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GIS
Implementation as a Decision Support Tool for Planning and Managing Development Interventions

by

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Abstract

The aim of this study is to examine key implementation and managerial issues surrounding the use of a Geographic Information Systems (GIS) as a Decisions Support Tool (DST) for planning and managing development interventions. Ever since the emergence of GIS as a powerful analytical tool in almost all spheres of human endeavour, many organisations involved in development work have adopted its use. But the challenges of conceiving and implementing a GIS in ways that are more responsive to the problems that trigger its purchase remains a daunting task to many development organisations; even those with a wealth of experience in GIS. This is one of the motivating factors for this study. In this research, some relevant themes in GIS implementation and GIS management as a Spatial Decision Support System (SDSS) were examined in the literature review. A case study research strategy was used focusing on the experience of the Nelson Mandela Bay Municipality Enterprise GIS (EGIS). The study examined how the system is been ran and what other development organisations can learn from this experience. Data was collected and analysed using a mixed research methods approach. The findings show a good level of GIS acceptance among municipality staff. However, running the system is not hitch free. A couple of problems and challenges were identified on the field. It is recommended that the municipality like most development organisations seeking GIS solutions should put the user at the centre of every technical innovation in GIS as a DST.

Keywords*: Decision Support Tools (DST), Enterprise GIS (EGIS), Geographic Information Systems (GIS), GIS implementation, GIS management, Spatial Decision Support Systems (SDSS)*

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"Keyonghen khen"

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List of abbreviations and acronyms

ASPRS	American Society of Photogrammetry and Remote Sensing
BIS	Business Information Systems
CAC	Computer Animated Cartography
CAD	Computer Aided Drafting
CBO	Community Based Organizations
DAC	Development Assistance Committee
DBMS	Database Management Systems
DDSS	Development Decision Support Systems
DEM	Digital Elevation Models
DSS	Decision Support Systems
DST	Decision Support Tools
EDSS	Environmental Decision Support Systems
EGIS	Enterprise Geographic Information Systems
ESRI	Environmental Systems Research Institute
GIS	Geographical Information Systems
GPS	Global Positioning Systems
GSDI	Geospatial Data Infrastructure
GSIT	Geospatial Information Technology
GSS	Geospatial Sciences
GST	Geospatial Technology
GUI	Graphic User Interface
HIS	Health Information Systems
ICT	Information and Communication Technologies
ICT4D	Information and Communication Technologies for Development
IFAD	International Fund for Agricultural Development
IGOs	Intergovernmental Organizations
IMF	International Monetary Fund

JPEG	Joint Photographic Expert Group
LAN	Local Area Network
LIS	Land Information Systems
LRIS	Land-Related Information Systems
MIS	Management Information Systems
NAVSTAR-GPS	Navigation System with Time Ranging and Global Positioning Systems
NGOs	Non-governmental Organizations
NMBM	Nelson Mandela Bay Municipality
NMMU	Nelson Mandela Metropolitan University
OECD	Organization for Economic Cooperation and Development
RDBMS	Relational Database Management Systems
SDSS	Spatial Decision Support Systems
SIDA	Swedish International Development Agency
SIS	Spatial Information Systems
SNA	System of National Account
UNGIWG	United Nations Geographic Information Working Group
UNSDI	United Nations Spatial Data Infrastructure
USAID	United States Development Aid
URISA	Urban and Regional Information Systems Association
WWW	World Wide Web

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CHAPTER ONE

INTRODUCTION

1.1. Study background

Decision making in development interventions can be a daunting task. It involves a careful selection from competing alternative options of seeking effective solutions to challenging problems in planning, managing and realizing development works. Overcoming such challenges will require discreet considerations over information and data related to the focal point of whatever development intervention that there is. But humanity is being surrounded by a complex world of information; its excess or paucity of which can steer decision makers into crafting misguided policies. The availability of relevant and timely information is therefore a defining factor in successful development decision making processes.

Advances in Information and Communication Technologies (ICTs) in recent decades has enhanced decision making in development works but has however placed the world on an information super highway in which information needs to be carefully analyzed and synthesised to be valuable in any decision making process. Decision Support Systems (DSS) are the main tools for conducting such analyses. They can be alluded to the steering wheel used to plough through the complexities of today's information super high way.

DSS has varied meanings and interpretations. They can be summarily described as a set of diverse information and knowledge management tools used to inform judgments on what course of action to take in development interventions. To Leung (1997: 4), a DSS is "any system that can support decision making". BfG (2000) cited in Matthies et al (2007: 123), DSS is an "interactive, flexible, and adaptable computer based information system specially developed for supporting the recognition and solution of a complex, poorly structured or unstructured, strategic management problem for improved decision-making". Following from these definitions, DSS can be qualified as decision making tools. These tools however, come in different forms and with varied capabilities and fields of application. Remarkable among them are Spatial Decision Support System (SDSS). Examples of SDSS are Geo-Information Technologies (GITs). But GIT is just a generic term describing cognate disciplines and technologies used to capture, process, analyze, store and communicate geographically referenced information. One leading DSS in this group is a Geographical Information System (GIS). GIS can be described in terms of the processes underlying its functioning or in terms of its component parts. As a process, a GIS can be regarded as a computerized system for gathering, entering, processing, analyzing and visualizing geospatial data to enable informed decisions. In terms of its component parts, a GIS is a computer hardware and software geographical data processing system guided by a set of procedures and people to support decision making within an enterprise or organization.

What constitutes a GIS is as varied as the perspectives of the authors advancing them. To Tomlinson (2007:1) a GIS has "wide-ranging applications across the industrial and intellectual landscape' and therefore 'tends to resist simplistic definition" *(ibid).* However, what unifies the different views are the five 'Ms' defining the use of GIS as advanced by Longley et al (2006: 45): "mapping, measurement, monitoring, modeling and management". To these authors, GIS builds "representations" that "helps us assemble far more knowledge about the earth than is possible on our own" (*ibid:* 65). Obermeyer and Pinto (2008: 20 - 39), places a GIS within the broader context of an "Information Technology (IT)" and "fully integrated Information System (IS)" which serve organizations in managerial decision making. These include "problem recognition and diagnosis, solution generation, alternative evaluation and selection, solution implementation and feedback" (*ibid:* 31). These are areas some of the areas where the trademarks and capabilities of GIS can be fully exercised

The focus of this study is to examine key issues in GIS implementation and management and to establish important lessons which development organizations and practitioners can learn in this process especially in the context of a developing country. The concepts of DSS, SDSS and GIS as identified above provide the main framework for this study. GIS application capabilities as a SDSS shall be examined as well as the process through which it can be conceived and implemented in development organizations. Many authors have articulated the need for proper implementation of GIS in organizations seeking GIS solutions. For example, Aronof, (1991: 249) points out that a successful implementation of GIS is not determined by acquiring hardware and software systems alone, but also by people involved in the GIS. Heywood et al (2006: 347), express related views. The people here relates to human and organizational issues that affect GIS implementation, management and use in concerned organizations. But successful implementation and management are long term processes that need to be monitored and evaluated to determine the degree of progress and to learn new lessons that can make the system live up to its full potential of assisting organization to make more informed decisions in the development interventions.

1.2. The Problem statement

Ever since the emergence of GIS as a powerful analytical tool in almost every area of human endeavour, several development organizations and other stakeholders in development governance have adopted its use. Many of these organizations run in-house GIS or contract external expertise to meet their geospatial information needs. They range from local government organizations such as municipal authorities, sub national and national governments, private organizations, Non-Governmental Organizations (NGOs) to Intergovernmental Organizations (IGOs). The United Nations Geographic Information Working Group (UNGIWG: 2008) for instance anticipates a United Nations Spatial Data Infrastructure (UNSDI) to promote interagency cooperation and sharing of geospatial data and information to facilitate decision making at various levels of the organization. The United States Agency for International Development (USAID) in Albania (2003), reported that GIS enhances its ability to understand what projects are going on, where they are located and who they are serving. This helps the organization to track programs better, improve reporting and plan strategically. It adds that "maps built on a comprehensive statistical database, show important relationships among a diverse set of variables that help to maximize development assistance programs conducted by USAID, NGOs and donors, as well as the Government of Albania" *(ibid).* According to Aronof (1991: 260 -261) the use of GIS leads to "increased efficiency, new non-marketable and marketable services, better decisions and intangible benefits". To Campbell and Masser (1995: 27), GIS acquisition is motivated by "the desire to correct operational weaknesses". This is one priceless benefit in the purchase of a GIS. Obemeyer and Pinto (2008: 166) in presenting GIS cost-benefit analysis emphasize that the potential of GIS to "improve the overall efficiency and productivity in organizations whose missions rely on geographically referenced data has never been greater". Similar views are shared in Longley et al (2011: 42). They articulate in very simple terms that "GIS is used to improve many of our day-to-day working and living arrangements".

It will require volumes of literature to fully unmask the enormous potentials and benefits of a GIS in planning and managing development interventions. They have been so compelling as to spur an across the board adoption in almost all sectors of development intervention in both public and private organisations. Its spatial data processing capabilities and potentials to support decision making for planning and managing of development interventions need little emphasizes.

But how can a fully functional GIS be conceived and implemented in a development organization; and made more responsive to meeting the data needs of such organizations? This has always been a daunting task to many organizations even those with a wealth of expertise in the GIS domain. Proper GIS implementation strategies are an inseparable component of a successful GIS purchase. A total lack or shortage in this aspect will assist no better than in making the system counterproductive to the organization. Most intriguing also is the fact that a fully functional GIS will still require sound judicious management in order to live up to its expectations of contributing to the organization's business as a SDSS. GIS management is therefore part of the GIS implementation which all are long term formative processes to make the technology more relevant and responsive to the organization's geospatial intelligence needs. It requires occasional evaluation to determine progress across time and to generate knowledge about good practices.

This is the main focus of this study - to investigate core issues in GIS implementation and management. It is an opportunity to draw invaluable lessons on good practices to cultivate when contemplating GIS solutions in development organizations.

This research work seeks to answer frequently posed questions and concerns about a GIS as a Decision Support Tool (DST). They include:

i. What is a GIS, how does it work and what is special about it?

ii. How can a GIS be conceived and implemented in an organization?

iii. What is the role of a GIS in development works?

v. What are the key managerial issues and challenges in the usage of this technology?

vi. What are user perceptions about the effectiveness of this tool in meeting their needs?

vii. How can the system be made more responsive to these needs?

viii. What are the basic considerations when contemplating a GIS solution?

These are some of the core issues to be addressed in this research using the case of Enterprise GIS (EGIS) in the Nelson Mandela Bay Municipality (NMBM).

1.3. Aim and Objectives of the Research

1.3.1. Aim of the research

To examine GIS implementation as a Decision Support Tool in planning and managing development interventions.

1.3.2. Objectives of the research

The aim spelt out above will be met within the framework of the following objectives:

i. Examine a Geographic Information Systems within the wider context of Geospatial Information Technology (GITs)
ii. To investigate how a GIS can be conceived and implemented in a development organization using the case of the Nelson Mandela Bay Municipality Enterprise GIS
iii. Showcase the role of GIS as a DSS in development work using the example of the Nelson Mandela Bay Municipality GIS.
iv. Evaluate the extent to which GIS implementation in the municipality has been successful and the organizational challenges and problems facing this process
v. To establish lessons that can be learned from this case and to advance a set of good practices and recommendations regarding GIS implementation in development organizations

1.4. Value and motivation for the research

The motivation for this study goes far beyond the academic purpose for which it is intended. These motivations are three fold. First it is an opportunity to narrow the gap in literature. This gap is between GIS as a cross disciplinary science that has found application areas in developmental studies and GIS as a field of study on its own

The role of GIS in development practice is on a spectacular rise. This accounts for why some educational establishment such as the Nelson Mandela Metropolitan University (NMMU) - South Africa (2010) and the University of Lund - Sweden (n.d.) offer elective GIS modules in Development Studies. The University of Helsinki – Finland summer school (2009) offer courses in participatory GIS in Development Studies. The University of Manchester School of Environment and Development (n.d.) in the United Kingdom, has also pointed out that students enrolling for its Master programme in Information and Communication Technologies for development (ICT4D) could find the GIS Masters programme interesting.

Despite these efforts to incorporate GIS into mainstream Development Studies, the technology remains alien to several a development practitioner and consequently to many development organizations especially in Africa. Some of them have good business cases requiring GIS solutions but however, lack the knowledge and expertise to ensure that GIS is not only incorporated in their workflow but that this is done in ways that will enable the system to function properly and sustainably. The need to include human and organizational issues (GIS implementation and management issues) in GIS tuition for Development Studies therefore need not be overemphasized. This research aligns with this thought. It seeks to investigate on what development organizations and development practitioners can learn from a GIS, its implementation and management. It will generate valuable knowledge and ideas which many development practitioners and organizations will find useful when contemplating GIS solutions in their work flow.

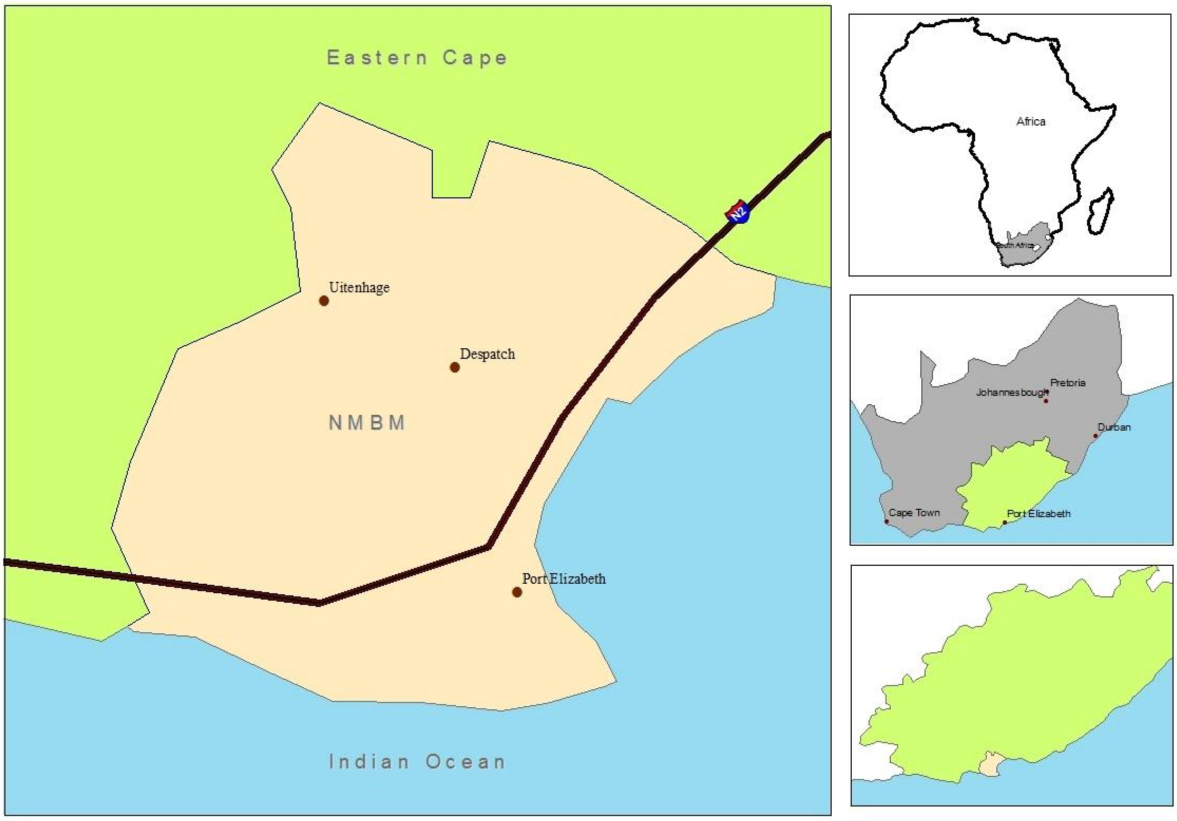
Besides, the realities of today's knowledge/skilled-based economy are becoming more apparent than ever before. To be able to survive the tides of today's competitive job market, development practitioners will be compelled to offer more than just theorizing on development. This calls for an urgent necessity for development practitioners to diversify their knowledge and skills. One way to do this is to expand on the cross disciplinary approach to studying development and social phenomenon. The need for a study of this nature will be valuable in this respect.

Secondly, as an academic field on its own, the bulk of research in GIS leans mainly towards the science, techniques and applications of a GIS. Consequently, literature on human and organizational issues in GIS has been given limited attention thereby neglecting GIS implementation issues. Cragila and Masser (1996: 2) indicates that "it is surprising to find that relatively little systematic research has been carried out…on the diffusion of geographic information technologies in key sectors such as local government". Diffusion is the "processes whereby technological innovations such as GIS are adopted and taken up by various groups" *(ibid).* This neglect has created a gap in literature. Giving GIS implementation and managerial issues limited attention will only put the discipline on the verge of a utopian science. Its true value lies not only in our understanding of the science behind it, but also very much on its applications and benefits which can only be reaped through a well thought process of adopting a GIS as a SDSS. As GIS application areas continue to expand, the need to emphasize on its proper conceptualization and implementation is primordial. This research seeks to highlight this need. Knowledge generated will be of value in removing some institutional and technical bottlenecks to the widespread adoption and successful use of GIS by development organizations.

The impetus for this study is further fueled by my career outlook as prospective development practitioner. I consider the use of GIS to be invaluable in my career ambitions in the field of development research. Besides, GIS is been rapidly diffused through government, nongovernmental and private sector business apparatuses. This diffusion poses lots of challenges especially in a less developed world which lags behind considerably compared to its northern counterpart. Campbell (1996: 26) indicates that "differences in the extent of diffusion have been related to variations in national policies on data availability and widely differing institutional arrangements". Data availability and institutional arrangements unlike in the developed world are in most cases lacking in the developing world. The single most important way to overcome these challenges is through proper conceptualization, implementation and management of a GIS. This calls for sound knowledge on GIS and on GIS management to oversee its diffusion process. Conducting research on GIS implementation and management is invaluable in anticipating a career path that requires extensive use of GIS and other geospatial information technologies. For example, in the Republic of Cameroon from where I originate, the uptake of GIS in the public service has been timid and slow. This research will serve to illuminate my understanding of GIS implementation and will also provide government services back home with an understanding of GIS applications, implementation and management.

1.5. The Study Area

The case study for this research is the Nelson Mandela Bay Municipality (NMBM) GIS unit. The Municipality was created in 2001 and is named after South Africa's political icon and former President, Nelson Mandela. It is one of the southernmost metropolis on the African continent. The municipality is located some 33° 57' 29" S and 25° 36' 00 "E. It covers three main urban areas, Port Elizabeth, Uitenhage and Despatch. Port Elizabeth is the chief city in this area. The neigbouring surroundings are predominantly rural. The map 1.1 below shows the location of the NMBM in South Africa.



Map 1.1 Location of NMBM in South Africa

According to the 2007 Community Survey Report published by Statistics South Africa (2009:8) the NMBM population stood at 1, 050 950 spread over an area of 1950 kilometres square (NMBM, 2011:21). Its population is mixed (black Africans, Coloureds, whites, Indians and Asians). Isixhosa is the main African language spoken in this area but the English Language and Afrikaans are also widely spoken. The main economic activities in the area are manufacturing, commerce, community service and tourism.

1.6. Chapter Outline

Chapter One

This is the introductory chapter for this study. It provides the reader with the conceptual framework for this study by looking briefly at the concepts of Decision Support Systems, concept of Geoinformation Technologies and Geographic Information Systems. The main research issues are presented and the need for the research justified. The chapter is organized around the following main heading: the study background, the problem statement, aim and objectives of the research, value and motivation for the research, the study area and the chapter outline.

Chapter Two – Review of Literature

The chapter presents the reader with relevant views in literature. It discusses the perspectives of some authors regarding important issues bordering on this study. It is organize around 11 themes as follows: the concept of Decision Support Systems (DSS), meaning and scope of Geoinformation Technologies (GIT), Geographic Information Systems (GIS): meaning and scope, GIS applications and benefits, meaning of GIS implementation, GIS Implementation models and approaches, GIS Management, meaning of monitoring and evaluation, concept of development planning and management, development organizations what they are and research and research methods.

Chapter Three – Research Methodology

The focus of this chapter is to discuss the procedural steps towards resolving the research problem and questions as well as accomplishing the objectives of this study as spelt out earlier in Chapter one. It consists of a description of the research strategy, the data collection and data analysis methods, GIS and Cartographic process for thematic map production and the delimitation and limitations of the research methods used.

Chapter Four – GIS and its Implementation Findings

The main purpose of this chapter is to resolve the first three questions of this research as well as to accomplish the first three objectives outlined above. It is divided into three main sections. Section one is on GIS within the wider field of Geoinformation Technologies (GITs), section two on GIS Implementation in the NMBM and section three is on GIS application in the area.

Chapter Five – Questionnaire Results

This chapter presents the reader with the questionnaire results obtained from the field. It seeks to present what the user of the NMBM GIS perceives about the effectiveness of the NMBM EGIS as a SDSS, the problems and challenges they face when using the system and suggestions on how to make the system work better for the municipality. The three main sections for this chapter are the data presentation section – a chronicle of the results obtained on the field. The other two sections are the data analysis and the synthesis section.

Chapter Six – Conclusion and Recommendations

This is the concluding chapter for this study. The reader will be presented with a review of the previous chapters, a brief summary of research findings and a set of recommendations. These recommendations will be drawn largely from experience gathered on the field and will focus on GIS and GIS implementation in development organizations and GIS for development practitioners. It will also provide an opportunity for self-reflection and research outlook or future perspectives of this study.

CHAPTER TWO

LITERATURE REVIEW

Introduction

The focus of this research is to investigate the implementation of Geographic Information Systems (GIS) as a Decision Support System (DSS) in planning and managing development interventions. In this study the concept of a GIS will be examined in relation to Geoinformation Technologies (GITs) and the role these technologies play in development work. A further objective will be to evaluate the degree of GIS implementation success of in the study area thereby creating learning opportunities for development organizations and development practitioners seeking GIS solutions. This chapter presents the reader with some key themes and concepts that are related to this study. It is organized around the following headings: the concept of Decision Support Systems (DSS), meanings and scope of Geoinformation Technology (GIT) and GIS, GIS application and benefits, GIS implementation and management, the concept of monitoring and evaluation, the concept of development planning and management, meaning of development organizations, and finally, a view on research and research methods.

