# The Evolution of GIS ICT Applications for Sustainable Utilisation and Management of Natural Resources in Agriculture and Rural Development of Gauteng

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## Abstract

The evolution of GIS applications in Gauteng Department of Agriculture and Rural Development (GDARD) was addressed in the study about Rationalisation and Optimisation of Spatial Information Exploration (ROSIE) report which reflects the GIS history in GDARD before 2003. That report revealed that there was a "large degree of duplication, unconsolidated information resources within the department, and non-provision for wider access to spatial information".

This study focuses on the complexity of introducing centralised GIS decision-support ICT applications in GDARD after 2003, with focus on a particular GIS ICT application for GDARD known as the Gauteng Integrated Decision Support (GIDS) system. The purpose of conducting this study was to determine to what extent the adopted strategies, methods and processes are contributing to the attainment of the policy mission for "sustainable utilisation and management of natural resources" in Gauteng. The methodology used reviews GIS usage, skills and access to spatial information i.e. e-service delivery.

The data was collected from individuals from GDARD, other Gauteng Provincial Government (GPG) departments, GPG agencies and GDARD stakeholders. The data was analysed using an interpretive qualitative method of research in the context of policy, strategy and operations and their influence on the effectiveness and efficiency of integrated GIS systems. The findings of this study indicate that the stakeholders needs for e-service delivery have not been not fully met. It recommends that the Chief Executive Officers (CEO), Chief Information Officers (CIO) and Chief Financial Officers (CFO) should jointly evaluate, direct and monitor ICT projects to ensure that the major business drivers and benefits like e-services are effectively and efficiently delivered.

## Declaration

I declare that this report is my own, unaided work. It is submitted in partial fulfillment of the requirements of the degree of Master of Management (in the field of ICT Policy and regulation) in the University of the Witwatersrand, Johannesburg. It has not been submitted before any degree or examination in any other University.

Michael Malema
31 March, 2014

## Dedication

My sincere dedication to my family for understanding, supporting and sacrificing quality family time while conducting this research. The Gauteng Provincial Government especially Gauteng Department of Agriculture and Rural Development's Knowledge Management, Agriculture, Conservation, Environment, Veterinary Services and Rural Development branches. A special dedication to the Information Systems and Technology's GIS subcomponent of the Department that won the 2010 South African Center for Public Service Innovation (CPSI) award for innovative enhancements of internal systems of government through the GIDS GIS ICT Application project which is the subject matter for this research, first place winner of the 2011 United Nations Public Service Awards (UNPSA) in the category for advancing knowledge management in government as a reward for the creative achievements and contributions of public service institutions which lead to a more effective and responsive public service and the MEC for Gauteng's Department of Agriculture, Rural and Social Development's Excellence Award in recognition for outstanding performance and hard work in Information Systems Management and ICT governance.

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## Glossary of Terms

### Agricultural Decision Support System

A custom Agricultural Information Management System for Gauteng Department of Agriculture and Rural Development.

### Change Advisory Board

An IT change management committee that ensures that IT change controls are effectively and efficiently managed.

### Gauteng Integrated Decision Support

Integrated GIS datasets which are well coordinated and organised into one application to support spatial decision making in the fields of Agriculture, Nature Conservation, Environment, Veterinary Services and Rural development.

### Geographic Information

The term “geographic information” pertains to information about a location or something at a particular location on the earth’s surface.

### Geographic(al) Information System

A GIS or geographical information system, is a system used for the input, editing, storage, maintenance, management, retrieval, analysis, synthesis and output of geographic, or location based, information.

### IDRISI

A desktop GIS package, developed by Clarke University in the USA, in part through the sponsorship of UNEP, providing a wealth of easy-to-use tools for performing spatial analysis of geographic data sets, including remotely sensed images, at a low cost.

**Knowledge Management**

Knowledge Management is the management of activities and processes for leveraging knowledge to enhance competitiveness through better use and creation of individual and collective knowledge resources.

**Local Area Network**

A network of communications system suitable for use locally within a ring topology comprising of nodes connected to adjacent nodes by links.

**Metadata**

Information about the content, quality, condition and other characteristics of data or a dataset.

**Memorandum of Understanding**

An agreement to provide for the cooperation of the Parties involved.

**Master Systems Plan**

An overarching plan where information systems and technology are aligned to the broader business processes of a service with an objective to lead an organisation(s) to greater competitive advantage.

**Occupation Specific Dispensation**

A strategy used to attract and retain employees by applying specific conditions for remuneration.

**Open Source Software**

Open source software is a method of sharing code to develop and refine software programs. It involves developers at many different locations and organisations.

**Operational Level Agreement**

An agreement between the providers of an operation or operations and the customers of an operation or operations that specifies the conditions of a specific operation(s).

**Software Development Life Cycle**

A model of software engineering used throughout the production of software development.

**Spatial information**

Spatial information refers to information concerning anything with a spatial reference or clearly definable position in space.

**Spatial Data Discovery Facility**

A facility established to inform members of the geo-information community about Base Spatial Dataset Custodianship Policy and the Policy on Pricing of Spatial Information Products and Services.

**Service Level Agreement**

An agreement between the providers of a service and the customers of a service that specifies the conditions of a specific service or services.

**Standard Operating Procedures**

A set of rules to govern how an organisation implements its processes.

**Participatory GIS**

Integrated GIS and decision-making tools that are intended to involve different stakeholders and the public for solving complex planning problems and its aims and objectives are building consensus between the host of PGIS, stakeholders and the public.

**Project Management Body of Knowledge**

A body of knowledge that provides insight into the role of leadership in the management of projects, and other forms of principles used in successful projects.

**Software Maintenance Agreement**

An agreement between the providers of a maintenance service and the customers of a maintenance service that specifies the conditions of maintaining a specific software.

**Web-based GIS**

A GIS system providing access to spatial information in the form of maps to users via a web-browser.

**Wide Area Network**

A WAN is formed using Frame Relay Protocol and a telephone network interface unit.

**World Wide Web**

The World Wide Web is a large, heterogeneous, distributed collection of documents connected by hypertext links. The most common technology currently used for searching the Web depends on sending information retrieval requests to “index servers”.

## List of Abbreviations

| | |
|---|---|
| AD | Active Directory |
| AD | Assistant Director |
| ADSS | Agricultural Decision Support System |
| ARD | Agriculture and Rural Development |
| CAB | Change Advisory Board |
| CBA | Cost Benefit Analysis |
| CD | Chief Director |
| CIO | Chief Information Officer |
| CPSI | Center for Public Service Innovation |
| COBIT | Control Objective for Information and Related Technology |
| DACEL | Department of Agriculture, Conservation, Environment and Land Affairs |
| DEA | Department of Environmental Affairs |
| DIR | Director |
| DLARD | Department of Land Affairs and Rural Development |
| DPLG | Department of Planning and Local Government |
| DRP | Disaster Recovery Planning |
| ECA | Environment and Conservation Act |
| EIA | Environmental Impact Assessment |
| EIMS | Environmental Information Management System |
| EIS | Environmental Information System |
| EU | European Union |
| EXCO | Executive Committee |
| GCRO | Gauteng City Region Observatory |
| GCR | Gauteng City Region |
| GDACE | Gauteng Department of Agriculture Conservation and Environment |
| GDARD | Gauteng Department of Agriculture and Rural Development |
| GDP | Gross Domestic Product |
| GEGDS | Gauteng Economic Growth Development Strategy |
| GIDS | Gauteng Integrated Decision Support |
| GI | Geographic Information |
| GIS | Geographic(al) Information System |
| GISCo | GIS Committee |
| GOSP | Gauteng Open Space Project |
| GPG | Gauteng Provincial Government |
| GPS | Global Positioning System |
| GSSC | Gauteng Shared Services Center |

| | |
|---|---|
| ICT | Information Communications Technology |
| IS | Information System |
| ISAD | Information Society And Development |
| ISDM | Information System Development Methodology |
| IP | Internet Protocol |
| IT | Information Technology |
| ITU | International Technology Union |
| JCSE | Johannesburg College for Software Engineering |
| KM | Knowledge Management |
| LAN | Local Area Network |
| MCDA | Multi-criteria Data Analysis |
| MEC | Member of Executive Committee |
| MoU | Memorandum of Understanding |
| MSP | Master Systems Plan |
| NDAFF | National Department of Agriculture, Forestry and Fisheries |
| NEMA | National Environmental Management Act |
| NSIF | National Spatial Information Framework |
| OSD | Occupation Specific Dispensation |
| OSS | Open Source Strategy |
| OLA | Operational Level Agreement |
| PC | Personal Computer |
| PAIA | Promotion of Access to Information Act |
| PAJA | Promotion of Administrative Justice Act |
| ROSIE | Rationalisation of Spatial Information Exploration |
| RSA | Republic of South Africa |
| SADC | Southern African Development Countries |
| SDI | Service Delivery Improvement |
| SDLC | Software Development Life Cycle |
| SDDF | Spatial Data Discovery Facility |
| SDIA | Spatial Data Infrastructure Act |
| SOP | Standard Operating Procedure |
| SITA | State Information Technology Act |
| PFMA | Public Finance Management Act |
| PMBOK | Project Management Body of Knowledge |
| PEI | Provincial Environmental Importance |
| PGIS | Participatory GIS |
| SABS | South African Bureau of Standards |
| SMA | Software Maintenance Agreement |

| | |
|---|---|
| TOR | Terms of Reference |
| UN | United Nations |
| UNPSA | United Nations Public Service Awards |
| UP | University of Pretoria |
| VETS | Veterinary Technology Services |
| WAN | Wide Area Network |
| WWW | World Wide Web |
| WHS | World Heritage Site |
| AD | Assistant Director |
| DD | Deputy Director |
| Dir. | Director |
| CD | Chief Director |

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# 1. Chapter One: A Perspective on the Evolution of GIDS GIS ICT Application for Agriculture and Rural Development in Gauteng

## 1.1. Introduction

Today's society is regarded as an information society whereby ICT is fundamental for acquiring knowledge and creativity, improving the standards of living through productive participation in the social and economic sectors. Various ICT technologies are used for communication in today's information age e.g. ICT Applications, Local Area Networks (LANs), Wide Area Networks (WANs) and World Wide Web (WWW) via the Internet . As organisations demands increase, the current age Information Technology (IT) Chief Information Officer (CIO) plays a role to portray current and future enterprise capabilities through implementation of strategies that recognise the need to support growth through strengthening IT services and people (Gartner, 2007). There is often lack of participation by organisation executives to add value by meeting the stakeholders needs. There is also lack of IT governance by critical role players like the Chief Executive Officers (CEO), Chief Information Officers (CIO) and Chief Financial Officer (CFO) who should determine the major business drivers and benefits in order to effectively and efficiently deliver e-Services.

The scope of this study is on GIS ICT Applications, Local Area Networks (LANs), Wide Area Networks (WANs) and the Internet because these underpinning ICT technologies form integral the parts of converged ICT technologies. GIS technology is recognised for its power to integrate information and being a decision-support tool for monitoring and managing the natural resources in many organisation across the world. GIS ICT Applications are innovative technological tools that use a combination of software, data extracted or collected from various sources like satellites by people. The data is modelled and stored in databases, spatially manipulated and displayed in a form of global positioning systems points, thematic maps, charts or graphs.

