IEM domain. Direct quotations are presented in the tables to reflect the authentic verbatim nature of the open-ended question responses used to gauge the opinions of the participants in the group interviews.

The topics for discussion were formulated around the concepts of the three main themes of EIA, GIS and people as well as the five sub-themes within the scope of this study: knowledge management; informed decision making; commitment by involved parties; authentic public participation; and good governance. Responses were recorded and transcribed for argument analysis and the outcome of the focus group discussions were analysed and presented in two ways.

Firstly, comments were presented in Tables 4.10 to 4.14 in the same table format of ‘promotional’, ‘non-promotional’ and ‘related’ factors according to the sub-themes of this study that highlight the opinions of participants regarding the shortcomings of the current EIA process within the scope of this study. Secondly, in Tables 4.15 to 4.20 the opinions of participants are presented in the framework of a SWOT analysis to evaluate the feasibility of web-based GIS usage to facilitate effective EIA in practice.

To counter the abundance of tables, tabled contents are discussed in groups of similar matter instead of necessarily referring to every table as it appears in text. In this section Tables 4.10 to 4.14 are discussed. These tables focus on the shortcomings of the EIA process within the scope of this

study and these challenges are also the sub-themes of the study with the aim of turning the challenges into opportunities for informed decision making in EIA.

Table 4.10: Focus group responses: The need for knowledge management in EIA

Promotional factors	Non-promotional factors	Related issues
"Knowledge needs to be available, accessible and understandable by all involved parties."	"Very few members of the public read the newspaper and go to the library to read the EA reports."	"Civil society is becoming more aware of their rights and what is right and wrong."
"All parties able to relate to the size and impact of the proposed development project using visual and ethnographic methods."	"Currently data is not reliable or validated and often information cannot be shared because of incompatibility."	"The media should be used to create awareness and encourage learning of the need for legislation and compliance and self-regulation."
"Informal community members to be involved as they may be aware of risks and hazards."	"Costs spent on developing a platform for knowledge exchange can be saved later."	"Relevant information should be available on a user friendly platform."

Table 4.10 expresses the focus group conviction that web-based GIS usage for knowledge exchange will potentially bring the EIA closer to the people and encourage education, learning and self-regulation as well as raise awareness of avoiding and mitigating environmental impacts. Furthermore, pooled knowledge from all involved parties need to be made available and accessible to all participating parties by using available resources such as the media to raise awareness of the risks associated with negative impacts and the benefits of precautionary decision making and planning for mitigation.

Table 4.11: Focus group responses: The need for informed decision making

Promotional factors	Non-promotional factors	Related issues
"Decision making at strategic level could be enabled through web-based GIS usage as decision makers will be better informed of the multidisciplinary context of environmental management."	"Information exchange regarding the impact of the proposed project is not sufficient. I&APs need to know what is going to be erected and what the impact will be."	"Basic information is public knowledge. Therefore it should be made available and accessible to all involved parties. A website showing the spatial aspects and potential impacts related to current projects will be very helpful."

"Visual impact allows forecasting. Alternative sites or alternative patterns for development can be shown and adapted for informed decision making."	"The EIA shows that the positive outweighs the negative impacts."	"GIS provides access to relevant information made up of spatial data combined with attribute data of the location and triggers specific to the area, should inform and expedite decision making."
"Information about vulnerable and sensitive areas and previous environmental hazards or risks experienced by the community necessary."	"Government bases decisions on zoning without considering the details or benefits of the proposed development project."	"Decision making authorities need to learn to read the proposal and make objective decisions. A holistic approach to decision making is needed."

Table 4.11 indicates that EIA decision making is not as effective as it should be, since the necessary information is not current or available or accessible for easy use to inform decision making. GIS provides information of impacts in visual format to encourage better understanding and to inform decision making. Specialists' reports in Records of Decision (RoDs) should be made available to all involved parties to inform timely decision making so that the time frames of the EIA process would be adhered to and the positive impacts of the projects outweigh and mitigate the negative impacts.

Table 4.12: Focus group responses: Commitment by involved parties in EIA

Promotional factors	Non-promotional factors	Related issues
"Involved parties can be in different places for decision making."	"It is difficult to get everyone to engage." People use old processes and are often reluctant to change unless they have to."	"GIS usage needs to be mandatory [part of the EIA process or a requirement of NEMA regulations] for involved parties to commit so there will be no resistance to web-based GIS usage.
"Information needs to be available for decision making; records of past projects should be used to grow the data base so that knowledge exchange could be accessible to everyone, even the inexperienced."	"Developers are usually concerned about profits and to keep costs down. Developers know the process, monitoring and EA requirements and know what they can get away with."	"There has to be a strong driver to encourage a step up to new strategies and practice. GIS usage can be a marketing tool for the EAP to gain a reputation for GIS informed decision making."
"Web-based GIS usage will add transparency to the EIA process. Baseline information of the receiving environment will highlight the need for specialist reports early on in the process."	"Focal people who represent I&APs and local government often support privileged groups and this could cause jealousy between ethnic groups."	"Access GIS usage and knowledge exchange will improve awareness amongst local municipalities of environmental impact."

"Awareness of impacts has the potential to encourage risk preparedness towards sustainable communities."	"Developers may not want focus on sensitive areas in practice and they may not want the EAP to call for specialist reports that will increase the cost."	"Local municipalities should become more involved in decision making of project proposals in their jurisdiction by visiting the development site."

Table 4.12 indicates that involved parties represent a heterogeneous group who are not aware of IEM and the principles of sustainability. Involved parties are committed to their own goals, operate independently and seem to respond better to a mandatory process. Awareness of the need for understanding the concept of environmental management and impact assessment would encourage networking, holistic thinking, collaboration and integration towards a common goal based on IEM. An interactive forum will encourage conflict resolution.

Table 4.13: Focus group responses: The need for authentic public participation in EIA

Promotional factors	Non-promotional factors	Related issues
"Web-based GIS usage enables a quick response regarding the information in public domain and related concerns to the EAPs."	"Data managers choose to make information avail-able to users."	"Sometimes the public can sway the opinions of competent authorities regarding final decisions."
"GIS tools for informed decision making will depoliticise the process and better inform the public and increase transparency via an interactive forum."	"Specialist reports in the public domain are not always available at public meetings, only at libraries and in newspapers."	"Many people already use Google Earth to browse the environment, this tool will add to the practice of knowing your environment."
"The Internet adds advantage of exposure to a large sample of the public. The public will be able to answer interactive questions posed by the EAP with direct relevance to the project. They will be able to see visual evidence of the proposed project and the potential impacts and proposed mitigation."	"In rural areas it is crucial to draw in the informal community leaders who have access to information regarding sensitive and vulnerable areas and historical spatial information that can be red-flagged for caution."	"Participatory decision making could be enhanced with visual maps that people can relate to. People would be able to see their village and other landmarks that will potentially increase their knowledge and awareness of potential impacts and trade-offs related to development projects."

Table 4.13 indicates that relevant information needs to be accessible and available in the public domain and modern communication tools and visual maps using GIS technology in practice will potentially encourage authentic and effective public participation.

An online platform for public participation will potentially depoliticise the process, inform all parties, increase transparency, reduce conflict and minimise the need to appeal the competent authorities' (CA) decision. However, in terms of ownership of GIS usage for effective EIA, government is earmarked as a strong driver for implementation to ensure compliance with legislation and to encourage good governance.

Table 4.14: Focus group responses: The need for good governance in EIA

Promotional factors	Non-promotional factors	Related issues
"If government took ownership of a GIS platform for knowledge exchange, it could be a free service to all stakeholders."	"If the owners of a GIS application was business or industry there would be an affordability factor because they would probably charge for usage."	"The strategy to implement GIS usage for effective EIA will be a sustainable solution, but who will be responsible for the cost to design, develop and implement the tool?"
"Government is a strong driver and GIS usage will be in compliance with legislation." "Government's role should be supportive and GIS usage should be mandatory."	"Government operates by their own rules. That is why authorities cannot make decisions and they generally don't keep to time frames." "Government may not want to implement GIS usage that makes the EIA process transparent."	"Searches will be possible according to key impacts, listings or type of project."

Table 4.14 indicates that there is an element of scepticism and distrust experienced by other involved parties in EIA regarding the intent of government. Some projects are perceived to be fast tracked and others rejected for reasons not related to the EIA process. High staff turnover in government departments also point to the lack of good governance.

In the next section the opinions of participants are presented in Tables 4.15 to 4.20 and frameworked in a SWOT analysis format to evaluate the feasibility of web-based GIS usage to facilitate EIA. The comments were grouped into manageable concepts of the SWOT matrix namely Strengths, Weaknesses, Opportunities and Threats to ensure that constructive conclusions could be formulated in order to identify patterns, trends and relationships between the various themes of EIA, GIS and people in the scope of this study.

The opinions of the participants are mostly presented as direct quotes to highlight the authenticity of the findings in the analysis and interpretation of the results. Furthermore, some comments in the SWOT matrix may appear trivial or wishful, but they reflect the transdisciplinary nature of the study and have been included as direct quotes to express the emotive opinions of the participants. Therefore, where deemed necessary, a summary of the comments or pronouncement and occasional preferable solution is presented along with highlighted points in the interpretation section that follows the tables.

4.1.5 Focus group outcomes: SWOT supports GIS usage in EIA

SWOT analysis is used in this section to provide a structural framework for gathering, structuring and presenting data in order to review strategy, position and direction of a proposition. In terms of this study SWOT is utilised to seek validity and greater insight into the research topic as well as reliability of the outcome of the research through saturation of data sourcing and credibility of interpretation of the presentation of the findings. Furthermore, SWOT analysis was employed in this instance as it supports the investigative approach of multi-disciplinarity and triangulation adopted. It stems from the need to decide whether or not a goal is attainable and it is used as a tool for comparative studies and to implement change initiatives.

A SWOT analysis of the findings of every focus group is presented in this section followed by an interpretation of the data to evaluate the feasibility of web-based GIS usage as a platform for knowledge management to facilitate the EIA process. The researcher considered combining Tables 4.15 to 4.20 in this section by summarising the data and presenting it as one table. However, it was decided to present the findings in the original form and detail as direct quotes under separate focus group discussions around the main theme of EIA, GIS and people. The reason was mainly to retain the authenticity of the transdisciplinary approach to the study as well as the transdisciplinary nature of the participants in this data sourcing method. In Tables 4.15 to 4.20 the responses from different focus groups discussions on the feasibility of GIS in EIA are related.

Table 4.15 indicates that the skills are available to develop GIS usage to present the necessary spatial variables to inform EIA. GIS usage could be stimulated by incorporating it into the mandatory BA or EIA proposal for project development approval. Sharing of visual data through web-based GIS usage would ensure that users have access to the same information without necessarily being in the same place at the same time.

GIS usage would potentially encourage compatible data sharing and interactive knowledge exchange. The demand for skilled GIS users would create job opportunities in this new discipline. In interpreting the opinions of these participants, the proposed solution of GIS usage to facilitate effective EIA is considered feasible and the critical issues highlighted as weaknesses and threats could potentially be transformed into opportunities and strengths.

Table 4.15: Tertiary GIS expert responses on the feasibility of GIS in EIA: A SWOT analysis

STRENGTHS	OPPORTUNITIES
"Technology and skills are available to develop and implement GIS usage." "Multi-criteria decision making tools [GIS tools combining spatial data and human knowledge of land typologies such as land use, property ownership and zoning] are available to inform effective decision making."	"GIS could enable a forum for information exchange on a repository style platform [a database that grows as users add relevant data]." "Job opportunities will be created for people with GIS skills and experience." "Should GIS usage be part of the mandatory EIA process, involved parties would be obliged to use the application."
"Google maps could be used as base maps." "Google makes the public aware of spatial aspects of life." "ArcGIS maps can be added to the base map as a mash-up to present the spatial distribution of the project activities."	"DEA&DP or DEA could add requirements to the standard BA or EIA application that requires GIS usage."[Requirements that needs to be met using GIS could be added BA or EIA application (such as the needs and suitability section) that needs to meet multi-criteria evaluation.
"Complex GIS data can be presented as a user friendly .jpeg image. Visual and textual display of information enables better understanding of potential impacts and display alternatives for optimal site selection." "Illiterate users could initially use display options where they click layers on/off against a Google Earth backdrop."	"Public participation as a Skype-like session on the web page is possible. I&APs unable to attend a meeting due to spatial constraints could interact on an online forum [using blogs or streaming media[8] for on-line chats or online surveys] I&APs register and comment online to encourage integration where people may not be in the same room, but will be on the same page [having access to the same information]".
WEAKNESSES	**THREATS**
"EAPs need to employ people with GIS skills."[To ensure decision making based on informed spatial analysis].	"What if the public sees web-based GIS usage as 'just another way to hide the truth from us'?"
"It is difficult to get people to use the same web site [because people choose to use their own data or familiar data or by agreement]. Data sharing is difficult [because data is not always compatible with software of viewers used for analysis]. GIS usage needs to be mandatory [part of the mandatory EIA process] for all to use the same system. Available data may be in someone else's domain [someone (an EAP or consultant or proponent of the project) owns raw data and only shares it once their own intelligence has been added to it i.e. in a .jpeg or.pdf shape and the raw data that is needed for analysis may not be available."	"Should government own and administer GIS usage in EIA, the democratic and transparent nature of effective EIA based on informed decision making may become politicised." "Data is not standardised and needs to be vetted or groundtruthed". "If users need to pay for access to the information, will they be willing to pay?" "Involved parties are used to business as usual and may not like the change in protocol."

[8] Streaming media is multimedia that is constantly received by and presented to an end-user while being delivered by a provider. Streaming can be live or on-demand streaming where the information is saved and then broadcasted. Interactive communication using streaming media is possible through live chat sites or online surveys (Grant & Meadows 2009; Kellner 2013).

Table 4.16: NGO I&APs' responses on the feasibility of GIS in EIA: A SWOT analysis

STRENGTHS	OPPORTUNITIES
"GIS usage has the potential strong to bring everyone together and encourage people potentially impacted by the project to participate. It could be the cyberspace platform that allows for critique as well as organised public participation."	"There are too many mandatory regulatory processes requiring public participation [such as the pp required for the Waste Act and for EIA for the same project]. Web-based GIS usage could potentially enable a combined public participation process for EIA and Waste." "We need to broaden the economic discussion and web-based GIS usage has the potential to address challenges in resource economics." "The library and newspaper is ineffective for information exchange."
WEAKNESSES	**THREATS**
"SA has a dual economy with a general divide between people who have and don't have. The visual aspect enabled by GIS usage could expose inherent conflicts and ethical issues that could undermine the approval of the proposed development project."	"Government and developers walk together [collaborate] and ignore civil society. Civil society does engaging for free whereas developers and government officials are cutting the pie three ways [sharing profits] and if they give civil society a weak cup of Glen tea they have gone a long way."
"SANBI developed GIS based applications, but we cannot access it as it is incompatible with the technology available to us."	"Stakeholder engagement is reducing due to burn-out [stakeholder fatigue] and disillusion with previous processes. "Civil society is conditioned to leave decision making to others in important positions."
"People in positions of authorities such as case officers are not paid to be passionate about their work, but to keep a steady stream of work flowing to bring money into the government coffers. Government may not be interested in supporting GIS usage for effective EIA."	"EAPs are applying for exemption of the public participation process and the credibility of EIA is on shaky ground [when it is no longer aligned with NEMA and IEM intent that public participation is crucial to the EIA process]." "Decisions made by competent authorities often contradict specialist's expert opinions [such as when the CA ignores the specialist's opinion for caution or no-go as in the case of gas fracking in the Karoo that is going ahead despite predicted negative impacts on the environment.

Table 4.16 indicates that this focus group recognised a strong social aspect allowing for transdisciplinary collaboration towards authentic public participation that could potentially be provided by web-based GIS usage. Opportunities were noted where GIS usage for public participation would avoid duplication of mandatory public participation processes and subsequently save time and costs. It was noted that in the current EIA process in practice, involved parties who benefit financially

from the proposed project collaborate and share profits whereas the role and voice of the public is voluntary.

Furthermore, the current EIA practice allows for exception of the public participation process. It was felt that the EIA is on shaky ground as it is not aligned with the intent of NEMA and the IEM principles. The threats that were highlighted included the concern that civil society [the public] have become disillusioned and sceptical of the EIA process in practice and becoming apathetic towards participating in voicing their opinions. Distrust in the possibility of government supporting GIS usage to inform effective EIA was also noted. In concluding the interpretation of the opinions of this focus group, a need was identified for change towards a more transparent and effective EIA process that could potentially be facilitated by GIS usage. Table 4.17 indicates that there is a need for change in how EIA's are managed and that GIS usage would be a feasible solution as a platform for knowledge management to facilitate EIA and other processes.

Table 4.17: Competent authorities and GIS experts in government's responses on the feasibility of GIS in EIA: A SWOT analysis

STRENGTHS	OPPORTUNITIES
"We have the technical guys [skills and competence] available so web-based GIS usage should not be a problem and bandwidth is not a problem in Cape Town. GIS experts can use a basic viewer." "Cape Town has better opportunities to succeed than more rural areas where less technology is available to districts and smaller municipalities."	"The planning, environment and waste departments need to share and integrate data. Strategists and technicians need to be involved. Specifications for data collection need to be standardised and all the main players need to get together to ensure specifications are coordinated." "Forums need to take place at national level and inform provincial and city level."
"If GIS usage in EIA [such as a GIS application for inform all involved parties of relevant information related to the development project] could be driven by government, it could save money in the long run and streamline EIA and other processes."	"Multi-disciplinary input is needed. Competent authorities (CA) and scientists need to work together [collaborate] and not oppose each other. All documentation concerning the proposed development project should be available (scoping, draft reports, records of decisions) and linked to the GIS viewer."
'GIS usage should enable the applicant to have access to the database with a current picture of his application in the EIA process [a visual display of the site of the proposed application on a web-based GIS map]."	"Baseline information is currently in different departments and everyone is updating their information independently. A central database is needed that grows as EIA data is collected."
WEAKNESSES	THREATS
"Most historical data from previous EIAs and other relevant reports are not geo-referenced and it is difficult to locate a proposed project [on Google Earth if there is no geographical positioning].	"The biggest problem is intellectual property [parties not sharing information that they feel they own] and people working in silos [parties working independently of one another]."

Many current applications for proposed development projects are not geo-referenced." "We use CBA maps, but there are gaps in the information, so we use own attribute tables." "The viewer that we use is old and the utility information is up to ten years out of date." "Authorities have access to data that links land use and CBA updates.	"Smaller municipalities have one man [don't have the human resources and skills] to do the job and a small budget. The government won't be able to afford a project like this." "The main constraints to the implementation of web-based GIS usage are information collaboration, technical resources, database development and funds to manage it."
"Data needs to be updated. The CBA maps were developed in 2008/2009 and a lot of land use information is outdated [is desk top EDM is done without a site visit, decisions are made based on incorrect land-use data]."	"Some socio-economic data is too evaluative and interpretation of sensitive social information on a public domain might be open to misrepresentation [people may be targeted because of exposure to their wealth or poverty]."
"Management blames external forces and employees blame the managers. People in positions of authority at local and provincial level have different opinions and styles [they follow different procedures and have different decision making systems and requirements] and it causes projects to stall."	The problem is to get the officials [case officers and competent authorities] to read the information. Case officers and competent authorities in government will be interested in web-based usage if it is quick and easy to use [user-friendly]."

The technical skills are available and within the scope of this study Cape Town offers favourable opportunities to successfully drive GIS application to encourage interdepartmental integration and multi-disciplinary collaboration, forums for knowledge sharing, standardised data, geo-referenced data and a growing database. The benefits derived from GIS usage would alleviate current threats such as protection of intellection property and knowledge will be available and accessible for parties to work together. Opportunities need to be created to encourage on-going capacity building including management with vision to transform challenges such as affordability and budget constraints, conflict between management and employees, lack of trust and commitment from decision making authorities to read and understand EIA proposals.

An interpretation of the responses captured in Table 4.18 highlights a number of issues and indicates that the current EIA practice, to be effective, requires certain critical issues be addressed. Web-based GIS usage has the potential to transform critical issues into opportunities and strengths such as providing relevant baseline information upfront to expedite and enhance the EIA. Visual information will encourage communication between EAPs and I&APs and details of key I&APs could be identified and listed for future reference.

Screening and forecasting as well as simultaneous referencing of the location before, during and after development can streamline the process and assist in alternative site selection. GIS usage will add transparency to the process and reduce political gatekeeping and allow for critique during the process rather than at appeal stage when the EIA process is often delayed for conflict resolution.