2.1. Concept of Decision Support Systems (DSS)

DSS is the main concept that pulls together other themes in this research. The focus of this section is on what DSS represent and the subtle differences and similarities between the different types. There is no consensus on what constitutes a DSS but they are generally accepted as systems that can support decision making processes. Reeve and Petch (1999) regard them as a class of information systems that help mangers to take decisions by providing tools and models with which to analyze policy relevant information. One typical example is general purpose statistical modeling packages. To Leung (1997), DSS is only an improvement over Management Information Systems (MIS). The subtle difference between the two is that MIS are considered to be less flexible and less effective compared to DSS which are usually conceived and designed to provide broad-based approaches to solving structured, semi-structured or unstructured problems. Wegener and Masser (1996) asserts the fact that there has been a massive growth in specialist services in the GIS industry one of which is the development of decision support systems for commercial marketing operations; while Campbell (1996), in discussing perceptions about GIS, describes this technology as a

DSS. Uran and Janssen (2002) in an article highlight the increasing adoption of DSS in decision-making processes. Power and Sharda (2005), discussed the concept and research directions in model-driven DSS in which they admit the behavioural and technical challenges that surround the design, development and implementation of model-driven DSS. Some authors have advanced a more industry oriented explanation of DSS; that is their views on DSS are more discipline focused. For example, Matthies et al (2007) in an article mention "Environmental Decision Support Systems (EDSS)". DSS therefore can be viewed from several perspectives. However, the singular factor unifying these views are found in the role DSS play - the provision of intelligence using computerized tools and information systems to support rational decision-making in business. The term Decision Support Tools (DST) is also used interchangeably used to describe DSS.

A leading example of an industry focused DSS is in Spatial Decision Support Systems (SDSS). Voivontas et al (1998) and Arampatzis et al (2004) in their respective articles mentioned GIS - based decision support systems. These are alternatives terms for SDSS. However, the delicate line that sets SDSS apart from a generic DSS is found in their ability to handle geospatially referenced data. SDSS are built with capabilities to process and store large amounts of geospatial information (geographically referenced information) unlike with generic and traditional DSS such as Management Information Systems (MIS), Health Information Systems (HIS) or a Business Information System (BIS) which have data processing capabilities that are limited to handling essentially non-spatial information or attribute information. This explanation concurs with Leung's (1997) view that SDSS models incorporate capabilities of capturing and processing spatial data, and providing a variety of outputs for solving spatial problems.

These perspectives presented in literature are valuable to this study. It illuminates the reader's understanding of key and recurrent concepts in this study – DSS, SDSS, DST and GIS-based DSS. They all suggest and substantiate the fact that SDSS are built to incorporate GIS technology. They will be used increasingly in this research to describe the core functions or role of a GIS in development work - providing intelligence for decision making. The main limitation in literature however lies in the neglect of implementation and management issues of these systems. These are key components in the successful purchase of these technologies. They have a strong bearing on the degree of success in the use of these technologies. This research is an attempt to deal with this challenging problem in the field of GIS.

2.2. Meaning and scope of Geoinformation Technologies (GITs)

GIT is an encompassing term for related disciplines that deal with spatially referenced data. It is known alternatively as Geospatial Information Technology (GSIT), Geospatial Sciences or Technology (GSS - GST), Geoinformation Sciences or simply as Spatial Information Sciences (SIS). Others have called it Geoinformatics and Geomatics. Most significant in whatever description is the fact that GITs relate to cognate disciplines that deal with spatially referenced data. The discipline as suggested by Goodchild, (1992, cited in Lo & Yeung, 2007:458) is;

'…concerned with basic and applied research that aims to understand the nature of geospatial information and its application in scientific research'

Bossler (2002) in an article in The Manual of Geospatial Science and Technology identify three geospatial technologies – Global Positioning System (GPS), GIS and Remote Sensing to the omission of photogrammetry and surveying included by Konecny (2003) in his description of GITs. Yet they mention all these technologies to the exclusion of cartography which provides the single most important technique and interface used to visualise geospatial data. It is the science behind maps and provides the medium through which data held in geographic databases is communicated to the end user as information.

The role of cartography is captured by Harvey (2008). He examines in greater depth the relationship between GIS and cartography which essentially is the sharing of information and knowledge about that world. While geographic information represents things and events that have been observed in the real world, cartography aids the geographer, GIS persons and users to represent these things and events using symbolization techniques. Maps in all forms are therefore the main medium of visual communication GIS representations.

Konecny (2002) and Rizos (2003) describe the Navigation System with Time Ranging – Global Positioning System (NAVSTAR-GPS). It is a system of satellite-based radio-positioning and time-transfer system created and managed by the United States Department of defence since 1993 but has been of enormous benefit to the civilian community who apply GPS in wide range of activities. GIS has been a major beneficiary of this technology. As a geopositioning system, it has been of enormous significance in georeferencing GIS data. Georeferencing here pertains to assigning real world geographic coordinates to GIS data.

Remote Sensing on its part is useful in the capture of valuable data that can be used in a GIS. It is used to derive information about the geography of an area without any immediate contact usually by measuring the amount of electromagnetic radiation, emitted, reflected or scattered back into a sensor thereby creating an imagery of the observed object. To Longley (2011 & 2006) "it is the measurement of physical, chemical, and biological properties of objects without direct contact". Konecny (2003) "defines it as a method of obtaining information from distant objects without direct contact made possible by the generation of forces between the sensing device and the sensed object". Simonett (1983, in Lo and Yeung, 2007) observe that remote sensing usually refers to the gathering and processing of information about the earth's environment, particularly its natural and cultural resources through the use of photographs and related data acquired from an aircraft or satellite. This seems more practical definition compared to the views advanced above and fulfills the desire of this research to point out the significance of this technique in acquiring geospatial data for GIS. It also aligns with the views of American Society of Photogrammetry and Remote sensing (ASPRS, 1983) cited by Light and Jensen (2002). Essentially, they consider remote sensing to involve the remote extraction or acquisition of information through a recording device or sensor.

Photogrammetry on its part is akin to remote sensing. Its techniques are also used to extract information on the physical characteristics of the environment but however concern itself more with "geometric measurements of objects in analogue or digital images" (Konecny, 2003:106). To Longley et al (2011:241, 2006: 209) photogrammetry is used to capture measurements from photographs and other image sources. This serves as an important input into a GIS.

By and large, there are huge amounts of literature that will explain these techniques and technologies in greater detail. The key feature of GITs is their interdependence. While a GIS relies on Remote Sensing for data acquisition support, Remote Sensing in turn utilizes the data processing and data storage capabilities of a GIS. This interdependency is a delicate reality in geospatial sciences. Some of the sub disciplines in GITs requires the other to boast its capabilities as spatial decision support systems. However, the serious limitation in its literature is the presentation of each of these sub disciplines to the exclusion of the other. This partly is due to the extensive scope of their subject matter and techniques. The rich picture of their interdependence has in the greater part been concealed. It is more beneficial to examine a GIS from within the wider context of its interrelationship with other GITs. This is one of the objectives of this study. The interrelationship will be illustrated later in this research to enable the reader and other stakeholders of spatial information sciences in development organizations to gain a full appreciation of the wider picture of a GIS.

GIT is therefore multidisciplinary science. In terms of providing decision makers with valuable geospatial data/information, it cuts across GIS, Remote Sensing, Cartography, Global Positioning Systems, photogrammetry and to some extent, surveying. It also shares a lot with computer software development systems and Information Technology (I.T.)

2.3. Geographic Information Systems (GIS): meaning and scope

The purpose of this theme is to examine the concept of a GIS. It is widely held within the GIS community that the formulation of a precise and concise definition of GIS is hard to come by. Its applications are complex and the technology is rapidly evolving and expanding thereby incorporating new technologies and systems that boasts its capabilities even more. Hence most attempts of coming up with an ideal definition are usually fraught with subjectivity. While admitting this claim, it must also be stated that a precise and concise explanation of the term cannot be dismissed. Its understanding is the bed rock on which to build a GIS experience especially for beginners. This is one of the objectives this study seeks to achieve. A GIS definition is primordial without which there will always be gross misperceptions of what it stands for. For example, DeMers (2005) pointed out that many people due to the lack of a proper definition of GIS have misconstrued and likened the system to Computer Assisted Cartography (CAC) and Computer Aided Drafting (CAD). GIS software programmes in fact have different capabilities, functions and applications built in them despite resemblances in their Graphic User Interface (GUI) with CADs and CACs.

GIS definitions abound in literature. Few are examined here to chart the path to the reader's understanding of the concept of a GIS. Huxhold (1991) among other perspectives views a GIS as a system that contain map information stored in a digital database and which can then be plotted or displayed when needed to produce a map. He likens it to a system that can produce a printed report. Just as a printed report is one of the products of any information system, a map is one of the products of a GIS.

To DeMers (2005), a GIS is a tool that allows for the processing of spatial information, generally information tied explicitly to and used to make decisions about some portion of the earth. He qualifies this as a working definition of GIS but goes further to explain a GIS largely according to its sub systems. The data input subsystem used to collect and process spatial data from various sources, data storage and retrieval subsystem that organizes the spatial data in a manner that allows retrieval, updating and editing, data manipulation and analysis subsystem that performs tasks on the stored data and the data reporting subsystem that displays all or part of the database in tabular, graphic or map form. He equally illustrates the relationship between a GIS and a typical Land Information Systems (LIS).

Lo and Yeung (2007), synthesise a GIS as computer-based systems specially designed and implemented for two subtle but interrelated purposes: managing geospatial data and using these data to solve spatial problems. It is considered a special class of information systems designed to process geospatial information. They explain the delicate line that separates a GIS from other spatial information systems such as Computer Assisted Drafting (CAD) and Computer Assisted Manufacturing. This is in geographical referencing and geographic scaling of spatial data. They point out to the alternative names of GIS at application levels such as Land Information Systems (LIS) and Land-Related Information Systems (LRIS).

ESRI (2010) describes GIS as a technical tool for comprehending geography and making intelligent decision; a tool used to organize geographic data so that a person reading a map can select data necessary for a specific project or task. It goes further to describe a good GIS programme which normally should be able to process geographic data from a variety of sources and integrate it into a map project. This perspective of a GIS can be credited for viewing the technology as a means to an end; it emphasizes the decision-making aspect of GIS. This definition however is not elaborate and comprehensive enough.

Chang (2010) offers a definition that point out to GIS processes and procedures. To this author, it is a computer system for capturing, storing, querying, analyzing and displaying geospatial data. The system will usually consist of components – the hardware component such as the computers, digitizers, scanners, GPS receivers and the software components which are the source codes and Graphic User Interface (GUI) as common with most systems today. The people are the third component and include the GIS professionals. They define the purpose and objectives of the GIS and provide the reasons and justification for using GIS. GIS infrastructure is also a key component. It is the necessary physical, organizational, administrative and cultural environments that support GIS. This is a comprehensive description of a GIS but it however narrows down the people component of GIS only to the GIS professionals who create the data to the exclusion of the users who account for why data is produced. This view also fails to identify data, procedures and application as key components in every GIS. This had been covered in an earlier occasion by Rhind (1989, cited in Lo and Yeung, 2007: 2); a description favoured by this study. He defines a GIS as;

'…a system of hardware, software, and procedures to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data for solving complex planning and management problems'

A close view is shared by the United States Geological Survey (USGS, 2007). The organisation describes GIS as follows:

'A GIS is a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location'.

The varied perspectives above on what constitutes a GIS are all valid and are relevant to this study. However, they are by no means exhaustive to forestall the need for one of the major objectives of this study which is to come up with a concise but comprehensive explanation and description of a GIS, how it functions and its processes. This will be useful to a lay reader or development practitioners seeking a gentle introduction to GIS. Most importantly, GIS shall be presented within the framework of a wider field of Geoinformation Technologies (GITs), an approach which has been neglected in literature. Treating a GIS as though it were a standalone technology has a serious weakness. It does not give the reader the richer picture - how it benefits from sister technologies such as cartography, remote sensing and Global Positioning System (GPS). This is one of the differences this research seeks to make. It will address questions such as: what are GITs and what is a GIS? How are they related, what can development organizations and practitioners learn from this?

2.4. GIS applications and benefits

GIS has been described as an application-led technology. This is the main push that accounts for its procurement at all levels. Ever since the conception of this technology, its applications areas have widened from a narrow focused application on land and natural resources management to application in almost all sectors pertaining to human activity and the environment. Application can be described as the use of spatial data analysis and modeling tools embedded in GIS software to understand vast arrays of geographic datasets. An exhaustive illustration of GIS applications will entail huge volumes of literature. GIS has found applications in almost every level of human intervention. This sections attempt a discussion on some of these applications areas.

Onsrud et al (2000) outlines some of these application areas. These include applications in crime analysis, emergency preparedness and response, public health, transportation planning and management, water resources and urban and regional planning.

Other application areas have been elaborated in the "Manual of Geospatial Science and Technology" (Bossler et al, eds. 2002). In this manual, McMaster and McMaster (pp. 551 - 561) classify GIS applications into biophysical and human-social applications. The biophysical applications include use of GIS in ecology, forestry, soil science land use planning as well as management of natural resources at different scales over space and time. Biophysical applications aim at managing natural resources in a sustainable manner and to preserve protected areas. Human-social applications include use of GIS in planning and private businesses activities. The manual further discusses the different levels of GIS application ranging from the local government level, through to national and international level.

Environmental Systems research Institute – ESRI (2004), points out to GIS applications in the oil and gas sector. GIS helps petroleum companies to manage a wide range of location based information such as leases, where to drill wells, route pipelines, build a refinery, environmental sites, facilities and retail outlets and other areas across their varied business portfolios. This leads to improved communication, greater efficiency, and better decision-making in the oil and gas sector.

Heywood et al (2006) identifies the value of GIS in answering questions about location, patterns, trends, conditions and implications of phenomenon in the real world. It is useful in addressing concerns such as; where a particular feature is found; understanding the geographical patterns of a particular phenomenon, where changes have occurred over a given period, where certain conditions apply, what the spatial implications will be if an organization takes a certain action and several more. These are the kind of questions around which complex GIS applications are built. They pose challenges that are only better answered with the analytical capabilities of a GIS. According to Longley et al (2006) GIS applications inter alia include topographic base mapping, socio-economic and environmental modeling, global modeling and education. The authors identify what they term the 5 'Ms' of GIS viz: mapping, measurement, monitoring, modeling and management. GIS applications are meant to answer or fulfil these 5 'Ms'.

Lo & Yeung (2007) identify application areas in the academic sector such as research in humanities, science and engineering. In the business sector, they point out to GIS applications in banking and insurance, real estate management and retail analysis. Other areas include multipurpose mapping, land resource management and public management, security and law enforcement. It is also used in health care; for example mapping epidemiological patters. GIS is used as an intelligence gathering tool in the military to enforce command and control.

Applications in Government sector, business and service planning, logistics and transportation as well as the environment have also been widely discussed by Longley et al (2011). In government, GIS is used in tax assessment, inventory applications, policy analysis and management. In business planning, GIS is an invaluable asset in market area analysis especially when geodemographic databases are integrated with standard GIS software. In logistics and transportation, GIS has helped service and delivery companies to substantially reduce their operating cost in the field. It is also useful in anticipating or locating disaster prone areas. GIS assist in environmental protection and conservation, comparing past and present conditions as well as in comparing environmental conditions prevailing in different nations.

Key benefits of GIS applications as highlighted by Aronof (1991) include “increased efficiency”, availability of “new nonmarketable services” and “new marketable services” “better decisions” and other “intangible benefits”. Huxhold and Levinsohn (1995) shares same views by pointing out to “improved operational efficiency,…improved effectiveness,…increased wealth as a result of more effective expenditure…increased profits from effective decisions,…” and “making it easier to do business”

As pointed out earlier, GIS applications are diverse and wide-ranging even within one application area. For example, we find many environmental applications in ecology, forest resource inventory, and land use planning. Applications can range from simple tasks such as desktop mapping to very complex tasks using more sophisticated decision support systems.

In literature, GIS applications are wide ranging and scattered, are not none exhaustively treated and in the most only shallow discussions pointing out passively to GIS use. They may not be found in one piece in core GIS literature thereby occasioning the reader to find more applications by reading literature from other disciplines that have absorbed GIS knowledge into its mainstream literature. Besides, most of these discussions are not based on empirical evidence. This is one major flaw in entire GIS literature. This study seeks to brave the challenge of carrying out an empirical investigation on application capabilities of GIS as widely held in literature. It seeks to illustrate real world use of GIS in local government business particularly in development planning and management in in the Nelson Mandela Bay Municipality (NMBM). It encourages cross disciplinary cooperation between GIS and Developmental Studies.

2.5. Meaning of GIS implementation

The success or failure of GIS is often attributed to how well it is implemented and managed. This is a common feature of information technologies. This accounts for the firm assertion by Huxhold and Levinsohn (1995) that a successful GIS is built and not bought. These authors share the widely held views among the GIS community that implementation and management processes are primordial in the procurement of a successful GIS. This section looks at the meaning of GIS implementation.

Aronof (1991) describes GIS implementation as the point where technology and the people meet. This description upholds the unanimous view that successes or failures in GIS are not caused by the technology itself but by the people. Better still, the leading factor in a GIS performance lies with organizational politics and the context where it is been introduced. Campbell and Masser (1995) subscribe to this view in their description of GIS implementation. They consider implementation as the means through which adaptations are transmitted to the often wary members of the organization. In other words, implementation is the process by which innovations become absorbed into the organizational context where it is being introduced. The organizational context here points out to the people who by willingly accepting or rejecting innovations become a defining factor in its success or failure.

Implementation has also been likened to diffusion. In (ibid) diffusion is viewed as the fundamental process that is responsible for the transfer of innovations so that they become a daily part of the lives of a large section of society. To Craglia and Masser (1996) diffusion refers to the process whereby technological innovations such as GIS are adopted and taken up by various user groups. Wegener and Masser (1996) describe it as a process by which older, out-dated technologies are replaced by more advanced, more efficient and hence more beneficial ways of doing things. Diffusion and implementation have been judged as synonymous to one another but Campbell and Masser (1995) argue on the contrary. To them, it is most appropriate to consider diffusion within the context of a GIS as an umbrella concept that encapsulates awareness raising, adoption, implementation, routinization and utilization and assessment of the consequences of the entire exercise for the individuals and organizations concerned. Obemeyer and Pinto (2008) provide an explanation for this. It lies in the fact that diffusion was usually referred to mean the acceptance and use of technology by some subset of the general population while implementation typically referred to the acceptance within organizations of new technical processes or models. However, they dismiss this claim on grounds that its validity has been lost over the years thereby bridging the gap that warrants the terms to be used interchangeably. Hence to Obermeyer and Pinto (2008), diffusion and implementation are synonymous terms. By citing Rogers, (1983) they consider diffusion and implementation to mean the 'process through which an innovation is communicated through certain channels over time among the members of a social system".

Implementation views as expressed above both have theoretical and practical significance to this research. They are critical in the reader's understanding of this term which will remain recurrent throughout this work. Practically, implementation is highly regarded as a key towards any successful absorption of GIS in an organization's work routine. Alternative terms could be adoption and utilization. However, there is a slight variation in how some authors view implementation.

This research argues that any attempts to take up GIS applications in an organization usually requires effective planning for implementation and management from when the system is first thought of or conceived through to when operations start. It views implementation as a lifelong irrespective of whether the system is been built from scratch or it is been refined or upgraded. Implementation is regarded in this study as a context bound process. Some organizations may have no previous exposure and experience in the use of a GIS while other may be upgrading to newer technologies, other organizations may be more receptive to GIS technology in their workflow while others may seem rebellious to its introduction. Hence there is no one-fit- all process of implementation. This research upholds the different views and meanings of implementation. However, it seeks to dwell more on how implementation has been carried out or preferably, what are the main features of implementation and how have they been put in place in the NMBM? It also seeks to understand implementation challenges so as to create learning opportunities for development organizations contemplating GIS solutions. Somers (2002) enumerated some of the challenges. They include a skillful GIS leadership and management, education and training, and managing risk and politics. But it is worth noting that these challenges will vary between organizations and can only be understood by carrying out an empirical study of how GIS has been implemented in an organisation.

2.6. GIS Implementation models and approaches

GIS implementation theories, models and approaches seek to answer questions as to how the system can be integrated into the workflow of an organization to ensure that it functions properly as a DSS. The purpose of this section is to review some popular GIS implementation approaches in literature. Campbell and Masser (1995) discuss the theories of technological determinism, managerial rationalism and social interactionism. Most recently, Obemeyer and Pinto (2008) have discussed the content and the process implementation models. These two broad categories encompass other sub categories depending on overall nature of implementation. Other approaches are suggested by Tomlinson (2007) and Longley (2011).

To Campbell and Masser (2005), technological determinism suggests that the adoption and implementation of a technological innovation is guided by its inherent advantages or benefits and by its technical superiority. Implementation in this case is a rational response to correct an established technical weakness in the current system or technology. This implementation approach is essentially technical thereby limiting the range of issues that need to be considered. The main constraints to adoption in this approach are accounted for by technical failures, incompetence and lack of skill and ignorance of potential users. Managerial rationalism or “economic determinism” (Campbell, 1996), is an implementation approach guided by a rational management strategy. It reaps both the benefits of competent management and improvements in technical innovation. Constraints to implementation in this approach are poor management and the technical worth of the implementation. Social interactionism considers the adoption and effective implementation of a technology as the result of interaction between the technology and potential users within a particular cultural and organizational arena (Simpson, 1993 cited in Campbell and Masser,1995). Adoption of innovations depends on trends in society. Reason for adoption is to enhance status of power and implementation is constrained by social and political processes.