The background of this study is based on the study about Rationalisation and Optimisation of Spatial Information Exploration (ROSIE) report for Gauteng Province Department of Agriculture and Rural Development which was presented in 2001 to the former Gauteng Department of Agriculture, Conservation, Environment and Land Affairs (GDACEL) currently renamed Gauteng Department of Agriculture and Rural Development (GDARD). The main findings of the report were that, "rather than there being a need to eliminate a large degree of duplication through rationalization, rationalization should serve the purpose of consolidating the information resources within the department, and providing wider access to this information to officials within DACEL, in order to increase their effectiveness and efficiency in performing their work" (Gavin,2001). A ten years (2003 – 2013) strategy for GDARD was developed in support of the recommendations for the study about ROSIE within the Gauteng Department of Agriculture and Rural Development. Currently there is a need to review progress made with regard to acquiring and developing ICT

application solutions to assist the department with elimination of large degree of duplication, consolidation of information resources and provision of wider access to information, in view of the current ICT service convergence forces which have led to high demand for rapid application development, prototyping, content management and e-service delivery. This research aims to explore how Gauteng Department of Agriculture and Rural Development's ICT Applications have evolved to provide an integrated provincial management system for sustainable utilisation and management of natural resources that will make information available to citizens in an open, innovative, responsive and smart way. It seeks to understand the value added by such tools to farmers, ecologists and environmentalists of Gauteng in interacting with government in the areas of agriculture, conservation and environment. The purpose of this study therefore is to review effectiveness and efficiency of the Gauteng Integrated Decision Support (GIDS) GIS ICT application and the advances in the integration of this application into the GDARD business processes over the period 2003 to 2013.

GDARD considers geographic information systems (GIS) as a crucial tool for carrying out Agriculture and Rural Development mandate because Agriculture and Rural Development operations are mainly location-based and GIS spatial decision making tool helps the organisation to improve its effectiveness and efficiency in support of the organisation's service delivery objective at all levels i.e. policy level, strategic level and operational level in order to address the competing and conflicting land use prioritisation challenges. Between the period 2005 and 2010 GDARD GIS strategy implementation resulted in an integrated GIS application known as GIDS aimed to manage, monitor and reserve land for Agriculture and Rural Development within the context of project ROSIE principles of eliminating duplication, consolidating the information resources and providing wider access to information in order to increase effectiveness and efficiency. Practical application of the technology has proved to be successful by winning the South African Center for Public Service Innovation (CPSI) award for innovative enhancements of internal systems of government through the GIDS project. The organisation was again awarded the 1st place winner of the 2011 United Nations Public Service Awards (UNPSA) in the category for advancing knowledge management in government as a reward for the creative achievements and contributions of public service institutions which lead to a more effective and responsive public service.

This study's focus is on reviewing the evolution of ICT Applications for Agriculture and Rural Development in Gauteng, specifically GIDS application for the GDARD. It explores how GIS applications are developed, managed and implemented to ensure effective and efficient information dissemination, it identifies the components of GIS (e.g. human resources, software, hardware, data sets, costs) that influence the successful implementation and integration of GIS tools to deliver public services. The applied implementation strategy is analysed in the context of the User Needs Analysis (UNA), Software Development Life Cycle (SDLC) and COBIT IT

governance frameworks to assess IT strategic direction, control, responsibility, accountability and managed IT operations. In order to address key concerns of IT-enabled investments and improved service delivery, the study will also focus on the strengths and weaknesses of the relevant public service institutional framework, policies and regulations. These prescripts will assist to determine common elements that are or may cause a disjuncture between Agriculture and Rural Development business policies and the relevant ICT policies. Since the South Africa's telecommunications sector is key to ICT data transportation, the inherent tensions outlined by Gillwald (2005) will form the basis of assessing digital divide factor influence on ICT Applications for improved service delivery. The recommendations of this study will be used to inform the future ICT strategies, policy and regulations.

## 1.2. Background

Gauteng Province is one of the smallest provinces among the nine provinces of the Republic of South Africa. Gauteng is also described as an economic engine of the Republic of South Africa and the Southern African Developing Countries (SADC) region. Approximately 75% of Gauteng land surface is occupied by settlements i.e. urban, rural, industrial and mining whilst a small amount of the land is used for agricultural related activities. The rapid population growth and urbanization in the province continues to exert pressure on the land reserved for Agriculture and Rural Development activities for sustainable natural resources management, hence it is imperative for Gauteng Provincial Government to promote natural resource management practices through ICT as an enabler to facilitate service delivery in Agriculture and Rural Development.

In 2011, GDARD convened a food security summit and declared with its stakeholders representing government, business, non-governmental organisations, civil society, farmers, academic institutions and other role players in food security interventions, to reaffirm the right of everyone to have access to safe and nutritious food, consistent with the right to adequate food. Noticing that poverty remains a major cause of food insecurity, sustainable progress in poverty eradication is critical to improve access to food. Revitalisation of rural areas is a top priority in the provincial development agenda to enhance social stability and redress the rural-urban migration. The summit's objective was to coordinate active collaboration towards achieving food security for all in the province. All stakeholders pledged and committed to make efforts to mobilize and optimise the allocation and utilisation of technical and financial resources from all stakeholders to implement sustainable food security in the province (GPG, 2011).

Food scarcity in both the rural and some urban parts of Gauteng Province has drawn political and government attention to look at possible means of using ICT as a tool for modern agricultural practices and food security but similarly with other portfolios of government, there is generally a

disjuncture between business policies and ICT policies. For example, ICT governance is considered as an executive function of an organisation but there are no policy instruments to ensure that the public service executives supports ICT policies and budgets to sufficiently ensure ICT governance implementation. Gauteng Department of Agriculture and Rural Development (GDARD) derives its mandate from Section 24 and Section 27 of the Republic of South Africa's constitution, which forms part of the Bill of Rights. Schedules 4 and 5 of the constitution stipulate the following policy objective regarding natural resource use and management; "To defend and promote the people's right to an environment that is not harmful to their health or wellbeing. Combat pollution and ecological degradation, to promote conservation and to secure ecologically sustainable development and use of natural resources, whilst promoting justifiable social and economic development. Control and manage health risks of animal origin, ensuring livestock production and the availability and affordability of safe, healthy, high quality food and animal products" (RSA,1996, section 24). GDARD's vision is to be "leaders in agriculture and rural development" and its mission is to "provide an integrated provincial management system for sustainable utilisation and management of natural resources towards "a better quality of life for all" (GDARD, 2009, p16).

Among the 12 South African Government 2010-2014 policy goals, Gauteng Department of Agriculture and Rural Development (GDARD) is the lead department for service delivery of outcomes 7: Vibrant, equitable, sustainable rural communities contributing towards food security for all and Outcome 10: Protect and enhance our environmental assets and natural resources (GDARD Annual report, 2009-10, p7, RSA). The key policy challenges and issues for Decision-making in Agriculture and Rural Development include delivering the vision and mission for natural resource management are with regard to for example, loss of agricultural land towards infrastructure development projects in Gauteng, determining crop suitability for agricultural purposes, demarcating zones with high agricultural potential commonly known as agricultural hubs, protection of agricultural related activities and reservation of land for food security in the province, encroachment on natural conservancies, illegal activities that contribute to air and land pollution like hazardous waste disposal, non-compliance with environmental management regulatory requirement for development. GIS has been the main ICT solution to resolve the discourse of issues raised above, through integrated spatial planning between the Branches; Agriculture, Nature Conservation, Natural Resource Management, Environment and Rural Development.

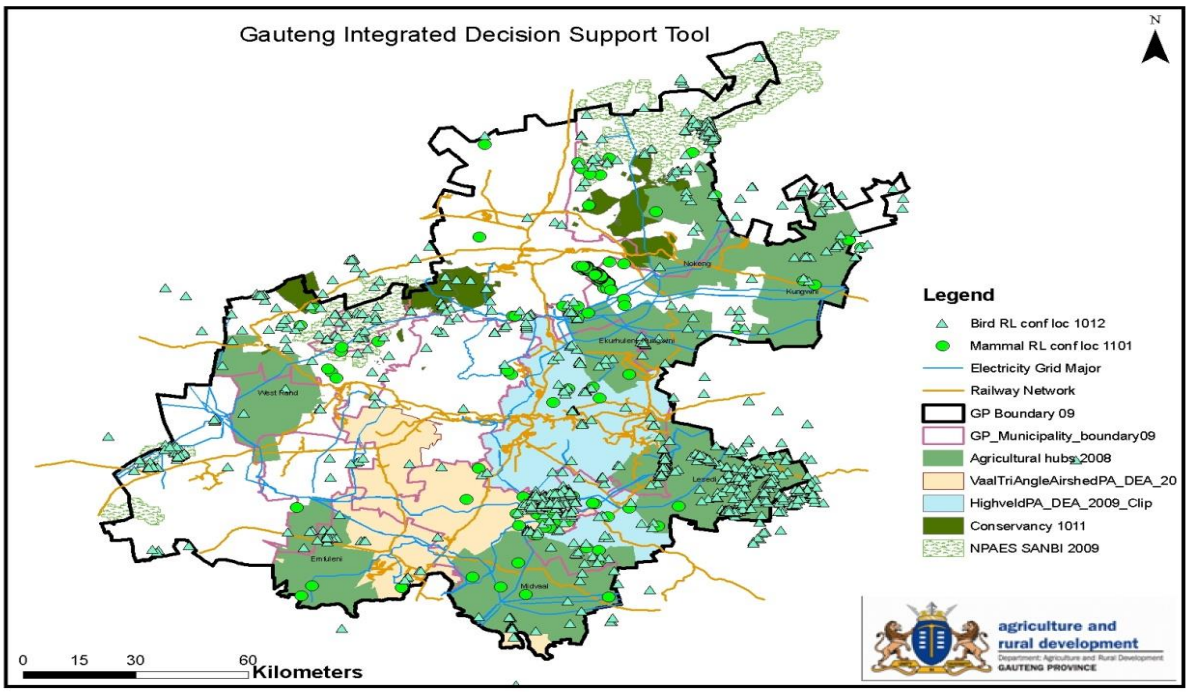
The challenges outlined above result in disputes over the lucrative spatial decisions in support of agricultural land reservation informed by ICT Applications like GIS because Natural Environmental Management Act (NEMA) and Environment and Conservation Act (ECA) precede agriculture practices in the country. In 2003 Gauteng Department of Agriculture and Rural Development adopted the 2004-2007 medium term expenditure framework (MTEF) for the period ending 2014.

During the key address note for tabling the strategic plan, the former MEC indicated that; 'If we are to meet the needs of present generations without compromising the ability of future generations to meet their own needs, then we must focus on not only the conservation and management of our natural resources, but also the social and economic dimensions of development' (DACEL, 2003).