Table 4.18: GIS specialists' responses on the feasibility of GIS in EIA: A SWOT analysis

STRENGTHS	OPPORTUNITIES
"Effective communication between the EAPs and I&APs is crucial and communication on a web site can not harm." "Screening is very important for large projects and GIS usage with baseline information of the project available upfront will expedite and enhance EIA.	"A GIS application would be useful to specialists as No-Go sites or hotspots could be visually red-flagged under a generic label of vulnerability or sensitivity." Securities could be put in place for heritage or cultural sites or data related to vulnerable species such as bat or bird information as members of the public may vandalise protected areas [if this data is accessible on a web-based application where all involved parties collaborate and share access to information."
"Forecasting would be very valuable for instance if GIS usage can show a map of what an area looked like before, during and after the development takes place and upload computer generated models to streamline the decision." "A web site providing access to visual information regarding current project applications and approved projects as well as land use and property ownership would be very valuable." "Visual indication of project specific impacts as well as the surrounding area will create awareness of potential cumulative impacts."	"Communication tools such as texting and television and radio media networking could link in with the GIS application to play a more active and rigorous role than merely presenting EIA data in newspapers." "Currently appeal stage is the first opportunity for involved parties to resolve conflict. GIS usage has the potential to alleviate the appeal stage of the EIA process by creating a platform will enable continuous interaction between to inform decision making." "The appeal is also a very costly situation for everyone. The process is often delayed and it costs the developer a lot of money." "I&APs do not benefit financially."
WEAKNESSES	THREATS
"Sometimes the EIA is used for mitigation only. Authorities give the go-ahead for the development before the EIA has been done."	"Industry grows and the exponential impact of all the small projects causes a large impact. A well-managed database updated with current and existing projects and land-use is needed to inform decision making."
"Information exchange regarding the impact of the proposed project is currently inefficient. The EAP may have a web site with some relevant information related to the project but it is not shared. Communication between EAPs and I&APs is a problem."	"Sometimes the development grows too quickly for effective information exchange to keep up." "I&APs come on board late in the process and then they comment at the end of the period and the application is delayed. But it is not necessarily due to devious intent."

According to the opinions of participants reflected in Table 4.19 access to visual and textual information early on in the EIA process and available to all involved parties through web-based GIS usage will encourage informed decision making as well as a more transparent process.

Table 4.19: EAPs and industry GIS experts' responses on the feasibility of GIS in EIA: A SWOT analysis

STRENGTHS	OPPORTUNITIES
"The EIA report is 'a big fat file' that no-one has time to read. A platform with visual and textual information would be more interesting and user friendly." "It will also encourage people who don't have time to attend the current requirement for public participation in all the different processes [Waste Act and EIA requirements] to commit to online participation."	"Benefits of GIS usage include a potential reduction in costs. The largest expense goes to paying for a specialist and cost will be reduced if a baseline study of groundtruthed information is available and accessible."
"Access to information early on in the process makes the application more effective and the process more transparent." Public participation gives I&APs a voice and a strong call to government that they cannot make rules but not live by them."	"Two way communications between the EAP and the community will enable a good relationship and both will be able to inform each other about the impact on the project and the impact on the community and environment."
WEAKNESSES	**THREATS**
"The CBA maps are often not compatible with other software. Data incompatibility makes accurate observation impossible as scales and specifications of mapping vary. "EIA, zoning and planning goes to DEA&DP in the Western Cape, mining or energy related projects go to DEA and gets fast tracked."	"Many clients only look at [focus on] profit and the economic side. If the EAP appointment becomes a tender process at government level, the cheaper EAPs will get all the work [the best or most professional EAP may not be the cheaper and standards may drop]. I&APs sees the client paying the EAPs and wonder if they could still be objective in terms of IEM in the EIA process?" "If Government put out the tenders, would EAPs tender and then be paid by government?
"Involved parties have a lot of information but it goes into a black hole [it is not used and gets filed for an indefinite period]." "Maybe if it gets uploaded the voice [public awareness] might help government to behave more transparent - especially if there is a platform for critique/comment."	"Often the process is delayed or it ends up in an appeal. This could be due to the fact that information is not available early on in the process and I&AP do not know about the project." "Lack of information exchange between authorities and involved parties is a barrier GIS usage."
"The EIA procedure and intent gets 'muddled'[the way the application is processed by the case officers could be irregular and not conform to time frames and the intent of EIA in theory]". "Who has control? DEA&DP is seen as the most efficient department." "Where does authority reside?"	"An independent screening process could add value. However, due to scepticism between involved parties, a screening study of the project location by an objective party will ensure everyone starts off 'on the same page' [with access to the same information]."

According to the opinions of the participants quoted in the content of Table 4.19, environmental governance seems to be in a state of flux. Some proposals, particularly those related to energy and mining, are fast tracked through national DEA. At the same time, at provincial level in the Western Cape, DEA&DP EA invokes planning and LUPO zoning regulations as well, that are often ignored at national level. Online records of reports will be a strong call to government to act in a more transparent manner. Opportunities created through GIS usage include a potential reduction in costs as a baseline study of the site of the proposed project would reduce specialist costs and combine participative processes and increase knowledge exchange regarding the impact of and on the project and the community.

Weaknesses include incompatible software and lack of knowledge management that could potentially be rectified through an interactive platform that would also encourage transparent behaviour by all parties. Threats include a profit focus and scepticism towards apparent lack of a holistic understanding of the EIA process by the government. Table 4.20 brings the views of consultants who use GIS into play. The benefits of GIS usage emphasise the added transparency of the intentions of involved parties.

Table 4.20: Consultants' responses on the feasibility of GIS in EIA: A SWOT analysis

STRENGTHS	OPPORTUNITIES
"All project proposals could be geo-referenced." "Visual awareness of all development projects currently applied for and approved will assist in CEA." "A model can be built for multiplication of impacts that equals the cumulative impact." "We use CAD models to show past and future forecasts."	"Web-based GIS usage is a good platform for I&APs to participate and will highlight I&APs intention of really being involved and not only trying to boycott the project. It will make the public aware of their roles and responsibilities and encourage participation. "
'A web-based platform where a red flag appears on the website the moment your application is submitted." "Independent party screening will reach more people."	"EAPs won't be able 'to ask such ridiculous amounts of money' [in the opinion of the consultants, the pricing of specialists are costly]. Specialists who share their information can ask for a fee or they can share intellectual property as a marketing tool."
"All data that is in the public domain should be uploaded." "A constraints plan should be drawn up before the official process starts."	"The specialist has already been paid for the information so the developer should share it." "It is public domain anyway."
"A depoliticised platform that operates strictly within time frames and legal framework of NEMA."	"Development is in a state where what you do has to be in writing."

"Google Earth plus cadastral maps and EIA information plus SDFs."	"The way we work these days is to make sure whatever we report will hold up in court."
WEAKNESSES	THREATS
"In South Africa it is difficult to get all involved parties on the same page to streamline the process. Government has their own set of rules. We have appealed many times and government says it is because of lobbyist pressure. Our significance is not significant."	"A lot of money [investors] is leaving the Western Cape because DEA&DP make wrong decisions [investors go elsewhere as EIA process is seen to be ineffective]. Government might not like the transparency of GIS usage."
"Government officials do not understand the EIA and cannot make decisions. Decision making authorities refuse to look at the merit of the case. They only look if it is within the urban edge (PSDF)."	Government says they don't know what to do. It is because they have not been practicing within their own rules. They don't keep timeframes and if you complain they reject the proposed project."
"Information needs to be groundtruthed. If you ask Cape Nature they will go to CBA and they say everything is 'pragtig en mooi' and the botanist says 'hier gaan boggerall aan'[land use change is not updated]."	"The EIA is getting a bad name. The proposal gets rejected – not because of the bio-physical status, but because of the planning component that overshadows it."

Opportunities presented by GIS usage includes that it will allow for the exchange of current standardised and geo-referenced data on-line. Threats and weaknesses include the lack of cooperation between parties and the lack of holistic vision of the intent of environmental management that is affecting the reputation of the EIA process. Knowledge management needs to focus on collecting and presenting current information for effective decision making. This concludes the coverage of qualitative findings and the attention shifts to the findings of quantitative data sourcing.

4.2 THE QUANTITATIVE FINDINGS

In line with the mixed method approach adopted in this study, both qualitative and quantitative data gathering was employed to ensure the best results yield. In this section, quantitative survey results are used to give precise and testable expression to the qualitative findings already examined. The survey methodology and technique for presentation of results are recapped in the first subsection, before the results are presented by theme in sequential subsections. The response counts are tabled in Table 4.21, on which diagrams highlighting the proportional distribution of total group frequencies and the discussions in the following subsections are based. Statements were formulated around the key factors that were highlighted during the qualitative focus group discussions.

4.2.1 E-survey methodology and quantitative results

The quantitative data sourcing method employed in this section involved an e-survey questionnaire that recorded the perceptions and opinions of respondents by means of a five-point Likert scale.

Table 4.21 Quantitative results from e-survey

	Response counts by agreement category (n=12)					
STATEMENTS AND THEMES	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**	**Total**
THEME 1: Ease of access to EIA information						
1. Awareness of need for tools to inform EIA	0	6	3	0	3	12
2. Sufficient information for current EIA decisions	0	8	2	0	2	12
3. Access to sufficient information for effective EIA	0	3	0	7	2	12
4. Standardised guidelines for decision makers	12	0	0	0	0	12
Total theme responses	*12*	*17*	*5*	*7*	*7*	48
THEME 2: GIS for informed EIA						
5. Usage of spatial tools for spatial awareness	12	0	0	0	0	12
6. Web-based GIS for user-friendly interaction	10	2	0	0	0	12
7. Geo-referenced spatial location of projects	10	2	0	0	0	12
8. GIS for learning of spatial aspects of EIA project	0	12	0	0	0	12
9. GIS for attributes of proposed project for EIA	0	12	0	0	0	12
10. GIS users create attributes and variables for EIA	2	6	4	0	0	12
Total theme responses	*34*	*34*	*4*	*0*	*0*	72
THEME 3: GIS for EIA knowledge exchange						
11. Impacts are not linear and project specific	12	0	0	0	0	12
12. GIS incorporates data of cumulative impacts	12	0	0	0	0	12
13. GIS incorporates socio-economic information	3	9	0	0	0	12
14. Access to spatial information informs of impacts	0	12	0	0	0	12
15. Awareness of biodiversity vulnerability for EIA	7	5	0	0	0	12
Total theme responses	*34*	*26*	*0*	*0*	*0*	60
THEME 4: GIS for commitment by all parties				0	0	
16. Spatial awareness increases understanding	3	9	0	0	0	12
17. Access to information increases commitment	2	7	3	0	0	12
18. EIA users are ready to commit to GIS usage	1	0	11	0	0	12
19. Web-based GIS encourages transparency	0	12	0	0	0	12
20. Web-based GIS encourages knowledge sharing	0	8	4	0	0	12
21. All relevant information available to all parties	6	6	0	0	0	12
22. Previous records as benchmark for future EIAs	8	4	0	0	0	12
23. Stakeholders commit to mandatory GIS usage	0	7	5	0	0	12
24. Stakeholders commit to voluntary GIS usage	0	5	7	0	0	12
Total theme responses	*20*	*58*	*30*	*0*	*0*	108
THEME 5: GIS for public participation						
25. Web-based GIS information for participation	2	9	1	0	0	12
26. Web-based GIS engages a wide audience	4	7	1	0	0	12
27. Monitoring could avoid appeals and delays	11	1	0	0	0	12
28. Web-based GIS usage improves awareness	4	8	0	0	0	12
29. GIS usage authenticates public participation	3	9	0	0	0	12
Total theme responses	*24*	*34*	*2*	*0*	*0*	60
THEME 6: GIS for good governance						
30. Web-based GIS usage requirements	2	10	0	0	0	12
31. Government support for GIS as mainstream tool	3	9	0	0	0	12
32. Government funding for web-based GIS usage	1	5	2	2	2	12
33. Support for standardised GIS specifications	0	12	0	0	0	12
34. Web-based GIS usage supports transparency	3	9	0	0	0	12
35. We support web-based skills and capacity	3	4	3	1	1	12
Total theme responses	*12*	*49*	*5*	*3*	*3*	72

The target respondents focussed on was selected through convenience sampling of environmental assessment practitioners (EAPs) and DEA&DP case officers (six respondents from each group). The survey focused on the aim of this study to examine the feasibility of GIS usage in EIA for effective practice. The survey comprised 35 statements grouped into six topical sections (see Appendix A for the survey instrument). A five-point Likert scale was employed as an ordinal method of numerical measurement for statistical analysis.

The first theme was introductory to gauge the attitude of the respondents towards the importance of ease of access to information in the EIA domain and presented GIS usage as a potential solution to shortcomings encountered in this area. The other five topics covered the five sub-themes that are explored throughout this study as shortcomings in EIA and subsequently also opportunities for effective EIA in practice.

These sub-themes embrace knowledge management, informed decision making, committed involved parties, authentic public participation and good governance. The six topics were covered in the survey as 35 statements that gauged the responses of participants on a five-point Likert scale as they indicated their agreement or disagreement to these statements ranging from “strongly disagree” and “disagree” on the lower end of the spectrum through “neutral” in the middle and “agree” and “strongly agree” on the upper end of the scale.

The e-survey was submitted to the focal contact at DEA&DP for distribution to case officers and also to a convenience sample of EAPs. The questionnaire was designed so that participants could respond on-line and the completed document returned by e-mail. The respondents’ answers were analysed and expressed as frequency counts in Table 4.21 to enable summarising of the data as averages and proportional distributions.

The findings of every theme was collated and presented in graphic format to visually display the perceived support for GIS usage. As mentioned in Chapter 1, the sample universe was estimated at thirty potential respondents. However, only 12 responses (40%) were received back. Even though this low total number of responses limits the representivity of results, the data represents opinions of a sample of experienced case officers and practitioners and therefore reflects resolute conviction regarding the themes.

Excepting Theme 1 (60%) the absolute majority (>85%) of respondents selected ‘agree’ or ‘strongly agree’ with the feasibility of GIS usage to add value to EIA. Therefore, it was decided to summarise the findings as one summary table and graph in Figure 4.1. A summary of the conclusions from each of the six topical themes, including analysis of the measured outcome and interpretation of the results are presented in the next section from 4.2.2 to 4.2.7.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	
SCORES	35%	50%	9%	3%	3%	100%

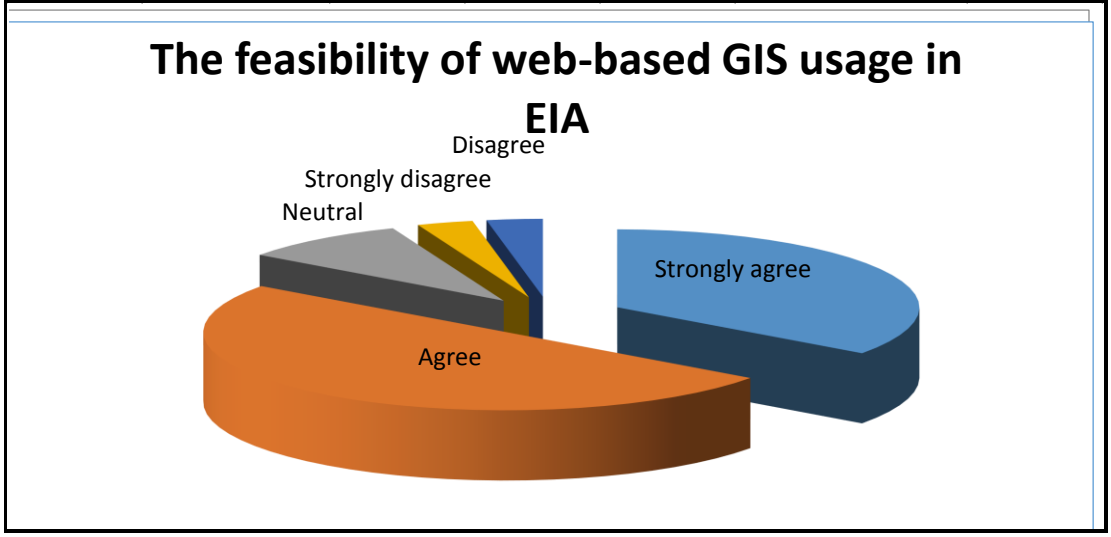


Figure 4.1: The majority of e-survey respondents supported the feasibility of GIS in EIA

The majority of respondents (85%) support the feasibility of web-based GIS usage to facilitate the current EIA process in the Western Cape. The findings support the research concept of integrating technology and policy to improve processes and bring execution of the law closer to the people.

4.2.2 E-survey: GIS for ease of access to EIA information

The first theme of the survey was designed to assess the opinions of the participants, who represent EAPs and case officers, regarding the ease of access to information, availability of information and understanding of strategies and policy of all spheres of government as presented in Table 4.2.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	
SCORES	25%	35%	10%	15%	15%	100%

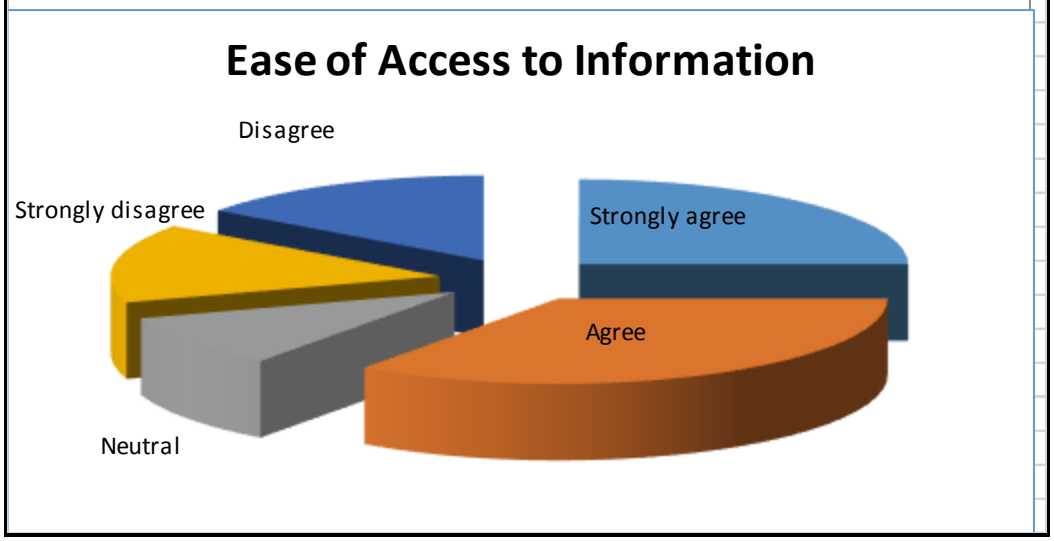


Figure 4.2: Opinions of respondents regarding ease of access to EIA information

From the results displayed in Figure 4.2, 60% of the respondents conveyed that they understood national strategies and policies, had access to information for decision making, that information was available and that they felt a new framework would improve future environmental sustainability. Nearly one third (30%) nevertheless expressed disagreement. The relatively high level of agreement can be attributed to the fact that case officers have access to the information collected by EAPs and that they value informed decision making. It also highlights the need for new strategies and tools and a platform for integrated and informed decision making based on best practice to be implemented.

4.2.3 E-survey: GIS for EIA knowledge management

From the results displayed in Figure 4.3, nearly all the respondents strongly agreed or agreed and only 4% had neutral opinions on whether web-based GIS usage for knowledge management would facilitate the current EIA process.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	
SCORES	48%	48%	4%	0%	0%	100%

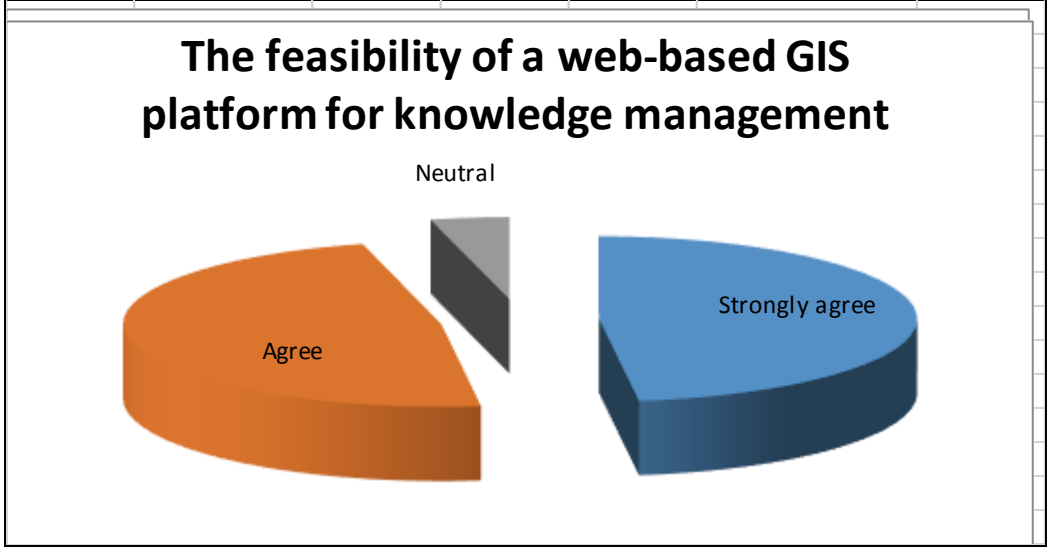


Figure 4.3: Opinions of respondents regarding feasibility of a web-based GIS application for knowledge management

The virtually unanimous agreement that a web-based GIS platform for multidisciplinary knowledge exchange would inform the EIA process on impacts that include socio-economic and biodiversity effects, that access to spatial knowledge would encourage a better understanding of the impacts that are likely to occur, and to create awareness of considering alternative options for mitigation, is convincing. The very high degree of respondent agreement with the feasibility of web-based GIS usage as a platform to transform critical issues related to the EIA, such as the lack of knowledge management, underlines the validity and rationale of the study and its findings.