The major flaws in the aforementioned approaches are their concentration on the nature of implementation to the neglect of processes of implementation. It is true that technical and managerial lapses generate a need for adoption but the authors remain silent on how to adopt. This weakness is addressed in Obemeyer and Pinto (2008) who examined the content and process model approach to implementation. The content model approach is based more on analyzing the factors that can speed up the implementation process. It identifies those variables that are significant to the adoption process and hence can be very much compared to the theories of technological diffusion as discussed above. Factors of implementation success can be diverse depending on the context. The authors among others enumerate clearly defined goals, sufficient resource allocation, top management support, implementation schedules, competent technical support and responsiveness to clients. Just as with the theory of technological diffusion, the content model dwells more on implementation needs to the neglect of the process by which implementation occurs or the dynamic nature of implementation. This concern is addressed by the process model.

The process model seeks to identify the key phases in the adoption process. According to Schultz and his colleagues (1987) cited in Pinto and Obemeyer (2008) there are two main sub phases in the innovation process namely: the initiation phase where the organization becomes aware of the innovation and decides to adopt it and the implementation phase where the organization engages in the activities necessary to put the innovation into practice and incorporate it with existing operations. They redefine "initiation" to mean "strategy" which is related to the early planning phase of the implementation process and "implementation" to mean "tactics" and is concerned with the actual process of adoption.

Tomlinson (2007) sets out a ten-staged methodology of procuring a GIS. In this approach the GIS acquisition process starts with considering the strategic purpose, plan for the planning of acquiring the technology, conducting a technology seminar to educate stakeholder, describing the information products so that stakeholders should be certain of what to get out of the system, defining the system scope in terms of its software and hardware components, creating a database design, choosing a logical data model, determining the system requirements, conducting cost-benefit, migration and risk analysis and making an implementation plan which illuminates the paths to GIS success in the organization.

Longley et al (2011) examine the GIS acquisition models as suggested by Clarke (1991). This is a four-staged model; the first three concerned largely with implementation strategy and deals with analysis of requirements, (including user requirements and cost-benefit analysis), specification of requirements and evaluation of alternatives. They are mainly preliminary activities towards implementation. The last stage is implementation of system. It is the stage where GIS system goes into operation. Longley et al (2011) credit this system for its widespread successes but it should also be noted that the system may not apply in all organizational contexts and can be very expensive and time consuming.

The process model and the last two as suggested by Tomlinson and Obermeyer and Pinto suggest implementation as a stage by stage process. However, Campbell and Masser (1995) had in an earlier occasion thought otherwise of a stage by stage implementation process on grounds that it is difficult to determine when implementation starts or finish as important decisions are often negotiated long before the actual purchasing of the equipment or facility. They therefore disregard implementation in their study as one stage within an inevitable linear progression towards utilization in favour of theories of "technological determinism, economic determinism and social interactionism" (Campbell, 1996: 23 – 45).

The theories advanced above are general theories of technological innovation based on mainstream Information Systems. They are only made relevant to or viewed in a GIS context. This study does not recommend a particular model as no single model will be enough. This is especially because implementation is a context bound process. The main aim here therefore is to investigate on good practices, individuals and development organizations should remain cognizant of when selecting a GIS. Whatever model that is preferred, it is important to ensure that it meets user needs in the most efficient way possible. This will depend on the organizational context. Some organizations may have no previous GIS exposure, and others may be improving on or upgrading to new system. This study focuses on an empirical investigation of how GIS has been implemented and is being managed in the NMBM, what drives the system, what makes it function, what users feel about the system and what other development organisations as well as development practitioners can learn from this experience.

2.7. GIS Management

Implementation is the process through which a GIS can be integrated into an organization as a decision support tool. But GIS implementation triggers changes which can only be sustained through sound GIS management processes. Management theory and practice therefore plays a critical role in GIS implementation. It provides the skills and knowledge to manage people, money and the technology. Huxhold and Levinsohn (1995), Somers (2002), Longley et al (2006), Obermeyer and Pinto (2008) and Longley et al (2011) all affirm the need to manage a GIS implementation process. This usually will occur throughout from conception, planning and implementation phases to the post implementation phase so as to counter technological, human and organizational challenges posed by the implementation process. Implementation and management are therefore hand in glove processes regardless of an organization's entry level into a GIS technology.

Huxhold and Levinsohn (1995) conceive implementation as involving; strategic planning, conducting needs analysis, and defining a design methodology for implementation and then the system implementation proper. They emphasizes management throughout these processes The transition phase when a GIS is implemented to when it starts running and is being managed is described by these authors as the phase where "the system goes from abstract to concrete". It is in this phase where concepts and plans are translated into working systems. It is characterized by the creation of products or deliverables. Issues about data collection processing and storage become imperative as well as staffing. Most significant here is a shift in the staffing composition from one that is more GIS implementation inclined, towards a staff that is more skilled in operating and managing a GIS. This transition stage has also been captured by Somers (2002) who indicates that once the system is in full operation; its components must be maintained, added to and phased out if necessary. Longley et al (2006) indicates the key groups involved in GIS management. These include the management board, the GIS team headed by a GIS manager; the users, external consultants and various customers. It is also a managerial decision to decide where to place the GIS unit within an organization's structure. Obermeyer and Pinto (2008) in their discussions focus on some post-implementation issues and challenges which can only be tackled through management. They point out inter alia to organizational politics, economic justification of GIS implementation, conflicts in policy and legal issues in implementing and using a GIS.

Huxhold and Levinsohn (1995) and Obermeyer and Pinto (2008) recognize the intimacy between GIS technology and Information Technology (IT). Somers (2002) takes this intimacy further by pointing out to some IT related operations in GIS which are usually resolved by GIS management. These include user support, trouble shooting, training, system management, network management, date management, vendor support coordination, configuration management and system backups. Longley et al (2011) cues in on these views by referring to Larry Sugarbaker (2005) who had earlier indicated that success in operational management of GIS requires customer support, effective operations, data management and application development and support.

Elsewhere, GIS management has also been implicitly referred to in the works of Masser (1998) and Reeve and Petch (1999). Masser discusses the role that governments play in shaping the development of national geographic information strategies. To him governments around the world can, and some have, established bodies with responsibilities for national geographic information coordination. Reeve and Petch on their part emphasized the need for system maintenance and review once it is in place and running. To them hardware and software will become out dated and replacement will have to be evaluated and justified. User requirements change with time and there will always be need to correct initial flaws in the system. All these challenges are resolved through GIS management.

GIS management as discussed in literature offers a generally theoretical perspective. Organizations have different GIS application, different software and hardware packages, different attitudes to GIS adoption and different manpower capabilities. Management challenges will therefore vary between organizations and tend to be more contexts defined. Such challenges can only be largely understood by engaging on an empirical study which is exactly the main focus of this research work. It is the only way to have a rich picture and to understand the context in which the system is been implemented and the management challenges there in.

Implementation and management has also been treated in literature as though it were an activity spanning over a definite period of time. This probably stems out of failure in literature to spell out the difference between implementing and managing a GIS and managing a GIS project, the latter which is more time bound than the former that appears seamless throughout the life of an organization as long as the need for a GIS remains relevant. Managing GIS will also differ from using a GIS in managing an intervention.

In this study, GIS management is regarded as a continual process which seeks to refine and adjust the system to the changing and challenging needs of the system across time. Such needs and challenges in some cases may not only be internal but in most cases are largely external to the organization such as technological innovations which may render current technologies obsolete. GIS implementation and management are therefore continual processes. They need to be monitored and evaluated to counter challenges which may bog down the system. This accounts for one of the objectives of the studies enumerated earlier which is to identify some of the challenges and problems inherent in running a full fledged GIS.

2.8. Meaning of monitoring and evaluation

As indicated in the previous chapter, one of the objectives of this study is to evaluate the extent to which GIS has been successfully implemented in the NMBM. It is therefore necessary to consider a section in this review on monitoring and evaluation to enable a reader to understand the meaning of these concepts. Monitoring and evaluation are hand in glove processes. The purpose of monitoring is to collect and archive information regarding progress or achievements recorded in an activity or an intervention. The process of making sense out of such archived information is through evaluation. That is using monitoring information to judge the effectiveness of a programme or development intervention.

According to Development Assistance Committee (DAC) of the Organization of Economic Cooperation and Development OECD (2002):

> *"monitoring is a continuing function that uses systematic collection of data on specified indicators to provide management and the main stakeholders of an on-going development intervention with indications of the extent of progress and achievement of objectives and progress in the use of allocated funds".*

It is also referred to as performance monitoring. On the other hand, it describes evaluation as:

> *"...the process of determining the worth or significance of an activity, policy or program. An assessment, as systematic and objective as possible, of a planned, on-going, or completed development intervention"*

These views are shared by Swedish International Development Cooperation Agency (SIDA) of the Swedish Ministry of Foreign Affairs (2007). It also aligns with the views of international development organizations such as International Fund for Agricultural Development (IFAD), World Bank, International Monetary Fund (IMF).

Evaluation has also been discussed elsewhere by Uusiklya and Virtanen (2000). In their article, they examine the concept of meta-evaluation; a kind of evaluation that aggregates and makes judgments from previous evaluations. The authors recommend that evaluation should be as transparent as possible so as to enhance organizational learning. Thoenig (2000) in discussing evaluation as usable knowledge for public management reforms, defines it as "an instrument or means for improving the capacity to learn about conducting successful change and defining achievable outcomes in the fields of public efficiency and effectiveness" while Hanson (2006) in his article on organizational use of evaluation, acknowledges the rapid growth in use of evaluations in organizations to produce knowledge. Of significance here however is their relevance to this research.

It was indicated earlier that the need for the management of GIS implementation need to be emphasized. Huxhold and Levinsohn (1995) emphasized post implementation management, Somers (2002) discussed managing GIS operations tasks in relation to ITs, Longley et al (2006, 2011) discuss key issues in managing a sustainable, operational GIS while Obermeyer and Pinto (2008) had also discussed key post-implementation issues which will require a good dose of management skills to handle. But the question that goes begging is how to make the GIS management process work better. Management is a long term formative process that seeks to make the technology more relevant and responsive to the geospatial intelligence needs of organizations using them. One surest way to achieve better implementation and management is by monitoring and evaluating the GIS system.

This work does not focus on discussing the theory of monitoring and evaluation per se but seeks to engage on practical steps used in conducting monitoring and evaluation. It involves gathering documented information about a programme and analyzing such information to determine progress towards set objectives or targets. The evaluation exercise in this study seeks to find out the degree of GIS implementation success in NMBM by measuring the perception of the user about the system.

2.9. Concept of development planning and management

In this study, GIS implementation is being examined as a decision support tool for planning and managing development interventions. This section presents the reader with an understanding of the concepts of planning and development management and how it is used in this study. According to the inter-American Society for Planning (1960) cited in Waterston (1971) development planning is;

> *"…the rational application of human knowledge to the process of reaching decisions which are to serve as the basis of human action".*

This works may seem quite dated but still have a strong theoretical and practical relevance in current development planning. From a series of views, Waterston synthesizes planning as an organized, conscious and continual attempt to select the best available alternatives to achieve specific goals which involves the economization of scarce resources. To him planning can be war time planning, physical planning (urban and regional or town and country planning) and economic planning. The two types of economic planning are anticyclical planning which seeks to stabilize economic growth within the framework of prevailing institutions and development planning which seeks to achieve economic and social progress through change – that is, development planning is a change plus growth development strategy.

Healey (1997) in addition to physical and economic planning, identify other recent forms of planning: policy analysis and planning, interpretative planning, collaborative planning. To Dale (2004) physical, economic and parts of policy analysis and planning are basically concerned with production systems and relations, centre structure, communication networks, laws or administrative structure while interpretative planning, collaborative planning and the rest of the other parts of policy analysis and planning lay emphasis on the mechanisms or processes of planning; that is how planning is done.

These views in literature notwithstanding, it is worth noting that planning is a complex and multifaceted concept with divergent interpretations. This accounts for why it becomes more advisable to delineate the context under which planning is discussed. This study considers development planning from a more generic perspective. It is a process that involves the rational sequencing and programming of development work; that is what course of action to take: - making decisions on what is to be implemented, how and when it will be implemented in line with development interventions policies geared towards achieving desirable development outcomes. This could be in the diverse fields of both physical and economic planning which usually involve decision-making processes of spatio-temporal dimensions.

The term development management on its part is also bewildered with diverse use across disciplines. This tends to cast a cloud of confusion as to a clear and precise definition of the term. Development management in the views of Dwivedi (2002) and Davids et al (2009) descends from development administration; a colonial practice that was converted into a field of study. A management perspective to development was to be born on account of criticisms among the academia and development practitioners that development administration as handed down by the colonialists had become too authoritative, clouded by elitist biases and was not living up to the challenges of time.

Clarke (2002) in an introductory note to "Handbook on Development policy and Management" describe it to mean "the management of development processes" which may not necessarily be limited to "development policy implementation". To him development management is synonymous to "management of development", "management for development" and "management in developing countries" which may have different connotations but with considerable overlap. To Davids et al (2009) development management is concerned with explaining theories of development and underdevelopment, institutions involved in development (e.g. Non-governmental organizations – NGOs and Community Based Organizations – CBOs) strategic approaches to development (e.g. community development and local economic development), the dynamics of development which embodies issues such as urbanization, foreign aid and gender issues. It also engulfs specific context under which development intervention is undertaken (could be a given political, economic, social, cultural, environmental or psychological context) and challenges of developing communities and societies. They further liken it to a management toolkit towards achieving development within the framework of set development objectives.

Clarke (2002) and Davids et al (2009) both conceptualize development management to occur at various levels. It is tied to the implementation of aid policies at the international level with transnational or international development organizations/agencies such as Non-Governmental Organizations (NGOs) and Inter-governmental Organizations (IGOs) as the main actors. An intermediary level application is by national governments concerned mostly with administering development interventions within national frontiers – a more traditional approach to development intervention. The micro level management is managing development intervention projects. These are specific development works usually conceived at some higher level of development management.

In this study, development management is all about managing change, development policies, and resources towards achieving desirable development outcomes. This research seeks to emphasize the role of GIS as a DST that can be used to achieve the objectives of development management.

2.10. Development Organizations: what are they?

This research aims to investigate on how development organizations can implement, manage and use GIS in their development decision-making processes or in implementing development policy. But what are development organizations, who are they, what is their role in development? These are some of the questions this review attempts to answer. The definition of the term development organizations will follow from the generic meaning of the word organizations.

The International Fund for Agricultural Development – IFAD (2008) cites Uphoff (1992) referring to organizations as:

"…a group of associations, formal or informal in which there are defined and accepted roles, positions and responsibilities, structured in some relationships to each other in order to achieve a specific objective(s)"

The phrase 'accepting roles' brings us closer to the use of the term institutions which has been used synonymously to refer to organizations but used in a different sense in neo-institutional economics. For example, North (1994) considers institutions to mean "rules of the game" and organizations "the players"; better still as initiators of institutional change. The World Bank (2000) in the World Development Report concurs with this view. They define institutions as:

"…sets of formal and informal rules governing the actions of individuals and organisations and the interactions of participants in the development process"

It then follows that development organizations would mean actors or agents of development intervention. For example, the Organization of Economic Cooperation and Development – OECD (2008) cites the definition of international development organization as advanced by the United Nations 'System of National Account (SNA) 1993' par. 4. 164:

"…entities established by formal political agreements between their members that have the status of international treaties, their existence is recognized by law in their member countries; they are not treated as resident institutional units of the countries in which they are located"

Without making value judgments as to the worth of this division of views between the traditionalists and neo-institutional economists, this research seeks to emphasize the role GIS can play in enhancing informed decision making in organizations. The focal point is on how GIS technology can be procured by such organizations. It is also worth noting that organizational policies/institutions affect such implementations. The interest here is on development organizations. In this research they pertain to organizations founded on the basis of advancing the development interests of its stakeholders. Stakeholders here could be primary or secondary. Primary stakeholders are the main beneficiaries of a development intervention and secondary stakeholders are the development agents or organizations. Hence development organizations could well be referred to as development agents. They seek to promote the development interests of their target communities. Development here is loosely defined as the achievement or attainment of desirable socio-economic, political and psychological conditions of living.

Development organizations could be private or public and range from both the local to the national and international levels. Development organizations on the world stage have been captured by Rourke (2008) in two major categories: – those within the traditional route; mainly states and government (nations and nation states) and those in the alternative route; mainly national and international development organizations governed independently of any states or governments.

States are both "government" and "quasi-government" (Desai & Potter, 2002) bodies. They are charged with coordinating public action towards achieving development within national frontiers. State can synonymously be referred to as nations; "a people who share demographic and cultural similarities, possess a feeling of community and want to control themselves politically" (Rourke, 2008) or nation-states "a sovereign… political organization with certain characteristics, such as territory, a population, and a government" (ibid.). Nation-states embody the idea of a nation. The main role of the state as a development agent is to ensure the development of its people; it creates the conducive environment on which development interventions can thrive. Traditionally, the state was the leading development agent but its monopoly has drastically declined; a post-World War II world order in which alternative development governance through transnational development agencies has gained a higher profile owing to a number of reasons:

> *"…increased international contact among states and people, increased economic interdependence, the growing importance of transnational issues and political movements, the inadequacy of the state-centered system for dealing with world problems, small states attempting to gain strength by joining together and successful IGOs providing role models for new organizations" (ibid.).*

International development organizations include both Inter-governmental Organizations (IGOs) and Non-Governmental Organizations (NGOs). These organizations operate at different level. For example IGOs such as the United Nations and its specialized agencies operating at the global level while the European Union and African Union are typical regional development organizations at regional levels. NGOSs operate from local grassroots community levels in the less developed world to big international development aid organizations in advanced industrialized countries. As put by Desai (2002), "they range from large Northern-based charities such as OXFAM to local self-help organizations in the South…mainly private initiatives involved in development issues on a non-profit basis". The aim of this study is to make an inquiry into how these organizations can implement GIS for informed decision-making. In this study, the NMBM; a typical local government agency charged with the management of the welfare of the people living within its jurisdiction will serve as an example from which to draw useful GIS implementation lessons.

2.11. Research and Research Methods

Research is a common practice in all spheres of human knowledge and inquiry. This has led to the generation of huge volumes of literature on this subject. The only difference is in the approach, aims and objectives, nature of the phenomenon been researched upon and the underlying theories. Hence, most discussions in the field of research tend to be highly contextualized in relation to the discipline and field of inquiry. This term will remain recurrent throughout this work and calls for its practical definition in this review. It is also worth noting that in this study, the term is used interchangeably with study, work and inquiry. This discussion presents an overview of the concepts of research and research methods and how they relate to this study. The broad scope of the term makes it difficult to come up with a single definition that will suit all fields of study. But research can generally be described as a systematic search, investigation or inquiry into some hidden or unclear area or body of knowledge with intent to generate finding that can be used to resolve problems in the real world.

Phillips and Pugh (1994) describe research as having three distinct characteristics that set it apart from mere gathering of knowledge and information. It is an open system of thought characterized by free thinking in which the researcher advances her/his views and can criticize and be criticized in return. Secondly, research involves critical analysis which is usually based on the researcher's knowledge, experiences and perspectives. Thirdly, it is based on generalizations, the limits of which are determined by the researcher. This is not a straightforward definition as compared to Clarke (1999) who views research as applying scientific procedures to collect and analyze data. To Stoker and Marsh (2002) research "offers ordered knowledge based on systematic inquiry". A more comprehensive and straightforward definition comes from The Higher Education Funding Council for England – HEFCE et al (2008). They define research as;

“original investigation undertaken in order to gain knowledge and understanding. It includes work of direct relevance to the needs of commerce, industry, and to the public and voluntary sectors; scholarship; the invention and generation of ideas, images, performances, artefacts including design, where these lead to new or substantially improved insights; and the use of existing knowledge in experimental development to produce new or substantially improved materials, devices, products and process, including design and construction”

Though quite a comprehensive definition, it fails to capture the pragmatic nature of research as considered in the suppositions of the Art and Humanities Research Council (2009). It puts forward a definition built around three key features: research must define a series of questions, issues or problems as well as aims and objectives to be addressed. Secondly, it must specify a research context by answering why it is important that this particular research be conducted in this area as well as specify what other research has been conducted or been conducted in this area. Lastly, the research methods to address the research questions must be spelt out.

The shortcoming in the definitions advanced so far is their failure to recognize or point out to the different types of research; they treat or define research as though all research were equal. This weakness is addressed in the work of Dahlberg and McCaig (2010). They identify basic research which develops knowledge without any regard to practical applications. Applied research is a problem driven research; meaning it seeks to resolve an identified problem in the real world. Evaluation research is a form of practical research that seeks to identify the effectiveness of some sort of practice. Action research is simultaneously conducted with its implementation to solve an identified problem and empirical and non-empirical research is based on whether the research relies on empirical evidence to make its observations. This study aligns with these views expressed in literature. It is a typical applied research – putting to practice applied research theory.

It is also common in literature to describe research based on the methodological approaches. This brings us to the concept of research methods. This has been described by Babbie and Mouton (2009) as methodological approaches or methodological paradigms. Drawing from these authors, research methods are referred to as “techniques that researchers use as well as the underlying principles and assumptions regarding their use”. These methods are broadly classified in literature as qualitative or quantitative methods. The mixed method paradigm has gained grounds over the years as a means to triangulate the weaknesses inherent in relying solely on quantitative and qualitative methods. Qualitative and quantitative research methods are widely identified in literature. But generally speaking, quantitative methods deals with numeric observations as commonly obtained in the sciences while qualitative methods are based more on textual analysis as in the arts and the humanities. Creswell (2003) posits that quantitative methods use postpositive claims for developing knowledge. That is, a causes and effects way of thinking based on measurements and observations and the test of theories. Qualitative methods on their part use constructive perspective. That is the researcher’s view of the world is socially and historically constructed with intent to develop a theory or pattern. Mixed methods base knowledge on pragmatic grounds. It offers a problem centred, pluralistic and pragmatic view of social reality by the researcher who gather both numeric and non-numeric information. This study adopts a typical mixed methods research approach – using both qualitative and qualitative research methods.