In view of the ever-increasing development pressure on agriculture land in Gauteng, GDARD adopted and implemented an ICT application solution to inform and guide all development and land use decisions related to agricultural land in the province to ensure that all available high potential agricultural land be classified, mapped and retained as far as possible for agricultural production purposes. GIS applications analyses and present information aiding policy decisions within Government departments. In terms of locating high potential agricultural land, GDARD GIS components aim is to provide information on the adequacy of land resources to feed present and future populations and on the location of zones with comparative advantages or limitations for agricultural production. Gauteng Province has six major hubs reserved for such agricultural activities.

In order to support the Gauteng Provincial Government (GPG) Priority 8: An efficient, effective and development orientated public service, ICT service delivery quality and access programme of action's responsibilities are carried out in terms of the GPG ICT Strategy, Promotion of Access to Information Act (PAIA), Spatial Data Infrastructure Act (SDIA), State Information Technology Agency (SITA) Act and COBIT IT Governance framework. The department established an information management component as a means to execute the strategic plan, with the aim for provision of the necessary information management systems and tools to assist the department in improving knowledge management and decision making around its mandate. The above mentioned policy objectives and applicable legislation resulted with the demand for GDARD to rely heavily on ICT Applications for decision support. The department uses a wide range of commercial and custom in-house developed applications like Gauteng Integrated Decision Support System (GIDS) which is a unique Web enabled GIS ICT application used to integrate natural resources data with other relevant base spatial data sets and disseminate geospatial data and associated attributes to decisions on policy, strategies and operations of the organisation. The figure that follows gives an overview of GIDS GIS application thematic map.

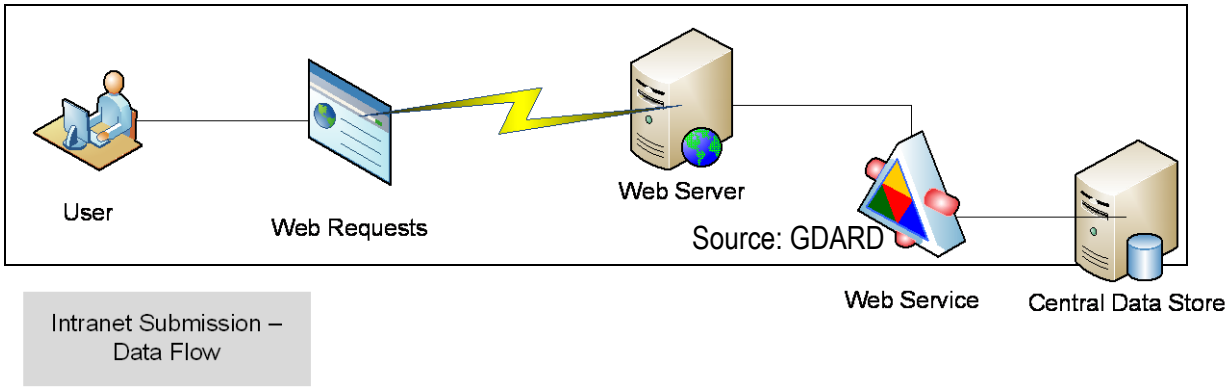
**Figure 1: GIDS GIS ICT Application Map**




**Source: GDARD, 2013.**

A web GIS is an integration of GIS and Internet technology used to access data and information without using a full package GIS software and to make spatial information available to a large number of people. It is a very useful way of disseminating spatial information to staff and the public, for effective decision making.

**Figure 2: GIDS Application Software Architecture**




**Source: GDARD, 2013.**

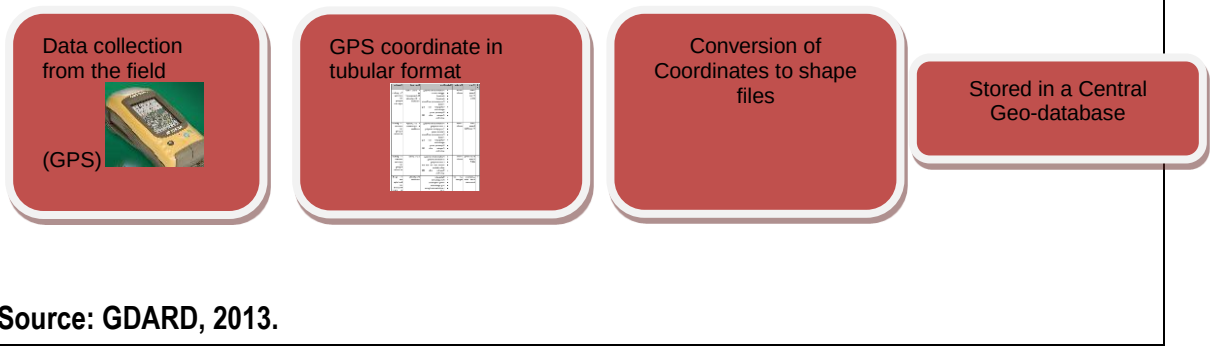
Figure 2 above, shows the GIDS software architecture overview and the next figure 3, shows how data is captured from the field by capturing Global Positioning (GPS) coordinates.

**Figure 3: GPS data collection**

**Source: GDARD, 2013.**

Figure 4 shows the data collection model and how the collected data is converted to electronic shape-files using software that allows it to be downloaded and stored in a Geo-database server and afterwards it can be accessible for decision-support on GIDS application.

**Figure 4: GIDS data collection model**




**Source: GDARD, 2013.**

## 1.3. The Public Service Institutional Framework

### 1.3.1. The Department of Public Services and Administration

The Department of Public Service and Administration is (DPSA) responsible for governance and related institutional framework for efficient and effective public services like corporate support, human resources, business processes, IT and governance. The DPSA's mandate is to ensure that IT is used as an enabler and to promote citizen centered ICT services. The institutions established to ensure implementation of this mandate is the State Information Technology Agency (SITA) and the Shared Services Centre specifically in Gauteng Province. The public service institutional framework has a direct influence on ICT policy and strategy implementation. The disjuncture between natural resource management policies, ICT policies and regulations impact on effectiveness of service delivery and thus has implications for the review of both policy environments.

There is uncoordinated collaboration in implementing the ICT governance strategy by CIOs between the SITA, the Provincial and Local spheres of government. Such institutional arrangements are not efficiently aligned to achieve optimal ICT millennium goals of e-Administration, e-Government and e-Service for the stakeholders. This study reviews the strengths and weaknesses of relevant policies, regulations and structures to explore the issues in order to inform policy intervention and to inform recommendations for future ICT strategies.

### 1.3.2. The State Information Technology Agency (SITA)

The State Information Technology Act 38 of 2002 and the State Information Technology Agency (SITA) focuses on centralising IT operations with the aim of saving costs. All Government Departments are required to develop Information Master Systems Plans (MSP) in order to align business and IT processes to ensure effective and efficient service delivery. This requirement is not closely monitored and there is a risk for misalignment of IT and business processes due to lack of an enforcement structure leading to noncompliance with regard to the MSP and other IT governance compliance requirements. The agency's limited resources have led to failure to implement certain critical IT projects.

### 1.3.3. GPG ICT Strategy

Gauteng Provincial Government (GPG) ICT strategy aims at venturing into new technologies to be in line with the global trends of ICT convergence and to take opportunity of integration and automation of service offerings in order to adopt the connected government approach. It also aims

at enhanced public service delivery through improved communication between government and communities by creating an enabled environment for the business sector to perform better, save costs and open job opportunities. GPG initiated the G-link project for broadband networking in the province in order to enable achievement of the above objectives. The province targets to build itself as a globally competitive city region and to be a gateway to the rest of Africa and the globe (GPG, 2012). Gauteng Province GDP is largely dependent on services and as such broadband infrastructure is seen as a tool for delivery of such services. For example capacitating stakeholders with e-services and skills development to ensure future realisation of the knowledge economy. The Province identified the need for more social and economic research is key because the pace at which policies are created is slower than technology trends.

There are opportunities to take advantage of cloud technology for public facing ICT Applications by aligning IT processes with business needs in order to strike a balance between business needs and technology. The mobile technology has increased IT service demands. Systems integration is becoming more crucial in order to deliver improved services to the citizens of Gauteng. Gauteng Province should capitalise on an ICT strategy that aims at transforming the provincial economy by determining how ICT can help to revive the province's economic competitiveness to boost domestic growth and foreign investments. New strategies are required for government to be more effective in dealing with challenges of increasing operational complexities and costs and as such, balancing ICT investments with operational needs and exploration of new technologies that can support the green ICT strategy is crucial.

### 1.3.4. The Gauteng Provincial Shared Services Center (GSSC)

The provincial government has mandated the Gauteng Department of Finance (GDF) to provide shared services for the province including ICT infrastructure. The Service Level Agreement (SLA) made between Gauteng Shared Service Centre (GSSC), Technical Support Services (TSS) division and Gauteng Department of Agriculture and Rural Development covers the provision of Support Services for the provision of support for the following services; Email and Shared Calendaring (via Microsoft Outlook), access to email is provided to facilitate the communication between the staff of the GPG, GSSC and their customers, according to the standards and policies of the GPG, Internet Access (via Microsoft Internet Explorer), connectivity to the Internet is supplied to customers according to the GPG standards and policies, access to the Enterprise-wide transversal service. Some of the enterprise-wide transversal service are hosted by SITA, standard Microsoft Office productivity tools and extended Productivity Services like Microsoft Visio and Project, WAN Services, connectivity within the GPG environment. The Wide Area Network is used by the GPG departments to connect to services hosted by the GSSC and its third parties. Service Desk Support Services are within GDARD and it includes logging of calls on issues raised,

escalation to the support team for resolution, change management service, introduction of new services and technology into their working environment, installations, moves, additions and changes within the working environment. The critical concern about the overall institutional arrangement is that the GDF CIO is regarded as the Provincial CIO whilst GDF is one of the GPG departments which also have their individual CIOs. Such an arrangement creates conflict among various GPG departments' CIOs regarding seniority and strategic decision-making.

### 1.3.5. GDARD ICT Strategy

GDARD CIO is responsible for alignment of GPG ICT strategy with GDARD ICT strategy and implementation of the IT governance framework recommended by DPSA. The GDARD ICT Strategy focuses on the achievement of the Provincial outcome for "ensuring an efficient and effective and development orientated public services and empowered, fair and inclusive citizenship through service delivery quality and access". The strategy implementation is overseen by an IT steering committee which is aimed at reviewing progress in implementing the strategic plan to deliver IT services, enable business processes, human resources, financial management, constraints and proposed solutions. The organisation's current ICT infrastructure strategy is to migrate to Cloud Virtual Server Solution as part of the departmental Knowledge Management programme. GDARD Head office, Regional offices and Nature reserves users can connect to GPG WAN using fixed and mobile data lines due to increased number of field workers. The high uptake of mobile devices by fieldworkers poses new risks of data security, theft and loss. This challenges have implications on mobile device allocation, management and regulation. The WAN provide connectivity between head office, regional offices and nature reserves, making ICT service centralised. Provision of optimal ICT Infrastructure, systems and support is critical to enable the Department to fulfil its mandate.