4.2.4 E-survey: GIS for informed EIA decision making

This section of the e-survey assessed the perceptions of respondents on the feasibility of web-based GIS usage to inform EIA decision making. The opinions of respondents were analysed regarding their understanding of spatial awareness, modern communication tools and screening of baseline information. GIS usage was evaluated as a platform to view spatial and non-spatial attributes for informed decision making. All the respondents agreed that web-based GIS usage has the potential to transform critical issues related to the EIA as all relevant information will be available early on in the process and accessible on a user friendly platform where all parties participate.

Figure 4.4 illustrates that 60% of respondents strongly agree and 40% agree that a web-based GIS application will potentially inform decision making. Respondents agreed that modern communication tools, such as the Internet and Google Earth, mobile maps and GPS encouraged spatial awareness amongst society and created opportunities to interact with geo-technology in a user friendly way.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	
SCORES	60%	40%	0%	0%	0%	100%

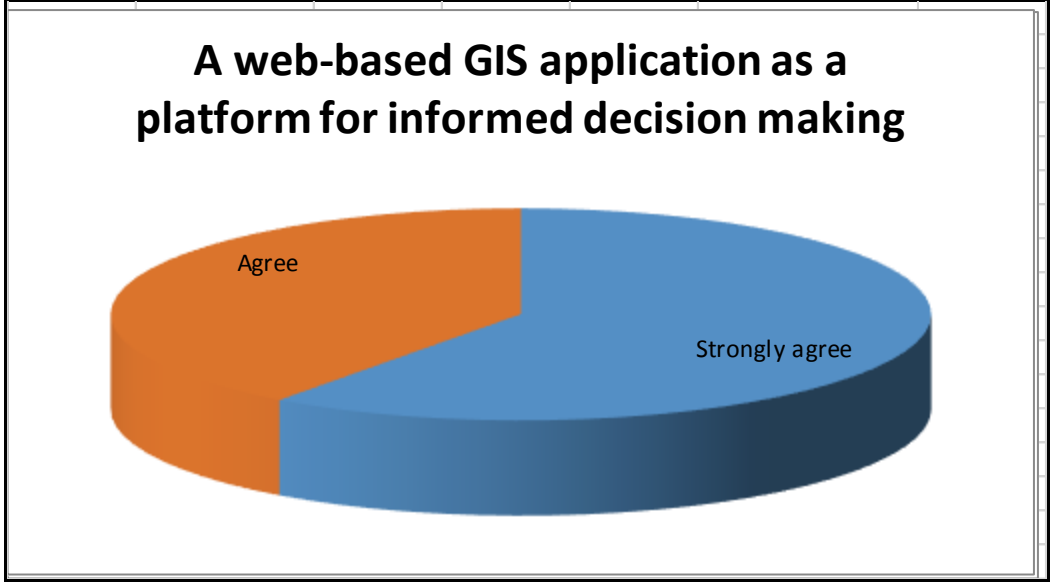


Figure 4.4: Opinions of respondents regarding feasibility of a web-based GIS application as a platform for informed EIA decision making

The importance of geo-referenced data was highlighted so that the spatial aspects of development projects could be located. Furthermore, respondents agreed that upfront baseline information of the location of a proposed project was crucial to streamlining effective decision making. Lastly the web-based GIS usage was elected as a potential long term solution to the critical issues of informed

decision making related to the current EIA process as GIS users can create the variables and attributes required for informed decision making.

The fact that all respondents agreed, endorses the feasibility of web-based GIS usage as a platform for information exchange to inform decision making. The respondents agree that a web-based GIS platform has the potential to transform critical issues related to the EIA as all relevant information will be available early on in the process and will be accessible on a user-friendly platform where all involved parties can participate.

4.2.5 E-survey: GIS for commitment of involved parties in EIA

The penultimate section of the survey assessed the opinion of respondents regarding the feasibility of web-based GIS usage for involved parties to commit more effectively. Responses regarding comprehension of the complexity of human-environmental relationships, access to spatial attributes, knowledge integration, improved transparency, knowledge sharing and web-based GIS usage as a solution to transform the critical issues were analysed.

Figure 4.5 illustrates that nearly 20% of respondents strongly agree, bringing the agree category to more than 70% in total. Nearly one third remained neutral on whether web-based GIS usage will potentially encourage involved parties to commit more effectively.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	
SCORES	18%	53%	29%	0%	0%	100%

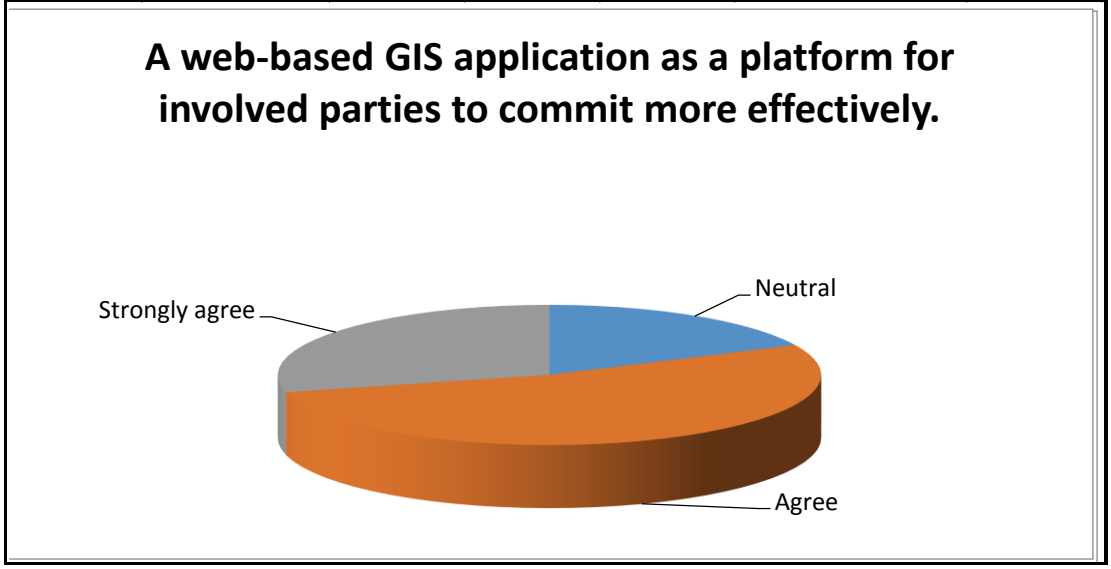


Figure 4.5: Opinions of respondents regarding feasibility of a web-based GIS for involved parties to commit effectively

The opinions of respondents confirmed the feasibility of a web-based GIS platform that can potentially allow all involved parties to adapt to a voluntary or mandatory application. With shared *bona fides*, the platform to collaborate and learn and make decisions based on relevant, current and validated and shared information and knowledge to inform transparent decision making, could become reality. The reason that nearly one third of respondents were neutral or unsure whether GIS would provide a platform for collaboration and integration of involved parties, may be attributed to their heterogeneity. Observational evidence gleaned during interactions with involved parties also revealed that most see their role as stand-alone projects, specifically accounting for a certain amount of scepticism towards other involved parties. This may be as a result of a history of lack of integration and commitment to holistic engagement and commitment to a common goal.

4.2.6 E-survey: GIS for effective EIA public participation

The last survey section, as presented in Figure 4.6, assessed the responses regarding the feasibility theme of GIS usage for effective public participation to involve society more authentically in EIA decision making. Opinions of respondents were obtained regarding the nature of audience access to a web-based platform with baseline information, monitoring of participation, opportunity for critique and comments to potentially improve public environmental awareness and participation. Again an overwhelming majority (near 100%) of respondents agreed that GIS usage would positively influence the public to renewed rigorous participation in authentic EIA processes.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	
SCORES	40%	56%	4%	0%	0%	100%

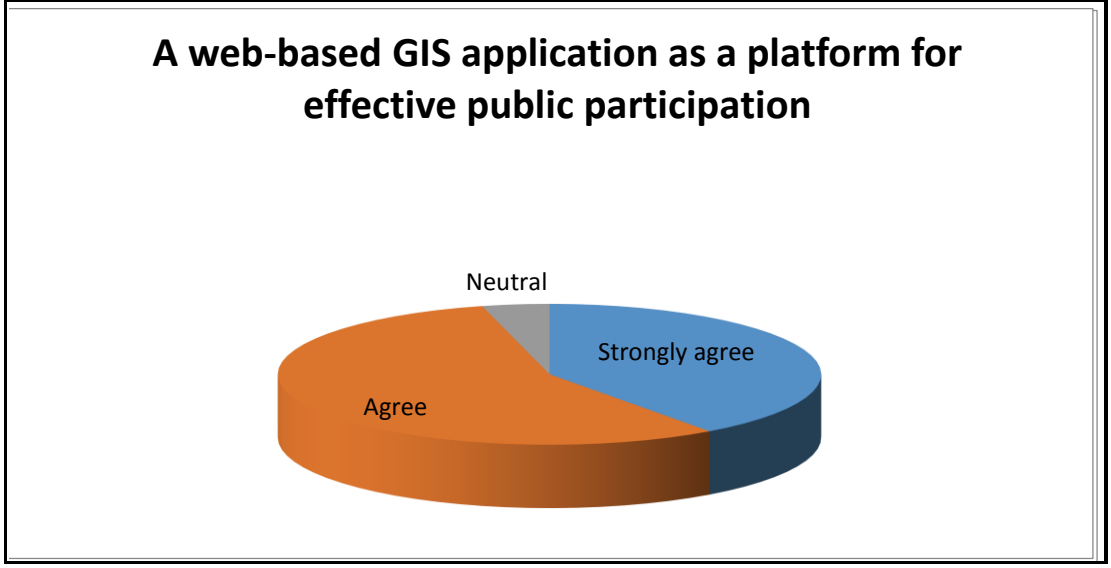


Figure 4.6: Opinions of respondents regarding feasibility of a web-based GIS application as a platform for effective public participation

Figure 4.6 illustrates that 40% of respondents agree strongly, bringing those in agreement to just short of 100%, with only an insignificant 4% being neutral regarding the feasibility of web-based GIS usage to potentially encourage more effective and authentic public participation in the EIA process. GIS usage with wide audience access to baseline information of a proposed project can potentially encourage those affected by the impact to participate effectively. Respondents agreed with the functionality of a web-based GIS platform to add transparency to the process to consequently avoid untimely appeals or delays to the EIA procedure. Access of relevant information to a wide audience would improve awareness of the need for current and future environmental sustainability.

4.2.7 E-survey: GIS for good governance

This section assessed the attitudes of respondents regarding governance of web-based GIS usage to potentially facilitate EIA as presented in Figure 4.7. Opinions of respondents were analysed under separate statements regarding funding, support, development, maintenance, standardisation, transparency, best practice and commitment. The majority of respondents agreed that a governing entity or authority was required to support GIS usage as a potential platform for objective EIA best practice, transparency and capacity building.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	
SCORES	16%	68%	8%	4%	4%	100%

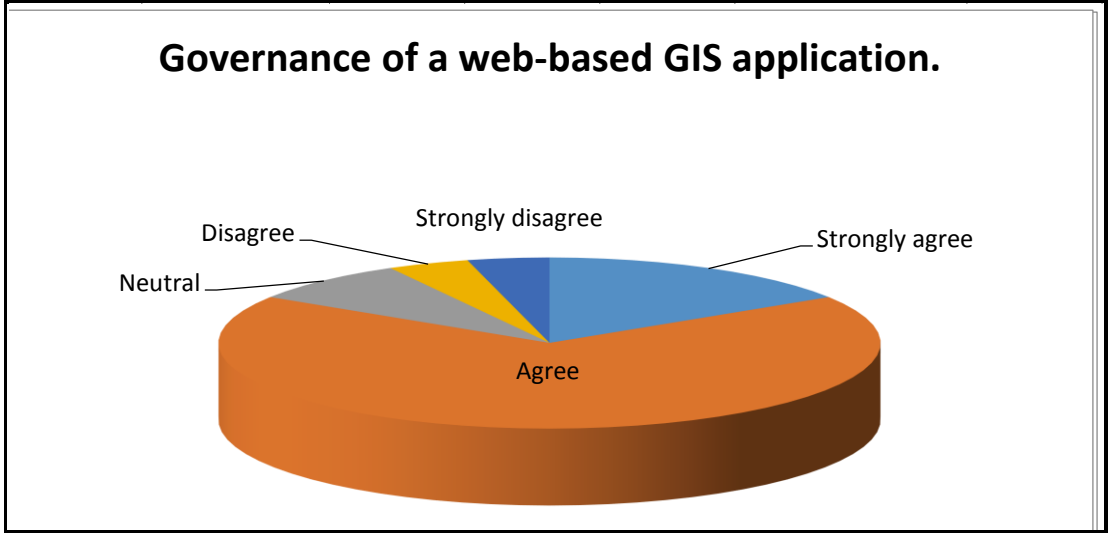


Figure 4.7: Opinions of respondents regarding good governance of a GIS

Figure 4.7 once again illustrates an agreement proportion above 80%, although only 16% of respondents agree strongly. Those declaring a neutral opinion or even disagreement (8%) on these critical issues related to the governance of web-based GIS usage to facilitate the current EIA process in Cape Town and the Western Cape are a small minority.

Respondent opinions were therefore in agreement on issues such as responsibility for costs, budgets and funding as well as government support and drive of a GIS for EIA. Most respondents agreed that a governing body was required who should be responsible for objective EA according to best practice, transparency and the necessary capacity building to employ a web-based GIS application to facilitate the current EIA process. Since such an overwhelming majority of respondents agreed, it is interpreted as an indication that government should support new strategies and tools as potential solutions to critical issues related to governance of the current EIA process.

In concluding this section, it should be pointed out that the majority of respondents in the e-survey concur with the opinions of participants in the previous sections. The mixed methods approach of data collection proves that within the framework of the current EIA process, knowledge management, informed decision making, commitment by involved parties, effective public participation and good governance is needed. These critical issues all relate strongly to the social component in the process that reiterates the role of people in EIA. Furthermore, the respondent participants supported the need for the integration of technology into the EIA process and agreed that GIS usage designed and developed to interact within the EIA framework, would be a feasible solution to facilitate effective EIA in practice.

In the following section the interpretations of all the findings of all the methods of data gathering regarding the feasibility of web-based GIS usage in EIA are presented as it relates to the sub-themes of the study. In other words, 'if' and 'how' web-based GIS usage would be potential solutions to turn the EIA shortcomings identified within the scope of this study into opportunities for an effective EIA process in practice that is aligned with the IEM sustainability principles.

4.3 DIRECTIVES DERIVED FROM FINDINGS

Viewed against the backdrop of the evidence presented, potential solutions to the research question, aim and objectives of this research are presented under the headings of the five sub-themes in this section. The analysed data highlight the need for integrating GIS (technology) into EIA (policy) and reconnecting EIA with people (involved parties) to raise the standard of EIA within the scope of this study towards effective and informed EIA in a practice aligned with the intent of the IEM sustainability principles.

4.3.1 GIS for knowledge management enables effective EIA

The opinions of the participants and respondents involved in the study attest to agreement that knowledge management can potentially facilitate the EIA process through the design, development and implementation of GIS usage. Perceptions of respondents indicate that appeal takes priority in

the current EIA due to lack of communication, lack of knowledge exchange and integration and lack of a holistic understanding of the EIA process. Case officers and competent authorities in government responsible for decision making blame the increase in decision appeals on lobbyist pressure from I&APs [the public]. However, opinions from other respondents indicate that the challenge lies in the need for effective decision making and the fact that authorities do not recognise the opinions of other parties as having significant merit.

GIS web-based usage will potentially manage and present relevant information for conflict resolution to alleviate the need for mediation and to prevent protracted litigation and appeal. EIA needs to go beyond compliance and a web-based GIS usage could enable a visual display of every phase of the project development and function as a platform for current, related, geo-referenced, spatial and non-spatial information accessibility early on in the process using modern communication tools already familiar to many people.

Furthermore, the research findings are in accord that knowledge management creates opportunities for trust and transparency in the EIA process. Communication, training, career growth opportunities, team work, tools, resources and leadership could potentially also be enhanced through GIS usage to enable all involved parties to collaborate, exchange knowledge and learn. A continuous discourse between involved parties and relevant information exchange through GIS usage could potentially keep systems, tools and operations current and in line with the requirements of users and policy. Skills, literacy and technology capacity building are major challenges in countries in transition such as South Africa and an increase in exposure and awareness of IEM issues to more people could encourage the increase of user literacy and job creation.

4.3.2 GIS for decision making informs effective EIA

Participants noted that the current EIA process lacks consistency, continuity and effectiveness and that a holistic and strategic approach to decision making is needed. There is a need to move away from linear thinking of what development impact will be, to dynamic processes of how the development will benefit present and future environmental sustainability.

Some parties involved in the EIA process are seen to withhold information and as a result existing information and reports may be in the public domain, but are not necessarily readily accessible. There is a need for best practice which includes knowledge exchange, a repository for relevant information and a grasp of the intent of sustainability for effective decision making.

Fortuitously, the majority of respondents agreed that the technical expertise is available alongside the ‘red-tape’ or incompetence experienced during the execution of some EIA procedures. They supported GIS usage as a potential long term solution to the critical issues of informed decision

making related to the current EIA process. It was noted that GIS users can create the variables and attributes required for informed decision making to be used in other areas of decision making such as risk assessment, disaster preparedness, community health and climate change research to explore costs and benefits associated with policies and problems. It was suggested that a national database could integrate all relevant information from where it could be disseminated.

Participants were of the notion that a website displaying relevant spatial information such as zoning, property rights, land use and current projects as well as attribute data of the location and specific area would expedite decision making. Furthermore, participants in the research focused on benefits of using GIS. Examples are opportunities for GIS users to be in different places for decision making, as the time and space constraint of having to go to a specific location to read documents will be reduced. Decision makers will be enabled to do forecasting for site selection from Internet or intranet linked computers. GIS usage can enable an integrated visual baseline study of the impact on the receiving environment 'as-is', followed by a forecast of a visible assessment of work in progress and a projected view of what the project is going to look like.

Research participants strongly suggested that relevant information be made accessible as a reference for new projects. Records of Decision (RoDs) regarding current or completed projects from surrounding area should be available in visual and textual format to alleviate language barriers and inform decision making. Respondents agreed that visual information alerts users to interact with geo-technology in an intuitive way and virtual reality tools such as GIS maps give people an intelligent sense of owning and understanding the environment. Furthermore, participants in the research process recommended a platform for collaboration and two-way communications between EAPs and I&APs regarding risks related to the impact on the environment and on the development project.

4.3.3 GIS usage encourages commitment by involved parties in EIA

An interpretation of the research data suggests that industry and business need to prioritise ecological, economic and social compromise and all involved parties need to commit to self-regulation in and beyond compliance with IEM, NEMA and EIA requirements towards future environmental sustainability. Web-based GIS usage will potentially add transparency to highlight the intentions of involved parties. However, officials and developers not in favour of transparency may undermine the usefulness of GIS. To encourage transparency and trust the opinions of NGOs from affected areas could be integrated into the scoping phase. NGOs and I&APs should orchestrate networking with key role players in the formal and informal domain. It was also mentioned that once an issue is displayed on a web-based platform it has the potential to gain national or international attention for public lobbying like gas fracking in the Karoo.