Conclusion

In this chapter some key themes and concepts related to this dissertation have been outlined. Decision Support Systems is an umbrella concept in this research and provides the main framework that pulls together the other different concepts and themes such as SDSS, GITs and GIS. GITs encompass cognate disciplines that deals with geographically referenced information amongst which is a GIS. The scope, meaning and some application and benefits of a GIS have been examined. Most central to this study however are the concepts of GIS implementation and GIS management. They are key aspects in the successful purchase and use of a GIS technology and provide the main foundation upon which this study is built. Monitoring and evaluation provide the essential yardstick against which implementation progress and successes can be measured. GIS Implementation and management are considered in relation to planning and managing development interventions. They are key concepts and have also been discussed. The main actors in the process are development organizations both in the public and in the private sectors and at different levels – local national and international. This chapter rounds off with an overview of the concepts of research and research methods and how they related to this study. Essentially, this study is based on the mixed method of research. It pulls together both quantitative and qualitative approaches to research.

CHAPTER THREE

RESEARCH METHODOLOGY

Introduction

The major theme in this work is to lay emphasis on GIS as a DST in development works. It accentuates a GIS as an invaluable tool in enhancing decision-making within development organizations. This capability has sparked its widespread adoption in development interventions in both public and private development organizations. But as pointed out earlier in this study, the process of adopting a GIS is hardly a smooth one even for organizations endowed with enormous GIS resources. These challenges have occasioned research on GIS diffusion in development organizations. This study investigate on some core issues in GIS diffusion; that is implementation and managerial issues affecting the use of GIS so as to draw valuable lessons on good practices when contemplating GIS solutions in development works. In this chapter, the procedural steps used to resolve the research problem and questions as well as to accomplish the objectives of this study spelt out earlier in Chapter one will be described. Figures 3.1 and 3.2 below illustrate the steps used to resolve the research problem and the contents of this chapter. It consists of a description of the research strategy, the data collection and data analysis methods, GIS and Cartographic process used to produce the thematic maps used in this study.

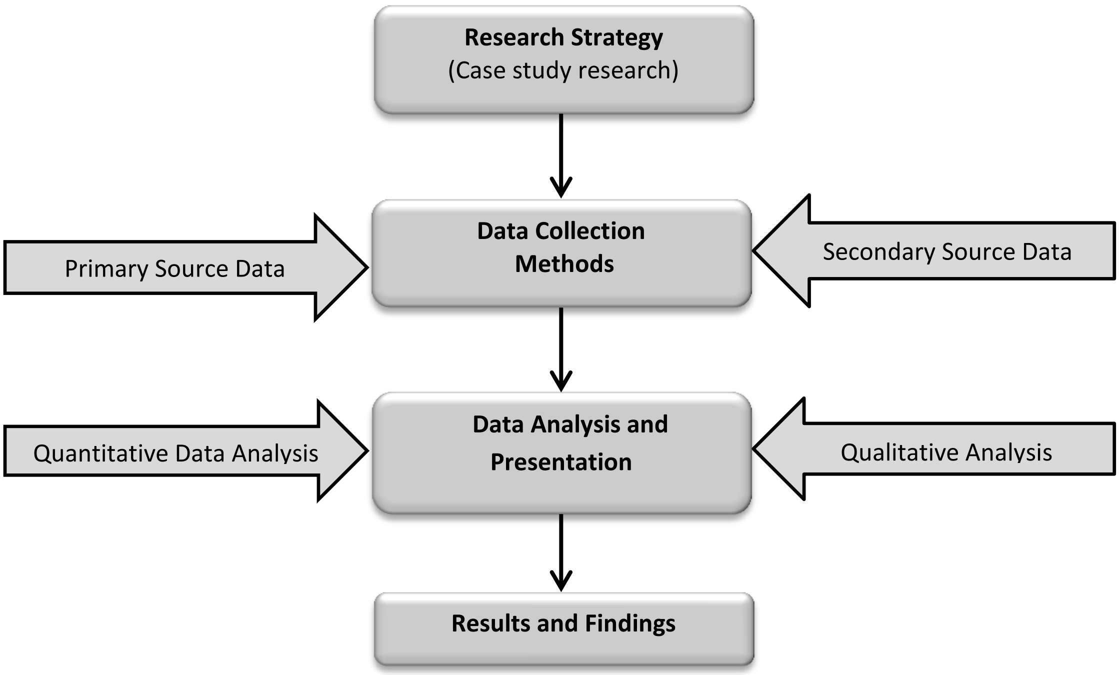


Figure: 3.1. The research procedural steps *(source: author's conception, 2011)*

3.1. Research Strategy

The research strategy used in this study is the case study approach. In this approach, researchers seek to observe and understand research subjects or phenomenon at a limited scale. Such a scale could be a group of person or a geographic setting. The results or knowledge generated at this level can now be applied at some scale larger than that previously examined. A case study research therefore seeks to understand large scale occurrences by delimiting the research reach so as to permit for intensive probing and investigation. A similar impression of case study research is described by Rudestam and Newton (2007:49). Case study is held by these authors to mean;

"…studies that focus on a single individual, organization, event, programme or process…or a specific, unique bound system"

Case study research could be a single case or "multiple case studies" (Gerring 2007:20). However, the level of detail to be observed tend to reduce with an increasing in the number of case studies. The research used a single case study. It is based on the Nelson Mandela Bay Municipality EGIS. The municipality runs a fully-fledged enterprise EGIS based on ArcGIS Server software produced by the Environmental Systems Research Institute (ESRI). GIS application in the NMBM is quite advanced and can be studied, replicated or modified and used by many development organizations requiring GIS solutions in their business.

The choice of a case study research strategy is conditioned by its manageability. It will be practically impossible to investigate all GIS applications, implementation and management cases to be able to draw valuable lessons. Focusing energy and resources on a single case study will prove more valuable. Besides, the resource and time limitation for this study does not favour a large scale study. A single case study research strategy therefore makes it easier to focus this research within the allocated completion time and the financial and material resources available.

The research methods used is the mixed methods approach which integrates both qualitative and quantitative approaches to collecting and analyzing data. Johnson et al (2007:123) synthesizes the following definition for mixed research methods:

"… type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g. use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purpose of breadth and depth of understanding and corroboration"

The mixed method therefore enhances the opportunities offered by both quantitative and qualitative research methods, a process which can also be described as a triangulation of research methods. It answers questions which otherwise could not completely be answered using a single method; that is quantitative or qualitative method alone. This research therefore follows both the radical humanist and the interpretive research paradigms.

The radical humanist or critical paradigm is one which focuses on the critical evaluation of reality. It follows from a typically qualitative research. In this paradigm the view of social reality is ontologically relative; the view that social reality is internally constructed based on our perception of the world, a stand point which supports a multi-perception of reality. This paradigm is epistemologically subjective. It does not aim to present the truth about world view but to ensure that different versions of the truth in social reality are recorded and reported. Hence the radical humanist paradigm views the social world from a perspective which tends to be nominalist, anti-positive and ideographic. The researcher is also slightly interpretive owing to some measure of quantification.

3.2. Data Collection Methods

This section explains the data collection methods used to answer the research questions and to accomplish the research objectives outlined in Chapter 1 of this study. It describes the nature, sources and instruments to that were used in the data collection process. Data was collected from two main sources - primary and secondary data sources.

3.2.1. Primary Source Data

Primary source data is relevant data which has not been previously collected, analysed and documented or archived. It can be alternatively described as first hand data. Three main techniques or instruments will be used to gather primary source data. These include self-completion questionnaires, field interviews with staff, informal discussions and field observations.

3.2.1.1. Self-completion questionnaires

The self-completion questionnaires were administered to GIS stakeholders in the various departments of the NMBM. These are essentially GIS technicians, GIS managers and users of the municipality's GIS products. The main reason for choosing this group is because of their close interaction with the system. This put them in a better position to answer most of the questions that can resolve the research problem. Self-completion-questionnaires were selected as a means of collecting primary data because of the speed at which it can be administered. It is the cheapest and easiest way to reach out to a wider audience, have a premeditated structure tailored to meet the research needs and can be completed at the convenience of the respondent. They however limit the possibility to prompt and probe.

In regards to the sample technique and sample size used to administer the questionnaires, respondents were selected based a non-probability sampling technique of 30 users of the system to whom a total of 30 questionnaires were administered. Though it is often pointed out that non-probability sampling methods weakens the basis of generalizing a study, it was the most convenient way to use in this study since it involves sampling the opinion of those who are familiar with the system under investigation. Hence non-random/non-probability sampling is a valid method in this study and provides solid grounds that can be used to generalize this study in the entire NMBM.

3.2.1.2. Field interviews and discussions

The use of questionnaires usually limits the possibility to prompt and probe respondents. To counteract this limitation, field interviews and discussions were used as a primary source data triangulation technique for questionnaires. Interviews were structured and unstructured – also called semi-structured interviews. They mode of administration was by face to face discussions. They were chosen for their flexibility and convenience to discuss pertinent research issues with leading GIS experts in the municipality. Discussions were recorded on jotters and were later synthesized and streamlined to the purpose of the research. This method was also corroborated by informal discussions with resource persons.

3.2.1.3. Field observations

The third way to collect primary data was through field observations. The main purpose of this technique is to triangulate the weaknesses inherent in the use of questionnaires and interviews especially as respondents at some point seem disinclined to answering too many questions. Besides, some questions were obvious to ask. An account of such information was kept on the jotter.

3.2.2. Secondary Source Data

Secondary source data is data which had been previously collected and is ready for synthesis and assimilation. Walliman (2006:52) describes it as "data that has been interpreted and recorded" Sharp et al (2002:148) as:

"...data collected by others and published in some form that is fairly readily accessible".

The main secondary data sources for this study include books and journals. They are an important source of textual information and were drawn largely from the Nelson Mandela Metropolitan University academic library (both from shelves and electronic/digital sources), personal books and archives. Other important sources used are the internet (The World Wide Web) and online journals.

3.3. Framework for Data Presentation and Analysis

This section describes how data collected was presented and analyzed. It provides the bases that enabled the transformation of data into information that answers the research questions. It follows both the mixed research methods approach; that is a research method that analyses both quantitative and qualitative data. Phelps et al (2007:217) describe quantitative data as data that "can be measured in numerical terms", while Godwin (2006: 29) says the following of qualitative data.

"Qualitative data allow us to investigate people's beliefs, values and actions…are non-numeric and may consists words, pictures, sounds or symbols"

The following sub sections describe the methods of data analysis and presentation that was used.

3.3.1. Quantitative Methods of Data Analysis and Presentation

This method deals with numerical data analysis. In this study it is essentially statistical data analysis and presentation methods. Data was analyzed and presented using univariate statistical analysis or descriptive statistics. This statistical method analyses the properties or qualities of one statistical variable at a time as opposed to bivariate and multivariate statistical analysis which seek to analyze more than one aspect of a statistical variable at a time.

Descriptive statistical techniques can be grouped into three main categories: summary statistics which involved the computation of statistical averages and percentages; graphical/pictorial description of statistical data using statistical charts – essentially the pie and the bar charts; and finally description of quantitative data using such simple statistical tabulations. These descriptive statistical techniques were supported by inferential techniques to explain and draw conclusions from information presented.

Quantification also made used of statistical scale of measurement such as the nominal scales; that is categorizes with no ranking, the ordinal scale; categorize with ranking, the interval scale that determines how intervals may be different or equal to each other and the ratio intervals whose basic experimental operation is to determine the equality of ratios.

3.3.2. Qualitative Methods of Data Analysis and Presentation

Qualitative data presentation involves describing research work and field observations in prose-like form; that is using descriptive text. Qualitative data was analyzed and presented using descriptive and interpretive research techniques. These include listing, coding and classifying.

Textual data was examined and grouped into relevant themes in the research thereby making the data ready for thematic and comparative analyses. It is during this process that their interconnectedness was interpreted to answer the concerns of this research work.

Another important way data was analyzed and presented was through the use of integrative or flow diagrams. These diagrams were used to pull details together in simple sketches to illuminate the reader's understanding of data presentation process. This was done in graphic form to illustrate some concepts and processes that forms part of the research. These integrative diagrams were illustrated and described using textual information.

3.4. Treatment of GIS and Cartographic Data

Some light weight GIS data and cartographic processing tasks were performed in this research to produce thematic maps that have been used for illustrative purposes. "Primary geographic data sources are captured specifically for use in GIS by direct measurements. Secondary sources are those reused from earlier studies or obtained from other systems" (Longley et al, 2006:200). No primary data was captured in this study as indicated of figure

3.2 below showing how the data that was used to produce the thematic maps for this study was treated.

3.4.1. GIS data input

As illustrated on figure 3.2 below two main sources of secondary data were used. These include shapefiles from the NMBM GIS and scanned map images. The GIS shapefiles and the scanned maps were brought into GIS software environment by importing them into a small sized geodatabase ready for processing.

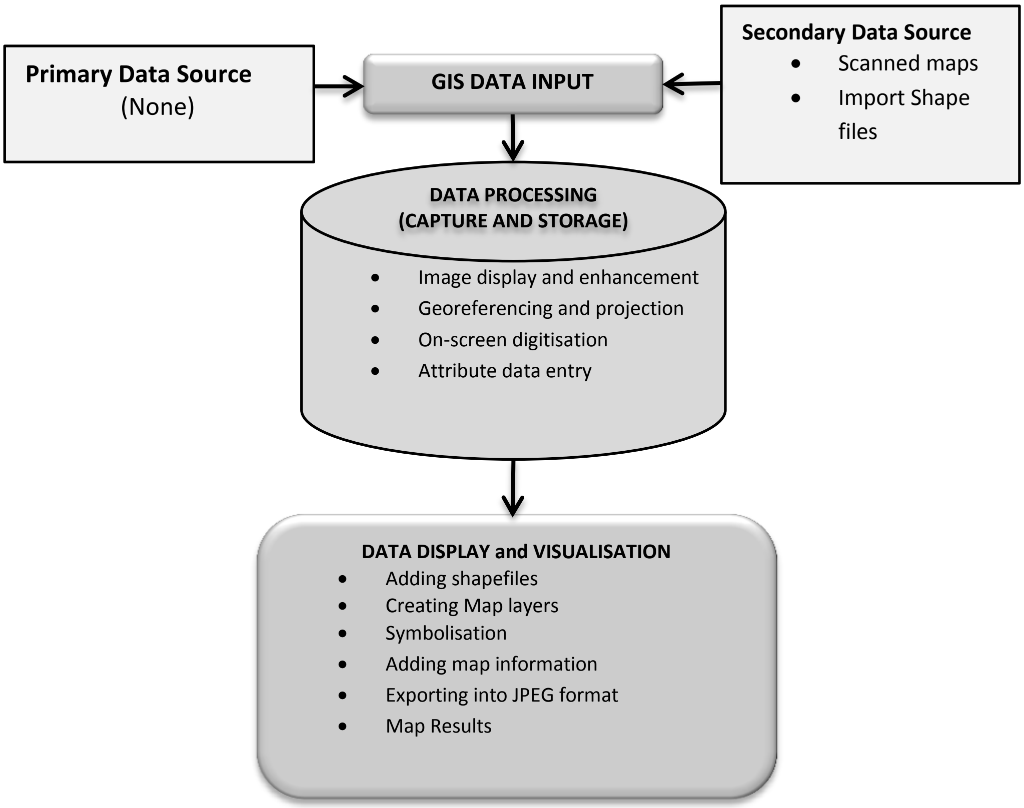


Figure: 3.2. The GIS data treatment process *(Source: author's conception, 2011)*

3.4.2. Data Processing (Capture and Storage)

The GIS data obtained was processed using ESRI ArcView 3.2 and ArcMap 9.2 GIS softwares. The main operations performed on this data to produce thematic maps are illustrated on figure 3.2 above. The scanned map was displayed, enhanced, georeferenced and projected to serve as a background image used to capture spatial information. The main data capture technique used here was on-screen digitization to create the shapefiles for the thematic map showing the study area on figure 1.1. Attribute and descriptive data were also added on attribute tables for labeling and classification/symbolization of features.

3.4.3. Data Display and Visualization

It was in this stage that the digitized shapefiles and shapefiles imported from the NMBM GIS were added, symbolised and visualized to produce thematic maps. The maps were exported in printable file formats; mainly JPEG (Joint Photographic Expert Group) format to produce the thematic maps that have been used for illustrative purposes in this research report.

3.5. Limitations and Delimitations of the Research and Research Methods Used

The research and the research methods used have their limitations and delimitations. Limitations are inevitable weaknesses in the selected research methods over which the study has limited control. Delimitations on the other hand are imposed restrictions such as the time frame to conduct this work and the selection of the study area.

This is a case study research. It is assumed that it is more suitable for an intensive study. However, the degree of intensiveness is only subjective. This case study research was designed more in consonance with the constraints of the time provided for its completion than with taking cognizance of a more intensive study. This however does not in any way nullify the value of this study. The knowledge generated remains a valuable asset in understanding GIS implementation and management in development organizations.

Case studies are also considered replicable in solving the same research problems elsewhere. This is an assumption that overlooks the fact that the same research problems may tend to have different variations in different contexts. This problem is further compounded if the selected case or site is not a perfect or an average representation of similar cases obtainable elsewhere. This limitation however does not bar the use of case studies to investigate phenomenon and answering research problems elsewhere out of its immediate study environment. Case studies are useful in investigating recent developments and in this study, the implementation of GIS technology in development work. GIS may not be a recent invention but it keeps evolving with technological development there by leading to new developments in the area. The NMBM runs an enterprise GIS which is a state of the art development in the GIS industry hence provides a perfect case study.

This study relies on secondary data to make observations but the theoretical bases or assumptions on which such data was collected are often overlooked. This increases the possibilities for the propagation of errors in secondary data into this research. This is particularly true with GIS data obtained through secondary sources.

It is also understood that the use of questionnaires for collecting data does not necessarily mean they are effective. Some people may not have been able to understand or complete them. Besides, one can never be sure if the right person filled out the questionnaire if it was not completed in the researcher’s presence. Even when the right persons did fill it out, there are possibilities that some people may not be able to complete questionnaire and some who complete may only do so for its sake without having to reflect if their choice of response tally with the actual reality on the ground.

Questionnaires administered and interviews conducted were limited to the staff of the NMBM. Such a restriction limits the possibilities of obtaining more valuable information regarding GIS implementation and management elsewhere. Besides, field observations offered the opportunity to collect information first hand but it is not possible to observe a large population by this method. However, there has been a reasonable coverage of GIS implementation and management issues so as to guarantee the value of this research.

The process of data analysis is usually subjected to lots of generalizations and so could be the case in this research especially when it comes to classifying, coding and relating information. Besides, not everyone will have the potential for a correct interpretation of the data that was collected and analyzed. This is not a problem that can be blamed on this research but such external weaknesses will lead to a breakdown in communicating the research results.

Conclusion

In this chapter, the research strategy has been spelt out. It is a case study research. It assumes a radical humanist research paradigm in which the view of reality or the social world is ontologically relative and epistemologically subjective. Besides, the procedures of collecting and analyzing data for this research have been discussed. It uses the mixed research methods approach – bringing together both qualitative and quantitative methods of data collection and analysis. The GIS and cartographic processes which were used to produce thematic maps for illustrative purposes have also been discussed. The weaknesses of the research methodology cover both the research strategy selected and weaknesses inherent in the various methods used to collect and analyze data.

CHAPTER FOUR

GIS AND ITS IMPLEMENTATION FINDINGS

Introduction

The focus of this chapter is to examine the concept of a Geographic Information Systems (GIS) within the wider context of Geospatial Information Technology (GITs). It was pointed out earlier in the literature review that an unclear understanding of what GIS is all about often leads to its misinterpretation in relation to other Decision Support Systems (DSS). Describing a GIS in relation to other GITs therefore would not only provide development practitioners with an understanding of the scope and focus of a GIS but will also reveal its richer picture in relation to sister disciplines in geoinformation sciences. This will set the grounds needed by development professionals to build a solid GIS experience. Empirical illustrations of how GIS has been implemented in the NMBM as well as its role as a SDSS in the municipality will be a further concern. These align with the first three objectives of this study as outlined in chapter one. The transcript for interviews conducted on the field for this chapter can be found on appendix 1 section of this work.

4.1. GIS within the wider field of Geoinformation Technologies (GITs)

A GIS is a typical example of a Spatial Decision Support System (SDSS) – computerized tools used to manage spatial data. But as a SDSS, a GIS has varying definitions some of which can be subjective. For the purpose of this study, it is defined in terms of the processes that characterize it. Rhind (1989: cited in Lo and Yeung, 2007:2) defined it is a:

> *"a system of hardware, software, and procedures to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data for solving complex planning and management problems"*

The question however, is just how exactly a GIS does this? How does it implement sister technologies such as remote sensing, Global Positioning Systems (GPS), surveying, photogrammetry and cartography? These are cognate disciplines to a GIS and have been collectively described as Geoinformation Technology (GITs). Other alternative descriptions include Geospatial Sciences or Spatial Information Technologies. These technologies contribute to a GIS as either data input or data output systems. A GIS on its part boasts of greater capabilities to store huge amounts of geospatial data. As illustrated on figure 4.1 below, GIS interacts with other GITs in three main ways. Data input systems on one hand provide platforms for capturing spatial data (geographically referenced data) into a GIS while the data visualisation system (output systems) on the other hand provides the public interface on which to visualise data held in a GIS. The data storage/manipulation system is the GIS itself which implements database technologies that hold and communicate geospatial data.