## 1.4. The Relevant Policies

### 1.4.1. The Spatial Data Infrastructure Act of 2003 (SDIA)

The National Department of Land Affairs and Rural Development developed the Spatial Data Infrastructure Act (SDIA). The act is established to guide the South African spatial information infrastructure through a committee for spatial information and development of an electronic metadata catalogue to provide for the determination of standards and prescriptions with regard to the facilitation of the sharing of spatial information. The act aims to provide for the capture and publishing of metadata and to avoid the duplication of such capture which costs the state enomours amounts of funds. The SDIA aims to address critical issues about data custodianship,

data systems platforms, metadata standards compliance, technology compatibility, interoperability and data centre platforms.

Implementation of the SDIA has been ineffective due to data custodianship challenges which led to the metadata-geodatabase not being updated. Most GIS intensive Government departments had high expectations like data sharing and collaboration through the initiative which seem be experiencing unknown difficulties. This has led to individual public service departments venturing into other opportunities. The act introduces Occupation Specific Dispensation (OSD) policy as a retention strategy for GIS specialists due to high GIS staff turnover in the country. The biggest challenge regarding implementation of the OSD is the requirement to register with the South African Council for Professional and Technical surveyors known as "PLATO". Capacity challenges to register with PLATO are experienced due to high volumes of applications to register with PLATO in order to be translated to OSD.

### 1.4.2. The Promotion of Access to Information Act 2 of 2000 (PAIA)

The Promotion of Access to Information Act (PAIA) gives effect to the constitutional right of access to any information held by the state, or by any other person, where such information is required to exercise or protect any right. The PAIA raises the demand for quick turnaround times from Government officials because it sets targets for public servants to respond to requests or queries of information and prescribes the obligations of both parties. This policy is aimed at facilitating service delivery but not all Government departments are geared to meet such policy requirements. GDARD has invested funds in projects that seek to address knowledge management and dissemination to address information capturing, processing and dissemination for compliance with PAIA turnaround times. Knowledge management approach was recommended as a relevant strategy and implementation of the initiative has progressed but not reviewed from an ICT Applications point of view and this is one of the reasons for conducting this study.

### 1.4.3. The Public Finance Management Act

Public services derive its budget mainly from the citizen's taxes and expenditure of such funds is guided by the Public Finance Management Act (PFMA). The purpose of the PFMA is to generally ensure that public funds are spent wisely to avoid over expenditure and under expenditure. The main weakness of the PFMA is that instead of supporting public service procurement systems, it is seen as being too rigid to allow co-ordinated and collaborated procurement of IT resources within Government. In most public service departments, IT is looked at from a technology supply point of view and not as an enabler of effective and effective service delivery by public servants to citizens.

The State Information Technology agency's objective is to centralise IT resources for efficiency but it is instead viewed by most IT managers as a bottleneck for IT service delivery.

### 1.5. The Summary of Introduction and Background

In summary, the introduction and background of the study focuses on the benefits and complexities of introducing integrated decision support ICT Applications. It gives a perspective of the impact of the underpinning ICT technologies in today's information age, the organisational demands vs the role of the CIO to influence ICT strategies. The GIS technology is introduced for its recognition to integrate the natural resources information, manipulate it, analyse it and visualise data to support decision making processes in order to attain the mandate for sustainable utilisation of natural resources. The research aims, the purpose of the review, background of the public service institutional framework, policies, regulations, strategies and structures are also discussed to determine their strengths and weaknesses that are or may cause a disjuncture between Agriculture and Rural Development business policies and the relevant ICT policies. The chapter concludes by outlining the expected benefits of introducing integrated decision support applications and sets the scene for the opportunity of e-Service delivery to address the organisation's business vision.

The chapter outline of the study is as follows; Chapter one: A perspective on the evolution of GIDS GIS ICT application for Agriculture and Rural Development in Gauteng; Chapter two: Literature review of the concepts, methodologies and frameworks applied in ICT Applications development; Chapter three: Interpretive qualitative research methodology for exploring rationalisation of spatial information; Chapter four: Report on findings about the evolution of GIDS GIS ICT application for sustainable utilisation and management of natural resources; Chapter five: Data analysis in the context of organisational benefits, knowledge management processes and public service delivery; Chapter six: Recommendations for the future GIS strategy and conclusion ; References; Appendix A: Documents used for information; Appendix B: Interview tools.

## 2. Chapter Two: Literature Review Of The Concepts, Methodologies and Frameworks Applied In the Evolution of GIS ICT Applications

Literature review helps to conceptualise and inform us better about the concepts, methodologies and frameworks applied in reviewing specific subject matters. According to the positivist approach, we identify our surrounding through the outcomes and the factors that predict it. The interpretive approach suggests that we know the world through processes and the patterns that describe it. ICT has always been used as a tool to deliver information and communication technology services used in today's world. ICT can contribute to issues of global importance, i.e. meeting the challenge of environmental sustainability which is a shared vision for Gauteng Department of Agriculture and Rural Development (Hanna, 2009).

This chapter is divided into three sections of literature review. The first section A gives an overview of relevant literature to gain understanding of the importance of information and communication technologies (ICT) in an information society. The purpose of GIS ICT Applications in agriculture and rural development is articulated in this section. The global experience of ICT Applications for socio-economic development, the use of the intranet, internet and spatial database engines for access to spatial information are also reviewed in section A. The next section B focuses on knowledge management tools used in the information society to get an understanding of how ICT Applications are practically used to identify, create, use, store and share knowledge. The last section C reviews the methodologies applied in analysing, developing, managing and controlling ICT Applications in organisations. The literature review concludes with a conceptual framework derived from the sections A, B and C.

### 2.1. Section A: An Overview of the Relevant Literature

#### 2.1.1. The Importance of Information and Communication Technologies (ICT) In an Information Society

Describing the importance of communication in an information society assist us to contextualise the ICT fundamentals for acquiring knowledge and creativity; improving the standards of living and encouraging productive participation in the economy. "The potential impact that ICT can have on individuals, businesses and governments depend largely on how policies are formulated and technology and markets evolve" (David, 2009).

Information and communication technologies like the Local Area Networks (LANs), Wide Area Networks (WANs), the Internet connectivity and access to ICT Applications like GIDS GIS ICT web applications are new forms of communication posing an information diffusion challenge to old

forms of ICT technologies. At the policy level, ICT evolution introduces new source of growth, new risks and challenges that threaten competitive advantage of organisations, raised competition in global markets, knowledge management and ICT infrastructure (Hanna, 2009).

GDARD's communication strategy vision is to be able "to engage its stakeholders on matters regarding sustainable use of natural resources" in both urban and rural farming communities where active farming activities occur (GDARD, 2003). In view of the need for public support and awareness about e-services initiatives to both urban and rural farming communities, the importance of communication in Agriculture and Rural Development is crucial in order to contextualise how communication drives technology to enable and promote citizen centred ICT services. Agriculture and Rural Development in the context of natural resources management practice constitute 10% of the of the total natural resources management threshold whereas 90% of the field's threshold focus is on the public relations element of natural resources due to the dynamics of evolving from the harvest and habitant era towards the leisure and recreation era. The primary goal of Agriculture and Rural Development is to protect, conserve and maintain sustainable use of the environment, "public relations role in natural resources management is key because the critical issue in managing natural resources is awareness, interest, attitude, opinion and belief" (Gilbert, 1975).

Pringle and David's (2003) article on rural community ICT applications supports Gilbert's view of community awareness. However, other essential elements for the success of ICTs in a rural context outlined by Pringle include; skills capacity, public access and locally appropriate content to demonstrate tangible ICT benefits in a rural area. ICT is regarded as a critical tool for public relations communication to facilitate socio-economic growth, therefore policy issues about convergence of ICT infrastructure access and ICT Applications need to be addressed. South Africa's telecommunications sector has been at the forefront of the country's infrastructural reform process, and was the first sector to confront some of the inherent tensions within the country's core policy objectives, including "the achievement of universal access to ICT services" (Gillwald, 2005).

Gauteng province has demonstrated its buy-in towards being an information society by adopting and adapting a number of strategies, for example knowledge management practices of e-Transformation, e-Agriculture , e-Decision-making, e-Government, e-Administration and e-Services contribute to address key objectives of efficiency and effectiveness towards public facing ICT applications. The Gauteng City Region Observatory (GCRO), through a partnership between University of Johannesburg, University of the Witwatersrand and Gauteng Provincial Government identified Gauteng city-region (GCR) which is an integrated cluster of cities, towns and urban nodes that together constitute the economic heartland of South Africa, accounting for 34% of national Gross Domestic Product (OECD, 2011).

Most natural resource stakeholders like farmers and farming communities of Gauteng reside outside the province's urban edge where terrain and economics of scale factors limit ICT network access. Examining how such communities' access GDARD electronic information services will assist to establish the magnitude of the digital divide and give general view of the extent to which ICT Applications contribute towards achieving the universal access obligation for social and economic development.

### 2.1.2. The Purpose Of GIS ICT Applications In Agriculture And Rural Development

General views about ICT Applications are to acquire knowledge and creativity, improve the standard of living, participation in social, political and economic sector. Value is regarded as the ability to distribute information to all participants in the economic system while at ICT application level, value is expressed in terms of interoperability, standards and quality of content, convenience and flexibility, reduced environmental impact, affordability, user-friendliness, availability and accessibility (Houghton & Sheehan, 2000).

Natural resource management involves urban environmental management which must integrate the spatial structural features of a city. The similar approach was adopted for GDARD approach to GIDS where the orientation data sets for Gauteng where acquired to form the base spatial data of various geographic features of Gauteng for example the geographic boundaries, roads, electricity, infrastructure etc. The additional spatial data integrated to these geographic features includes spatial data which is captured by the organisation for its different operations in the fields of agriculture, conservation, and environmental data for decision support. This form of urban environmental management addresses the problems that are spatially distributed as well as dynamic (Fedra, 2000).

The Republic of South Africa's key national outcome for comprehensive rural development is supported by the provincial strategic priority areas linked to outcomes oriented goals for ensuring that Gauteng becomes a modernised province with transformed agricultural sector that increase food security, economic inclusion and equality. This objectives are aimed to be achieved through implementation of various identified projects under the umbrella of a concept called urban agriculture. The article on development of a GIS application for urban forestry management planning states that green spaces are indispensable for the urban ecosystem in that, the trees, parks, urban and peri-urban woods can be the mitigation of temperature, pollution decreasing, protection from water run-off and soil erosion, aesthetics increasing and quality of places, providing a place for recreation, education and learning. Geographic Information Systems (GIS) has proved to be a powerful tool to inform decision making and manage land use efficiently and effectively

especially where there are competing priorities like Gauteng. The above stated study indicate and supports that information and communication technology (ICT) is a technology that can be adequately exploited in many scientific fields, aiming to help local authorities/administrations in decision-making processes. Furthermore, information systems have been widely used for environmental management issues and this diffusion affords many gains including reduction in projects and management costs. Conclusively, it is proven that GIS applications are an appropriate urban agriculture tool for public services (Tasoulas, Varras, Tsirogiannis & Myriounis, 2013).

e-Agriculture is an emerging field in the agricultural informatics, services, technology and information delivered or enhanced through the Internet and related technologies. E-Agriculture involves the conceptualisation, design, development, evaluation and application of new ways to use the existing or emerging information and communications technologies (Marciniak, Miroslawa, Ogonowski & Piotr, 2010). The most common e-Agriculture approach aims at improved information exchange and communication for the benefit of communities, service providers involved in the provision of agricultural, financial and communication services (Marciniak, Miroslawa, Ogonowski & Piotr, 2010). Content development is identified as critical for e-decision-making and e-Agriculture with issues relating to advisory services, field data collection, Internet support and network availability to access information. Agriculture and Rural Development in the information age is primarily driven by forces of converged technologies (i.e. web content, software applications, hardware and equipment) resulting in challenges of capacity, cost, scalability, flexibility, mobility and platform for innovation).