Transdisciplinary education of all involved parties is deemed crucial to encourage better understanding of the authentic intent of the EIA process. The general consensus among some involved parties is to know the process and try to get away with non-compliance due to ignorance of the intent of environmental legislation. Furthermore, the majority of respondents supported GIS usage to potentially encourage more effective and authentic engagement during the EIA process and to encourage risk preparedness towards sustainable living. Web-based GIS usage with wide audience access to baseline information of a proposed project could potentially encourage those affected by the impact to participate effectively and to consequently avoid untimely appeals or delays of the EIA.

Participants advised that it is difficult to get people to use the same web site as they are used to old processes of operating independently. To ensure involved parties commit to using the same web site and system, GIS usage needs to become part of the mandatory EIA process or be user-friendly and linked to modern communication networks such as Google Earth. Many people already use Google Earth to browse physical environment images and GIS usage in EIA could add on to the practice of knowing your environment where everyone can use the same system. Consequently, involved parties such as districts and municipalities will be encouraged to share information and develop a database of relevant information at local, provincial and national level to improve awareness of the holistic nature of IEM.

GIS usage in EIA can encourage knowledge networking and effective contact with I&APs in urban as well as rural areas. I&APs will be better informed on a social level and not feel intimidated by the project proponent or EAP. The majority of the respondents recommended that EAPs need to operate from an objective and independent approach with the necessary experience, knowledge and ability to manage and exchange knowledge for informed decision making. The outcome of the research further highlighted the critical issue that I&APs work as volunteers and see the client as paying the EAP. Therefore they question the objectivity of the EAP in the light that many clients focus on profits at all costs.

According to the participants in the research, comprehension by involved parties of the project in terms of what will be erected and what the impact of the proposed development will be is crucial. The technological processes required to suite the specific circumstances such as computers, cell phones, 3G cards and even ATM-type Internet booths or CDs with regularly updated information are available to demonstrate impacts by way of visual environmental intelligence. As mentioned in Chapter 3, ethnographic visual information that people can relate to, such as maps showing landmarks in the local area identifying features familiar to the local community, could encourage communication and knowledge exchange with direct relevance to the potential impacts and mitigation relevant to the

project. I&APs would be able to visualise their villages and other landmarks and increase their knowledge and awareness of potential impacts and trade-offs related to development projects. Furthermore, process documents should be presented in understandable format such as laymen's terms, in local languages with visual content to increase compliance monitoring.

4.3.4 GIS usage encourages focus on authentic public participation

New knowledge gained from the study recommends authentic public participation as a requirement of EIA to encourage interest group involvement through participative processes with a real attempt to engage, answer and understand the South African public. It was stressed that peculiar group issues of language, culture and literacy barriers should not be overlooked and that effective collaboration across disciplines by involved parties engaging through participative GIS usage could potentially increase as the understanding of cumulative impacts increase through visible environmental intelligence.

It was suggested that participation processes required in compliance with other legislation could be combined with EIA requirements to a single process to augment the challenge of time management experienced by participants who need to attend lengthy meetings with similar agendas related to different disciplines. Participants agreed that meetings scheduled for public participation should take into account times most suitable to most people. Alternatively, web-based meetings and the Internet present opportunities to engage with a wide spectrum of people across spatial, time and culture constraints.

A standardised virtual platform for public participation was recommended in order to eliminate vague and non-specific portrayal of development projects and related impacts. However, a solely digital format could potentially result in total loss of the human element in online participative processes. Participants concurred that the public participation process should be mandatory and options to waive the process should not be allowed. They recommended GIS usage to integrate links to functions or mediation forums to resolve critical issues and streamline the EIA process. It was also suggested that a list of recommendations by I&APs should be included in the BA and EIA report.

Respondents suggested that the details of key I&APs from different regions or disciplines, made available in the public domain for EAPs to refer to in addition to the project related registered I&APs, could expedite the process. Furthermore, involved parties, including the government decision makers, EAPS, consultants and I&APs, need to understand the rationale for public participation in the EIA process. I&APs often know about vulnerable and sensitive areas as well as previous environmental hazards or risks experienced by the community and through knowledge exchange relevant historical and spatial information can be geo-referenced and red-flagged for precaution.

4.3.5 Good governance is based on values and ethics

By national and international standards, good governance infers leadership of respectable financial, social, ethical and environmental practice. Despite the element of scepticism and distrust regarding the intent of environmental governance in South Africa, most respondents indicated that government is needed as a strong driver to support the necessary capacity building to institutionalise GIS usage. Opportunities where the feasibility of GIS usage facilitates good governance in the EIA domain are cited below.

In aligning EIA and good governance, respondents concur that the platform for effective EIA needs to be user friendly, current, relevant, validated, standardised and aligned with good governance and intent on the collaboration process as a strong driver to implement effective EIA. Furthermore, research participants agreed that the EIA process is seen to be politicised along with critical issues such as distrust, reluctance to share information and political gate keeping. Some projects are fast tracked or hijacked and rejected for reasons not related to the EIA process and some believe that GIS usage would be a key enabler to depoliticise the EIA process and could be a strong call to government to adhere to the principles of good governance instead of operating by its own rules and not adhering to time frames.

According to research participants, provincial and city level leadership have different opinions and different management styles. As a result the authorities blame external forces and employees blame the managers. There are opportunities for competent leadership with vision to assess the real costs and benefits associated with EIA proposals. GIS usage could potentially encourage leaders to transform excessive costs, budget constraints, intellectual property and conflict into operations based on trust and commitment. Respondents agree that GIS usage with access to current and relevant baseline information of the receiving environment will highlight the need for specialist reports early on in the process and potentially overcome the constraints of protecting intellectual property. As a result, involved parties such as specialists, EAPs and government would share information and exchange knowledge aligned with the transdisciplinary intent of EIA as a marketing tool through GIS usage.

Good governance practice includes the challenge of retaining competent staff as they are the authorities in EA decision making. An organisation cannot solely rely on the knowledge embedded in individuals as the content of social networks is subject to decay as a consequence of high staff turnover. GIS usage with a database as a repository for relevant knowledge management and information exchange can potentially ensure continuity of competent knowledge workers. Furthermore, jobs will potentially be created for technicians and data managers and opportunities will

be created for communication, training, tools and career growth in a trusting environment to promote competent staff retention. This chapter sums up opportunities for EIA in practice to become aligned with the intent of EIA policy and IEM sustainability principles towards an effective process. Communication, knowledge exchange and technology are good strategies for success. Furthermore, just-in-time solutions such as the institutionalisation of GIS usage, can create opportunities for involved parties as custodians and consumers of the finite environmental resources to collaborate and exchange knowledge of environmental impacts, mitigation methods and trade-offs in an environment of trust and transparency. Chapter 5 is the final chapter to summarise and conclude the study and make recommendations for future research.

CHAPTER 5: CONCLUSION AND RESEARCH RECOMMENDATIONS

This study advocates GIS usage in EIA supported by good governance and self-regulation based on integrated environmental management (IEM) principles and following a transdisciplinary approach for knowledge exchange with collaboration by all involved parties in EIA towards informed and effective environmental management and impact assessment. Chapter 5 brings the work to a logical conclusion. In this chapter the research aim and objectives as set out in Chapter 1 are revisited and expounded on in terms of the text locations where the objectives were examined, along with highlights of the insight gained in reaching objectives.

Furthermore, the GIS for EIA model that is graphically displayed in Figure 1.2 in Chapter 1 had been adjusted to usurp the insight gained from this study and is presented in Figure 5.1 in this chapter as a visual and textual descriptor to benefit understanding and interpretation of the conclusion of this study as an opportunity to unify EIA, GIS and people. The unification can potentially transform the EIA shortcomings into strengths and enable involved parties to collaborate through knowledge exchange to align their behaviour with IEM and self-regulation based on informed decision making. The original research idea that focused on GIS in EIA as research to design, develop and implement GIS in EIA, is recommended for future research and the study concludes with factors that could be considered and addressed in the future research project.

5.1 THE RESULTS VALIDATE THE VALUE OF GIS USAGE IN EIA

With regard to the aim of this study to investigate the feasibility of the usage of a web-based GIS application to facilitate the EIA process in practice, the outcome of every phase of the research process supported by the opinions of the participants, reinforced GIS usage as a feasible platform to facilitate effective EIA. To achieve the aim of this study, five objectives were presented in Chapter 1 and were examined in each of the remaining chapters in order to accomplish the projected outcome. In the following section the first objective is expounded on in terms of the methodology, methods and data sourcing process.

5.1.1 The research methodology: Transdisciplinarity and triangulation

The first objective examined in Chapter 1 was to carefully choose the most suitable research methodology and data sourcing methods for saturation of information to understand and validate this research within the complex domain of policy, technology and people in order to reach the required outcome. To set the scene the research problem was introduced in Chapter 1 as a dilemma facing leaders to support the need for improved living standards within the carrying capacity of the Earth. The main themes of the study focused on were the diverse domains of policy presented as EIA,

technology presented as GIS and people as users of the process as well as custodians and consumers of environmental resources. South African environmental legislation was introduced as it is of global standards and the EIA process as a tool of NEMA (Act 107 of 1998) became mandatory based on the holistic principles of IEM with people at the forefront of its concern and methods have been developed for effective environmental management. However, the practical implementation of the EIA is still marred by shortcomings. These shortcomings have been selected as the sub-themes in this study as they can be converted into opportunities for effective processes aligned with the IEM principles. These sub-themes are knowledge management, informed decision making, committed involved parties, authentic and effective public participation and good governance. Subsequently, there has been an urgent call by government and environmental managers for unified strategies and tools for effective environmental decision making and GIS has been highlighted as a potential solution to inform EIA decision making.

The initial aim of GIS in EIA was to design, develop and implement GIS in EIA, but through insight gained during the research the problem of a lack of informed decision making in EIA was identified. The amended aim became a feasibility study of GIS in EIA gleaned from the opinions of involved parties in EIA, IEM and GIS as participants in the research process. The motivation for employing transdisciplinarity as the methodology in the light of the complexity of the integration of policy, technology and people in this study was evaluated and found to be the most suitable. Combination with the rationale of selecting the mixed method approach of triangulation that enables qualitative and quantitative methods, provided a more holistic pathway to the truth. The transdisciplinary research methodology was selected as a multi-faceted research approach as the most suitable to respond to societal knowledge demands in attempting to solve complex problems for the common good. Triangulation was selected as the optimal data sourcing method for saturation of information to reach the required conclusion. Furthermore, a model that emerged through insight gained into the complexity of understanding policy, technology and people was used to clarify the transdisciplinary concept and variables of this study through the funnelling progression of the research approach as displayed in Figure 1.2 in Chapter 1. Furthermore, qualitative and quantitative data sourcing methods and tabled lists of participants are presented for measurement and interpretation in Chapter 4. In the next section the objective to examine literature is revisited.

5.1.2 The value of GIS usage for EIA

The second objective was to examine the motive of the research problem by means of scholarly literature in order to justify the rationale for this study and to evaluate the value of GIS usage for EIA

from publications of expert opinion. Web-based communication techniques based on electronic and digital tools were found to have the potential to inform interactive decision making across disciplines.

The benefits of web-based GIS usage in EIA include easy access to information, education in citizen illiteracy, knowledge exchange, stakeholder engagement, effective public participation and informed decisions. Challenges emerged that needed to be addressed, such as lack of capacity and skills, as well as dubious intent by certain EIA users and problems of corruption and lack of transparency perceived to occur in countries in transformation. However, it was evident from the literature studied that these challenges could potentially be successfully addressed. Furthermore, published experts noted that innovative and effective problem solving requires that values and ethics be reintroduced into decision making as the problems we face relate to the lapse of values showcased as greed, dishonesty, lack of transparency and lack of accountability. Subsequently, it was suggested in notes from conference proceedings and reports from speeches by leaders in environmental decision making (EDM) that the discourse between the scientific community, policy makers and stakeholders should be strengthened to develop synergies from various knowledge sources to unify the development of social upliftment, economic growth and environmental management. It was recommended that EIA should change from the need to clean up, to creating less mess to begin with.

EIA legislation was introduced, followed by comments on the shortcomings of the current EIA process within the scope of this study and potential opportunities for effective EIA. GIS was recommended as a useful approach in informed EIA in terms of systematic identification and evaluation of potential impacts in site selection, evaluating of trade-offs and mitigation of negative impacts. Journals and books that informed this study were listed in table format and case studies of GIS in EDM were examined to highlight potential challenges encountered in the development and implementation of GIS in EIA in countries in transition. Furthermore, the roles and responsibilities of people as involved parties in EIA were explored, as people are the actual agents impacting on the environment. The sub-themes were presented for review as opportunities for effective EIA. It was concluded that literature supports the need for new strategies and tools such as web-based GIS usage that has the potential to enable effective EIA. It was suggested that the current shortcomings in the EIA process could be converted into a step-up towards effective EIA. The chapter concluded with examples of GIS maps for informed decision making and encouraged all involved parties to gain access to maps using GIS to facilitate visual knowledge of relevant information. This to inform decision making and, in the light of the outcome of the scholarly review, web-based GIS usage in IEM was deemed a feasible solution to facilitate the disconnection between theory and practice in the EIA process. In the third objective that follows GIS and EIA were examined as spatial management tools.

5.1.3 Uniting EIA and GIS as spatial management tools

The third objective was reached in Chapter 3, which aimed to unite EIA and GIS as spatial management tools by means of a dual study of EIA and GIS. It examined the shortcomings of the current EIA process in practice within the scope of this study as well as the functionality of GIS to inform EIA towards IEM. Suggestions were made that the EIA process be made applicable to a broader context of non-project activities and focus on a more holistic emphasis of impacts and trade-offs so that development projects would profit a wider spectrum of beneficiaries. Furthermore, the EIA shortcomings were linked to IEM sustainability principles to highlight opportunities to improve standards and integrate technology, such as GIS usage, to facilitate effective EIA in practice. Solutions were sought not necessarily to approve more projects, but to inform EIA decision making towards effective, efficient, timely and consistent EIA processes in practice.

The role of scientific expertise, such as web-technology and modern communication systems such as Internet and Google Earth, to support salient environmental issues were seen to be at the centre point of transdisciplinary research. It featured prominently in strategic planning for effective IEM strategic development and throughout the full life cycle of the EIA process. Published research by experts on the effective use of GIS applications was integrated with the sub-themes of this study, which represented the EIA shortcomings, to verify the potential value offered by GIS to facilitate effective EIA in compliance with NEMA. Furthermore, the origin and initial development of the EIA process was presented as a timeline as well as a graphic display of the EIA as a systematic process displaying the interrelated stages in completing the entire process and operational limitations of time, cost, information and resources. The spatial functionality of GIS was presented for add further reliability to the argument for GIS in EIA and GIS was aligned with the sustainability principles of IEM that were listed along with a short description. GIS was further examined as potential solution to the shortcomings in the EIA process as it related to the sub-themes of this study and the IEM principles. In conclusion, GIS usage in computer games, prediction and monitoring tools and EDM maps were presented to validate the value added by GIS in EDM. The following section examines the fourth objective.

5.1.4 Opinions on web-based GIS usage in EIA

The fourth objective endeavoured to determine from empirical survey opinions of involved parties in the IEM domain whether web-based GIS usage in EIA would be a feasible solution to facilitate EIA in practice. The findings of primary qualitative and quantitative data sourcing was collated and analysed in detail so that dependable results and findings could be interpreted and presented sequentially in accordance with the research design diagram from Chapter 1. The qualitative and

quantitative findings were presented in tables in SWOT analysis format as well as graphics in line with the mixed method approach adopted in this study to ensure the best results. Chapter 4 therefore summed up the opportunities for EIA users to enhance understanding of the intent of EIA legislation in practice.

From the interpretation of the findings in Chapter 4, a support platform for the unification of EIA, GIS and people were constructed. It proved to be a good strategy for effective environmental management and impact assessment in an environment of trust and transparency among custodians and consumers of finite environmental resources. In conclusion, the findings were summarised as they related to GIS usage as a solution to the shortcomings in the EIA process towards informed EIA in practice within the scope of the study. In the section that follows the results from the final objective are summarised.

5.1.5 Enabling success factors for GIS in EIA

Chapter 5 encapsulates the whole study in line with the final objective, namely to conclude the feasibility study by highlighting the potential critical success factors that could enable effective EIA through the collaboration of GIS usage in EIA and to make recommendations for future research. The model introduced in Chapter 1 is revisited here in Chapter 5 as a consulting framework. It explains the environment where the introduction of change initiatives, such as web-based GIS usage in EIA (or other processes) will potentially facilitate effective and informed decision making based on the IEM principles of sustainability.

In the following section a summary of limitations and challenges encountered during the research are presented, followed by the amended model as a consulting framework that displays the reconnection between policy and people united through web-based GIS. Thereafter, suggestions are made for future research to design, develop and implement GIS in EIA. Critical success factors are revealed that should be considered in future research.

5.2 RESEARCH LIMITATIONS AND CHALLENGES ENCOUNTERED

The primary limitation encountered during this research related to the usage of quantitative methods as part of the mixed methods approach to data sourcing to provide alternative versions of reality to validate the outcome of the research. An e-survey using a 5-point Likert scale was used as an objective measurement instrument to achieve unbiased results as the researcher was actively involved in all the qualitative data sourcing methods. The limiting factors mentioned here are crucial for future researchers replicating these methods and instruments in sourcing data from government officials to be aware of these or similar challenges. The e-survey was designed so that participants

could respond on-line and the completed document returned by e-mail. The respondent's answers were analysed and expressed as a number to enable summarising of the data as averages and frequency distribution percentages. Originally the target population was a simple random sample of DEA&DP case officers as the researcher was promised access to and counted on a large probability sample within the sampling frame of case officers who represent the decision makers in government. A senior manager at DEA&DP offered to be the focal point to ensure that a sample universe of about 30 case officers and other officials in the department received and responded to the survey. The e-survey was sent to the focal point for distribution and the researcher had no control over the sample universe apart from the verbal agreement. After only receiving six responses it became obvious to the researcher that the envisaged large sample population was not responding. Further contact attempts proved futile and it was inferred that the content of the survey may have been perceived to be too transpicuous, the approach may have been too Eurocentric and top-down and the subjects may have felt they or their positions were under scrutiny hence the less than satisfactory response to the survey. To increase the sample universe under time constraint, the researcher approached a convenience sample of EAPs to participate in the survey and received another six responses that brought the total responses to 12. Even though this is a limiting factor, the data represents a sample of case officers who responded despite challenges. Even though the sample universe was small, the outcome of the e-survey was not insignificant as the response trends in quantitative research followed that of the qualitative research findings in support of web-based GIS usage in EIA.