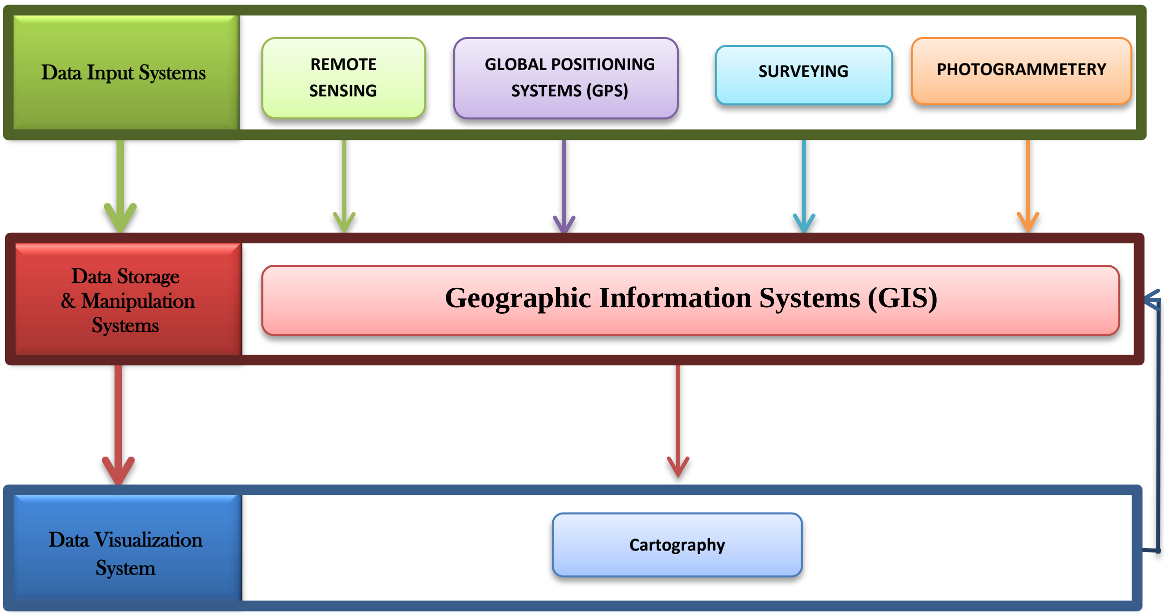


Figure 4.1. GIS in the wider field of GITs *(source: author's conception, 2011)*

4.1.1. Data Input Systems

As illustrated on fig. 4.1, the four possible data input systems to a GIS are remote sensing, Global Positioning Systems (GPS), surveying and photogrammetry.

4.1.1.1. Remote sensing

It is the science of acquiring information by imaging the physical or surface characteristics of an area of interest using sensor systems not in immediate contact with the area under observation. Remote sensors can be either passive – that is, they rely on electromagnetic energy emissions in the atmosphere to capture images or they can be active sensors meaning that they have the potentials to emit their own energy which is scattered back and recorded in the sensor system. Once captured, the imagery can be processed, interpreted an integrated into a GIS. Remote sensing is therefore an invaluable GIS data collection/capture tool. It provides the imagery required for GIS mapping while remote sensing in turn relies on GIS data processing and data storage capacities.

4.1.1.2. Global Positioning System (GPS)

According to Rizos (2002:78 & 82), GPS is a satellite-based radio-positioning and transfer system which can be used to obtain real-time positioning and navigation capability on the surface of the earth. He describes GPS as working in three segments – the space segment made up of a constellation of spacecraft which broadcast signals that allow users to determine position, velocity and time. The ground segment consists of ground control stations where the satellites are monitored and kept track of. The user segment is the most visible to the public and consists mainly of the tens of thousands of handheld and stationary GPS receivers and other hardware systems used to read the radio signals emitted from the space segment. This segment also consists of software (used to manage readings on computerized systems) and the procedures (used to handle/process GPS data).

The main input of a GPS into a GIS is that it enables the achievement of positional accuracy in GIS mapping. This is achieved by measuring ground control points for georeferencing (assigning geographic coordinates) GIS data sets.

GPS enabled georeferencing facilitates data projection (assigning GIS data to a specific coordinate system) and alignment when combining GIS data sets

4.1.1.3. Surveying

Surveying also has important inputs in a GIS depending on the mapping scale and nature of job under consideration. According to Harvey (2008:141), surveying is:

> *"the systematic collection of positional location and other location-related characteristics. It is an organized activity using known coordinate systems and procedures for attribute collection based on geographic representation and cartographic representation"*

The main contributions of surveying in a GIS is in the provision of attribute information (information describing mapped objects) collected from the field. In the same way, Computer Animated Drawings (CADs) produced through surveying can be imported into a GIS and integrated with attribute information for cartographic visualization in a GIS. Surveying is particularly suitable for large scale mapping in GIS.

4.1.1.4. Photogrammetry

Photogrammetry is the science and techniques of extracting reliable measurements and information from photographic images. Depending on the location from which these photos/images are taken, Light and Jensen (2002:234) identify terrestrial and aerial/space photogrammetry. Terrestrial photogrammetry uses photos taken closer to the ground surface while aerial photogrammetry utilise photos taken from air/space borne platforms. They could be either vertical (taken overhead) or oblique (viewing object from an angle). The major contribution of photogrammetry science in GIS is in:

- the provision of input data for topographic mapping in GIS especially Digital Elevation Models (DEM)
- provision of aerial photographs for thematic maps in GIS
- useful for aerial photo interpretation in GIS

4.1.2. Data Storage and Manipulation System.

The data storage and data manipulation system is essentially the GIS – a system for capturing, processing, analyzing, storing and disseminating geographic information. It is a convergence zone in the wider field of GITs; sharing the outputs and capabilities of other GITs. Input data from remote sensing, GPS, photogrammetry and surveying are less abstract compared to the contents of a GIS which is a typical simplification of reality through computer modeling.

For data to be migrated into a GIS, it must have the appropriate file formats/extensions readable by the GIS software system. Once loaded unto the computer system, the data can then be modeled using GIS software functions called tools. These tools are offered on a Graphic User Interface (GUI) and in the toolbox units of the GIS software. They have the capability to enable GIS data processing and analyses which help to simplify the complexities of the real world into forms that can be viewed as cartographic outputs by development policy makers.

Full-fledged GIS software systems implements database management technologies. This serves to hold and communicate large amounts of geospatially related information. It is this capability that sets a GIS apart from other GITs and non-spatial database management systems. The contents of a GIS is communicated to the user in map form, hence the strong bearing between a GIS and cartography.

4.1.3. Data visualization system

Cartography provides the data visualization system for a GIS. Its products are the single most important output of a GIS and it is perhaps most akin to GIS compared to other geoinformation technologies. To Longley et al (2006:265), cartography is "the art, science and techniques of making maps or charts". Same definition is shared by McMaster (2002:517). Maps and charts are the major ways a GIS communicates information held in its database. There are two forms of maps; hard copy maps (i.e. printed versions at all scales) or digital maps. Digital maps are also called soft copy maps and are easier to share among wide range of users. They are also easier to update compared to printed versions. They can well be distributed over several electronic media such as intranets and internets (web maps).

Maps could be thematic – representing few relevant selected themes or topographic maps showing the physical and human characteristics of the mapped area. Cadastral maps on their part display real property on the mapped area.

The main function of cartography in a GIS therefore is to communicate information. It serves as the user's window to GIS databases thereby enabling them to construe the complexities of the real world in a simplified form. Information communicated through cartographic processes forms the basis for informed decision-making.

Though an output system, cartography can also be used as an input system in a GIS. Previously published maps can be scanned, georeferenced and digitized back into a GIS database. That is they can be reproduced for updates or to rectify errors on previously published maps. This explains the backward link to the data storage and data visualization system on figure 4.1 above. It is one of the cheapest ways to get GIS input data. Accuracy issues must however, be verified prior to reproducing previously published maps.

4.2. GIS Implementation in the Nelson Mandela Bay Municipality

The central theme in this study is to examine GIS implementation as a DSS for development organizations. In the literature review section of this study some GIS implementation models and approaches were enumerated. It was further pointed out that GIS implementation is a context bound process; in which case no single process model will fit every situation. Hence this section seeks to emphasize more on how and what makes the system work better considering the case of the NMBM and what other development organizations can learn from this example.

For the purpose of this section, an interview was conducted with some GIS resources persons on the field. The transcript for this interview can be found on appendix 1 section of this study.

GIS operations in the municipality are reported to date back to the early 1990s. This was triggered principally by the drive to adopt state-of-the-art methods of handling geospatial data. During these years, GIS operations relied more on the use of Computer Animated Drawings (CAD) - software system used to draught engineering projects.

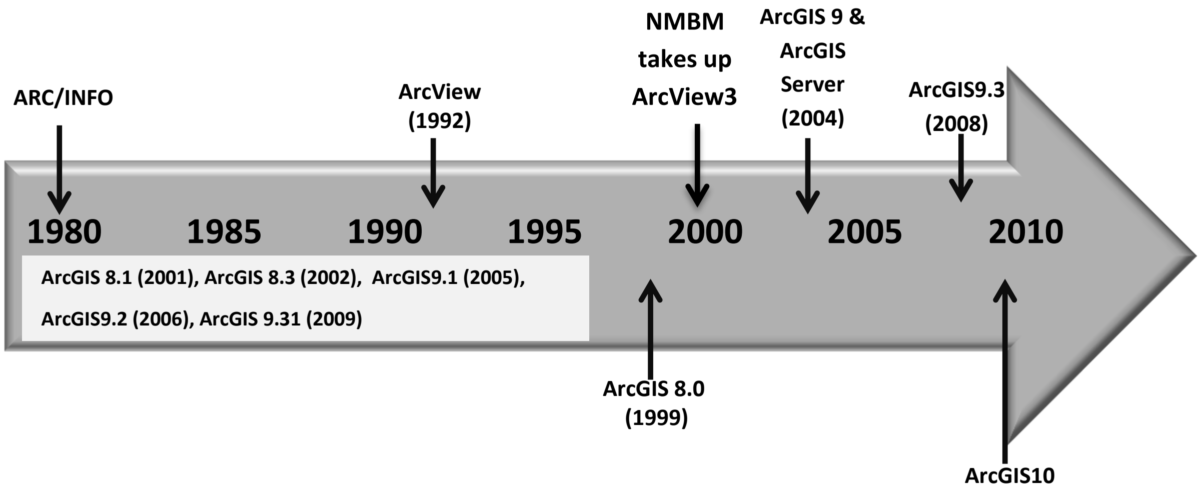


Figure 4.2. Some recent trends in ESRI GIS software development *(source: author's findings and conception, 2011)*

The municipality eventually took up the use of ArcView 3 in early 2000 and its software use has since remained consistent with upgrades in the ArcView and ArcInfo products as released by the Environmental System Research Institute (ESRI) – a GIS software developer and provider based in the United States of America. Figure 4.2 illustrates recent landmarks in the evolutions of ESRI GIS software products used by the NMBM.

The municipality has been implementing an Enterprise GIS (EGIS) for 11 years. It is a federated GIS technology for sharing GIS functions across an organization hence the name 'Enterprise GIS'. The system started running on ArcGIS for Server after ESRI founded this technology in 2004. ArcGIS for Server is the software system that allows organizations to "share Geographic Information Systems resources across an enterprise and across the web" (ESRI, 2011:5). The figure below illustrates how the NMBM implements its EGIS on ArcGIS for server technology and the different levels of interaction with the system in the organization.

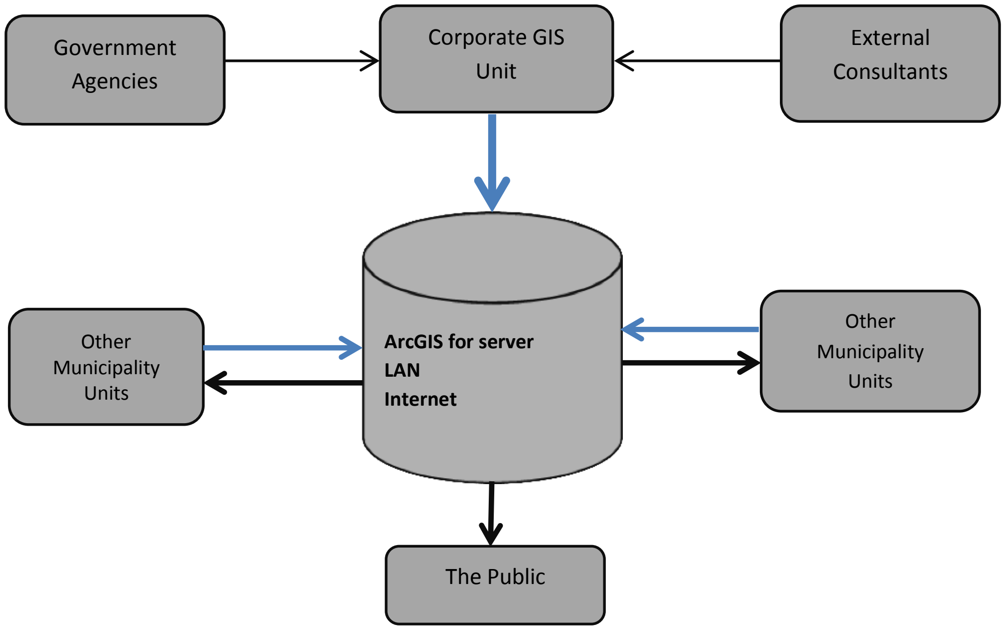


Figure 4.3 Illustration of NMBM EGIS *(Source: author's conception, 2011)*

At the top of the NMBM EGIS is the Corporate GIS Unit charged with the management of the system. It offers technical assistance such as capacity building activities to other units and handles GIS projects on behalf of the municipality. It liaises with other government services legally mandated to create certain datasets to procure NMBM's GIS datasets and updates as well assists in subcontracting some of the municipality's GIS operations to external consultants - outsourcing. The corporate GIS unit is the GIS data publishing house for the municipality; it manages the GIS server and ensures that its contents are free of errors and inaccuracies. The unit therefore reserves the monopoly of having full access to the system. This explains the big blue arrow on the figure 4.3 above.

Other units as illustrated on the diagram implements ArcGIS for Desktop. They use this function to navigate municipality's geographical databases, query and analyze GIS data to produce maps that are used in the daily operations of the units concerned. The back and forth arrows toward the server indicates how they interact with the system. The arrow pointing towards the server signifies that each municipality unit/department has the capacity to upload and share its own data on the server while the back arrow from the server indicates that they can only view uploads by other units/departments without any full access to modifying or updating such data. In such a situation, they are not much different from the public that acts as 'viewers only' of GIS data published on the municipality GIS server.

Running a GIS however is more than just the organizational procedures – how the system works. Most important is what makes it works; that is the components of a GIS. These include the software, the hardware, the people, the technical procedures, the data and ultimately the people/users of the system. The forgoing discussion pointed out the software system in use in the NMBM – ESRI ArcGIS products (ArcGIS for Server and ArcGIS for Desktop). The network is becoming an increasingly important component as distributed GIS continue to make its mark. Without it GIS functions/services will be limited to a single desktop. The NMBM relies of its Local Area Network (LAN) – (a system of interconnected computers over a limited area), to distribute GIS function/services among its users and on the internet to enable the public view its data on the World Wide Web (WWW). The other components are the hardware systems such as high speed computers, plotters, scanners and GPS receivers. The GIS data as well as the procedures of GIS science are vital in making the system work. Of all the components, the people/users of the system are the single most important determinant of whether a GIS succeeds or fails. Once the people accept the use of GIS technology, the path to a successful implementation becomes easier.

4.3. GIS application in the Nelson Mandela Bay Municipality (NMBM)

The availability of relevant and timely information is an indispensable asset in effective decision-making processes. As a DSS, GIS enables the NMBM to overcome the challenges involved in handling and analyzing huge amounts of datasets related to its jurisdiction. While real world GIS applications are vast, diverse and expanding, this section seeks to illustrate the unique application capabilities of a GIS which cuts across any other application area imaginable by examining its role as a Database Management System (DBMS) using the case NMBM GIS. This would be followed by a case scenario of how a GIS can be used to support road transport maintenance projects in the area.

4.3.1. The role of GIS as a data storage system in the NMBM

As indicated on section 4.1.2 of this study, a GIS in addition to been used as a tool for extracting information from other spatial data systems, modeling, analyzing and displaying such information, also plays the crucial role of a DBMS. It is this capability in GIS that has attracted the reliance of other GITs for the storage of processed information. On this account, a GIS has become more than just a mapping tool with a critical importance in decision-making. It provides information that is far beyond what meets the eye of a lay user of a map or a viewer of geoinformation.

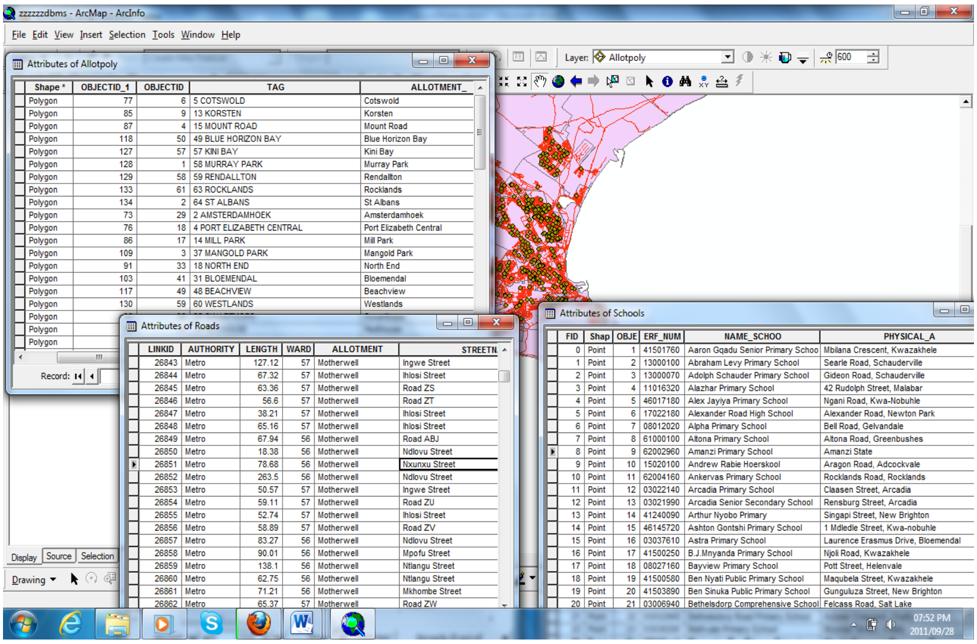


Figure 4.4 Screenshot of GIS relational database tables *(source: based on NMBM GIS data, 2011)*

The screenshot on figure 4.4 illustrates how a GIS implements a Relational Database Management System (RDBMS). This is a database system with a series of interlinked tables, each table storing information or data in two-dimensional rows (entities) and columns (records) which contain attribute or descriptive information of objects in the real world. Of the several relational database tables in the NMBM GIS, the screenshot on figure 4.4 above shows the tables for schools, the road network and municipality allotments. Each table has information describing the attributes of the feature it represents in the area and can be linked to one another. For example, a row on the database table represents a road segment. The segment has a name, length, and type, year of construction, a locality and a lot more. A row or an entity in the school database table represents a school, which has attributes such as the school name, its address, type of school, its enrolment and the list can continue.

Information held in these database tables are linked with maps using real world geographic coordinates; that is latitude and longitude measurements to show locational information.

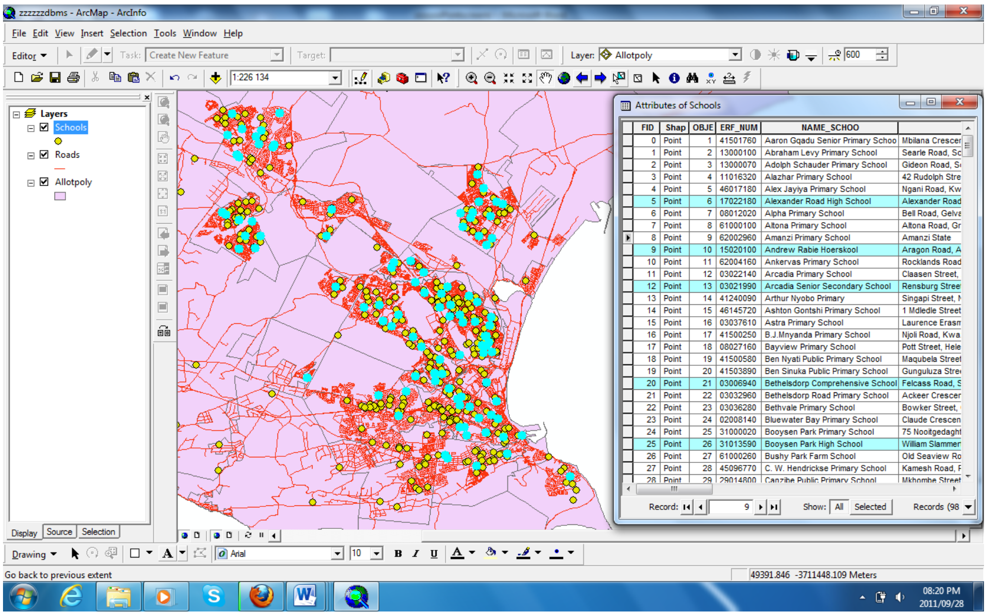


Figure 4.5 Query selection of all High Schools in the NMBM *(source: based on NMBM GIS data, 2011)*

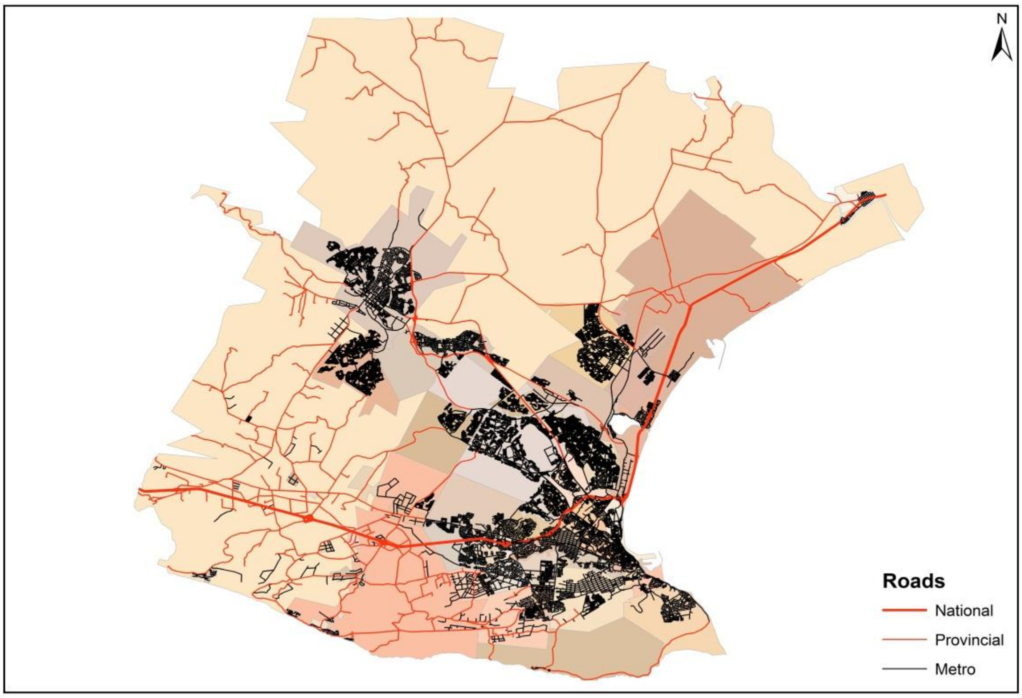
This provides descriptive intelligence not only about the characteristics of the objects represented in the geodatabase but most importantly the real world location of such objects. It is this capability that sets a GIS apart from other information and decision support systems. For instance, it is very easy using the system to query the database for all the High Schools in the NMBM. As illustrated on figure 4.5 above, all the high schools selected are highlighted with the cyan colour both on the table and on the map. This depicts a correspondence between information held in the database and their real world geographic location.