Another purpose of ICT applications in agriculture and rural development is waste management. The Gauteng Waste Information System (GWIS) is a web-enabled online system established to give effect to the provincial competencies bestowed by the National Environmental Management Waste Act 59 of 2008. The application is currently a non-spatial ICT application but developed to accommodate integration with spatial data in a GIS. An article, Sharifi et al (2009), claims that the evaluation of a hazardous waste disposal site is a complicated process because it requires data from diverse social and environmental fields. The key challenges discussed in the paper relates to processing of a significant amount of spatial information which can be used by GIS as an important tool for land use suitability analysis. Although the sitting process aims to locate a landfill that will minimize exposure to hazardous materials there are always other public, environmental or financial considerations which may dictates a compromise between environmental risks with other consideration linked to the unwillingness of local residents for landfill construction in their ambient surroundings. Such challenges are reportedly prominent in public service institutions in the developing countries like South Africa. The article argues that, safe and final disposal of hazardous waste in landfills is a missing element in the management of solid wastes in developing world. It recommends mitigating the impacts of hazardous waste on the environment and public health

through a rapid and efficient solution starting with landfill siting process using a MCDA approach guided by a panel of experts in the site selection process. Although the data that are used aim to secure high environmental and social standards the results that come up from the above methodologies lead to many seemingly appropriate locations. The suitability index should be applied to rank the proposed candidate sites and summarize the final selection (Sharifi, Hadidi, Vessali, Mosstafakhani, Taheri, Shahoie & Khodamoradpour, 2009).

### 2.1.3. Global Experience Of GIS ICT Applications For Socio-Economic Development

Agricultural land use planning is a leading issue for socio-economic planning aimed at achieving a sustained growth in production and increase in productivity. The global issue of concern is the high population growth rate against the limited amount of arable land. These circumstances have forced human populations to properly use the land by development of methods for optimal allocation of agricultural land to crops considering future needs of people, land capabilities and constraints as well as safeguard the agricultural resources for the future (Pilehforooshha, Karimi &, Taleai, 2014).

Socio-economic development is largely dependent on the use of natural resources and critical to this dependency is the sustainable use of such finite resources against infinite human needs. “It has long been accepted that, in a socio-economic sense, natural resources are those elements of the natural environment that have a use to man, and are therefore in demand, but wise supply falls short of the demand” (Perloff, 1969). The use of technology to facilitate socio-economic development has become more prominent and the operational dynamics thereof also poses policy and regulation challenges during the current information age. Wilson and Corey (2011), reviewed the global information society and came up with what they call the four spectra that help define information society i.e. devices, access, culture and governance. They introduce the concept of ubiquitous connectivity and new platforms for collaboration and information sharing that are considered as key elements for enabling new models of open innovation and mass collaboration. This concept set a scene about how electronically-mediated interactions are giving birth to virtual communities, transcending geography, institutions and disciplines ICT software and hardware cost/affordability, Internet access, network infrastructure availability and usage skills remain critical factors for using electronic media in delivering services. Current software applications demand high network access speed like broadband digital solution for transporting large packet of data cost effectively. Next generation network access like broadband which is a digital solution towards transporting large packet of data cost effectively are a typical example of future consumer demands. As killer applications evolve, bandwidth for heavy applications will be a future challenge (Hanna, 2009).

Hanna (2009) argues that ICT is an enabler for the transformation of all kinds of economic activities, national e-Transformation policies and strategies which the author regards as means to facilitate and compress the shift to the new techno-economic paradigm which refers to the network knowledge economy that we live in today. Principles of e-Transformation which is conceived as a process of fundamental structural change and shift to a new techno-economic paradigm are believed to be driven by ICT which is acknowledged as a powerful general purpose technology. Hanna (2009) identifies decentralised integration, network structures, adaptability, agility, customisation, knowledge capital, innovation ecosystems, transformative leadership, synergistic and change management as examples of e-Transformation. The literature disputes the view that e-Transformation within organisations is only about automation of existing processes and supports the view that it should actually encompass all elements of e-Transformation processes like policies, institutions and capabilities to leverage the new technologies. e-Transformation should not just focus on promoting the ICT industry or ICT investments but it should be guided by the overall development vision, goals and strategy of the country itself, which is the reason for this study to focus on ICT application in natural resource management for environmentally sustainable growth, elimination of poverty, effective and transparent governance, competitive and innovative economy, learning society, etc. The author concludes by defining e-Transformation as e-development, ICT enabled development, information society and knowledge economy collectively (Hanna, 2009).

With reference to the e-Transformation definition, it is clear that the concept of e-Transformation and network knowledge economy complement each other besides that network knowledge economy emphasises the network infrastructure element at local and global economics. According to (Houghton & Sheehan, 2000), Network knowledge economy "is one in which the generation and the exploration of knowledge has come to play the predominant part in the creation of wealth" which is relevant to e-Development, ICT enabled development, information society and knowledge economy. The common aspect of the above-mentioned concepts is that, they all contribute to socio-economic development to increase production, skills, learning, organisation and innovation. Houghton and Sheehan (2000) state that the intensity of knowledge economy has risen and our ability to distribute that knowledge has increased its value to all participants in the economic system. They refer to the following, as characteristics or key levers of the network knowledge economy; research and innovation, human capital, ICT infrastructure, networks and policy regulation. Literature on global experience reflect that ICT has always been perceived as a tool to deliver information services used in social and economic contexts of most developing countries and the developed world.

The integration of time in geographic information systems has been an ongoing research theme for many years. Since then, the literature about temporal GIS concepts and related topics like spatio-temporal database models has grown rapidly resulting in various GIS methodologies, models and

approaches. Geographical data definition is a mapping from spatial locations to values that may be any kind of data structures. The field provides a coverage of space using irreducible minimal regions, for example represented as a pixel. A mapping that assigns a value to each location at each time is called a spatio-temporal field. The distinction between an object based and field based view of geographic information is an important concept in geo-information science. Field based temporal GIS has been a key technology for integrated assessment modeling that is common in the climate change research. High resolution environmental datasets like imagery requires to be efficiently managed, analysed, processed and visualised because it is often large data sets and this has implications on the GIS components such as human resources, software, hardware, costs. This challenge has resulted in a demand for several environmental modeling software systems and GIS solutions but in order to choose a viable solution which is effective and efficient, user needs analysis has been recommended by most GIS researchers (Gebbert & Pebesma, 2013).

Natural environment information management system involves on-line instrument monitoring, data communications, database establishment, information management software development that relies on collecting effective and reliable environmental information. The article identifies such characteristics as salient features that increase the uptake for using and sharing of environment information by advanced information technology, and maximising timely and scientific foundation for environmental monitoring and management. The article demonstrates adoption of C# plug-in application development and uses a set of embedded GIS component libraries and tools provided by GIS Engine to finish the core of plug-in GIS application framework, namely, the design and implementation of framework host program and each functional plug-in, as well as the design and implementation of plug-in GIS application framework platform. The findings and recommendations adopted may be advantageous to GDARD by offering a technique for development of a dynamic plug-in solution that will assist the organisation to quickly establish a web-based GIS application solution by applying a visualized component collaborative modeling and GIS application integration. In addition, the solution is said to be compatible to ESRI platform or shape-file platform which is currently used by GDARD. As stated in project ROSIE report, the challenge for GDARD is providing wider access to spatial and non-spatial information to GDARD stakeholders. This article similarly recommends the integrated technology system and it outlines the theory behind multi-level and different-scales of application patterns. It takes into consideration the high uptake of technology for example computers and mobile smart devices as people begin to adopt such technology. It is due to such advances in technology that the demand for application design framework theories should adapt to current changes in order for ICT applications to generally be effective and efficient means to facilitate socio-economic development. The article views reliability of products as critical in reducing ICT applications project development cost including GIS. It specifies that GIS secondary developers would organise its key programmer to develop a GIS application framework and encapsulate some general-purpose core functions using different

technologies and strategies, but their purposes are the same, i.e. to reduce the workload of coding repeats, increase programming efficiency and provide project personnel with a favorable platform and workflow. The recommended framework consist six levels and two systems. They are spatial basic network level, data level, services level, application level, security authentication level, display level. This levels are comensorate to the key elements of a GIS used as a framework for project ROSIE in GDARD and they form part of the conceptual framework for this particular study. The only limitation of the plug-in application framework is the dependency on ArcGIS server Engine which may be a challenge to organisations that adopted different geo-database engines (Qun, Yujin & Yuena, 2012).

The high GIS costs of GIS are driving most organisations to consider open source geographical information system that would allow the efficient management and processing of massive GIS data and the spatial data analysis of relations between attribute and spatial data fields but the technical challenge of open source skills has resulted in very slow uptake of the technology which is the reason why the commercially-off-the-shelf (C-O-S) GIS software vendors are monopolising the GIS market.

### 2.1.4. The Use of The Intranet, Internet and Spatial Database Engines for Access to Spatial Information

This subsection discusses how the Internet can be used to access spatial information through GIS ICT Applications. The term Internet is usually used for the global encompassing public network. The Internet is the World's largest network consisting of a multifaceted mosaic of computer servers supplying information upon request to multiple client computers. The Internet is unified by common use of the protocol known as Internet Protocol (IP). The Intranet is private networks that use standard Internet technologies to link organisational computers and enable them to broadcast information within an organisation. Technically the two are identical with respect to the method of communication and the services they can support. An Intranet is usually separated from the Internet by an electronic device for filtering network traffic. In the context of Geographic Information Systems, the Internet has many potential uses, some of the most obvious being data publishing, product sales and distribution and GIS services. Ideal standard tools to access spatial information on the Internet include using the standard browser and server technology. Spatial database engine is a high performance geo-processing server offering extensive capabilities for managing and processing spatial data, it uses commercial off-the-shelf relational database management systems (Dodge, 1998).

The rapid expansion of the Internet provides spatial data suppliers with a completely new means for disseminating spatial information to the general public. At the same time digital maps can be

seen as an interface to the vast amount of information contained in public networks. Some new technologies have emerged as possible alternatives to plain Hyper Text Markup Language (HTML) solution, to implement more intelligent, interactive client applications. These clients are also capable of handling vector based spatial data. The new technologies open to the wide Internet audience give access to spatial information in the form of intelligent objects equipped with properties and behavior. Another benefit of geographic information to be delivered in object form is that a spatial object can contain different types of data, coordinates as floating-point values, attributes in various data types, even images or other multimedia, thus enabling flexible use of varying visualization methods in the browser (Verbree, 1999).