In terms of challenges and insight gained into critical factors encountered during this study, it was found that capacity building in the business milieu in Cape Town and the Western Cape is often based on personal resourcefulness and change initiatives that are randomly employed. Other factors include the miniscule environmental budgets at provincial level, distrust of national systems such as the NEAS proposal progress tracking system described in Chapter 2. This initiative has never been completed or implemented, work tools are ineffective, information is out of date and mapping systems incompatible. However, contrary to the anticipated outcome that the lack of skills, technology and funding would be the core limitation to effective EIA, it was found that the lack of capacity is not the only area of concern. Of interest is that the new insight gained from the opinions of the participants in this study, suggested that the main area of concern of the EIA process in the scope of this study are challenges such as the lack of communication and collaboration, lack of transparency and trust as well as the lack of values and ethics among involved parties in the EIA process in practice. These challenges point to mind sets and behaviour of people and fall beyond the scope of the study to become a much larger issue of human values and behaviour. The solution lies in a process of change

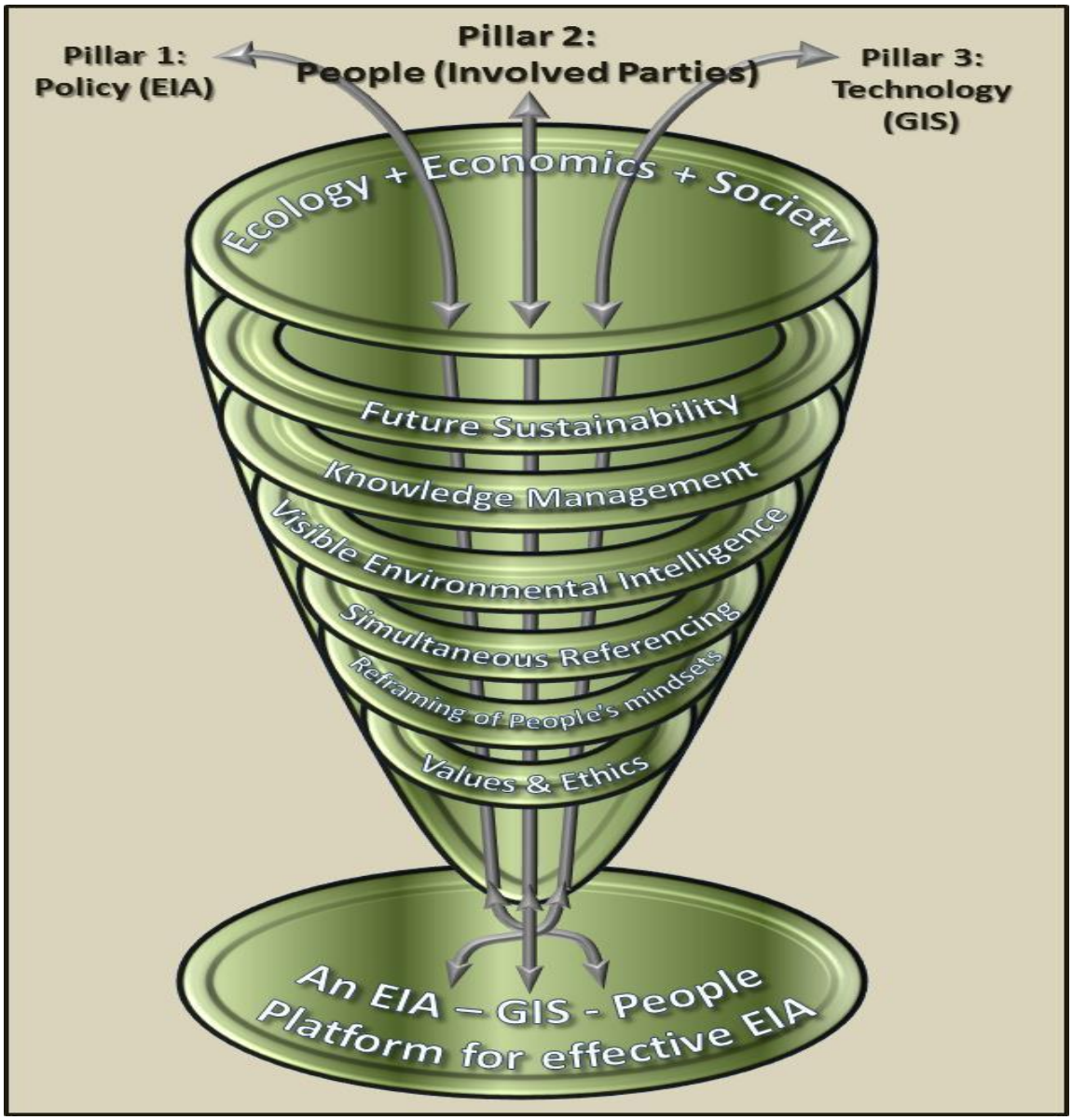
to reframe mind sets of people to look beyond project specific focus and profitability to consider cumulative impacts, social impacts, economic benefits and environmental thresholds.

The process of change will enable people to focus on creating a climate and culture where values, ethics, communication and best practice such as transparency, collaboration, dispute resolution and environmental equity prevail. Despite the fact that the outcome of the study points to primary challenges beyond the scope of this study, the concept of uniting people, policy and technology plays an important role in the solution. Effective knowledge exchange that informs decision making is at the apex of overcoming the challenge of reframing mind-sets as explained in the following section. Throughout this study the characteristics of GIS and IEM sustainability were linked and presented as opportunities to potentially transform EIA shortcomings into strengths and potentially reframe the mind-sets of people towards informed self-regulation. Reframed mind-sets relate to the process of change where involved parties collaborate through knowledge exchange to align their behaviour with IEM principles of sustainability.

In conclusion, suggestions related to a platform to reconnect EIA, GIS and people are presented in the following section

5.3 A MODEL PLATFORM TO RECONNECT EIA, GIS AND PEOPLE

This section wraps up the aim of the study and all the objectives to conclude that GIS in EIA is a feasible solution for effective and informed decision making within an environment based on self-regulation and the IEM sustainability principles. The model presented here, as well as the original model displayed in Figure 1.2, encapsulate the aim and objectives of this study as the original model emerged from insight gained from transdisciplinary variables examined. The amended model graphically displayed in Figure 5.1 similarly reflects on the findings and conclusion of the study as a platform to unite the variables concluded on in the study. In an ideal environment, involved parties need a platform to collaborate where values and objectives are aligned with a climate of mutual trust and respect to facilitate not only the EIA process, but initiate transformation towards future environmental, ecological and social sustainability. Figure 5.1 portrays this change initiative based on uniting policy, technology and people to enable reframed mind-sets of people in order to consider aligning decision making with policy, science and technology as well as IEM sustainability principles towards informed decision making and self-regulation.



Source: Adapted from Van der Merwe (2011)

Figure 5.1: EIA, GIS and People unite as a platform for effective EIA

The model relates to an ideal situation where the EIA becomes a strategic and integrated framework for IEM and sustainable development. In the model in Figure 1.2, GIS usage represents technology and created a platform for knowledge exchange towards effective EIA. However, the IEM framework needs to be integrated into the EIA framework. As a result the concept of an EIA-GIS-PEOPLE framework emerged from the main themes examined throughout this study to transform and facilitate the current EIA process and add future value to the domain of IEM in practice that is currently under scrutiny. To recap, EIA, GIS and People are the main themes of this study as well as the three pillars in this model that unite to enable effective EIA. In the diagram presented in Figure

1.2, these pillars are disconnected. However, as learning increased and new insight and understanding was gained from the evaluation and conclusion of the findings, the pillars united to become the EIA platform to enable effective IEM towards ecological, economic and social synergy. The integration of EIA, GIS and People relates to the extension of the project level focus to include knowledge of attributes and variables created by GIS usage to inform decision making. GIS usage has the potential to encourage transparency and present the visual impact of potential cumulative changes to the receiving environment by looking at past, present and future scenarios.

The term 'consulting framework' is used to describe the amended model. The meaning of the word 'consulting' refers to the action 'to deliberate', 'take counsel' or 'confer' as well as acting in 'an advisory capacity' (Collins English Dictionary 2009). For the purpose of the study it also refers to collaboration and sharing of information between parties as well as a frame of reference. Therefore, the consulting framework should be used in conjunction with the EIA process as a frame of reference to remind users of the importance of incorporating IEM principles and collaborating this knowledge into thought, planning and behavioural processes.

In the model in Figure 1.2 the horizontal bars presented the sub-themes of the study and were referred to as tiered steps to connect the pillars and enable a step-up in standards in the current EIA process. In the consulting framework in this chapter, the horizontal bars refer to practical tiered lenses that aid vision and connect the pillars as well as create opportunities for ongoing learning and understanding and continuous improvement. It relates to a change in mind-set enabled through a funnelling progression based on ethics and values, moving to reframed mind-sets to reconnect people with the EIA process through visible environmental intelligence enabled by GIS technology and knowledge management. In this ideal context, knowledge management ensures that all the requirements for best practice are in place towards future sustainability of economic, ecological and social compromise.

5.4 MODELLED LENSES OF OPPORTUNITY FOR GIS IN EIA

For the purpose of the study, the meaning of the word lens relates to meanings from the Collins Thesaurus (2002):

- An instrument designed to aid vision
- An object for correcting defective vision
- A channel through which something can be seen and understood
- A means of communication and access

Furthermore, in the context of the study the lenses are used to focus on opportunities available in situations that are currently experienced as challenges in the EIA process. The lenses allow users to

see, understand and access these opportunities. The sub-themes that were examined throughout this study represent the opportunities to link people with the new knowledge that is visible through the lenses. In the following sections the lenses as well as the links to the sub-themes are briefly explained.

5.4.1 A lens for values and ethics

Within the proposed expanded EIA framework, based on the EIA-GIS-People platform and focussed on IEM sustainability principles, the lens of values and ethics represents good governance and self-regulation. This implies governance that is based on transparency, trust and best practice. Once values and ethics are re-introduced into the process, continuous improvement of knowledge performance secure a climate of trust, transparency and commitment. Furthermore, involved parties, including I&APs, will be encouraged to cooperate across the disciplines they represent towards a common goal of ecological, economic and social compromise. In practice this could translate to rewarding I&APs for their resourcefulness as well as integrating other IEM tools, such as cost benefit analysis (CBA), in evaluating proposed development projects where precautionary planning is done, trade-offs are considered, impacts mitigated and polluters pay.

5.4.2 A lens for reframed mind-sets

The reframing of mind-sets lens represents an authentic process of participation by all involved parties. Reframing of people's minds refers to a process of change from archaic leadership to a mind set aligned with the IEM principles. A change in human behaviour can potentially be enabled through a mind set based on synergistic, efficient and responsible IEM. Furthermore, knowledge exchange, communication, education, continuous learning and best practice increase knowledge of the environment as well as the ability to be strategically aware of change and opportunities.

5.4.3 A lens for simultaneous referencing and collaboration

Simultaneous referencing refers to a scenario where involved parties understand the need for economic growth as well as commitment, collaboration, caution and sustainability. As a result, involved parties will be able to collaborate, exchange knowledge and continuously learn in order to make informed decisions. Commitment to gaining new knowledge and identifying trends and thresholds in EIA and IEM through modern technology such as GIS reveals new perspectives on the present and opens new options for future development. Simultaneous referencing also refers to an environment and frame of mind that simultaneously considers and collaborates to pool resources from past, present and future scenarios. This focus will guide high levels of commitment, proactive participation and awareness of the need to look beyond the current situation to consider future impacts and sustainability.

5.4.4 A lens for visible environmental intelligence

Visible environmental intelligence is a concept with a dual purpose. It refers to a reframed mind-set based on values and ethics and a holistic view of the need for vision and behaviour based on IEM principles. Furthermore, visible environmental intelligence refers to the ability of GIS to visually represent the benefits, threats and thresholds of development impacts on the environment as well as impacts of the environment on the development. Informed EIA will enable user friendly site selection, forecasting and awareness of potential cumulative impacts such as pollution emissions, changes in ecological processes and land use.

5.4.5 A lens for knowledge management

The overarching lens of knowledge management is the key enabler to implement and institutionalise policies, processes and technical applications for effective EIA in practice. Knowledge management allows involved parties to systematically engage in spatial planning and raises the equity in decision making that will have a direct effect on their local environment and lifestyle. Web-based communication techniques such as user-friendly GIS is recommended for interrogation, analysis, forecasting and informed decision making. All information will be accessible in one place and the new knowledge gained will contribute to knowledge repositories for re-use. Recognition of the garbage-in-garbage-out (GIGO) principle is crucial to control the profile of data quality and to ensure the effective operations of information systems management.

5.4.6 A lens for future sustainability

Future sustainability relates to an ideal world situation where IEM sustainability principles are integrated into the thought and behavioural processes of people as self-regulated consumers and custodians of environmental resources. In this scenario organisations will focus on the triple bottom line of economic, social and ecological compromise rather than on the profitability of the organisation. In the following section challenges, constraints and critical issues that emerged from the study, but falls beyond the scope of the research, are highlighted to potentially inform problem solving for future research.

5.5 SUGGESTIONS FOR FUTURE RESEARCH

As mentioned in Chapter 1 and referred to elsewhere in this study, the initial aim was to design, develop and implement GIS in EIA, but through the process steps of data gathering it became obvious that the research did not yet justify the costs involved as the primary challenges faced by involved parties in the scope of this study were related to underlying factors such as the lack of IEM principles in the EIA process. Furthermore, it was noted that despite the law being designed for the people and

that the South African Constitution (1996) place people are at the centre of the process of sustainable development, EIA was deemed to be disconnected from people due to the lack of IEM sustainability principles in practice. Furthermore, the technology was potentially available, a database was being developed by local government and similar GIS applications had been implemented successfully in various municipal departments as corporate GIS. Therefore, the aim of the study was amended to a feasibility study of GIS in IEM so that the research process would address the challenges and problems in the current *status quo* so that these problems could be alleviated ahead of the project to design, development and implementation of GIS in EIA.

Therefore, the original research topic related to investigating the design and implementation of a web-based GIS application would rely on the outcome of this feasibility study based on the opinions of involved parties in order to recommend the original topic for future research. As a result of the feasibility of GIS usage in EIA being proven from qualitative and quantitative findings as well as expert published literature, this study recommends the design, development and implementation of web-based GIS usage in EIA as a topic for future research. In the following section brief descriptions of critical factors based on insight from the research and from opinions of involved parties in EIA and GIS that will potentially be encountered are presented. These critical factors could be approached as sub-sections in the research or merely considered as auxiliary information to inform problem solving for future research.

5.5.1 EIA costs

Costs involved in the EIA and Basic Assessment Report (BAR) is a contentious issue as some of the involved parties such as the EAPs and specialists charge high fees. The role of EIA is criticised as only filling a need for direct profit. Government and developers are seen to share profits, but I&APs work on a voluntary basis representing civil society. Often the benefits of the development to the local community are negligible and may only include short term employment during the construction phase. Research could determine whether GIS usage with access to objective baseline visual and textual screening information with a CBA function could potentially reduce the high costs charged by specialists in the current EIA process.

5.5.2 Web-based GIS application costs

Costs involved in funding capacity building as well as the design, development and implementation of a web-based EIA-GIS application as a platform to facilitate the EIA process could be extensive. Web and database development is expensive in human resources, financial and maintenance cost. Capacity building could be funded either by increasing environmental funding via the provincial and national environmental budget coffers or through international aid. Research

should determine whether national budgets and provincial funding could allow for the implementation of effective new strategies and tools and whether there are opportunities for government, tertiary institutions, business and industry to combine resources to fund the implementation of change initiatives such as a web-based GIS application for effective EIA.

5.5.3 Ownership and integration of the GIS application

Government owned and administered decision making tools such as the proposed GIS application could conflict with the democratic and transparent nature of the application and it may become politicised. However, if industry owned and administered the application, high costs may be charged for access to the information. Research could investigate the most appropriate body to take ownership of and administer such an application.

5.5.4 Database development and systems integration

In terms of the practical implementation of the web-based GIS application, complete systems integration will be needed at provincial government level and information will need to be collected, disseminated and supported by all spheres of government. Constraints to the implementation of such an application include the question of which domain in government will be responsible for the administration as well as the apparent reluctance to adapt to change and the lack of information exchange between government and involved parties. Should the proposed web-based application be linked to a centralised national database, more people would be encouraged to share information and overcome the fear and distrust related to information usage. Research is needed to determine whether these barriers can be overcome through commitment by all parties to acquire the necessary skills and training to participate in improved processes through usage of the proposed application. Furthermore, research could be done to enable the development of a user-friendly GIS application for users with limited computer skills as well as users who have the skills and ability to use more complicated functionalities of the application as well as system integration of baseline information in different departments and database development.

5.5.5 The role of the media

Research is needed to determine whether the role of the media could change from presenting EIA data in newspapers to playing a more active and rigorous role in IEM in collaborating with involved parties, educating civil society and raising awareness of environmental law and regulation through television, video and television games and film. Modern communication tools such as texting and radio could be used and government could engage with the media as an auxiliary tool to drive effective policy and processes. Constraints include the financial implications of employing the media.

5.5.6 Securities to usage of the web-based GIS application

Another contentious issue that requires research is to determine whether web-based GIS usage in EIA should allow users to download information and upload data. For instance, if an amateur bird watcher spotted an endangered species of bird, should he be able to add it to a site of bird specialist reports for crucial knowledge sharing? How to best go about building such data bases through novice and expert field input? To prevent trolling, unique log-ins could be used by involved parties. Additionally, filters or securities could be put in place as some information, such as heritage or cultural sites or species information, should not be disclosed, as members of the public may vandalise it. Such sites could potentially be red-flagged as No-Go sites or hotspots under a generic label of vulnerability or sensitivity.

5.5.7 Integration of non-mandatory NEMA and IEM tools into EIA

As change in legislation is a long and complicated procedure and it is not advisable to attempt to create new legislation to facilitate a process, research is required to determine whether NEMA and IEM tools such as SEA, CEA, SIA and CBA should be linked or integrated with the EIA process. It could be included in web-based GIS usage in EIA to further improve the standards of EIA and empower the involved parties to learn new skills for future engagement.

5.5.8 Change initiatives regarding the roles of involved parties

The roles, intent and opinions of the developer and proponent of the project as involved parties, as well as contractors and construction workers, should be researched in terms of their involvement and collaboration in web-based GIS usage in EIA to facilitate effective EIA. The findings of interviews and focus group discussions with these involved parties would add an informative dimension to the insight gained in this study as these are the people responsible for a large part of the anthropocentric impact on the environment.

5.5.9 Change initiatives related to the EIA process

The current EIA process is sometimes regarded as contentious and suggestions were made to research the feasibility of a different EIA procedure. Constraints in the current process included the independence of the EAP while being paid directly by the client as EAPs find it hard to criticise the hand that pays them. A revised procedure should be researched to determine changes such as whether the proponent could submit an application for a proposed development to government and government goes through the usual tender process. EAPs tender independently and Government employs them to do the job. The EAPs still negotiate with the specialist as that relationship works well. Constraints related to the amended procedure include opportunities for corruption and political positioning in the absence of trust and equity.

5.5.10 Re-instating the screening process

Recommendations were made to reinstate screening into the EIA as it was removed from the mandatory EIA process due to process delays. Research should determine the potential of reintroducing the screening process through web-based GIS usage making baseline information of the project available upfront to expedite and enhance the EIA process.

The BA or EIR application for the proposed development project could be down- and uploadable from the DEA&DP website or a GIS for EIA website and as soon as the application is submitted, a red flag would appear at the location that is visible (online) to all involved parties. Baseline information should be sourced and constraints identified. The baseline report could be funded from the costs paid by the client at the application stage. At this stage the official process could start and a case number and case officer allocated to the project. An independent screening process should be conducted and the relevant information posted on the web page (by the independent screening expert) so that all involved parties can participate.

The screening process could include relevant and groundtruthed information added to a Google Earth map of the location to inform decision making at application stage. All documentation, such as the application, scoping, draft reports and public participation process, should be available online. Awareness of baseline information will add transparency and rigour, increase participation, inform decision making and potentially resolve conflict before the appeal stage to ensure a timely and effective EIA process.

5. 6 CONCLUSION

Within the scope of this study, man's imagination, reason, emotions and creativity has been evaluated throughout this research and the outcome of the discourse points to the need for change through strategies that can unite technology, policy and people towards effective environmental management and impact assessment.

Key issues that emerged from the discourse reflected on in this study indicate that the challenges experienced by EIA users within the scope of this study can possibly be addressed through the unification of EIA, GIS and people. New visions, missions, strategies and tools need to be realised to reframe people's minds into alignment with the sustainability principles of IEM. This argument is encouraged by universal, national and local policies and strategies such as Principle 1 of the Rio Declaration, the Constitution of South Africa and Bill of Rights as well as Max-Neef's human development model where humans matter.

In conclusion, this study advocates GIS usage in EIA supported by good governance and self-regulation based on integrated environmental management (IEM) principles and following a transdisciplinary approach for knowledge exchange with collaboration by all involved parties in EIA towards informed and effective environmental management and impact assessment.

Among the multitude of animals, which scamper, fly, burrow and swim around us, man is the only one not locked into his environment. His imagination, his reason, his emotional subtlety and creativity, make it possible for him not to accept the environment, but to change it.

Bronowski (1973)

REFERENCES

Abbas I & Okoje JA 2009 Application of remote sensing and GIS to EIA for SD. *Research journal of Environment and Earth Sciences*. Maxwell Science Publication.

Agency for toxic substances and disease registry: Toxic substances portal: DDT, DDE, DDD [online]. Available from www.atsdr.cdc.gov [Accessed May 2011].

Appleton KJ & Lovett AA (eds) 2008. *GIS for environmental decision making*. University of East Anglia. London: Taylor & Francis.

Appleton KJ & Lovett AA 2005. A GIS based visualisation of development projects. In Appleton KJ & Lovett AA (eds) *GIS for environmental decision making*, 181-19. London: Taylor & Francis.

Art of geography 2014. A definition of 'sense of place' [online]. Available from www.artofgeography.com/info/thesensceof place. Accessed 15 August 2014.

Atkinson SF & Canter LW 2011. Assessing the cumulative effects of projects using GIS. *Environmental Impact Assessment Review* 31:457-464.

Babbie E & Mouton J 2001. *The practice of social research*. Cape Town: Oxford University Press.

Barron C 2011. Getting companies to clean up their act: SA academic invited to serve on World Economic Forum. Business Times Newsmaker: Daniel Malan. *Sunday Times* July 24 2011:15.

Bishop I 2006. Developments in public participation and collaborative decision making. In Appleton KJ & Lovett AA (eds) *GIS for environmental decision making*, 181-19. London: Taylor & Francis.