As a DBMS therefore, GIS provides users with an array of tools on its graphic user interface (GUI) to manage huge amounts of data and to provide information used in supporting decision-making when planning for development interventions. This approach has been praised for several reasons. For example Longley et al (2006:218) indicates that it creates a centralized system of sharing and managing data in an organization, it helps eliminate redundancies and the cost of duplicating datasets as well as enforcing measures of data security and maintaining data standards.

It is the data held in geo-relational databases that enables data analysis and modeling for decision making when planning development interventions. Hence the main role of GIS as a database management system is in the provision of simple but comprehensive information which is of practical value to decision makers. The section that follows illustrates how information querying and retrieval from a geodatabase can be useful in planning and managing road maintenance works in the NMBM.

4.3.2. GIS application in road maintenance

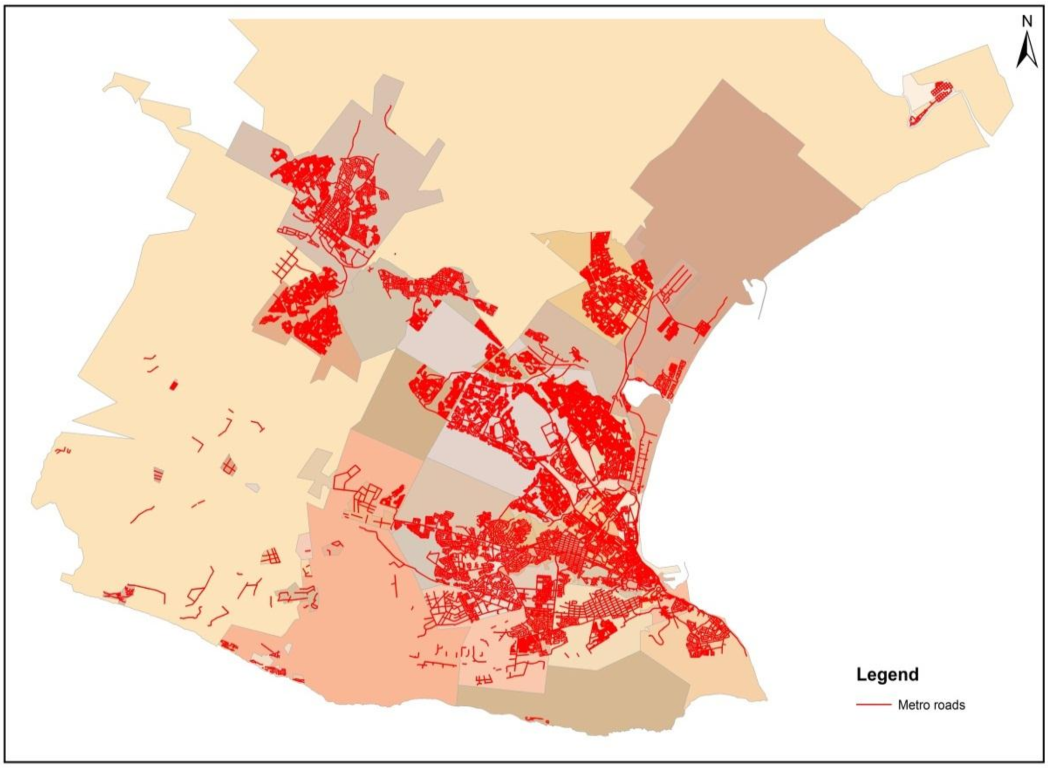
There are several ways in which a GIS can be used in road maintenance work. One such way is in conducting road inventory analysis. This is of critical importance in ascertaining the state of roads, assessing work load in order to make budgetary allocations in a financial year, as well as setting out road construction and road maintenance work plans. A GIS is crucial in providing first-hand information that can assist development organizations in accomplishing operations of this sort.



Map 4.1: NMBM road network *(source: based NMBM GIS data, 2011)*

Map 4.1 shows the entire road network of the NMBM. A GIS can provide comprehensive information on the attributes/characteristics of these roads. By conducting a road inventory analysis, the municipality will be able to understand what roads are and are not under its jurisdiction. From the map above, the three categories of roads in the area are – national roads, provincial roads and municipality (metro roads). Besides showing these roads on the map, the system can also provide decision makers with relevant information such as the total length of road network in the area.

Based on database computations from the system, the total road network in the area measures approximately 4468 kilometres square (Km sq.).



Map 4.2 Road network under the jurisdiction of the NMBM *(source: based on NMBM GIS data, 2011)*

However, in order to embark on road works, the municipality will have to focus mainly on the road network under its jurisdiction as portrayed map 4.2 above. The geodatabase provides query building tools that can be used to compute this information. Hence by running queries which can isolate municipality road network from the national and provincial road networks, the municipality can easily ascertain the total road network under her jurisdiction as shown on the map above. That is;

$$TR - NR + PR = MR$$

Where TR = Total Road Network in the municipality, NR = National Roads, PR = Provincial Roads and MR = Metro Roads.

From the database queries conducted, NR + PR stood at 976 Km. This means 3492 km of road are under the municipality's jurisdiction. That is:

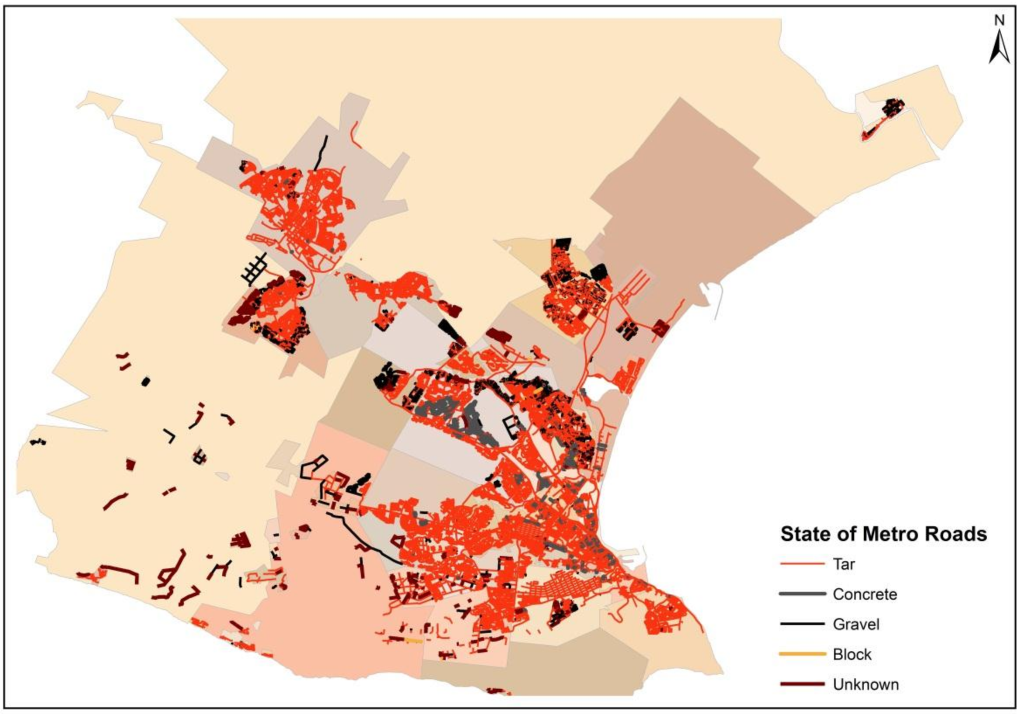
$$MR = 4468 – 976 = 3492 \text{ km of road stretch}$$

But the 3492 km of road network under the authority of the municipality has different surfaces ranging from tarred, concrete, gravel, block and unknown. The distances of each are calculable from the geodatabase illustrated on the table below.

Surface type	Length (Kms.)
Tarred	2729
Concrete	112
Gravel	515
Block	58
Unknown	184

Table 1: Total length of municipality roads by surface type

These different surface characteristics can also visualized from the geodatabase on the map 4.3 below.



Map 4.3: The different road surfaces of the NMBM *(source: based on NMBM GIS data, 2011)*

The availability of this information is critical in providing the decision-maker with a vivid picture of what is on the ground and what line of intervention to follow. This picture becomes even richer when georelational database tables are combined or compared with other data and tables containing information/data on the demographic characteristic of the area, traffic density, data on the relief of the area and several more. These combinations tend to reveal greater patterns in the spatial relationships of the area.

Conclusion

The main focus of this chapter was to achieve the first three objectives of this study. The initial objective was to examine the concept of a GIS within the wider GITs. As a SDSS GIS shares inextricable ties with other GITs. They either serve as a data input system; that is platforms used to capture information, or as output systems which are platforms for displaying and visualizing GIS data. The data storage and manipulation system is the GIS itself. GIS implementation in the NMBM has been going on for about two decades. The organization is currently implementing state-of-the-art technologies the GIS industry has to offer. It is based mainly on ESRI GIS software packages. GIS applications have also been examined using empirical data from the NMBM. Its role as a DBMS for planning and managing development work was highlighted as well as an illustration of how it can be applied in road inventory analysis. The subject of the next chapter is evaluating the degree of implementation success the NMBM EGIS. This will be done by measuring the user perception of the system.

CHAPTER FIVE

QUESTIONNAIRE RESULTS

Introduction

One objective of this study is to ascertain the user perception of NMBM GIS. Understanding what the user feels about the system is a key aspect in measuring GIS implementation success. In this chapter, empirical findings of user's opinion of the NMBM EGIS will be revealed. The indices used to measure the user perception are by no way exhaustive but provides the key metrics that development organizations can use to make decisions when contemplating GIS solutions or when measuring the degree of implementation success of an already existing GIS. The questionnaires were administered using a non-probability sampling technique of 30 users of the system; both GIS staff and lay users. The chapter begins with a presentation of the data collected. This will be followed by an analysis and a synthesis of the data. A sample of the questionnaires used for this study as well as a summary of how the data was collated is found on appendix 2 and 3 sections of this study.

5.1. Data Presentation

In this section, responses to the questionnaires administered will be described. It measures the general GIS awareness level of the users, what they feel about the quality of the system and the information they derive from it, the extent of system usage, its overall impact on municipality business as well as problems and suggestions that can make the system work better for the user.

5.1.1. Overall GIS Awareness

The main aim of this section was to test the overall GIS awareness level of the respondents as revealed on figure 5.1 below. Respondent were asked to indicate the extent to which they agree or disagree with their understanding of the general potentials of a GIS and if they feel it is an indispensable tool in municipality business. Of the 30 respondents, only 1 disagreed that she/he understands the general potentials of a GIS and that it is indispensable in municipality business.

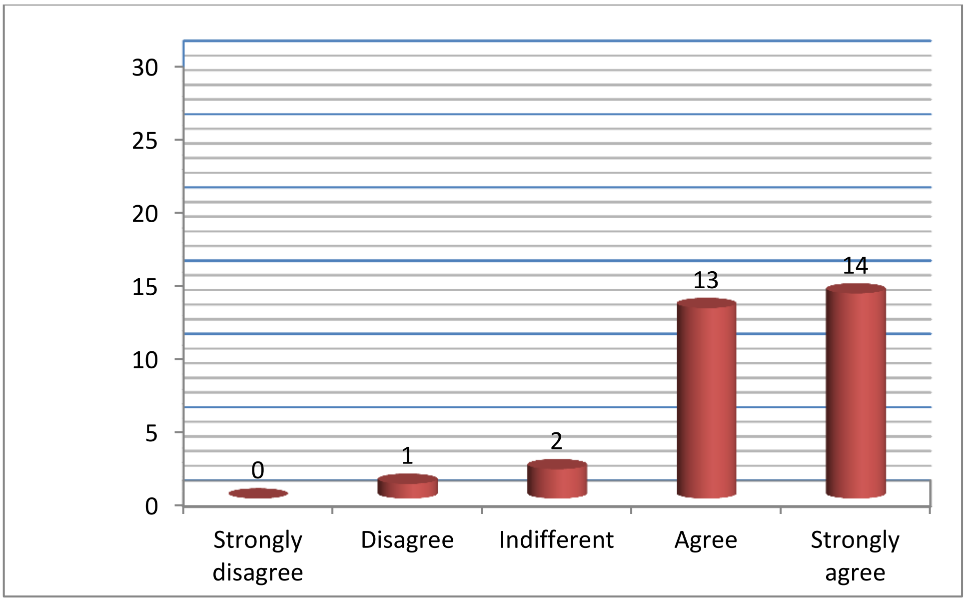


Figure 5.1. Level of GIS awareness among users

Of the remaining 29 respondents 2 of them choose to remain indifferent while 13 and 14 respectively agreed and strongly so that they understand the potentials of a GIS and that it is indispensable in municipality business. This reveals a strong awareness and a strong positive attitude of the respondents towards GIS in the Municipality.

5.1.2. The overall technical quality of the system

The overall technical quality of the system is a sum of three factors – its reliability, its user friendliness and its efficacy perceived within an ordinal scale ranging from poor to excellent

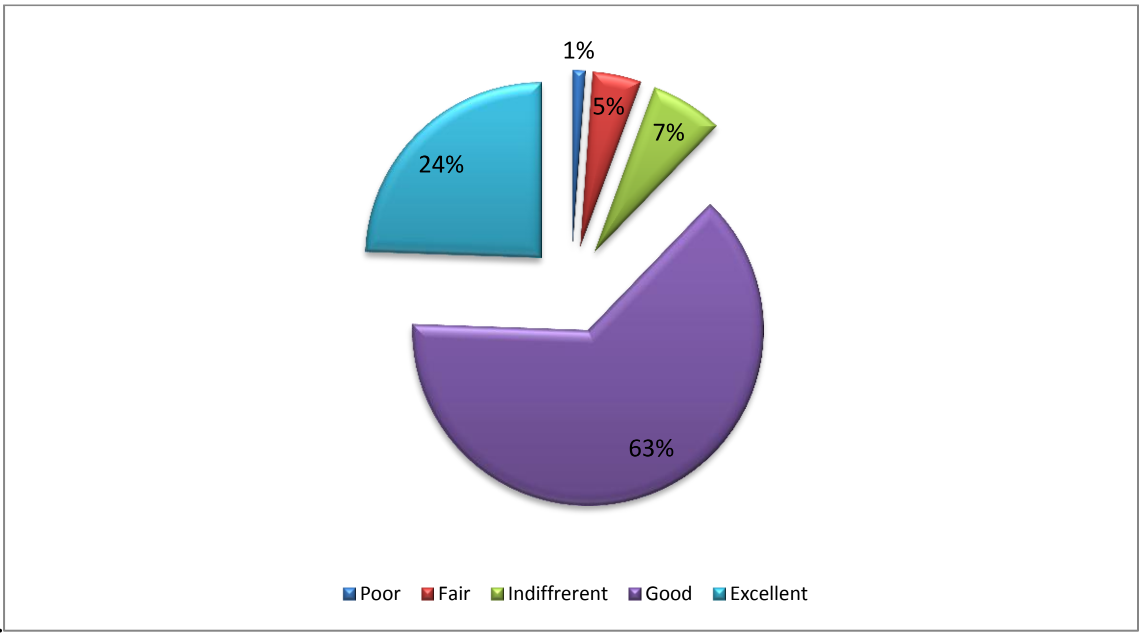


Figure 5.2. Measure of the overall technical quality of the system

as indicated on figure 5.2 above. Of the 30 respondents, 63 per cent, (that is 19 of them) think the system is good as against only 1 per cent felt the system quality is poor. This reveals a very high user satisfaction with the system in place.

5.1.3. Overall Information quality

The overall information quality of the system is a measure of four indices - its accuracy, its reliability, its accessibility and comprehensibility as perceived by respondents in an ordinal scale ranging from poor to excellent as indicated on figure 5.3 below.

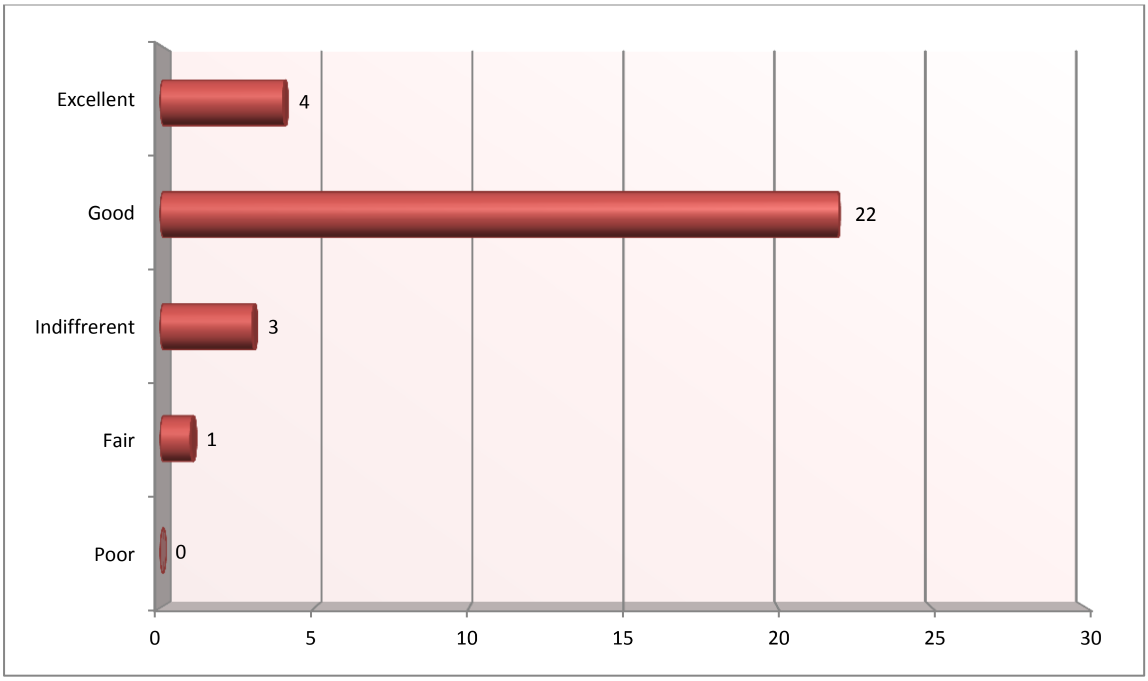


Figure 5.3 measure of the overall information quality produced by the system

Of the 30 respondents, 22 of them believe that the quality of information derived from the system is good, that is a about a 74 per cent share of the total sample space as against 4 per cent, (that is only 1person) rating the quality of information produced by the NMBM GIS as fair. This demonstrates that there is a high user satisfaction with information derived from the organization's GIS.

5.1.4. Extent of utility

The extent of utility is the degree to which respondents agreed or disagreed to whether the system is been fully exploited, whether they considered it an indispensable tool in their daily tasks and if the system facilitates their operations.

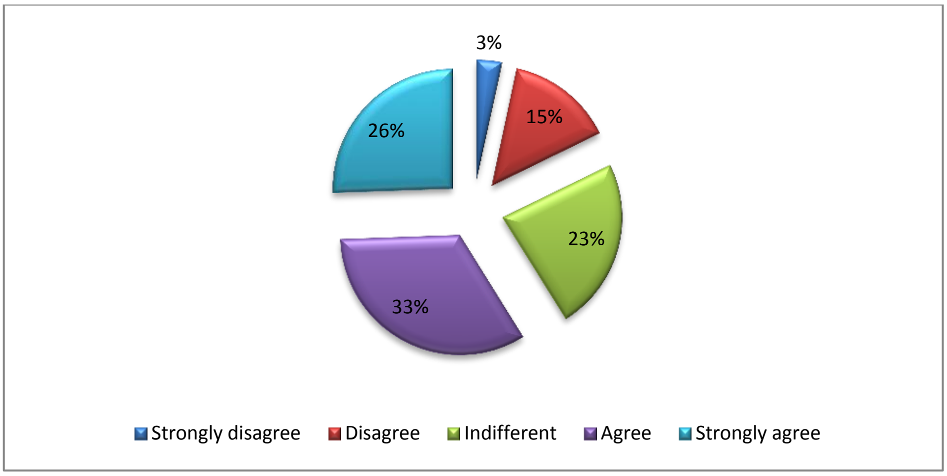


Figure 5.4 Measure of degree of usage

The results as portrayed on figure 5.4 reveals some degree of skepticism among respondents regarding the extent to which the system is put into full use. Of the total number of respondents, 23 per cent of them remained indifferent with 18 per cent expressing a negative view (that is 15 and 3 per cent disagreeing and strongly so) that the system is been put into full use. Of the all the respondents, 59 per cent of them viewed the extent of system usage from a positive point; that is 33 per cent and 26 per cent respectively agreeing and strongly so, to the statements.