In South Africa there is a growing awareness of economic importance of geographic data and consequent expanding use of GIS to exploit geographic or spatial information. The Department of Land Affairs and Rural Development's National Spatial Information Framework (NSIF) has made initiatives to develop GIS to enable information governance and decision making. Aligning efforts to develop spatial data infrastructure will enable the sharing and re-use of information, thereby producing savings through reducing the considerable costs involved in recapturing spatial data. The NSIF has framed a coherent spatial data infrastructure along similar lines to many other initiatives Worldwide, at both National and Provincial levels. The NSIF sponsors the development of a Spatial Data Discovery Facility (SDDF). The fundamental goal of the SDDF is to provide access to spatial data on the Webb. Through the SDDF, the NSIF hopes to minimise duplication of effort in the collection of expensive digital spatial data and foster co-operative data collection activities. The SDDF also seeks to provide access to GIS data sets that were not widely available and promote the standardisation and sharing of spatial data. The NSIF intend to provide links through the Internet to distributed sites where data are provided or maintained. By clicking the SDDF hyperlink of the NSIF Internet site, the SDDF can be accessed. This Internet based SDDF enables users to search for description of GIS data sets maintained by government and commercial organisation across the country by using a distributed metadata base system. The metadata contained in the SDDF nodes describes spatial data that exists in a variety of formats such as the digital GIS data, satellite imagery and hard copy maps. When combined with the World Wide Web, the SDDF provides a simple method of discovering through distributed sources what GIS data sets exists, where it is being produced and how it can be accessed (Department of Land Affairs, 1998).

The future of GIS on the Internet and World Wide Web creates the new opportunity to develop software for distributing geographic information. Because the local computers carry out the processing of objects, Internet traffic will be greatly decreased and the stability of system operation would be improved. GIS functionality, as an information system to manage and visualise spatial data will be in great demand across the Internet in the future. A concrete design of GIS network

distribution technology responds to the challenge of the technical and conceptual problems in delivering GIS capability across the Internet. Users of GIS often need immediate access to current data and information for proper analysis of GIS data. In the past, data sets were captured by an organisation to serve specific purposes and were mainly used by specialists within that organisation. The capturing of data sets represents substantial involvement for each organisation to maintain GIS databases and results in exorbitant levels of duplication. The high costs involved in data capturing and lack of efficient access to existing digital data stress the importance of finding alternatives to enhance GIS data sharing on a national and international level. The advent of the Internet and the World Wide Web provides a breakthrough alternative to spatial data sharing. The current situation in the Internet does not totally allow for global deployment of Net GIS-like services, the most important obstacles being the need for relatively fast Internet connection, and the still existing incompatibilities between Java virtual machine implementations. The experience gained thus far strengthens the assumption of Java's suitability for implementation of a web-based GIS application. Compared with the existing raster-based solutions, delivery of spatial information as individual objects has several benefits. These include the opportunity to interact with a local software object, for instance, to request additional object-wise Information (Dodge, 1998).

The high demand for public facing web based GIS introduced a new GIS approach for designing and implementing of a web-based GIS through Participatory Geographic Information System (PGIS) framework. The PGIS is characterised by the integrated GIS and decision-making tools that are intended to involve different stakeholders and the public for solving complex planning problems and its aims and objectives are building consensus between the host of PGIS, stakeholders and the public. The study's justification of public participation shares the similar principles of the user needs analysis methodology. It is slightly different to the user needs analysis because it points out the importance of public involvement during early planning stage of GIS projects with a spatial nature for future legitimacy and acceptance of these projects. The strengths of this approach and its benefits are recommended for public facing ICT applications like GIDS to take the public stakeholders needs into consideration in order for the web-based GIS solution to be effective and efficient in delivering Government electronic services. The PGIS framework integrates three components including a discussion forum, a mapping tool and a decision tool. The implementation of the proposed framework used a thin client-server environment with three-tier architecture. The PGIS methodology simplifies the system in terms of its user-friendliness, and encourage wider participation in the spatial decision-making process (Mekonnen & Gorsevski, 2014).

Chapter one, section A (introduction and background) of this study gives a background of GDARD's efforts and rewards brought about introducing web-enabled GIS in the organisation. The article by Wray and van Olst (2012) puts emphasis on the value of GIS and spatial data to

governments because most governments' data is spatially based and is best visualised and interpreted using a Web GIS mapping application. It reveals the inefficiency of GIS being a tool used only by GIS professionals, limiting the full potential of GIS to be citizen centric especially in public service organisations. An example of Web 2.0 mapping applications such as Google Earth, which have revolutionised public access to spatial data and GIS technology is stated and acknowledged for triggering the public expectations of what is possible online. GCRO has helped GPG including GDARD, to meet these expectations by spatially enabling their data and systems with fresh innovative Web GIS mapping applications and opening access to Gauteng and even wider access to anyone outside Gauteng who has access to the Internet.

## 2.2. Section B: The Knowledge Management Tools Used in the Information Society

### 2.1.1. The European Perspective on Knowledge Management

Knowledge is the combination of data and information, to which is added expert opinion, skills and experience, to result in a valuable asset which can be used to aid decision making. Knowledge may be explicit or tacit, individual or collective. Knowledge Management is the management of activities and processes for leveraging knowledge to enhance competitiveness through better use and creation of individual and collective knowledge resources. In the current information age, maximizing the benefits of knowledge as an asset is critical. Knowledge Management (KM) practices benefit organisations by improving performance and capacity for innovation. Most organisations recognise that successful KM implementations lead to new and improved business processes enabling multidisciplinary knowledge sharing, communication and collaboration (CEN, 2004).

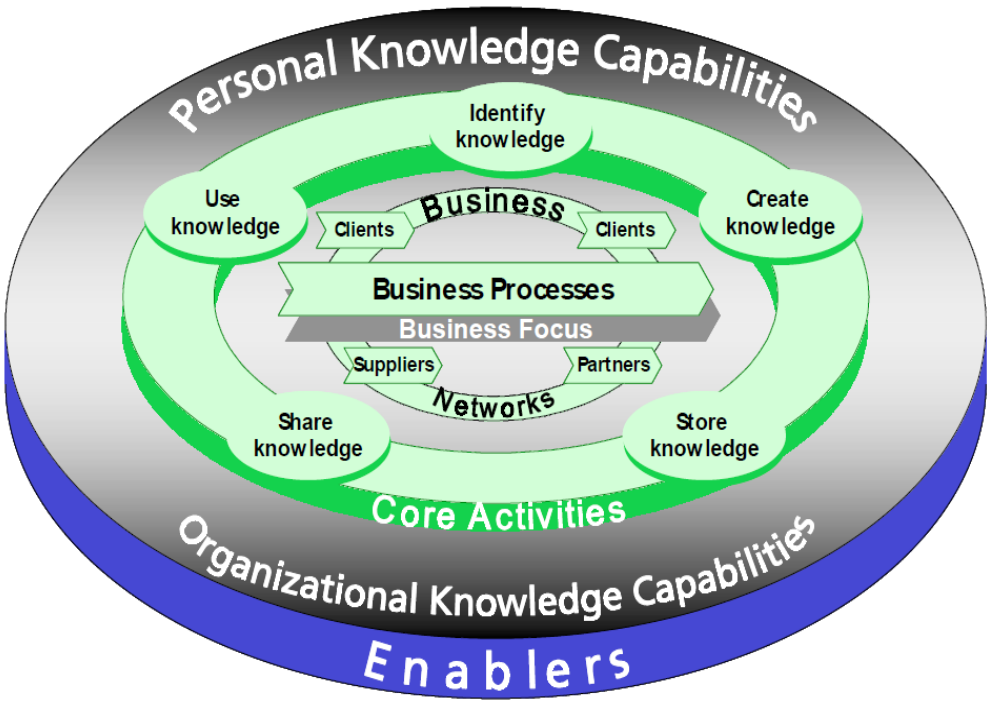



**Figure 5: The EU Knowledge Management Model** **Source: CEN, 2004.**

The European perspective on Knowledge Management is as follows;

a) The business focus should be in the centre of any KM initiative and represents the value-adding processes of an organisation, which may typically include strategy development, product or service innovation and development, manufacturing and service delivery, sales and customer support. These processes represent the organisational context in which critical knowledge, such as knowledge about products and services, customers or technology is created and applied. Furthermore, these processes are now becoming more and more inter-organisational, as organisations operate in business networks with suppliers, partners and clients.

b) Five core knowledge activities have been identified as most widely used by organisations in Europe: identify, create, store, share and use. These represent the second layer of the framework by forming an integrated process. These activities are typically performed in support of the wider business processes. Their integration and performance within an organisation have to be supported by the right KM methods and tools.

c) The enablers represent the third layer and comprise two main categories, called personal and organisational knowledge capabilities, which complement each other. These capabilities should be seen as the enablers for the knowledge activities outlined above. Personal knowledge includes those capabilities such as ambition, skills, behaviour, experience, tools and time management which have to be developed at the personal and group level in order to generate improvements from knowledge handling. Organisational knowledge capabilities are those that leaders have to establish in order to facilitate effective knowledge handling within the value-adding processes, by both internal stakeholders (such as managers and employees) and external partners (such as suppliers and clients). These capabilities include the mission, vision and strategy, the design of processes and organisational structures, measurement, understanding of the culture, the use of technology and infrastructure, as well as the development of the collectively available knowledge of an organisation called "knowledge asset".

The following sub-sections review how knowledge management practices of e-Transformation, e-Agriculture , e-Decision-making, e-Government, e-Administration and e-Services contribute to address key objectives of efficiency and effectiveness.

### 2.1.2. e-Government

e-Government refers to the use of information and communication technologies, particularly the Internet, to deliver government information and services (ANOA 2006). Electronic government systems use any and all forms of information and communication technology by Government to enhance operations, the delivery of public information and services, citizen engagement and public participation, and the very process of governance (GPG, 2009). ICT Applications in Government are used as a means to enhance service delivery through automating manual processes by developing or procurement of commercial-off-the-shelf software that meets the needs of an organisation. Computer and information applications like databases and software systems ensure efficiency through automated processes that improve administration for individuals, business and Governments. In view of the possibilities and opportunities of e-Government, several adopted it as a solution. The adoption of e-Government strategies by various Governments raises hopes with regard to improved efficiency and effectiveness of internal administration within Government and to relocate Government services away from Government offices to locations closer to citizens. According to the international development agenda by the United Nations and in line with the regional millennium development goals promoting the exchange of experiences, ideas and best practices concerning innovations in governance and public service administration contributes to social and economic development. e-Government is considered as an effective ICT means to renders online content sharing and collaboration.

e-Government initiatives cost substantial amount of money and yet efficiency and effectiveness issues remain unverified in most developing countries (i.e. improvement in productivity, management effectiveness and quality of service offered to citizens). A key concern regarding ICT Applications in many organisations is deriving value out of typical high costs associated with developing, buying and maintaining ICT Applications. There are usually high expectations to obtain true value from the investments made in ICT projects and demand on ICT application projects to meet organisations current and future operational challenges. ICT architecture for Government requires multi-tier organisation framework which consists of a client-server architecture in which the presentation, the application processing, and the data management are logically separate processes called 3 tiers (Dwolatzky, 2009).