Bishop ID & Lange E 2005. Using games for interactive landscape visualisation in landscape and environmental planning. In Appleton KJ & Lovett AA (eds) *GIS for environmental decision making*. London: Taylor & Francis.

Blaxter L, Hughes C &Tight M 1996. *How to research*. Berkshire: Open University Press.

Bourseiller P 2005. *365 Ways to save the earth.* New York: Harry Abrahams Publishers.

Bredell A 2009. DEA&DP 2009/2010 Budget speech DEA&DP 2009/2010 Provincial Minister [online]. Available from www.gateway.co.za [Accessed 7/2009]

Bronowski J 1973. *The ascent of man: Lower than the angels:* 19. Boston: Little Brown.

Brown JS 2009. *Spotlight*: John Seely Brown in conversation with Editor Sarah Powell about Brown's opinions on a range of issues about intervention, innovation and information technology [online]. Available from www.johnseelybrown.com/spotlight. Accessed 2009.

Brown I 1999. Developing a virtual reality user interface for GI retrieval on the Internet. In Appleton KJ & Lovett AA (eds) *GIS for environmental decision making*, 193-210. London: Taylor & Francis.

Brown I, Nicholls R, Walkden S, Jude S& Koukoulas S 2006. Using virtual reality to stimulate coastal erosion. In Appleton KJ & Lovett AA (eds) *GIS for environmental decision making*. London: Taylor & Francis.

Bruk SI 1979. Ethnographic maps. The great soviet encyclopaedia 1970-1979. 3rd ed [online]. Available from www.encyclopedia2.thefreedictionary.com [Accessed 28 August 2014].

Bulman R 2011. *EIAMS DEA Subtheme 3: Public participation*. Pretoria: Department of Environmental Affairs.

Burrough PA 1986. *Principles of GIS for land resources assessment*. Oxford: Oxford University Press.

Castells N & Guardans R 2008. The development of multilateral environmental agreements on toxic chemicals: Integrating the work of scientists and policy makers. In Hirsch-Hadorn G, Hoffmann-Riem H, Biber-Klemm S, Grossenbacher-Mansuy W, Joye D, Pohl, C, Wiesmann U & Zemp E (eds) *Handbook on transdisciplinary research*, 171-176. Bern: Springer.

Carson R 1962. *Silent spring*. Boston: Houghton Miffin Company.

Chang K-T 2010. *Introduction to geographic information systems*. 5th ed. Singapore: McGraw-Hill.

Chatfield T 2010. Why games are the 21st century's most serious business. *Mail&Guardian*, February 19 to 25:28.

City of Cape Town 2010. *Strategic information development and GIS development brochure*. Cape Town. Also available online from www.capetown.gov.za/en/sdf [Accessed May 2010].

CLUES 2008. Cape land use expert system [online]. Available from www.academia.sun.ac/cga [Accessed 18 May 2010].

Cokayne R 2011. Conveyancers curse online system. *The Star Business Report* April 28:10.

Collins English Dictionary 2009. Complete and unabridged. 10th ed. Glasgow: William Collins Sons & Co.

Collins Thesaurus 2002. Complete and unabridged. 2nd Edition. Glasgow: Harper Collins.

Common Ground 2005. *Calabash: A one stop participation guide: A handbook for public participation in environmental assessment in Southern Africa*. Cape Town: Southern African Institute for Environmental Assessment (SAIEA).

COPES 2010. Coordinated observation and prediction of earth systems [online]. Available from www.climateneeds.umd.edu [Accessed 10 June 2010].

Creswell JW 2003. *Research design: Qualitative, quantitative and mixed methods approaches*. 2nd ed. Thousand Oaks: Sage.

CSIR 2007. Enhancing the effectiveness of strategic environmental assessment in South Africa. Pretoria: Tin Roof studios

Davids I, Theron F & Maphunye KJ 2009. *Participatory development in South Africa: A development management perspective*. 2nd ed. Hatfield: Van Schaik.

DEA 2012. *Best practice for effective projects* [online]. Available at www.environment.gov.za/content/projects-/best_practices. [Accessed 6/2012].

DEA 2010. *Public participation 2010, integrated environmental management (IEM) guidelines series 7*. Pretoria: Department of Environmental Affairs.

DEA&DP 2010. DEA&DP recommends that EAPs use GIS for visual impact assessment [online]. Available from www.capegateway.gov.za [Accessed April 2010].

DEA&DP 2013. The NEMA and 2010 EIA regulations and process. Western Cape Government DEA&DP 27 August 2013.

DEAT 2002. *Stakeholder engagement: Integrated environmental management information series 3*. Pretoria: Department of Environmental Affairs and Tourism (DEAT).

DEAT 2004a. *Overview of integrated environmental management: Integrated environmental management information series 0.* Pretoria: Department of Environmental Affairs and Tourism (DEAT).

DEAT 2004b. *Review in EIA*: *Integrated environmental management information series 13*. Pretoria: Department of Environmental Affairs and Tourism (DEAT).

DEAT 2004c. *Life cycle assessment: Integrated environmental management information series 9*. Pretoria: Department of Environmental Affairs and Tourism (DEAT).

DEAT 2005. *South Africa's national biodiversity strategy and action plan*. Pretoria: Government Printer.

DEAT 2007a. *Strategic environmental assessment guideline, integrated environmental guideline Series 4*. Pretoria: Department of Environmental Affairs and Tourism (DEAT).

DEAT 2007b. *Cumulative effects assessment, integrated environmental management, and information Series 7*. Pretoria: Department of Environmental Affairs and Tourism (DEAT).

DEAT 2008. *A national framework for sustainable development in South Africa*. Pretoria: Department of Environmental Affairs and Tourism (DEAT).

Dennis Moss Partnership 2011. *GIS maps for EIA decision making: Alternatives in site selection and botanical constraints*. (Map). Stellenbosch.

Dvir R & Pasher E 2004. Innovation engines for knowledge cities: An innovation ecology. *Journal of Knowledge Management* 8:16-27.

Engel-Cox JA & Hoff RM 2005. Use of environmental monitoring data for air quality policy. *Environmental Science and Policy*: 8: 115-131.

ERM Environmental Resources Management 2008. *Annual Review 2008: Delivering sustainable solutions globally*. London: Watmoughs Print.

EAPSA 2011. *Launch of EAPSA certification process*. Held at CSIR head office in Pretoria on 7 April 2011 with live streaming in Durban and Cape Town [online]. Available at http:streaming.csir.co.za/?streaming. Accessed on 7 April 2011.

Enviroworks 2008. *Putting policy into practice*. Biannual environmental newsletter of City of Cape Town 2.

ESRI (Environmental Systems Research Institute). About ESRI and ArcGIS software [online] Available from www.esri.com [Accessed March 2011].

Funtowicz S & Ravetz J 1999. Values and uncertainties. In Hirsch-Hadorn G, Hoffmann-Riem H, Biber-Klemm S, Grossenbacher-MansuyW, Joye D, Pohl, C, Wiesmann U & Zemp E (eds) *Handbook on Transdisciplinary Research*:641. Bern: Springer.

Fredericksen DE 2010. Foreword in *UEMP projects reviewed document 2009*. Johannesburg; South African Cities Network.

GEOSS (Global Earth Observation System). GEOSS portal for earth observation and services [online]. Available at www.earthobservations.org [Accessed October 2009].

GECHH (Global Environmental Change and Human Health). Towards global human health and wellbeing in a changing environment [online]. Available at www.gechh.unu.edu [Accessed October 2009].

Gontier M, Mortberg U & Balfors B 2010. Comparing GIS based habitat models for applications in EIA and SEA. *EIA Review* 30:8-18.

Govender K & Audoin M 2007. Introduction to SEA. Enhancing the effectiveness of strategic environmental assessment in South Africa. *CSIR Annual Report*. Pretoria: Tin Roof Studios.

Gowa EK 2009. *Best practices in environmental information management in Africa: A Uganda case study* [online]. Joint publication of UNEP/GRID Arendal and NEMA Uganda with support from UNEP. Norway: Birkeland Trykkeri. Available from www.unep.org/pdf/UgandaCaseStudy.pdf [Accessed 2010].

Grant AE & Meadows J 2009. *Streaming media* [online]. Communicating technology: Update and fundamentals. 11th ed. Available at Wikipedia.org/wiki/streaming_media [Accessed 8/2014].

Grin J, Smith A & Voss JP 2008. Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy* 39:435-448.

Groenewald Y 2004a. The thin green line. *Earthyear* 3:23-26.

Groenewald Y 2004b. Unclogging the works. *Earthyear* 8:8-11.

Groenewald Y 2008. Govt plan may save threatened Ndumo. *Mail and Guardian* August 9-15:23.

Gupta J 1997. The climate change convention and ceveloping countries-From conflict to consensus? *Current opinion in environmental sustainability 1:207-213.*

Hardin G 1968a. The Tragedy of the commons. In Van De Veer D & Pierce C (eds) *The environmental ethics and policy book.* 3rd ed. Belmont: Wadsworth.

Hardin G 1968b. Lifeboat ethics. In Van De Veer D& Pierce C (eds) *The environmental ethics and policy book.* 3rd ed. Belmont: Wadsworth.

Hazell D 2011. Proceedings of conference: APPEA Environment conference held at Coolum, Queensland in October 2010 and INPEX Browse Limited [online]. Available at www.geoscience .gov.au [Accessed 2/2011].

Hearn G & Pace C 2006. Value-creating ecologies: Understanding Next Generation Business Systems. *Foresight* 8, 1:55-65.

Hector W (ed) 2009. *Issues report*. Proceedings of the DEAT conference evaluating 10 years of EIA held 24-25 November 2008. Somerset West: Department of Environmental Affairs and Tourism [online]. Available at WHector@deat.gov.za [Accessed 2009].

Heywood I, Cornelius S & Carver S 2006. *An introduction to geographical information systems*. 3rd ed. Harlow: Pearson Prentice Hall.

Higgens M & Morgan J 2000. *The role of creativity in planning: The creative practitioner. Planning, Practice & Research*. London: Taylor & Francis Limited.

Higgs G 2009. Application of GIS in addressing environmental problems through IT approaches. GIS Research. University of Glamorgan. *The Royal Geographical Journal* 175.

Hirsch-Hadorn G, Hoffmann-Riem H, Biber-Klemm S, Grossenbacher-Mansuy, Joye D, Pohl, C, Wiesmann U & Zemp E (eds) 2008. *Handbook on Transdisciplinary Research*. Bern: Springer Science & Business Media.

IAIASA 2011. (International Association for Impact Assessment of South Africa). News and events related to EIA [online]. Available from www.iaiasa.co.za Accessed March 2010-2011.

Ikapa Environplan & ECOSOL-GIS 2011. *Kogelberg biosphere reserve Framework plan: Critical biodiversity areas 2011*. (Map). Cape Town: Ecosol Conservation Planning Consultancy.

Jacob E 1988. Qualitative research: A defense of traditions. *Review of Educational Research* 59:229-235.

Jager J 2008. Foreword. In Hirsch-Hadorn G, Hoffmann-Riem H, Biber-Klemm S, Grossenbacher-Mansuy W, Joye D, Pohl, C, Wiesmann U & Zemp E (eds) *The Handbook of Transdisciplinary Research.* Bern: Springer.

Jarvis CH 2007. Grid enabled GIS: Opportunities and challenges. In Lovett A & Appleton K (eds). *GIS for environmental decision making* 165-175. Kentucky: Taylor & Francis.

Joerin F & Nembrini A 2005. Post-Evaluation of the use of geographic information in public participation processes. *Urisa Journal* 17:15-26. Des Plaines: Gale Group.

Jude SR, Jones AP, Brown I, Watkinson AR & Gill JA 2001. The application of visual technology for coastal zone management. In Lovett & Appleton (eds) *GIS for environmental decision making*. London: Taylor & Francis

Judge D, Stoker G & Wolman H (eds) 1995. *Theories of urban politics*. London: Sage Publications.

Kings L & Stimson B 2010. A Tribute to Reg Golledge. *Geographical Analysis* [online], 42: 1-4. Available from: http://onlinelibrary.wiley.com [Accessed 6 August 2010].

Kloppers E 2011. LagoonBay-sage maak draai in hof. *Sake24.com* [online]. Available from: Elma.kloppers@sake24.com [Accessed 2011].

Lear L 2007. *Introduction to the 40th anniversary edition of Silent Spring by Rachel Carsons*. New York: Henry Holt and Company.

Lee N & George C (eds) 2000. *Environmental assessment in developing and transitional countries. Principles, methods and practice*. Bognor Regis: John Wiley & Sons Limited.

Leedy PD & Ormrod JE 2005. *Practical research: Planning and design*. 8th ed. New Jersey: Prentice Hall.

Le Roux L 2005. *Qualitative research: Method in madness?* Working Paper. University of Stellenbosch Business School.

LEG201 Legal aspects of environmental management 2006. *Tutorial letter LEG 201/501 and 502*. Pretoria: Unisa Press.

Leonard A 2007: The Story of Stuff [online]. Available from www.storyofstuff.com [Accessed 8 September 2008].

Longley PA, Goodchild MF, Maquire DJ & Rhind DW 2005. *Geographic information systems and science*. 2nd ed. Chichester: John Wiley & Sons Limited.

Lovelock J 2006. *The Revenge of Gaia. Why the Earth is fighting back and how we can still save humanity*. London: Penguin Books.

Lukey P 2008. *The benefits of integrated environmental management*. Proceedings from the UEMP conference on appropriate environmental management held on 20-21 May 2009 at Somerset West.

Maathai W 2005. Tree Power. *Earthyear* Issue 1: 12-14.

Mabudafhasi R 2011. EAPASA launch media statement [online]. Available at www.env.gov.za/NewsMedia/Speeches/2011Apr7/Mabudafhasi_launcheseapasa.htm [Accessed April 7 2011].

MacFarlane R & Dunsford H 2008. GIS and environmental decision making. In Appleton KJ & Lovett A (eds) *GIS for environmental decision making:* 79-100. London: Taylor & Francis.

MacFarlane R, Haggett C, Fuller D, Dunsford H, Carlistle B, Mowbray R & Hext S 2004. *Tranquillity mapping: Developing a robust methodology for planning support*. Report to the Campaign to Protect Rural England, Countryside Agency, North East Assembly, Northumberland Strategic Partnership, Northumberland National Park Authority and Durham County Council, Centre for Environmental & Spatial Analysis, Northumbria University.

Macleod F 2011. Hazardous poisons taken off the shelf. *Mail & Guardian* May 20 to 26:1.

Malezewski J 2004. GIS based land use sustainability analysis: A critical overview. Progress planning 62:3-65.

Mambo & Archer 2007. An assessment of land degradation in the Save catchment in Zimbabwe. *Area* 39:380-391.

MAPA 2010. Maps of protected areas for biodiversity conservation using GIS and GPS [online]. Available from www.mapaproject.org [Accessed April 2010].

Margerum RD & Born SM 1995. Integrated environmental management: Moving from theory to practice. *Journal of Environmental Planning and Management* 38: 371-391.

Margerum RD & Hooper BP 2001. Integrated environmental management: Improving implementation through leverage point mapping. *Society and Natural Resources* 14:1-19.

Marsden CT 2005. Free, open or closed - Approaches to the information ecology. *Emerald Group Publishing Limited* 7:6-19.

Martens P, McEvoy D & Chang C 2009. The climate change challenge: Linking vulnerability, adaptation and mitigation. *Current opinion in environmental sustainability* 1:14-18.

Matomela D 2011. Frustration over minerals website. Electronic rights application process angers applicants. *The Star Business Report* April 28:1.

Max-Neef MA 2005. Commentary Foundations of Transdisciplinarity. *Ecological Economics* 53: 5-16.

Mbeki T 2008. Comments on Millenium goals in *A National Framework for Sustainable Development in South Africa* 2008. DEA 2008.

Miller D, Coleby A, Morrice J & Messager P. Visualisation techniques for planning renewable energy development In Appleton KJ & Lovett AA (eds) *GIS for environmental decision making*: 227-240. London: Taylor & Francis.

Milner H 2007. The problem of political drop-outs: Canada in comparative perspective. In Gagnon A & Tanguay B (eds) *Canadian Parties in Transition*, Chapter 20. 3rd ed. Toronto: University of Toronto Press.

Mitchell I 2001. An Assessment of Cumulative Effects in Strategic Environmental Assessment: A critical review of South African practice. Master's thesis. Stellenbosch: Stellenbosch University, Department of Geography and Environmental Studies.

Morin E 1999. *Seven complex lessons in education for the future.* Paris: UNESCO publishing.

Mouton J 1996. *Understanding Social Research*. 1st ed. Pretoria: JL Van Schaik Publishers.

Mouton J 2001. *How to succeed in your Master's and Doctoral Studies: A South African Guide and Resource Book.* Pretoria: Van Schaik.

Murtugudde R 2009. *Regional Earth System Prediction: A decision making tool*. Department of Atmospheric and Oceanic Science. Maryland: University of Maryland Press.

Naidoo P 2010. Climate Change: Sixth time lucky? *Financial Mail* 3 December 3, Issue 208: 44.

Neubert S 2000. *Social impact analysis of poverty alleviation programs and projects. A contribution to the debate on the methodology of evaluation in development corporations.* GDI book Series No 14. London: Frank Cass Publishers in association with the German Development Institution (Berlin).

Nicolescu B 2002. *Manifesto in transdisciplinarity*. (Translated from French by K-C Voss). Albany: State University of New York Press.

Norris P 2001. *Civic engagement, information poverty and the Internet worldwide*. London: Cambridge University Press.

Norton B 1991. *The environmentalists' dilemma. Towards unity among environmentalists*. New York: Oxford University Press.

Norton B 1994. Integration or reduction: Two approaches to environmental values. In Van de Veer D & Pierce C (eds) *The environmental ethics and policy book* 3rd ed, 198-213. Belmont: Wadsworth.

Oosthuizen M, Matthys C & Hector W 2011. The environmental impact assessment and management strategy (EIAMS) for South Africa 2014 Subtheme 2: Knowledge and information. Department of Environmental Affairs (DEA) 2014. EIAMS (Draft).

Pandor N 2010. Statement by the minister of science and technology at the green economy summit 18-19 May 2010 held in Johannesburg. *Business Times*.

Pascal R, Milleman M & Gioja L 2000. *Surfing the edge of chaos: The laws of nature and the new laws of business*. New York: Three Rivers Press.

Patel E 2010. Statement by the minister of economic development at the green economy summit 18-19 May 2010 held in Johannesburg. *Business Times*.

Pinson D 2004. Urban planning: An undisciplined discipline. In Lawrence RJ and Despres C (eds) *Transdisciplinarity in theory in practice*. Special issue on transdisciplinarity: 503-513.

Pohl C & Hirsch-Hadorn G 2007. Core terms in transdisciplinary research. In Hirsch-Hadorn G, Hoffmann-Riem H, Biber-Klemm S, Grossenbacher M, Joyce D, Pohl C, Wiesmann U & Zemp E (eds) The Handbook of Transdisciplinary Research. Bern: Springer.

Ralston S; De Villiers C, Manuel J, Pence G & Te Roller K 2009: *Where are we going? Fine scale systematic conservation plans and their contribution to environmental assessment.* Stellenbosch: Cape Nature Scientific Services.

Rampedi I & Joubert E (eds) 2007. *Reader for research and development in integrated environmental management.* Pretoria: Unisa Press.

Rashmin G 2004. *Use of GIS for EIA: an interdisciplinary approach*. Interdisciplinary Science Reviews 29:1-11.

Repetti A, Soutter M, Musy A 2006. Introducing SMURF: A software system for monitoring urban functionalities [online]. Available from www.sciencedirect.com.oasis.unisa.ac.za [Accessed April 2010].

Repko AF 2008. *Interdisciplinary research. Process and theory*. Thousand Oaks: Sage publications.

Riso National laboratory for sustainable energy 2009. Map of wind resources in South Africa. *Science Daily* 4 November 2009. Available from www.ScienceDaily.com [online]. Accessed 6 August 2010.

Robinson AG & Schroeder DM 2009. Greener and cheaper. The conventional wisdom is that a company's costs rise as its environmental impact falls. Think again. *The Wall Street Journal Business Insight* March 23 [online]. Available from www.online.wsj.com [Accessed 24 March 2009].

Rossouw N, Davies S, Fortuin H, Rapholo B & de Wit N 2004. *Country report: South Africa 2004*. DEAT 2004.

South African National Biodiversity Institute (SANBI) 2011. Biodiversity GIS [online]. Available from http://bgis.sanbi.org/profile/profile.asp [Accessed 6 May 2011].

South African Institute of Chartered Accountants (SAICA) 2010. The King Report on Corporate Governance for South Africa. Johannesburg: SAICA.