5.1.5. Overall impact of GIS on municipality business

Respondents were asked to rate the overall impact of GIS in municipality business on a scale ranging from strong negative impact through to a strong positive impact as on figure 5.5.

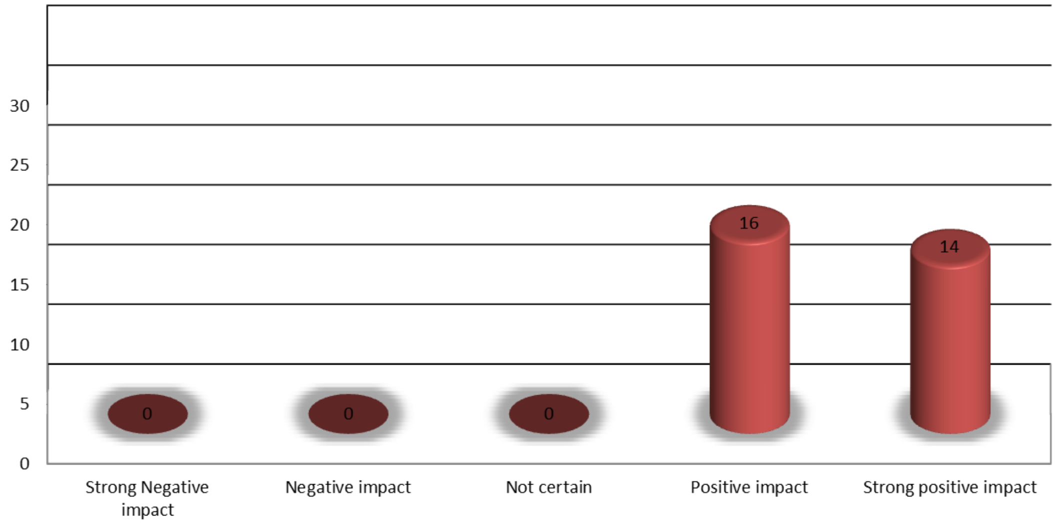


Figure 5.5. Overall impact of GIS on municipality business

As indicated above, the response was overwhelmingly positive with none of the respondents choosing to answer in the negative or expressing indifference. The overall impact here does not only entail individual impact in terms of enabling the user to perform their job/tasks effectively and efficiently, but also aggregates the benefits it offers in terms of enabling the municipality to make better decisions.

5.1.6. Problems and challenges using the system

In this section of the questionnaire, respondents were required to list some of the major problems and challenges they face working with the NMBM EGIS.

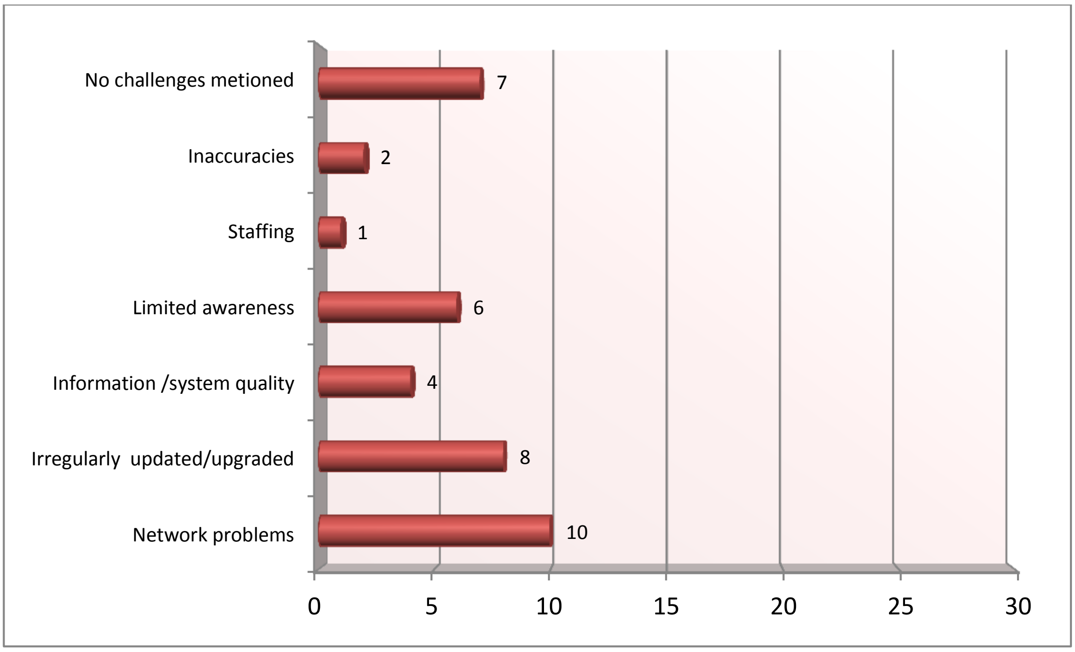


Figure 5.6: measure of problems and challenges

Most of the problems and challenges enumerated can be grouped as shown on figure 5.6 above. The most recurrent of the problem enumerated is the network problem. It was identified by 10 of the 30 respondents. This is closely followed by irregular updates of the system as identified by 8 of the respondents. Another serious problem identified is limited GIS awareness in the NMBM. This was pointed out by 6 respondents. Other problems identified are associated with system and information quality, problems of inaccuracies on GIS data as well as problems of limited staffing. Of the 30 respondents, 7 of them did not report any challenge or problem using the system.

5.1.7. Suggestions to make the system work better

The suggestions advanced can be grouped into three categories namely: regular updates and upgrades on the system, sensitization and additional training and the inclusion of additional servers. As indicated on figure 5.7 below, 30 per cent of the respondents, (i.e. 9 of them) suggested that the system should be regularly updated and upgraded. Sensitization and training workshop to boost the level of GIS awareness was suggested by 23 per cent (that is 7 of the respondents) while 10 per cent (that is 3 respondents) believe that including an additional server will improve system performance.

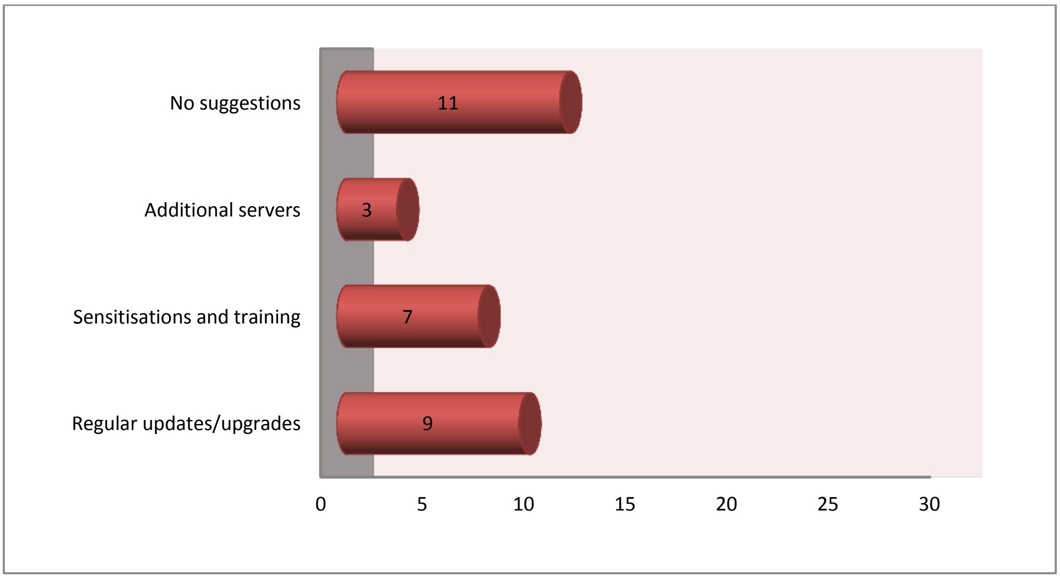


Figure 5.7 Suggestions from respondents on how to improve system performance

Of the 30 respondents, 11 of them offered no suggestion regarding what can be done to enhance the system.

5.2. Data Analysis

It has been argued that it is most beneficial to allow GIS operations to run for some time prior to evaluating its success and failures. This gives the user enough time to interact and gain familiarity with the system. However, there is no clear time table on when evaluation should start or end. This makes it a bit difficult for organizations seeking to evaluate GIS implementation progress. However, of greater importance is to conduct baseline or pre-implementation studies prior to assessing levels of success. This helps to establish bench marks against which post implementation evaluation can be measured.

Understanding what the user feels about a new technology is of critical importance in measuring success levels. It is for this reason that an assessment of GIS awareness among users of the NMBM EGIS was included in this study.

From the data presented, it is easier to conclude that there is a good level of GIS awareness among the respondents. It leaves the impression that they understand the significance of GIS as a high-priority requirement in facilitating development intervention tasks in the municipality. In assessing the user awareness of the system only 2 % of the respondents disagreed as opposed to 45% and 43% who respectively agreed and strongly so that they understand what a GIS has to offer and that it is an essential requirement in municipality operations. This positive view builds a strong GIS case irrespective of whether respondents have only a nodding acquaintance of the system. Pre or post implementation studies revealing such a perception for any development organization seeking GIS solutions is a pointer to the fact that adopting GIS would be relatively successful. GIS implementing in such a milieu will require very little effort in gaining user acceptance.

However, gaining user acceptance is not enough. These positive attitudes need to be supported over time. Continual evaluation will help set blue prints on where to enhance system performance without which user acceptance will begin to lapse. This accounts for other metrics of system performance such as the technical quality and quality of information produced by the system. The data presentation above indicates a very high user satisfaction with the NMBM GIS. What is adequate about such satisfaction in any GIS evaluation studies should not necessarily base itself on current industry standards of a GIS, but more on the workability of the system in satisfying the needs of the user. Of course successful GIS implementation is not in how much the system complies with standards set by leaders of technological change but much in how the users perceives and accepts the system as workable to them. Most often, leaders of technological change would assume that new techniques and methods of doing things are more efficient yet they will have to get the user acquiesced into using new systems especially as people find it hard leaving the comfort zone of having a better acquaintance with previous system compared to new ones where they will have to readapt. Hence in every GIS implementation or process of technological change, the user should remain central in the mind of those championing or creating the system.

The technical quality of a system is also as good as the quality of information it provides the user. This is the overall essence of any information system. A state-of-the-art and a user friendly piece of GIS hardware or software equipment that does not satisfy the relevant information requirements of the user leaves so much to be desired. An overwhelming majority of the respondents - 74 per cent as illustrated on figure 5.3 above were of the opinion that the NMBM GIS meets their information needs. However, this is not without hitches as many of the respondents indicated that there is need to regularly update and upgrade the system without which information quality will be on a down turn.

But it can also be argued that a strong urge to purchase or implement a hardware and software system that produces information of the highest quality does not necessarily guarantee implementation success. What is the essence of installing state-of-the-art GIS equipment and to produce information of the highest quality which will neither be utilized in the internal or external operations of an organization? Hence in measuring GIS implementation success, development organization will always have to take cognizance of system utilization. As illustrated above, 59 per cent of the respondents affirmed that the NMBM GIS is being fully exploited as opposed to 18 per cent who answered in the negative. These negative expressions however should not be misconstrued for negative sentiments in the adoption of GIS solutions in the NMBM. It actually means the respondents believe that the system has much to offer than it does at the moment. In other words, the respondents believe that the system is still being under exploited.

This positive attitude is further reflected on the responses given to an evaluation of the overall impact of GIS in municipality business. None of the respondents answered in the negative. They are overwhelmingly of the opinion that the system impacts positively on municipality business. These impacts are usually difficult to measure. Monetary pay offs may be easier to quantify. For example looking at the sales of GIS services to external clients. However, it becomes very difficult to measure the impact of implementation in terms of is contribution to user efficiency and to the organization saving cost and time in some business operation facilitated by GIS. The impact can only be felt by the absence of the application of such a technology. Hence in introducing GIS technology, development organizations should not rely on calculating monetary returns but should rather consider more the non-monetary benefits that will accrue to the organization for adopting a GIS.

Like in any other human endeavour, implementing a GIS is not a problem or challenge free undertaking. This is a common feature inherent in every information system. Problems and challenges here will refer to operational weaknesses that inhibit the user from exploiting the full potential of the system. Some of these were identified in the NMBM GIS. The best organizations can offer in such a situation is to manage such weaknesses. Just as with the overall decision to adopt GIS solutions for an organization, improving or managing problems and challenges inherent with adopting a GIS should hinge on the user perception of the system to ensure that whatever innovation that is been put in place should reflects user needs otherwise organizations will risk destabilizing decision support systems which respond fairly well to user needs. Monitoring and evaluating system usage therefore should remain a key component of a GIS implementation and GIS management process. Hence, as revealed on figure 5.7 above, the NMBM just like any other development organization should regularly upgrade and update its system as well as educate and train its personnel as top priorities suggestion of making the system work better for the user.

5.3. Synthesis

This study set out to examine GIS as a DSS in planning and managing development policy interventions. One of the core objectives was to evaluate the extent of its implementation success in the NMBM and the organizational challenges facing its implementation so as to be able to establish lessons and set of good practices that other development organizations can take into consideration when contemplating GIS solutions. There is no other proper way to understand this picture than to capture the user perception of the system before and after its operations start. The user view remains a key indicator as to how the system works and how it could be made to work better. This accounts for why monitoring and evaluating information systems as described in literature cannot be truncated from GIS implementation and GIS management processes. This is self-evident in the results presented above depicting the sampled opinion of 30 users of the NMBM GIS. The results provide a blue print on which the municipality or any other development organization can use to improve the performance of their GIS. Starting from the overall awareness of the potentials of a GIS and the need to adopt it, the technical and information quality produced by the system, the degree to which such information is put into full use, to the overall impact of the system, the problems involved in running it as well as possible solutions to handle such problems, the GIS user remains the key informant on the wellness of the other components of the entire system. Hence every successful implementation begins and ends with the user.

But the question to ask at this juncture is just how successful has GIS implementation been in the NMBM. It was pointed out earlier in the literature review that GIS implementation and

GIS management are continual processes which seek to refine and adjust the system to the changing and challenging needs of the system across time. Such needs and challenges in most cases may not only be internal but also external to the organization such as technological innovations which may render current technologies obsolete. These processes need to be monitored and evaluated to counter challenges which may bog down the system. This accounts for one of the objectives of the study enumerated earlier - to examine the challenges inherent in running a full-fledge enterprise GIS.

However, judging from the evaluation exercise in this study, the NMBM EGIS has been remarkably successful despite some challenges. Gaining the acceptance of the user as portrayed on the data presentation section of this chapter is an enormous step ahead. It creates an easy path towards making room for improvements that could boast the potential of the system in place.

Conclusion

In this chapter, the opinion of the user regarding the NMBM enterprise GIS has been presented and analyzed. The system has gained enormous acceptance from the user. There is a high level of awareness and a strong positive attitude among the respondents towards GIS in the municipality. The study also reveals a very high level of user satisfaction with the system and the quality of information derived from it. The overall impact of the system on municipality business is overwhelmingly positive. However, some respondents identified a number of challenges and possible suggestions that could make the system work better. In the analysis, the importance of having the user of the system in mind when managing a GIS has been emphasized. This is of a critical importance since user acceptance determines other metrics used to determine GIS implementation success. There is good reason to believe that the NMBM GIS has the potential to be more successful than it has been judging from the positive feedback from the users.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

Introduction

The overall aim of this research was to examine GIS implementation as a Decision Support Tool (DST) for planning and managing development interventions. This aim was met within the framework of the following objectives: to examine GIS within the wider context of Geoinformation Technologies, investigate how GIS can be conceived and implemented in a development organization using the case of the NMBM GIS, showcase the role of GIS as a DSS in development. Further objectives included evaluating the extent to which GIS implementation in the NMBM has been successful and the organizational challenges and problems facing this process. It finally sought to establish lessons that can be learned from this case as well as advance a set of good practices and recommendations regarding GIS implementation in development organizations. This chapter summarizes the research findings of this work based on the outlined objectives. It also outlines some recommendations for the future, looks at possible contributions to knowledge as well as setting out an opportunity for self-reflection.

6.1. Summary of findings and conclusion

It was pointed out in the literature review for this study that due to a wide range of GIS applications areas, rapid and continual technological advancements, it has become difficult for GIS practitioners, researchers and academics to agree on a single precise and concise definition of GIS. This has sparked off waves of debates on what is and is not a GIS especially in relation to other SDSS. This accounts for the first objective of this study which was to examine the concept of a GIS not only as a self-sustaining SDSS, but most importantly within the wider frame work of other geoinformation technologies. It is expected that this will not only help development practitioners and organizations seeking introduction to GIS but will also give them a broader picture of how the system functions. To attain this objective, a precise definition of a GIS was advanced in terms of the processes that characterize it and its interrelationship with its input and output systems. It is this interrelationship that gives GIS its outstanding strengths and capabilities compared to other geospatial sciences and database management systems.

In the second objective, this study sought to examine how development organizations can conceive and implement GIS as DST. It was emphasized in the literature review that GIS implementation is indispensable in the successful purchase of a GIS. Development organization and practitioners are urged to consider implementation issues before adopting its use or carrying out innovations on existing SDSS. Implementation is viewed as a long term process that requires proper management. It involves selecting from alternative models and approaches to implementation. The process should be properly monitored and evaluated to set implementation blue prints. While this study does not favour any particular model, it used the case on the NMBM GIS to highlight some of the major issues development organizations should remain cognizant of when considering GIS solutions. Findings indicate that the NMBM has been running its GIS for about two decades. It currently runs an EGIS - a federated system for distributing GIS functions across all units/departments under the municipality's administration. The software in use are ESRI GIS software packages – ArcGIS for Server for distributing GIS functions on municipality LAN and ArcGIS for Desktop for authoring GIS shapefiles. The server is administered by its corporate GIS Unit.

However, implementing GIS involves more than just how the system runs. It is also of critical importance to consider what makes it run. Besides the software systems as pointed out above, other essential components of a GIS include the hardware systems, the data and the procedures/algorithms of GIS science. Of increasing importance is the network without which GIS data sharing will be limited over computer desktops there by also limiting its usage. It is worth noting that utility is one of the key metrics used to measure GIS implementation success. The network systems used to distribute GIS resources in the NMBM include the NMBM LAN and its connection to the World Wide Web (WWW). They enable the availability of GIS functions to a wide range of users. But of cardinal importance among all the components of a GIS are the users/people. Their acceptance of the system is leading determinant of whether it succeeds or fails. GIS implementation should therefore begin and end with this component.

To meet the third objective of this study, the role of the GIS as a DSS was showcased. In the literature study it was indicated that the main push factor for procuring a GIS is its application. GIS application areas are wide ranging and expanding as the capacities of a GIS continue to grow. The role of GIS as a geospatial database management system was illustrated using data from the NMBM GIS. This capability cuts across any other GIS application area imaginable. Illustrations were based on how data is held/stored in a GIS using relational database tables. It also considered a case scenario of how a GIS database can be of value in road network inventory and analysis. Most valuable of this application capability is in a GIS not only providing the user with descriptive information but above all with location information using real world geographic coordinates thereby revealing greater patterns not readily discernable in non-spatial database systems.

The fourth objective of this study was to evaluate the extent to which GIS implementation in the municipality has been successful and the organizational challenges and problems facing the process. In the literature review, it was indicated that monitoring and evaluation are invaluable tools in managing GIS implementation processes. It provides the backdrop against which system performance and implementation successes or failures can be judged. In this study the objective was not only to evaluate implementation success but also to illustrate a typical approach to monitoring and evaluating GIS implementation. As evident in chapter five of this research, the measure of GIS implementation success begins and ends with the people - that is the user of the system. The end users has a close relationship with the system, knows how it functions and how well it meets their needs. Hence their opinion about the system will be more illuminating to management's understanding of what implementation decisions to make. This study sought to measure the user perception of NMBM GIS to achieve this. It tested the overall knowledge of the users of the municipality's GIS which revealed a strong awareness and a strong positive attitude of the respondents towards GIS in the municipality as well as very high level of user satisfaction with the technical quality of the system in place and the information it produces. A measurement of the extent to which the system is put into full use indicates that users believe it has more to offer than it currently does and they overwhelmingly believe it has a positive impact on municipality business. The main problems and challenges pointed out by the users of the systems has to do with network issues, irregular updates and upgrades, limited awareness of the full potentials of a GIS by some potential users. They also pointed out to some information quality issues. They suggested that regular system updates, GIS training and sensitization workshops as well as getting additional servers would make the system work better.

Regarding lessons that can be learned from the NMBM GIS experience, this study has emphasized the need for GIS as a SDSS and highlighted the need to put the user at the forefront when considering GIS solutions and any other technological innovations. The study revealed a good level of user acceptance of GIS in the NMBM despite other problems and challenges facing its implementation process. This acceptance provides the municipality with a good potential to improve on the system and to reap greater benefits offered by this technology. In implementing GIS therefore, development organizations will always have to make the user see reason in using the system without which the system is doomed for failure.

6.2. Recommendations

This section deals with the fifth objective of this study which is to establish lessons that can be learned from the GIS implementation in the NMBM and to advance a set of good practices and recommendations regarding GIS implementation in other development organizations. Hence recommendations made here include; those specific to the case study in question, recommendations directed to development organizations and in the third case recommendations to tertiary establishments offering training in developmental studies.

Respondent enumerated some of the challenges they face using the system. They pointed out to network issues such as the system running on slow speed there by hampering logging in and accessing information held in the system. They also pointed out to irregular updates of the system which poses currency challenges. Information quality issues and limited awareness of what the GIS can offer its users were also pointed out. Respondents suggested GIS sensitization workshops, regularly updating and upgrading the system and enabling the system to run on good speed that can increase user access to information as some of the things that should to done to improve on the performance of the system. This study recommends that municipality's management should attend to these problems and challenges. They have been advanced by the users of the system who are more versed with its performance and stand a better chance to inform management. These problems should be treated among the top priorities regarding information management in the municipality.