The Gauteng Provincial Government's e-Government vision is to be open for business from any place and at any time through the use of e-Government applications and create one point of entry for all its Citizens. Gauteng Provincial Government regard e-Government as the ICT-enabled route to achieving good governance through increasing efficiency of Government operations, enhancing transparency, and providing better services to citizens and businesses. The Gauteng Provincial Government e-Government vision is to be open for business from any place and at any time through the use of e-Government applications and create one point of entry for all its Citizens. The e-Government Business Unit within the Gauteng Shared Service Centre commissioned a project for the development of the monitoring and evaluation framework for e-Government and Information Society and Development. The project is an integral part of the Gauteng Provincial Government's e-Government programme which seeks to introduce improvements in service delivery, across provincial and local Governments, through effective e-Government applications and services.

The Wray and van Olst (2012) article gives some background about e-Government in South Africa in the context of a global shift to fully connected governments. The practical example of the GCRO GIS website is used to explore and portray the Gauteng provincial government evolution of GIS in the context of spatial data and tools required to make informed decisions pertaining to future development. The article brings into the scene the definition of collaborative government, which is defined as working in conjunction with others and empowered by the introduction of Web 2.0 technology, the result is referred to as Government 2.0. which is about leveraging the power of Internet-based Web 2.0 tools to change the way governments interact with society, share information and ultimately, achieve better outcomes for citizens (Hughes, Macmillan & Medd, 2008).

Schofield (2009) looks at how the business of Government, i.e. service delivery, is affected by ICT application development processes. The author looks at the technology and processes for handling the logistics of Government, the requirements of governance and the demands for efficiency and

compatibility with innovation, and the cost thereof in proportion to Government affordability because software development is seen as a risky process. The software development process relies on the quality of the service required and a successful software development project of a software development project is determined by the maturity of the processes used to deliver. Most software projects are deployed meeting at least 75% of the required specification for a number of reasons. The hardest and riskiest step in system acquisition is understanding what is required and thus the user requirements gathering process and sign off to the specifications agreed is crucial to keep the ensure that the software is delivered within the agreed specifications. This measure covers both the user and the developer for quality control and project control purposes. Understanding the business needs usually involves negotiation between different stakeholders, analysis of the business requirements and derivation of system requirements (Dwolatzky, 2009).

The above experience is evidence that development of custom software requires good management. In the ICT Applications development environments, it is generally believed that IT projects fail frequently and most successful application developers find a solution to the challenge through a combination of methodologies for custom software development and project management because of the bad track record of systems delivered late and not meeting user expectations. A workshop aimed at fostering experience sharing sponsored by the Swedish Program for Information and Communications Technology in developing Regions (SPIDER) looked at opportunities for formulating new projects and research ideas to enable formation of partnership with the focus to learn a model for ICT application, environment and development. The workshop discussions centered on questions of power and equity, poverty reduction, collective learning and private sector involvement in order to invest in ICT to foster development.

e-Government applications are hosted centrally in Gauteng Provincial Government. The idea of rationalising the use of resources to reduce poverty and generate wealth includes ICT resources. Gauteng online information services are in a form of Internet websites that provide relevant information such as; Children and youth services, social and welfare development, senior citizens, people with disabilities, education and training, health services, housing services, safety and security, grants, victim support and empowerment, economic and organisation development, Agriculture and Rural Development, public transport, roads and works, online schools and vendor management services. Examples of on-line information services in GDARD on line transactions like applying veterinary health certificates for importing and exporting animal products, conservation permits, waste information system for compliance with waste transportation and disposal.

### 2.1.3. e-Administration

e-Administration considers the citizen as a consumer or customer who has rights to claim personalised and efficient public services. It corresponds to the South African democratic slogan of "government for the people by the people" with a strategy of citizen satisfaction improvement. The output of effective e-Administration is increased involvement of the public in the decision-making processes of the government. e-Administration is about public organizations seeking to improve the services rendered to the citizen, by reducing the cost and time through using ICT applications. The author presents three types of e-administration tools, namely; transparency, facilitating procedures and personalize services. For example: e-Procedure, personalized account, on-line payment, file checking, etc. These tools are appreciated by the customer-citizen, who seeks outstanding services. The second type of tool aims to consult with the "passive" agent-citizen, in order to improve the acceptation rate of a policy. e-Voting is the most representative tool. The last kind of tool aims to favour the participation of the active citizen by allowing the citizens to generate new ideas, debate them and developing constructive propositions.

e-Administration deals primarily with the back-end processes, internal structures of Government and has an internal focus. In other words, e- administration refers to the internal mechanisms, processes and structures of Governments. e-Administrative initiatives are introduced to increase the efficiency of administrative processes through automation and ultimately to ensure greater Government transparency (Curtin, 2007). e-Administration applications development, hosting, support and maintenance are a sole responsibility for individual Gauteng Provincial Government's Departments. Electronic administration software applications in GDARD are the MEC referral, contacts database, software library and GIS software application for decision-making with regard to environmental sensitivity, conservancies of endangered species, protected heritage sites and agricultural potential hubs. The idea of rationalising the use of resources to reduce poverty and generate wealth includes rationalisation of ICT resources through e-Administration.

The demand for high capacity internet services to accommodate e-Administration in both developed and developing countries is increasing. Convergence of value added services such as voice, data and media services to be transmitted over the same network could have an enormous impact on economic and social development, increasing productivity, lowering transaction costs, facilitating trade and increasing retail sales and tax revenues. Examples of online information services are online opinion polls, email responses, transactions on line like completion and electronic submission of tax returns, single virtual counter service for information and service delivery (David, 2009).

The critical factors affecting the successful implementation of ICT projects in Government include inadequate funding, high operating costs, lack of ICT policies, lack of coordination, focus on internal traditional administrative applications rather than public facing applications for effective information processing and distribution and unstable ICT resources. Project management is crucial for implementing ICT Applications projects because ICT project implementation success critically depends on skilled project team resources, management support, ICT facilities quality, information systems quality and perceived benefits. The social and economic benefits of e-Administration prevail when individuals, businesses and Governments use ICT to contribute towards sustainable development (Gichoya, 2005).

### 2.1.4. e-Services

e-Services is simply means electronic citizen services. The focus of e-services is mostly the supply and demand of e-Services. An analysis of the demand of e-Services reveals how the internet has created a new window for citizens to interact with the public sector through the means of electronic services (e-Services). The study gives a perspective of how the western world is competing to offer as many e-Services. The key focus on e-services is about how citizens access e-services. The present study applies a demand perspective focusing on which e-services citizens actually use. The use of e-services during a specific period is analysed based on log-files from the largest provider of e-services. The study fuels a discussion of whether or not the offerings of municipal offering of e-services are driven by technology fads or if they are exponents of an investment in the future that aim at improving the quality of life of citizens. The study recommends a change in focus beyond singular phenomena and technical capabilities but to also focus on uptake, deployment, and implications of the public sector providing electronic services to its citizens and thus opening the discussion of citizen inclusion in or exclusion from the e-society (Henriksen, 2006).

The diffusion of e-Services in GPG departments is at different levels of development and maturity. Most reports on success and failure are aggregated at national level and not at provincial level. Such bias is negative because the individual provincial Government departments cannot gauge their progress and compare among themselves in order to learn from successful departments. There is mention of numerous success stories in literature and evidence that successes do not balance with the investments into the projects.

e-Services are key components underpinning e-Government while ICT infrastructure facilitates creation and distribution of knowledge and information to enable sharing knowledge across geographic boundaries. Policy and regulation provides a framework for global and local usage and interaction of knowledge. Internet connectivity is key to access electronic services like web applications. These are new forms of communication posing an information diffusion challenge to

old forms of organisations and Government resulting in key local and global actors influencing Government and markets to build new models of collective action and bottom-up development. On the policy dimension, ICT revolution introduces new source of growth, new risks and challenges that threaten competitive advantage of countries, raised competition in global markets and in knowledge management (Hanna, 2009).

Lack of ICT literacy skills limit the potential use of e-Services. e-Skills project introduced by the National Department of Communications is an attempt to address ICT literacy skills in the South Africa. The RSA Government strategy aims at addressing the same problem irrespective of efforts to address ICT skills shortage in South Africa.

### 2.1.5. e-Transformation

Investment growth in the ICT technologies by most organisations including public services has increased and such investment require validity of the extent to which the intended outcomes are achieved. The impact of such outcomes on the social and economic landscape requires effective institutional policies. In the current information age, ICT is enabling the transformation of all kinds of economic activities: financial services, manufacturing, transportation and logistics, education and health care, media and entertainment, public services, science and innovation and more. e-Transformation policies and strategies are regarded as a means to facilitate and compress the shift to the new techno-economic paradigm guided by principles of e-Transformation, i.e. decentralised integration, network structures, adaptability, agility, customisation, knowledge capital, innovation ecosystems, transformative leadership, synergistic and change management. At an organisation level, e-Transformation goes beyond automation of existing processes to encompass fundamental redesign and innovation of business processes and practices, the internal relationships within the organisation, the relationships between the organisation and its stakeholders and operating environments. The implications for this requires acting on all elements of e-Transformation process like policies, institutions and capabilities to leverage the new technologies and not just promoting the ICT industry or ICT investments. The ends of e-Transformation should be guided by the overall development vision, goals and strategy of the country itself: environmentally sustainable growth, elimination of poverty, effective and transparent governance, competitive and innovative economy, learning society (Hanna, 2009).

The radical transformational change towards citizen-centric public services and policy outcomes through the transformational impact of e-Government to meet the demands of continually changing, globalized society. e-Government is believed to have a transformational impact on government's performance, governance, and public service. Chatfield's (2009) paper examined the relationship between public service reform through e-Government and actual government

performance. A multi-method approach was adopted to provide a citizen-centric, online income and other tax returns filing and payment services for individuals and corporations. Although e-Government research results on the transformational impact are mixed, transformational impact on performance and service process reform were achieved and this is the reason why Governments worldwide are engaged in public service reform initiatives through e-Transformation. There are fears achieving organisational transformation of bureaucracy through e-Government is highly risky and complex because of internal stakeholder buy-in and commitment required from policy makers, management, and public servants. The limitations of the study lies in the level of risk and complexity of gaining external stakeholder trust in government. The main concerns about public access to the internet and effective use of new ICT application tools before the public administration can achieve the potential transformational impact of e-Government and realize the desired policy outcomes (Chatfield, 2009).

## 2.2. Section C: The Methodologies Applied in Analysing, Developing, Managing and Controlling ICT Applications in Organisations

### 2.3.1 Integrated use of Geographical Information Systems (GIS) and Multi-criteria analysis (MCDA)

The integrated use of geographical information systems (GIS) and Multi-criteria analysis (MCDA) is one of the recommended methodology applied in several fields of research with proven benefit from the integrated use of geographical information systems (GIS) and Multi-criteria analysis (MCDA) such as addressing the environmental and land management issues, or territorial and urban analysis. This methodology emphasises is based on a combination of spatial multi-criteria decision problem, geographical data (input) is and transformation into a resultant decision (output) either by interfacing a Geographical Information System (GIS) with Multi-Criteria Decision Analysis (MCDA) methods which are basic tools in the field of environmental valuation and management" The approach has capability to support decision-making, involving several different aspects to be taken into account at the same time. This output is a key indication of integrated use of geographical information systems (GIS) which is also a key objective of this research. The negative side of the method is its approach which assumes the spatial homogeneity of alternatives within the case study area although this is often unrealistic, because of the differences in the evaluation criteria The paper present a new MCDA-GIS integration tool and show-cases its potential. The paper ends with the conclusions that recommend integrated GIS such as GIS-MCDA (Massei, Rocchi, Paolotti, Greco, & Boggia, 2014). The article's strengths is taking into consideration the integration using existing GIS software which has relevance to the state of GIS in GDARD before the centralisation and integration strategies were implemented. Advantages of the methodology are

the inclusion of the users which is advantageous for improvement of the integrated GIS and the user orientated approach to successful integrated GIS implementation.