Sanchez LE & Morrison-Saunders A 2011. Learning about knowledge management for improving EIA in a government agency: The Western Australia Experience. *Journal of Environmental Management* [online], 92:2260-71. Available from www.researchrepository.murdoch.edu.au [Accessed 2011].

Saunders M, Lewis P, Mark NK & Thornhill A 2009. *Research methods for business students*. Harlow: Prentice Hall.

Seto K & Shepherd JM 2009. *Global urban land-use trends and climate impacts*. Yale: University of Georgia Press.

Shorter Oxford English Dictionary. Vol 2. 6th ed. Oxford: Oxford University Press.

Shutidamrong & Lovett. Riding an elephant to catch a grasshopper: Applying and evaluating techniques for stakeholder participation in land-use planning. In Appleton KJ & Lovett AA (eds) *GIS for environmental decision making:* 149-164. London: Taylor & Francis.

Smith J 1983. Qualitative versus quantitative research: An attempt to clarify the Issue. *Educational Researcher* 12:6-13. New York: Sage Publishers.

Sowman M, Fuggle R & Preston G 1995. A review of the evolution of environmental evaluation procedures in South Africa. *Environmental Impact Assessment Review* 15:45-67.

Steyn SC 2008. Creative leaders as an imperative to sustain the economy of knowledge. Doctoral dissertation. Bloemfontein: University of the Free State. Department of Economics.

Stotko O 2011. News and next events. *IAIASA Western Cape Autumn Newsletter* [online], 1 (3). Available at www.iaiasa.co.za [Accessed March 2011].

Theron F & Saunders J 2009. *Scientific writing skills and social research methodology: An introduction to basic techniques*. Hatfield: Van Schaik publishers.

Theron F, Oosthuizen R & Cloete F 2006. *Guidelines for Writing Academic Papers*. School of Public Management and Planning. University of Stellenbosch. (Edited and modified by Swilling M & Muller A for the purposes of the MPhil in Sustainable Development Planning and Management 2005).

Thomson C 2010. Organisational change initiative failures: A South African Perspective. MBA dissertation. Johannesburg: Milpark Business School.

Tobin P & Snyman M 2004. *Storytelling and Knowledge Management: What's the story so far?* Pretoria: Gordon Institute of Business Science.

Tobin P & Volavsek P 2006. *Knowledge management measurement in South African organisations.* Gordon Institute of Business Science. Pretoria: Unisa Press.

Unisa 2009. Theoretical and Applied Ethics (PLS2116) Section C. *Environmental ethics*. *Ecological sustainability in ethical perspectives. The concept of sustainability*. Pretoria: Unisa.

Van der Merwe C 2011. Evaluating innovative cultural enablement within allied technologies limited: A reflective case study. MBA dissertation. Johannesburg: Da Vinci Institute for Technology Management.

Van der Merwe JH & De Necker PH 2012. Guidelines for research reporting. University of Stellenbosch: Department of Geography and Environmental Studies.

Van der Merwe JH 2009. Faculty of Arts and Social Sciences Graduate School (previous web page) [online]. Available at www.sun.ac.za [Accessed June 2011].

Van der Walt A 2004. *The assessment of cumulative effects in a developing country context: The case of South Africa*. Presented at the April 2004 Annual IAIA Conference in Vancouver. Vancouver: International Association for Impact Assessment.

Van Niekerk A 2008. CLUES: A web-based land use expert system for the Western Cape. Doctoral dissertation. Stellenbosch: Stellenbosch University, Department of Geography and Environmental Studies.

Vaughn A 2010. Climate change challenge for computer games. The Guardian 31 October [online]. Available from www.theguardian.com [Accessed 1 November 2010).

Vlok C 2007. *Course in exploring Geographical Information Systems*. Department of Geography. University of South Africa. Pretoria: Unisa.

Walmsley B & Tshipala KE 2007. *Handbook on Environmental Assessment Legislation in the SADC region.* Development paper 179. Johannesburg: Published by the Development Bank of Southern Africa in collaboration with the Southern African Institute of Environmental Assessment (SAIEA)

Wright A & Burns M 2007. *Trade-offs – What to choose and what to lose. Enhancing the effectiveness of SEA in South Africa.* CSIR Report. Pretoria: Tin Roof Publishers.

Young R 1996. Knowledge management [online]. Available at www.knowledge-management-online.com [Accessed 10/2013].

Zhang CB, Wong W, Wu CX & Xiong YJ 2008. Qualitative method of visual landscape EIA based on GIS: A case of the Ming Tombs. *Shentai Xuebao/Act Ecologica Sinica* 28 (6).

Zille H 2009. *Newsletter from SA Today* 7/2009 [online]. Leader of DA and premier of Western Cape. Available at leader@da.org.za [Accessed 2009].

PERSONAL COMMUNICATIONS

Calaca C 2011. Corporate GIS City of Cape Town. Corporate GIS offices. Discussions on 27 September 2010 regarding the feasibility of GIS in EIA and the technology available to implement a GIS for EIA application.

Cocks M 2010. Co-developer of SANBI BGIS website. Cape Town. Interview in November 2010 about the usage of a GIS web based tool to facilitate Environmental Management decision making during a BGIS workshop at the University of the Western Cape.

Dippenaar S 2010-2012. EAP and Specialist. Stellenbosch and Somerset West. On-going conversations between 2010 and 2012 regarding IEM. EIA and BA process in practice in Cape Town.

Fortuyn H 2011. Expert in the domain of EA. Currently with DEA&DP. Telephone conversation in March 2011 regarding terminology for stakeholders in the EA process.

Hazell D 2011. Geologist working for INPEX in Australia. Informal discussion 12 May 2011 regarding the integration between government and industry in Western Australia to encourage collaboration and sharing of knowledge to inform decision making re disaster preparedness and EA. Cape Town.

Kritzinger K 2009. MPhil graduate from the Sustainability Institute, working for Green Cape and an expert in renewable energy. Informal discussions between 2010 and 2012 regarding the rationale of the study and critical issues related to sustainability in practical business processes. Cape Town and Somerset West.

Lukey P (2008, 2009). Environmental management and Deputy Director-general in Climate change at DEA who facilitated at the DEAT conference in Somerset West 24-25 November 2008, UEMP conference 20-21 May 2009 and Green paper for Climate Change discussion workshop in 2011. Informal and formal discussions during these conference and workshop proceedings

regarding environmental legislation, climate change, implementation and institutionalisation of guiding principles for sustainable development. Somerset West 2008 and 2009, Cape Town 2011.

Mabudafhasi R 2011. DEA spokesperson at Green paper discussion on Climate Change in Cape Town in February 2011. Formal and informal discussions during the workshop regarding the relationship between government and the media. Cape Town 2011.

Roos M 2010. Senior officer working on the ISIS integration data base. Discussions on 22 September 2010 regarding the ISIS integration and database development as well as GIS applications for informed environmental decision making. Cape Town Civic Centre.

Smith K 2010. City of Cape Town Environmental Affairs. Discussions on 13 October 2010 regarding the integration of systems at City of Cape Town, development of GIS applications and the ISIS data base. Civic Centre City of Cape Town.

Steyn SC 2010. Lecturer at Da Vinci Graduate School Institute for Technology Management. Interview and discussions in March 2010 and March 2011 on the integration of ecology, economics and society as well as knowledge management and innovation. Johannesburg and Cape Town.

Stipinovich A 2010-2011. GIS at City of Cape Town. Discussions in November 2010 and 24 May 2011 regarding the rationale and practical implementation of web-based GIS usage in EIA in Cape Town. Cape Town.

Stotko O 2010-2012. Environmental engineer and member of IAIASA board in the Western Cape. Ongoing discussions on 3 May 2011 and between 2010 and 2012 regarding GIS and sustainability in EA and business processes. Cape Town.

Swilling M 2010. Sustainability Institute University of Stellenbosch. Discussions in May 2010 regarding the feasibility of web-based GIS usage for EIA and IEM and sustainability. At the Sustainability Institute, Stellenbosch.

Terrapon H 2011. SANBI. Telephonic discussion on 29 July 2011 related to SANBI operations, CBA maps and new projects on the local front and abroad. Somerset West.

Theron F 2011. Senior lecturer at the School of Public Leadership. Faculty of economic and management sciences. Discussions on 9 May 2011 on public participation. Stellenbosch University.

Van der Merwe JH 2011. Professor and head of Geography and Environmental Studies at Stellenbosch University. Ongoing discussions between 2010 and 2014 related to the research paradigm, EIA and GIS. Stellenbosch University.

Van der Merwe S 2011. EIA consultant and Director. Environment and Planning at Dennis Moss Partnership, Town and Regional Planners and Environmental consultants. Discussions (July and August 2011) related to GIS maps for EIA and IEM decision making. Stellenbosch.

Van Dyk E 2011. Head of geomatics City of Cape Town. Discussions on 13 October 2010 related to the ISIS database and the original aim of the study to design and develop and implement GIS for EIA. Civic Centre. City of Cape Town.

Van Niekerk A 2010. Lecturer and developer of CLUES. Discussions on 20 April 2010 regarding the feasibility of the study topic which was to design, develop and implement a GIS application to facilitate development projects. Department of Geography and Environmental Studies. Stellenbosch.

Volschenk T 2011. Town planner/lawyer and EA consultant. Stellenbosch. Ongoing discussions and interview between June and August 2011 regarding the feasibility of web-based GIS for EIA in practice.

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APPENDICES

APPENDIX A

A.1 FOCUS GROUP DISCUSSION AND SURVEY DOCUMENT

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GIS APPLICATION IN ENVIRONMENTAL MANAGEMENT DECISION MAKING IN CAPE TOWN
FOCUS GROUP DISCUSSION FOR RESEARCH BY ESTER BRINK 24 May 2011
For attention:
Ms Amalia Stipinovich Amalia.Stipinovich@capetown.gov.za
Mr. Ivano Mangiagalli Ivano.Mangiagalli@capetown.gov.za
Mr. Dennis Leidler Dennis.Laidler@pgwc.gov.za
Mrs. Ester Brink rainbowscorpions@hotmail.co.za

RE: BACKGROUND TO THE RESEARCH AND DETAILS OF THE FOCUS GROUP DISCUSSION INCLUDING QUESTIONS:

The first of the final primary data collection involves small focus group discussions with structured questions related to the main objectives of the study. The discussion will take place at 11h00 at Amalia Stipinovich's office. All information will be treated with ethical discretion and therefore be anonymous.

1. RESEARCH TITLE: GIS APPLICATION FOR EIA IN CAPE TOWN

2. THE AIM OF THE STUDY:

To determine the feasibility of a web-based GIS application to facilitate the current EIA.

3. AN ABSTRACT FROM THE STUDY:

In South Africa, the DEA commits to Integrated Environmental Management and Impact Assessment (IEM EIA) centred on sustainability principles and alternative tools to enhance the current EIA that is still flawed by project specific focus (EAPSA launch 2011).

Networks such as the Internet, Google, web-based tools, software and digital data link the world and provide people access to economic, ecological, scientific, political and legal systems. Transdisciplinary and multi-disciplinary knowledge needs to be appropriately transmitted to make understanding of the complex human-environment relationship possible (Marsden, 2005). The researcher postulates that a GIS web-based application has the potential to function as a platform to facilitate EIA.

This paper reports on a feasibility study of the opinions of EIA stakeholders to assess a GIS application to facilitate the current EIA. Five themes aligned to NEMA (Government Gazette 3330, 2010) are focused on.

A GIS web-based platform (Information Management System, DEA 2011) for:
Information and Knowledge exchange
Public Participation
Stakeholder engagement
The functionality of a GIS application to inform EIA decision making
Ownership of the GIS application

Secondary findings indicate that web-based GIS applications are in use and have proven to transcend time and space to access all stakeholders, assist knowledge exchange, inform interactive decision making and improve development outcomes. Primary findings point to benefits of information management, informed decision making, access to baseline information, knowledge of cumulative and social impacts and the need for user friendly technology.

Barriers to change include cost, intellectual property, lack of data management for spatial functionality, limited bandwidth, need for a national data provider and lack of technical capacity for service delivery.

The study highlights best practice initiatives and makes recommendations how the majority of the barriers can potentially be alleviated should the GIS application be mandatory, driven by government and implemented at local municipality or city level.

4. STRUCTURED QUESTIONS TO GUIDE FOCUS GROUP DISCUSSIONS:

The questions have been set under separate headings related to the five themes mentioned in the abstract. Every theme will be presented through a brief literary study as background information, followed by the questions. Every theme is arranged on a separate page to ensure clarity of the document.

4.1 THEME ONE: THE FUNCTIONALITY OF A WEB-BASED GIS APPLICATION FOR INFORMED DECISION MAKING:

A brief literature study relates:

The tool is web-based to ensure that information is current (Walmsley 2007).

Although SANBI's Critical Biodiversity Area maps represent the best available information, they need to be ground-truthed and updated to take into account new information such as errors or changes in the land cover. Ideally a mechanism should be put in place to capture and record this information (Ralston 2009).

According to Longley et al (2005), information systems help us to manage what we know by making it easy to organize, store, access and retrieve, manipulate, synthesise and apply knowledge.

Van Niekerk (2008) trusts web technology to have the capability to solve geographical problems facing our complex world.

Murthugudde (2009) claims that the use of high resolution earth system predictions can generate sustainable earth system management of resources.

Marsden (2005) adds that modern communication networks with increased bandwidth enable greater diversity of data such as visual colour images, graphics and videos. This technology can be used to assist learning as visual and textual stimuli enhance better understanding of environmental impacts and optimal land use options.

Web-based tools and GIS creates opportunities for user friendly interaction with geographical and spatial information. Modern digital communication networks crisscross the world and access to information is on hand (Morin 1999).

A visual image of development impact over space and time! If it works it can have an incredible impact. A picture is worth a thousand words! (Kritzinger, 2009).

4.1.1 QUESTIONS: In your opinion:

4.1.1.1 How can a web-based GIS application facilitate EIA decision making?

4.1.1.2 Is the technology and skills available in the Western Cape to operate an efficient and effective web-based GIS application to inform EIA?

4.1.1.3 How can a web-based GIS application potentially incorporate cumulative and strategic environmental assessment to assess the impact and to enhance current EIA practice?

4.1.1.4 What are the barriers that prevent a web-based GIS application to facilitate EIA?

4.1.1.5 Are there any features that the web-based GIS application should contain to inform EIA decision making?

4.2 THEME TWO: A WEB-BASED GIS APPLICATION AS A PLATFORM FOR STAKEHOLDERS COMMITMENT TO EIA.

A brief literature study relates:

Seto and Shepherd (2009) concur that GIS could be a long term solution to commitment by all stakeholders as the variables and attributes required for decision making can be created by GIS.

Internationally, web-based communication techniques based on electronic and digital tools inform interactive decision making. Users include governments, the media, political groups and the public. Benefits of a GIS web-based tool include easy access, reduction in citizen illiteracy, education, debate and participation in decision making (Milner, 2007).

A tool made up of the scientific concept of advanced technology, modern communication networks, transdisciplinary knowledge combined with real world information such as maps will balance visual literacy and textual literacy to enable people to communicate and exchange knowledge to better understand the complexity of the human-environment relationship (Brown, 2009).

Electronic communication transcends time and space and allows for easy access with geographically dispersed stakeholders (Norris, 2001). Le Roux (2005) postulates that the disadvantage of web-based communication is that participants are required to have a high degree of computer literacy. However, another train of thought is that citizen illiteracy will be reduced as society is increasingly exposed to modern communication networks (Milner 2007).

Van Niekerk (2008) emphasizes that the modern communication networks such as the Internet creates a platform for environmental education and spatial analysis of land use options to a wide audience and give all people the opportunity to develop the understanding, skills and capacity to achieve effective participation?

4.2.1 QUESTIONS: In your opinion:

4.2.1.1 Would access to baseline information of a development project in a given area encourage those potentially affected by the impact of the project to get involved?

4.2.1.2 How can a web-based GIS application (as a platform for stakeholder commitment to EIA requirements) facilitate networking between various stakeholders?

4.2.1.3 What is the propensity of stakeholders in Cape Town to change from business as usual to commitment to a web-based GIS application to facilitate current EIA?

4.2.1.4 What are the barriers that prevent stakeholder commitment to accept a web-based application to facilitate EIA in Cape Town?

4.2.1.5 Are there any features that the web-based GIS application should contain to inform EIA decision making?

4.3 THEME THREE: A GIS WEB-BASED TOOL AS A PLATFORM FOR TRANSDISCIPLINARY INFORMATION AND KNOWLEDGE EXCHANGE

A brief literature study relates:

According to Jager (2008) the modern world is characterized by rapid change and complex problems such as climate change, poverty and lack of governance. She suggests a transdisciplinary approach in which a wide range of disciplines collaborate. Scientists and non-scientists need to find solutions to concerns faced by the public and the policy makers.

In the same way planners and EAPs need to work together to determine temporal and spatial aspects of development instead of eclipsing each other (Ralston 2010 cites the National Biodiversity Framework 2007).

Interpretive guidelines and training of users are highlighted as one of the major challenges most specifically where the selected units do not make intuitive sense. It is therefore vital that the planner is available in the early phases of implementation to answer technical questions and help interrogate the plans to ensure adequate understanding by users (Ralston 2009)

Due to the complexity of multi-disciplinary impacts on the environment, effective EIA is a challenge. In theory a GIS web-based tool has the potential to facilitate complex multi-disciplinary cross-discipline collaboration and knowledge exchange to inform decision making. EIA is a process that cannot be simplified as all the variables and factors that interact on the project have to be considered.

A transdisciplinary approach is in line with complexity management as the approach is a project and a tool just as the GIS web-based application is a project and a tool. It is an approach that looks at the coordination of disciplines. It is a combination of firstly the world as it is, followed by technological disciplines of what we are capable of doing, thirdly the planning discipline of what we want to do and finally the complex reality and what we should do based on local and global concerns for the human species and life in general. Only in transdiscipline can we aspire to find solutions to situations as poverty, unemployment and sustainability (Max-Neef 2005)

According to Van Niekerk (2008) Google Earth creates opportunities for users to interact with geo-technology in an intuitive way. Web mapping tools will allow users to visualize and learn about the environment in a user friendly way that promote understanding.

Longley et al (2005) claims that science and practical problem solving methods merge as a solution centered discipline through interdisciplinary team work.

Business decisions have to be made under time and financial constraints and people generally do not have time to read lengthy documents. Combining modern communication technology with environmental management legislation and compliance monitoring as a platform for multi-disciplinary knowledge exchange will reduce the bulk of the paper trail, expedite the process and inform decision making simultaneously (Steyn 2010).

4.3.1 QUESTIONS: In your opinion:

4.3.1.1 How can a web-based GIS application as a platform for multi-disciplinary and transdisciplinary information and knowledge exchange provide stakeholders with the information they need to participate in a meaningful way?

4.3.1.2 How can a web-based GIS application assist stakeholders in understanding the implications of project impacts, alternatives and solutions related to the project.

4.3.1.3 How can a web-based GIS application integrate, collaborate and exchange multi- and transdisciplinary knowledge with geographic and spatial information?

4.3.1.4 What are the barriers that prevent the web-based GIS application from effective multi- and transdisciplinary information and knowledge exchange?

4.3.1.5 Are there any features that the web-based GIS application should contain to enable multi- and transdisciplinary information and knowledge exchange?

THEME FOUR: A WEB-BASED GIS APPLICATION AS A PLATFORM FOR EFFECTIVE PUBLIC PARTICIPATION

A brief literature study relates:

If development is to be sustainable, the public should participate in development efforts. Community participation has emerged as a multi-dimensional approach linking to and integrating with the building blocks of development (Gebremedhin 2004)

The biggest disadvantage of web-based communication is that participants are required to have a high degree of computer literacy (Le Roux 2005). However, citizen illiteracy will be reduced as society is increasingly exposed to modern communication networks (Milner 2007).

Active and effective public participation in addressing public challenges is enabled by the Internet as well as information and communication technology (Norris, 2001).

Electronic communication transcends time and space and allows for easy access with geographically dispersed participants.

4.4.1 QUESTIONS: In your opinion:

Does a web-based GIS application as a platform for communication and knowledge exchange have the potential to make the public participation process more effective and authentic and empower the participation of the public?

4.4.1.2 How can a web-based GIS application (as a platform for public participation) broaden capacity building? (Local languages, ethnographic communication, computer booths in remote areas).

4.4.1.3 How can a web-based GIS application allow the public to be involved throughout the project process? (To ensure their concerns and aspirations are understood and considered by decision makers) (DEA 2010).

4.4.1.4 How can a web-based GIS application store and present modes of communication such as fact sheets, web sites, public comment, focus group discussions, surveys and deliberative polling (DEA 2010)?