During the interviews conducted with the GIS resources persons in the field, financial constraints and limited budgetary allocations for GIS was pointed out as one of their main challenges and problems in managing GIS in the municipality. Increasing the financial resources available for a managing the system will boast the potentials of the system above its current limit. It is worth noting that financial resources though often overlooked when listing the components of a GIS is of strategic importance in assembling all the other components of a GIS and making them work. One way to increase financial resource without having to put the municipality's budget under any strain is to grant the GIS Unit some autonomy in carrying out external GIS consultancies to increase its budget line.

While on the field, it was noticed that the NMBM GIS rely on external organizations to obtain some of its datasets – that is GIS data outsourcing. This is understandable as the production of some datasets has legal implications. Besides there are specialized government services charged with the production of some datasets. Data sharing has also become a common practice within the GIS community especially with the growth of Geospatial Data Infrastructure (GSDI). These factors notwithstanding, it is advisable to cut down on high levels of interdependence in GIS operations. This is essential in avoiding the system getting grounded due to one of the groups/agencies not been able to deliver GIS products/services on record time. It is worth note here that the most important thing about information is not only its availability but very much so on a time bases.

The recommendations outlined above are not limited to the NMBM. It is also relevant to any development organization contemplating GIS solutions or upgrading their systems. Organizations that are already convinced of the need to run a GIS should focus on key requirements that make a successful GIS. These have been discussed in this study. Most cardinal of these requirements is the user. They should be able to get the user to understand what the system can do for them and how to use the system in order to be able to implement a successful GIS.

To tertiary establishments offering training in developmental studies, GIS tuition is recommended in development studies curricular as part of skills development programme for development professionals. Some establishments have started up with this laudable task. However, the technology remains alien to several a development practitioner and consequently to many development organizations especially in Africa. Some of them have good business cases requiring GIS solutions but however, lack the knowledge and expertise to ensure that GIS is not only incorporated in their workflow but that this is done in ways which will enable the system function properly and sustainably. The need to include GIS tuition should not only be limited to the teaching the techniques of using the software but also human and organization issues; that is issues affecting GIS implementation and management in development organization. A cross disciplinary approach in development studies that incorporates GIS literature is therefore highly recommended.

6.3. Contribution to knowledge?

While it is not a requirement for this study to make an original contribution to knowledge, it is worthwhile attempting to point out how this study might have gone this far. But what exactly is contribution to knowledge? To Phillips and Pugh (2010: 41), "it does not mean an enormous breakthrough that has the subject rocking on its foundations…" but means among others "carrying out empirical work that hasn't been done before, making a synthesis that hasn't been made before, using already known material but with a new interpretation…being cross-disciplinary and using different methodologies…" *(ibid: 69-70)*. Based on this definition of original contribution to knowledge, this section seeks to point out how this work might have done so?

In the first instance, this study seeks to encourage a cross weave of GIS literature with literature in the field of developmental studies not only in terms of encouraging development practitioners to take up training courses on how to manipulate a piece of GIS software, but much training as to understand how to run a GIS runs in a development organization. This cross disciplinary outlook can be judged as a significant contribution to knowledge in the field of development.

Secondly, this study is bringing up the concept of Development Decision Support Systems (DDSS) and encouraging development researcher and academics to take up this concept.

Thirdly, it took a fresh look what constitutes a GIS. It went out of the box to explain and describe a GIS from a perspective that has been bypassed or neglected by some leading texts in the field of GIS.

6.4. Further studies and self-reflection

There is need to triangulate and further confirm the facts reported in this research. This can be achieved by carrying out a follow up study which can be compared to this one to determine the long term validity of the claims reported. The facts reported are a reflection of what was obtained in the field, but human perception can change over time. This calls for further investigation into this area. It will also be appropriate that a future investigation should separately analyze the perceptions of both the technical and non-technical staff using the NMBM GIS.

This study was born out of out of a desire to incorporate a new concept in the field of development – the concept of Development Decision Support Systems (DDSS). Developing development policy interventions today require complex analyses which can be simplified using computerized systems. These systems are many and diverse and do not form the immediate focus of most development researchers today neither has it been pulled together as a subject area on its own. Development experts do heavily rely on such systems to make key decisions. It is worthwhile researching this area in greater depth. Development practitioners, students and researchers should spearhead this process.

On a personal note, this work has been a painstaking adventure requiring great amounts of diligence. From when the proposals succeeded up to this stage, it has been a relay journey from literature search, processing data/information to make it fit for assimilation in consonance with the research questions, aims and objectives, through to the field work and final reporting. Though tough, it was an interesting experience. Encouragements and positive remarks from supervision can only be alluded to oil in the lamp that keeps the flame alive. There wouldn't have been any fun in doing this work without such encouragement.

Going to the field took so much time and preparations. Shuttling to and fro making preliminary acquaintances, careful planning, fixing and catching up with appointments, rescheduling plans and sailing through the challenges of disparities with preconceptions and realities on the field and getting to talk people round for assistance in the data collection process. Once back from the field, all necessary data had to be collated, interpreted, presented and analyzed to achieve the aims and objectives of this work.

Sincerely, it was a very stressful exercise. At some points in time, it was a nerve racking exercise. All these coupled with block sessions to attend, lots of submissions to make within tight date limits, financial burdens and worries of survival were all hurdles that requires enormous energy to go through. However, the courage and determination not to go back or give it up saw this work through to this stage.

Most probably some of the loopholes experienced in planning for this research could be avoided if it were to be done the second time. But the single advice to those contemplating postgraduate research is to bear in mind that it can be as easy and as difficult as you make it. It is rewarding to find fun in doing your work, being determined to succeed and planning and organizing yourself as well as keeping a clear, precise and concise research focus. It is an extremely rewarding exercise at least intellectually.

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Appendix

Appendix 1: Interview Transcript and Conception of GIS implementation

SECTION A: Aims is to understand the past and present implementation of GIS components in the municipality

1. **Asked to know the first GIS operations started in the municipality**

This was in the early 1990s.

2. **Asked what triggered the need to adopt GIS?**

Technological development and changes

3. **What was the earliest software system used by the NMBM and how it has changed over the years**

Made to understand that NMBM used REGIS in the earlier years (what is it?) and CADs. In the early 2000 ArcView 3 and Municipality software use has followed developments in ESRI product evolution – ArcGIS 8, ArcGIS 9 and ArcGIS 10. This means reason for changes in software has been informed by the advantages offered by new upgrades in GIS software products.

4. **Asked about the software system in place now.**

Just upgraded from ArcGIS 9.3 to ArcGIS 10. ArcGIS Server, ArcSDE and SQL.

[but will like to know about the **ILIS** *and* **programming** *work going on at the ground floor* ***- an aside****]*

5. **The GIS hardware equipment in place**

GIS software vendors have often recommended high speed computers for the municipality GIS.

Information on the number of pcs (27 pcs) with GIS software installation

[But will want to know more about the approximate number of pc running on NMBM GIS system and are there insufficient numbers to support the workload, what about other hardware equipment such as plotters, scanners, GPS etc]

6. **The total GIS man power for the municipality GIS**

Understand there are currently four members in the corporate GIS Unit – a manager with Master in Town planning, 3 GIS analysts with Honours in GIS and 1 programmer.

But am also concerned about the GIS staff out of the Corporate GIS Unit - for example the staff working on the system at the print and copy service

7. **What data sets does the municipality have –** just a detailed description /exhaustive list

SECTION B: To understand GIS application in NMBM business

8. **The organization structure of GIS Unit in the municipality – its functions and how it relates to the administration and other units within the municipality**

Understood that the main functions of corporate GIS unit is to publish maps, offer technical advice to other departments requiring GIS in the NMBM, capacity building for other units/services of the municipality, handle GIS projects for the municipality.

I however also wish to understand more – to which department does it belong in the general structure of the municipality, will need a list of the other units (addresses) using GIS for possible interviews/questionnaire administration, understand relationship more with the print and copy centre and is it under the Corporate GIS unit? What is the GIS man power of the other services?

9. **A brief description of What are the application areas/how GIS is been applied/used**

10. **Application challenges**

Lack of knowledge by users to understand the capabilities of the system/ what it can offer them/ how they can benefit from the system.

11. **How the system can be made more useful**

Run GIS training programmes and workshops / create GIS awareness

SECTION C: GENERAL ISSUES

12. **Strengths & Weaknesses**

(You can discuss the strengths from your observations and on weakness from your observation external dependence on data creation i.e. the municipality does not create its own data – it depends on external clients and other governments services)

Financial constraints/ limited resources under budgetary allocations, IT infrastructure, GIS is interdependent

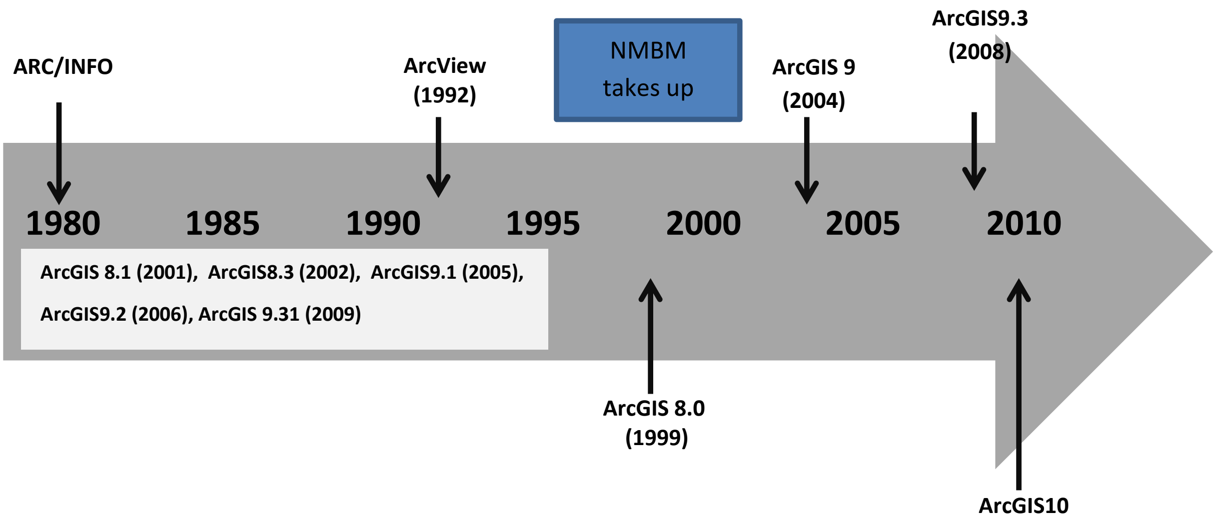
However, I wish to understand further how "IT infrastructure" is a weakness to the GIS systems in the NMBM – i.e. how does it negative impinge on municipality GIS /

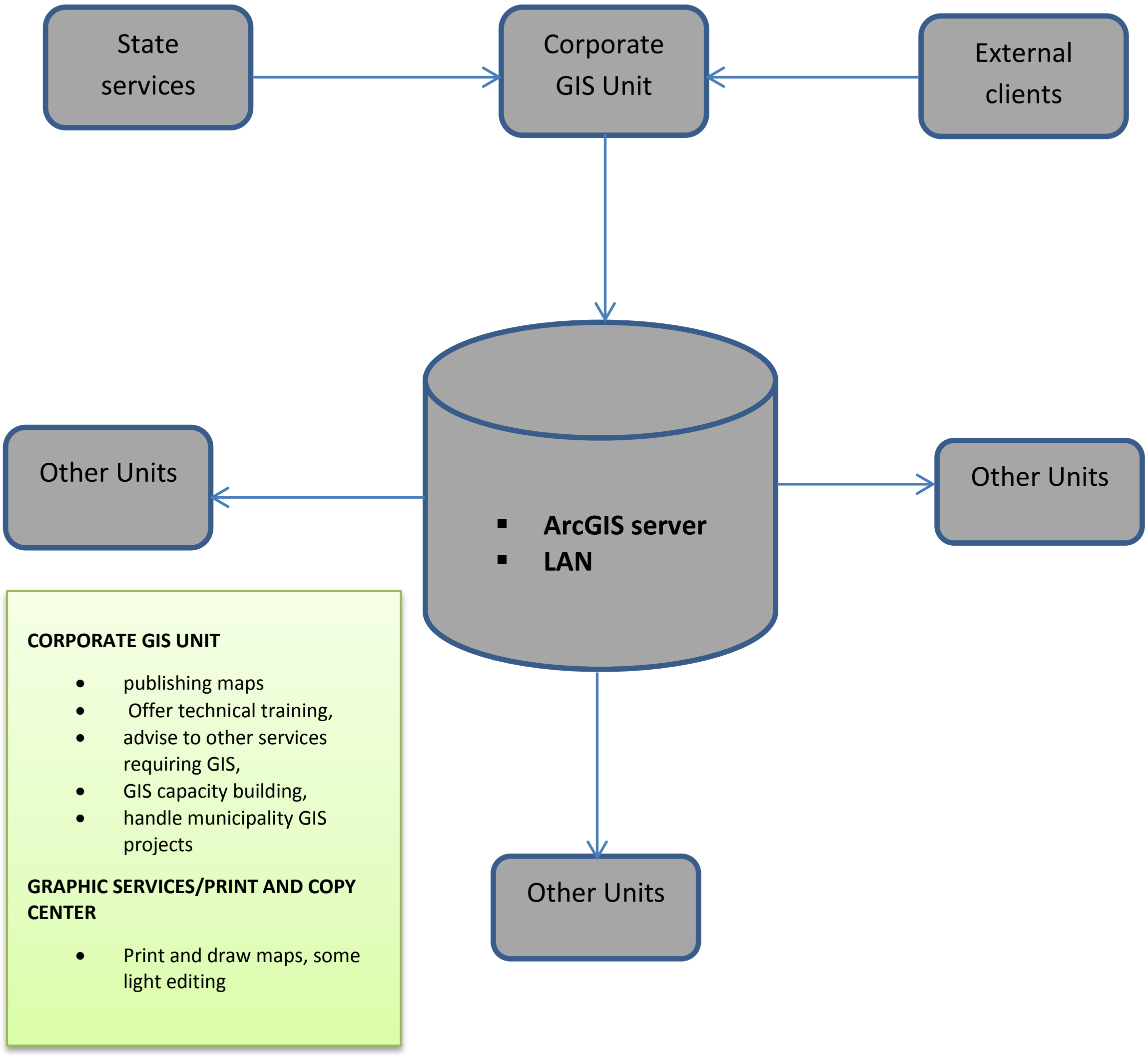
I understand your data is externally captured – Do you mean in terms of relying on other municipality departments to get the data or on private organization or state departments?

What do you think of the corporate GIS or Municipality creating and managing its own datasets rather than depending on external data?

13. **Advice to organizations seeking GIS implementation**

It should be user triggered – that is the user should see the need for using the GIS otherwise t won't be successful


ARC/INFO
ArcView (1992)
NMBM takes up
ArcGIS 9 (2004)
ArcGIS9.3 (2008)
1980
1985
1990
1995
2000
2005
2010
ArcGIS 8.1 (2001), ArcGIS8.3 (2002), ArcGIS9.1 (2005),
ArcGIS9.2 (2006), ArcGIS 9.31 (2009)
ArcGIS 8.0 (1999)
ArcGIS10


State services
Corporate GIS Unit
External clients
Other Units
ArcGIS server
LAN
Other Units
CORPORATE GIS UNIT
publishing maps
Offer technical training,
advise to other services requiring GIS,
GIS capacity building,
handle municipality GIS projects
GRAPHIC SERVICES/PRINT AND COPY CENTER
Print and draw maps, some light editing
Other Units

Appendix 2: Sample of completed questionnaire

Dear Respondents, I am YUNGONG Theophilus Jong, a student from the Nelson Mandela Metropolitan University. I am conducting research on **GIS implementation as a Decision Support System in development work**. I will be most grateful if you will be able to assist me in completing this questionnaire. The information you give is confidential and meant strictly for academic purposes.

Section A: Department/ Service Information *(tick or circle)*

1. In what department do you work? Public Health - Waste Management
2. Do you use maps and GIS products from the GIS Unit? **YES** **NO**
3. Are you a technical GIS staff? **YES** **NO**

	Strongly disagree	Disagree	Indifferent	Agree	Strongly agree
4. I understand the general potentials of a GIS	1	2	3	4	5
5. GIS is indispensable in municipality business	1	2	3	4	5

Section B: Rate the technical quality of the Municipality's GIS in terms of its : *(tick or circle)*

	Poor	Fair	Indifferent	Good	Excellent
6. Reliabilitv	1	2	3	4	5
7. User friendliness	1	2	3	4	5
8. Efficacy	1	2	3	4	5

Section C: Rate quality of information produced by the system in terms of their: *(tick or circle)*

	Poor	Fair	Indifferent	Good	Excellent
9. Accuracy	1	2	3	4	5
10. Reliability	1	2	3	4	5
11. Accessibility	1	2	3	4	5
12. Comprehensibility	1	2	3	4	5

Section D: Indicate the extent to which the system is put into full use as in the following:

	Strongly disagree	Disagree	Indifferent	Agree	Strongly agree
13. Its potential is been fully exploited	1	2	3	4	5
14. I am constrained to use GIS in my job	1	2	3	4	5
15. The system facilitates my job/tasks	1	2	3	4	5

Section E: How will you rate the overall impact of GIS on Municipality business? *(circle answer)*

1. Strong negative impact **2.** Negative impact **3.** Positive impact **4**. Strong Positive impact

5. Not sure

Section F: What are the major problems and challenges you face working on or using the system?

The lack of staff understanding what GIS can be used for. The buy in from the top structures in understanding the need for more staff to be educated on GIS and to be equipped with computers that would allow them to use the Corporate GIS. Networks to outlaying Depots to slow and staff loose interest in using Corporate GIS. Not enough staff in my Directorate that could assist with rolloing the GIS out and implementing various GIS systems____
____
____
____

Section G: What suggestions should be made to have the system work better for you?

The last date that maps/SDE layers where updated should be available in Corporate GIS. More IT staff should be trained on GIS related issues that could assist staff with queries. In house training centre should accommodate GIS related training specifically on Corp GIS. More technical staff should be available that could assist in developing various GIS related systems and queries in Direcatorates.____
____
____

Thank you for your assistance

Appendix 3:Collation of questionnaire findings

Section A: Overall GIS awareness

	Strongly disagree	Disagree	Indifferent	Agree	Strongly agree
Understand general potentials of GIS	0	0	3	14	13
GIS indispensable in Municipality Business	0	1	3	12	14
Overall GIS awareness	0	1	6	26	27
	Strongly disagree	Disagree	Indifferent	Agree	Strongly agree
Understand general potentials of GIS	0	0	3	14	13
			10%	47%	43%
	Strongly disagree	Disagree	Indifferent	Agree	Strongly agree
GIS indispensable in Municipality Business	0	1	3	12	14
		3	10%	40%	47%
	Strongly disagree	Disagree	Indifferent	Agree	Strongly agree
Overall GIS awareness	0	1	2	13	14

Note:
The overall GIS awareness was measured by asking respondents to indicate the degree to which they agree or disagree that they understand the general potentials of a GIS and whether a GIS is indispensable in municipality business. These views were converted into percentages form and the average number of respondents out of these percentages

Section B: The Overall quality of the system

	Poor	Fair	Indifferent	Good	Excellent	Total
Reliability	0	1	1	21	7	30
user friendliness	1	2	3	14	10	30
Efficacy	0	1	2	22	5	30
Overall Technical Quality of System	1	4	6	57	22	90

NOTE:
The overall technical quality of the system was measured as a sum of three factors - reliability of the system, its user friendliness and its efficacy perceived within an ordinal scale ranging from poor to excellent as indicated on the table. The results were then displayed on the pie chart.

Section C: Information Quality						
	Poor	Fair	Indifferent	Good	Excellent	
Accuracy	0	0	1	24	5	30
Reliability	0	1	4	21	4	30
Accessibility/Availability	0	1	3	23	3	30
Comprehensibility	0	2	2	21	5	30
Overall information quality	0	4	10	89	17	120
Average number of respondents		1	3	22	4	30

NOTE:

The overall information quality of the system is a sum of 4 parameters - its accuracy, its reliability, its accessibility, and comprehensibility perceived by respondents in an ordinal scale ranging from poor to excellent as indicated on the table. Dividing the sum of each scale by the sum of the overall information quality and multiplying it by the sample space which is the 30 respondents, we get the average number of respondents for each scale. E.g. 89÷120*30 = 22.25 which is 22 respondents for the overall information quality as good

Section D. Overall utilisation of the system						
	Strongly disagree	Disagree	Indifferent	Agree	Strongly agree	Total
System been fully exploited	1	8	11	7	3	30
I am constrained to use the system in my job	2	4	7	12	5	30
The system facilitates my job/tasks	0	1	3	11	15	30
Overall degree of exploitation	3	13	21	30	23	90

NOTE:

The degree to which the system is utilized was determined by respondents indicating to what extent they disagreed or agreed that they system is been fully exploited, that they are constrained to use it in their job and whether it facilitates their job or task. The sums of the scale ratings produced the displayed result for the overall utilization of the system.

Section E: Overall Impact on Municipality Business				
Strong Negative impact	Negative impact	Not certain	Positive impact	Strong positive impact
0	0	0	16	14
Note: Respondents were asked to indicate on the questionnaire how they felt was the overall impact of a GIS on the municipality business. They were allowed to choose as indicate on the table.				

Section F: Problems/Challenges Using the system	
Problems/Challenges	**Number of Respondents**
Network problems	10
Irregularly updated/upgraded	8
Information /system quality	4
Limited awareness	6
Staffing	1
Inaccuracies	2
No challenges mentioned	7
Note: Respondents were asked to indicate on the blank spaces of the questionnaire what the major challenges and problems they face when using the system. After going through all the questionnaires, their major concerns were related to the categories listed.	

Section G: Suggestions by respondents to make the system more effective	
Suggestions	**Number of respondents**
Regular updates/upgrades	9
Sensitizations and training	7
Additional servers	3
No suggestions	11
Note: The suggestions listed by the respondents were regrouped into the categories indicated on the table	

Appendix 4: University research Documents

- Permission to Submit Final Copies of Treatise/Thesis
- Declaration by Candidate
- Ethics Proforma for Treatise