4.4.1.5 What are the barriers that prevent the public participation process from commitment to a web-based GIS application to facilitate EIA in Cape Town?

4.4.1.5 Are there any features that the web-based GIS application should contain to facilitate the public participation process?

4.5 THEME FIVE: OWNERSHIP AND ADMINSTRATION OF A WEB-BASED GIS APPLICATION

Repetti et al (2006), the developers of SMURF (system of monitoring urban functionalities), propose that a GIS web-based tool be established and maintained at city level. They suggest that the existing structures and dynamics of a city such as the availability of the necessary skills including database management skills and computers will determine the operability and durability of the system.
The biggest weakness in the EIA process is the absence of compliance monitoring and enforcement (SDCEA 2008).
Best practice – I assume it will be in the form of a policy document (e-questionnaire response 2010).
QUESTIONS: In your opinion:
4.5.1.1 What is the potential of web-based technology and communication networks with potential increased bandwidth (to enable greater diversity of data such as visual colour images and graphics) to develop a web-based GIS application in the Western Cape/Cape Town to facilitate current EIA?
4.5.1.2 Who would be the most appropriate body to take ownership of and administer a GIS web-based tool to facilitate the current EIA process?
4.5.1.3 Would implementation of a web-based GIS application at local city or district level potentially ensure that stakeholders and decision makers are informed of knowledge on micro- and mesa- scale to inform holistic decision making?
4.5.1.4. How can a central national data base ensure standardization of data, validation of data sources and metadata management?
4.5.1.5. How can barriers to acceptance of a web-based GIS application be overcome through a strong driver such as national or provincial government?
4.5.1.6 How can the barrier of Intellectual Property be overcome should a web-based GIS application be mandatory to facilitate the EIA process?
4.5.1.7 What are the barriers that prevent national or provincial government from commitment to a web-based GIS application for facilitate EIA in Cape Town and the Western Cape.

A.2 THE E-SURVEY USING A LIKERT-SCALE AS A MEASURING INSTRUMENT FOR QUANTITATIVE DATA SOURCING.

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This research is conducted towards obtaining a Master of Arts degree in Geography and Environmental Studies at the University of Stellenbosch. The research is conducted under formal academic supervision. The university guarantees anonymity of all participants and that all information will be treated in a scientifically ethical manner.

GIS FOR EIA IN CAPE TOWN

The feasibility of a web based GIS application for knowledge exchange in the current EIA.

This is a structured e-questionnaire targeted at respondents who are Environmental Assessment Practitioners (EAPs) in Cape Town, Western Cape). EIAs for proposed projects in Cape Town are assessed at provincial government level (DEA&DP) for approval. As background information a summary of the study and brief quotes from the literature are presented as research rationale.

1. SUMMARY:

In South Africa, environmental strategists realize that new strategies and tools are needed to facilitate the current EIA process. The DEA commits to Integrated Environmental Management and Impact Assessment in compliance with NEMA regulations (2010) and best practice to improve the current EIA process. IEM is centred on sustainability principles and alternative tools to enhance the current EIA (EAPSA launch 2011). Integrated Environmental Management (IEM) implies that all business strategies and plans are committed and are part of one overall process.

Core problems with the current EIA process are lack of knowledge exchange, lack of information to inform, lack of stakeholder commitment and narrow project specific focus. Web mapping tools such as a web based GIS application will allow users to visualise and

learn about the spatial aspects of the environment in a user friendly way to promote learning and understanding of all relevant aspects of the EIA.

The Internet (Google, web based tools), software and digital data link the world and provide people access to economic, ecological, scientific, political and legal systems. Multi-disciplinary knowledge needs to be appropriately transmitted to better understand complex human-environment relationships (Marsden 2005). This research postulates that a web based GIS application has the potential to function as a platform for knowledge exchange to facilitate EIA.

GIS has the potential to change business decisions. A web based GIS application can inform the EIA by making it easy to access information (organise, store, retrieve and apply knowledge). It has the potential to present relevant information such as the geo-referenced location, site maps and regional baseline information of the project to all stakeholders (EAPs, I&APs, local municipalities, districts, decision making authorities in government and the media).

The web based GIS application would operate as a one-stop platform to communicate the required information to the stakeholders. To be effective, data should be managed and hosted centrally in a national database with the web based GIS application interacting with non-spatial information for analysis. Specifications for standardization of data collection would ensure that the database and data sets are synchronized.

To broaden the Public Participation Process and address the concerns of the public, the application can potentially provide online reports in local languages, visual images and ethnographic maps that the public can relate to. The application can store records of key stakeholders and I&APs, NGOs and constituents for future projects in the area.

The City of Cape Town has recently introduced the Smart City Project that provides access to technology for communities that would otherwise not have been possible. The mobile phone industry is also becoming a good platform for integrated spatial and non-spatial information exchange as most people have access to this technology.

Literature study indicates that web based GIS applications currently in use provide useful information to stakeholders, assist knowledge exchange, inform interactive decision making and improve development outcomes. Primary findings point to benefits of data management, informed decision making, access to baseline information, knowledge of cumulative and social impacts and the need for user friendly technology.

Barriers to change include intellectual property rights, cost of integrating data, cost of technology, lack of data management for spatial functionality, limited bandwidth, need for a national data provider and lack of technical capacity for service delivery.

The majority of the barriers can potentially be alleviated should the web based GIS application be part of the mandatory EIA process supported by all stakeholders (including global funding organisations).

Five themes run concurrently throughout the study. The opinions of EIA stakeholders taking this survey will be grouped under these five themes as listed below. The themes focus on areas of concern in the current EIA process (NEMA EIA Regulations 2010).

1. The functionality of a web based GIS application to inform EIA (what the application can do);
2. Information exchange (i.e. what it is used for);
3. Public (i.e. how to engage society authentically);
4. Stakeholder engagement (i.e. how to get the key players to commit more effectively); and
5. Ownership of the web based GIS application (i.e. who will manage the system)

2. E-QUESTIONNAIRE OF THE OPINIONS OF STAKEHOLDERS INVOLVED IN EIA:

Statements below are related to the five themes mentioned in the summary. Each theme and its questions are grouped on separate pages. Selected references from literature that are associated to the themes are provided as background information.

2.1PLEASE ANSWER THE FOLLOWING QUESTIONS ABOUT YOU:

a) Are you an Environmental Assessment Practitioner (EAP)?

Yes ☒

No ☐

b) If No Please state your role in the EIA process? Click here to enter text.

2.3 PLEASE EVALUATE THE FOLLOWING STATEMENTS.

INDICATE YOUR OPINION WITH A CLICK ON THE HIGHLIGHTED WORD "Strongly Disagree". A DROPDOWN ARROW WILL APPEAR WITH A SELECTION OF OPTIONS. PLEASE CHOOSE THE RELEVANT OPTION BY CLICKING ON IT (Strongly disagree, Disagree, Neutral/Unsure, Agree, Strongly Agree)

1. I understand the strategies of National, Provincial and local Environmental Affairs (DEA, DEA&DP and City of Cape Town) with reference to the need for new tools to facilitate the current EIA. Neutral/unsure
2. The requirements of the current EIA process provides access to information to inform the EIA process. Neutral/Unsure
3. I have access to all the information I require for effective, efficient and timely EIA.Agree
4. Standardised guidelines for best practice are required to ensure effective and efficient EIA by EAPs. Strongly Agree

THEME ONE: THE FUNCTIONALITY OF A WEB BASED GIS APPLICATION TO INFORM EIA DECISION MAKING: (what the application can do)

Selected references from the literature:

Seto and Shepherd (2009) support a web based GIS platform as a potential long term solution to commitment by all stakeholders. The variables and attributes required for decision making can be created by GIS.

Internationally, web based communication techniques based on electronic and digital tools inform interactive decision making. Users include governments, the media, political groups and the public. Benefits of a GIS web based tool include easy access, reduction in citizen illiteracy, education, debate and participation in decision making (Milner, 2007).

Statements continue.

Please evaluate the following statements:

5. People are becoming more spatially aware through access to spatial management tools such as Google Earth maps, Mobile Maps and GPS.Strongly Agree
6. Access to Google Earth, Internet and web-based technology create opportunities for users to interact with geo-technology in a user friendly way. Strongly Agree
7. The spatial location of the proposed project for EIA should be geo-referenced. Strongly Agree
8. Environmental decision makers and Environmental Case Officers and EAPs should have access to spatial knowledge exchange to learn more about the location and spatial aspects of a proposed project. Agree

9. Web-based GIS usage will provide upfront baseline information of the location and area attributes of a proposed project to streamline the current EIA process. Agree

10. GIS users can create variables and attributes for EIA decision making as a potential long term solution for informed EIA decision making. Agree

THEME TWO: A GIS WEB BASED TOOL AS A PLATFORM FOR MULTI-DISCIPLINARY INFORMATION AND KNOWLEDGE EXCHANGE

Selected references from the literature:

Due to the complexity of multi-disciplinary impacts on the environment, effective EIA is a challenge. EIA is a process that cannot be simplified as all the variables and factors that interact on the project have to be considered. A web based GIS application has the potential to facilitate complex multi-disciplinary collaboration and knowledge exchange to inform decision making (DEA 2011).

A tool made up of advanced technology, modern communication networks, trans-disciplinary knowledge combined with real world information such as maps, will balance visual literacy and textual literacy to enable people to communicate and exchange knowledge to better understand the complexity of the human-environment relationship (Brown, 2009).

Statements continued.

Please evaluate the following statements:

11. The impacts of project activities are not necessarily a linear process impacting only on the specific location.Strongly Agree

12. Web-based GIS usage has the potential to incorporate cumulative impacts (biodiversity fragmentation, water and air pollution). Access to this information will inform the EIA process Strongly Agree

13. Web based GIS usage has the potential to incorporate strategic socio-economic information to assess the holistic nature of impacts on the environment to inform the EIA process. Agree

14. Access to spatial information and knowledge of the proposed project can make spatial analysis possible and give stakeholders a better understanding of what impacts are likely to occur. Agree

15. Even though very few EIAs are rejected due to impacts on the biodiversity of the environment, awareness of biodiversity vulnerability is important for EIA decision making. Strongly Agree

THEME THREE: A WEB BASED GIS APPLICATION AS A PLATFORM FOR STAKEHOLDER COMMITMENT TO EIA. (How to get key players to commit more effectively)

Selected references from the literature:

Van Niekerk (2008) emphasizes that modern communication networks such as the Internet creates a platform for environmental education and spatial analysis of land use options to a wide audience and give people the opportunity to develop the understanding, skills and capacity to engage effectively.

Electronic communication transcends time and space and allows for easy access with geographically dispersed stakeholders (Norris, 2001).

Statements continue.

Please evaluate the following statements:

16. Stakeholders will gain a better understanding of the complexity of human-environmental relationships through web-based GIS usage for knowledge exchange of the spatial aspects of the environment.Agree
17. Access to web-based GIS baseline information and potential cumulative impacts will encourage stakeholder commitment to the project.Neutral/Unsure
18. Stakeholders in Cape Town are ready to adapt to a multi-media web based GIS application of integrated multi-disciplinary knowledge to inform EIA decision making. Neutral/Unsure
19. Stakeholders in Cape Town will commit to a web based GIS application to potentially improve the transparency of the EIA process? Agree
20. Barriers to knowledge exchange created by stakeholders refusing to share “intellectual property” (a term used to describe proprietary information) could potentially be reduced should the information be made accessible via web-based GIS usage.Neutral/Unsure
21. All relevant information such as historical data, previous RoDs and data generated by EIA processes should be collated and made accessible to all stakeholders involved in EIA.Strongly Agree

22. Relevant data of EIA projects should be stored and made available through web-based GIS usage as a benchmark for future EIAs. Strongly Agree
23. Stakeholders will commit to web-based GIS usage if it is part of the mandatory EIA process.Neutral/Unsure
24. Stakeholders will commit to web-based GIS usage if it is a voluntary process. Neutral/Unsure

THEME FOUR: A WEB-BASED GIS APPLICATION AS A PLATFORM FOR EFFECTIVE PUBLIC PARTICIPATION. (How society can participate more authentically in decision making)

Selected references from the literature:

The biggest disadvantage of web based communication is that participants are required to have a high degree of computer literacy (Le Roux 2005). However, citizen illiteracy will be reduced as society is increasingly exposed to modern communication networks (Milner 2007).

Active and effective public participation in addressing public challenges is enabled by the Internet as well as information and communication technology (Norris, 2001).

Statements continued.

Please evaluate the following statements:

25. Web-based access to baseline information of a project in a given area can encourage those members of the public potentially affected by the impact to get involved in decision making.Neutral/Unsure
26. Web-based GIS usage will create a platform for spatial analysis that will be useful to a wide audience.Neutral/Unsure
27. Web-based GIS usage integrated into the EIA procedure could monitor public participation and subsequently avoid appeals and delays of the EIA process Strongly Agree
28. Benefits of web-based GIS usage include an improvement in public environmental awareness and increased participation.Agree

29. Web-based GIS usage with online access to multi-disciplinary knowledge (ground-truthed specialist reports and alternative options) can potentially inform and empower the public to authenticate the public participation process.Agree

THEME FIVE: OWNERSHIP AND ADMINSTRATION OF A WEB BASED GIS APPLICATION (who will manage the system)

Selected references from the literature:

Repetti et al (2006), the developers of System for Monitoring Urban Functionalities, propose that a GIS web based tool be established and maintained at city level. They suggest that the existing structures and dynamics of a city, such as the availability of the necessary skills including database management skills and computers, will determine the operability and durability of the system.

Best practice – I assume it will be in the form of a policy document (2010 e-questionnaire response to the researcher).

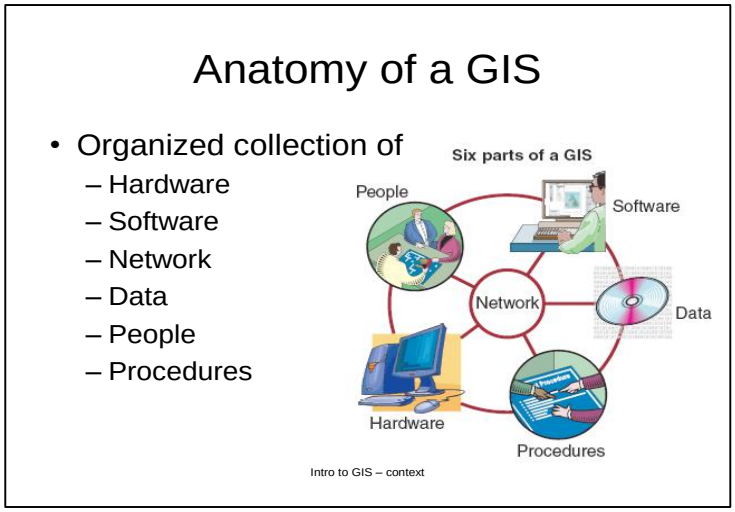
Statements continued.

Please evaluate the following statements:

30. The development of a web-based GIS application requires a large budget and support. Agree
31. Government support is needed to ensure web-based GIS usage becomes a mainstream tool to facilitate the current EIA process in practice. Strongly Agree
32. Provincial Government should seek funding to develop and implement web-based GIS usage in EIA.Agree
33. Government support of web-based GIS usage would ensure that the EIA process is performed according to best practice that includes transparency.Agree
34. Government support is crucial to ensure data sets standardisation according to compatible specifications to enable usage by all stakeholders.
35. Our organization supports the acquisition of web-based GIS skills and capacity to improve the EIA process.Agree

APPENDIX B

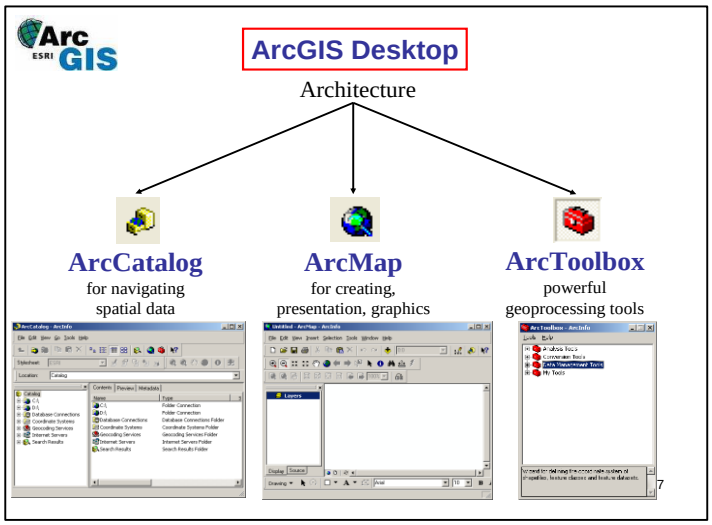
B.1 THE ANATOMY OF GIS



Poona (2010)

Figure B.1: Diagram explaining the anatomy of GIS

Software includes the source code and the user interface such as menus and graphical icons. ESRI software products are very popular and set the trends in GIS software. ArcGIS is the main software product. People are the GIS professionals who use GIS. Infrastructure includes the environment that supports GIS such as the required skills, data standards and patterns (Chang, 2010).



Poona (2010)

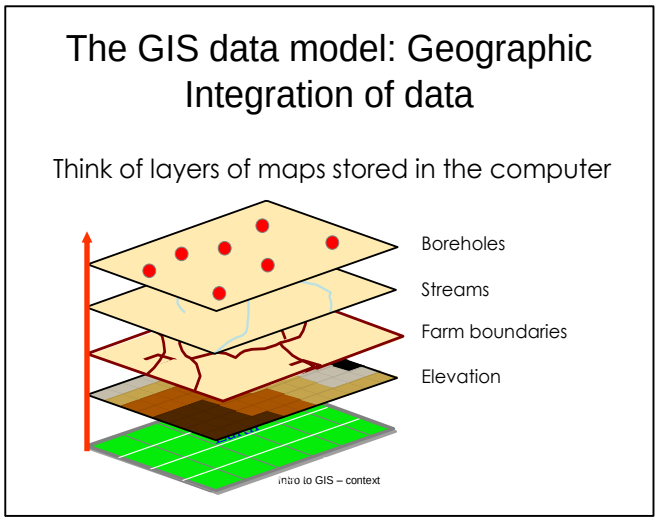
Figure B.2: Layout of ArcGIS

GIS uses geospatial data. Earth's surface is referenced to latitude and longitude coordinate values. However, map displayed features are usually projected in x and y coordinate values. There are Vector and Raster data models. Vector data models represent spatial features in GIS and uses x and y coordinates to represent discrete features such as boreholes, streams and farm boundaries. Vector data models can be geo-relational or object based, with or without topology, simple or complex. Raster models are made up of a matrix of cells where the value in each cell indicate whether phenomena are present or absent.

Raster models are ideally suited for computer analysis. However the data files are very large and includes unnecessary data as each cell must be populated with data. The spatial dimension of the phenomenon is not very accurate as the maps resemble blocks that are not very representative of the features they represent and don't make very nice maps. Raster models cannot represent topology and network modelling cannot be done with raster data. Raster is ideal for mapping continuous surfaces such as temperature, air pressure, average annual rainfall and height above sea level. It is also very appropriate for processing other data types such as satellite data that share raster data structure (Chang 2010; Vlok 2007).

Vector data files are usually much smaller that raster data, but the data is more intelligent since topology can be built in. The spatial dimension is also more accurate than raster. However, vector data models are more complex. The building blocks are points which are combined to form lines and areas. Input and editing can be time consuming compared to raster data input. Vector data models are used for analysis and network modelling.

Geometry and topology is used for map overlay. Data needs to be topologically adapted (cleaned and corrected) so the lines meet at nodes and all polygons are closed. To create topology for a new data layer produced as a result of overlaying, the intersections of lines and polygons need to be calculated using geometric principles. Through vectorisation and rasterisation, raster and vector data can be adapted (Chang 2010; Vlok 2007).



Poona (2010)

Figure B.3: The GIS data model: showing geographic integration of Vector and Raster data

B.2 GIS OPERATIONS

GIS operations can be grouped into data acquisition, attribute data management, data display, data exploration, data analysis and GIS modelling. Data can be acquired from the Internet, digitized from paper maps, satellite images, GPS data, field surveys, street addresses and text files with x and y coordinates. Attribute data management is the management of the characteristics of spatial features through relational database models. Data display includes the design and creation of maps. Data exploration explores the general trends in spatial and attribute data and use map-based tools such as data classification, aggregation and comparison to process data (Chang 2010).

Goodchild in Longley (2005) suggests that Information Systems researches the fundamental issues arising from the creation, handling, storage and use of information. GIS researches the fundamental issues arising from geographic information including GIS design, GIS data and methods that arise from the use of GIS.