### 2.3.2 Cost Benefit Analysis (CBA)

The CBA methodology was developed as a technique to inform decision-makers on whether a project investment would yield the necessary benefits. Without a firm understanding of the implications upon budgets there is a danger of over commitment and subsequent failure of implementing a GIS. Although understanding of the technical issues within the specialists' discipline has increased substantially, the business context of GIS is still not well understood. The complex technical issues are mainly in line with the need to integrate GIS on to the corporate information systems architecture and a large number of organisational and behavioral issues are introduced. An emerging solution is the use of Cost Benefit Analysis based on a systems philosophy and the acceptance of a multiple-methodology approach based on some recognised critical success factors. Some factors focus purely on the task of structured code production, while others take a much wider perspective and consider supporting the process from the business analysis to final implementation (Coulson, 1992).

During the preliminary phase to implement GIS, the information strategy team needs to determine which of the number of competing possibilities will provide the greatest net benefits for the organisation similarly to GDARD challenge to prioritise competing land use needs. A relevant technique, which is often used in these circumstances, is the Cost Benefit Analysis. To implement CBA effectively, much can be learnt from the success and failure of pioneer organisations and from contacts with the potential hardware and software data suppliers. Contacts with the external environmental can shorten GIS application development times and can help to avoid repeating the costly mistakes of others. Many GIS projects groups appear to go about the task of generating information about the external environment in fairly informal ways like attending conferences, inviting demonstrators from vendors, reading relevant material and making visits to reference sites. A more structural approach would be to conduct research surveys. Although the external environment will provide a context for a project team's work, the major emphasis should be internal activities such as Cost Benefit Analysis, User Needs Analysis and risk analysis (Reeve, 1988).

The CBA methodology is more appropriate to an environment where there is direct monetary values and the cost are defined, although it is said that few organisations have fully tested the implications of GIS. Reviewing the cost associated with the GIS project is not an easy task due to the number of cost components, which need to be included and may not be immediately apparent. In most occasions it difficult to project monetary value on future return on investment. The feasibility study is thus critical during inception of GIS projects and where possible, through to the

implementation and running cost of the system. The recommended stages during the planning process are the functional requirements study, system implementations planning, systems evaluation and solution, systems integration and startup (Tomlinson, 1989).

The CBA methodology is not popular to most GIS managers because it attempts to quantify the benefits in monetary terms rather than qualifying the benefits. The main reason that contributes to resistance against the CBA methodology is because GIS outputs are not as easily quantified and as such qualitative approaches are more relevant to services environments as opposed to the manufacturing environments. There is no single approach recommended to solve this challenge. The successful deployment of GIS has mainly attributed to mixed-approaches that when combined yield success.

Coulson (1992) states that "although almost every project team feels obliged to use Cost Benefit Analysis in some form or another, almost everyone who has actually used it is actually aware of its limitations". All the costs which a system would generate over its lifetime are accounted for in a consistent monetary basis. Similarly all the benefits which could account from the system over its lifetime are allocated a money value, and thus it should be possible to calculate a cost benefit ratio. There has been resistance to adopt this method of evaluation because current technology investment assumes that successive technological developments improve efficiency and have lower capital cost. For example if an organisation waits for a year before investing in IT, then the advantage of new technology is lost, but the loss (in cash terms) will be apparently lower. On the other hand once investment has taken place, operating costs start to undermine that investment, as it in turn becomes outdated (Coulson, 1992).

The level of investment in GIS is another particular concern for those charged with developing a GIS implementation strategy. A small start may be ineffectual, however a major corporate investment may over stretch an organisation and be counterproductive. Most organisations may be seeking a middle path and it may be that economic theory can provide an insight into the boundary between success and lack of success of the investment. Theory indicates that for each investment there is a theoretical limit for how much benefit can be obtained. However, as investment rises the theoretical benefit does not arise in direct proportion but by a series of steps called "critical mass". The higher the investment, the larger the critical mass and the greater is the theoretical benefit. Another GIS initiation strategy exists where organisations start with GIS in relatively specific application areas. This has usually been successful because a low investment by being highly specialised, does achieve its objective, in both a short time and within its low budget. There is a danger, of attempting to scale up this state of affairs. Any wider GIS development has to be more general as opposed to specific and the economics of a wider scope mean that a system has to have greater flexibility and hence complexity. An optimal development is attained by combining

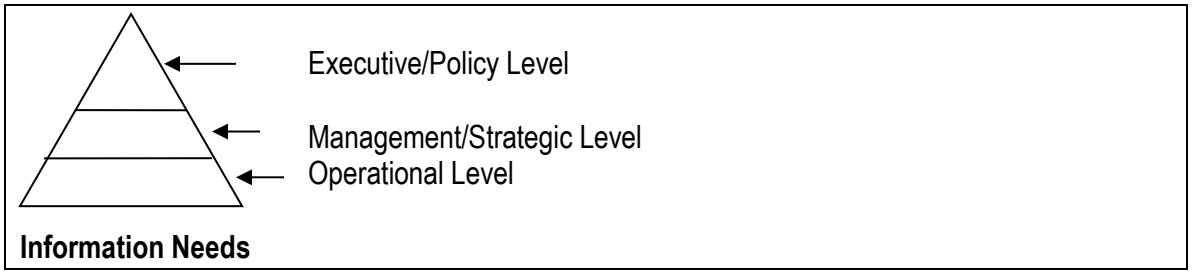
applications that are similar in type for early development yet planning a system with generality and flexibility as an insurance against future demands (Reeve, 1998).

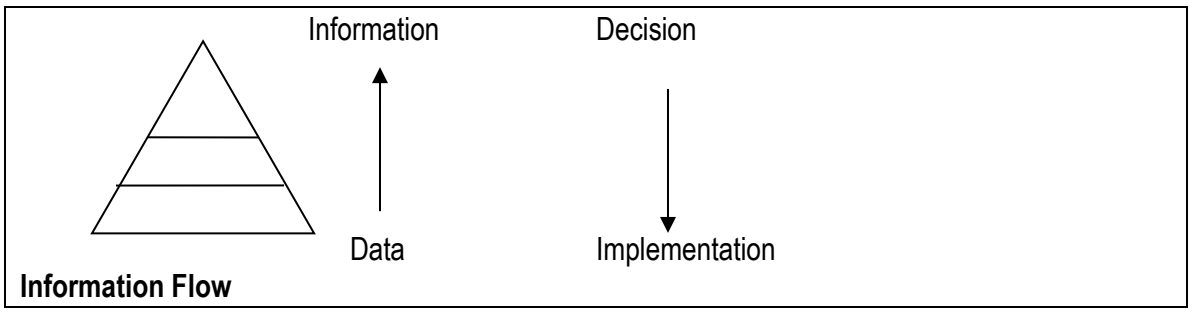
### 2.3.2. The User Needs Analysis Methodology

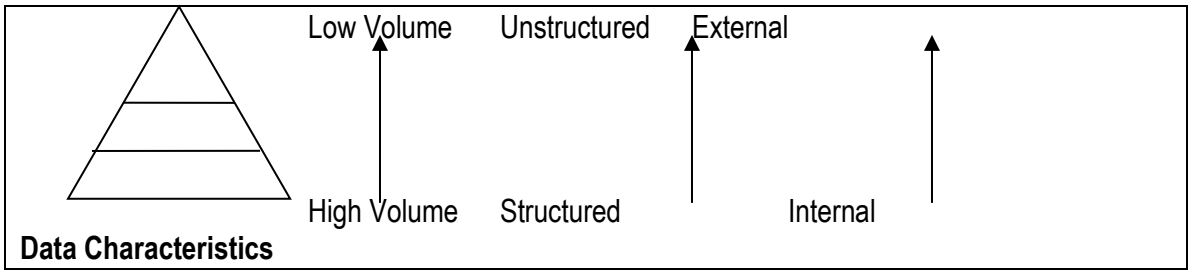
In Government, ICT Applications are mostly acquired to improve effectiveness and efficiency in order to realise cost savings, meaning getting more for less and resulting in higher productivity and competitive advantage over rivals e.g. responding more quickly to client and stakeholder's needs. Because information systems are only worthwhile when they assist people, it is therefore necessary to consider people's genuine needs rather than imposing systems on people. User Needs Analysis methodology is done by means of interviews, questionnaires, observing existing processes and analysing data flows, determine the demand for information systems. Certain elements of this model are recommended for this study against the CBA model based on the discussions and proven limitations of the CBA.

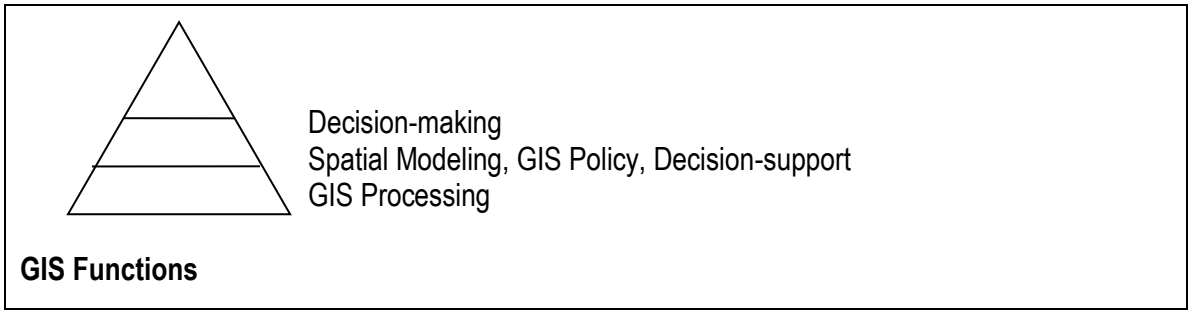
The cost of GIS goes well beyond the pure acquisition of hardware and software. All the cost which a system would generate over its lifetime should be accounted for on a consistent monetary basis. The number of cost components which need to be included may not be immediately apparent, and for those which are identified it may sometimes be difficult to provide an exact monetary value ahead of time. Typical categories which cost associated with a GIS proposal might fall under are procurement costs, start-up costs, data conversion costs, other data costs and ongoing costs. A common failure in cost benefit analyses of information systems proposal is to fail to cast the net wide enough when considering cost. Conversely, it is possible to exaggerate cost by not anticipating cross benefits from cost (Alter, 1992). The user needs are determined by different functions in an organisation. Each level of functionality has distinctive information requirements, hence distinctive kinds of information demands as indicated below in Figure 6 below:

**Figure 6: The Information Levels**






**Source: Alter, 1992.**

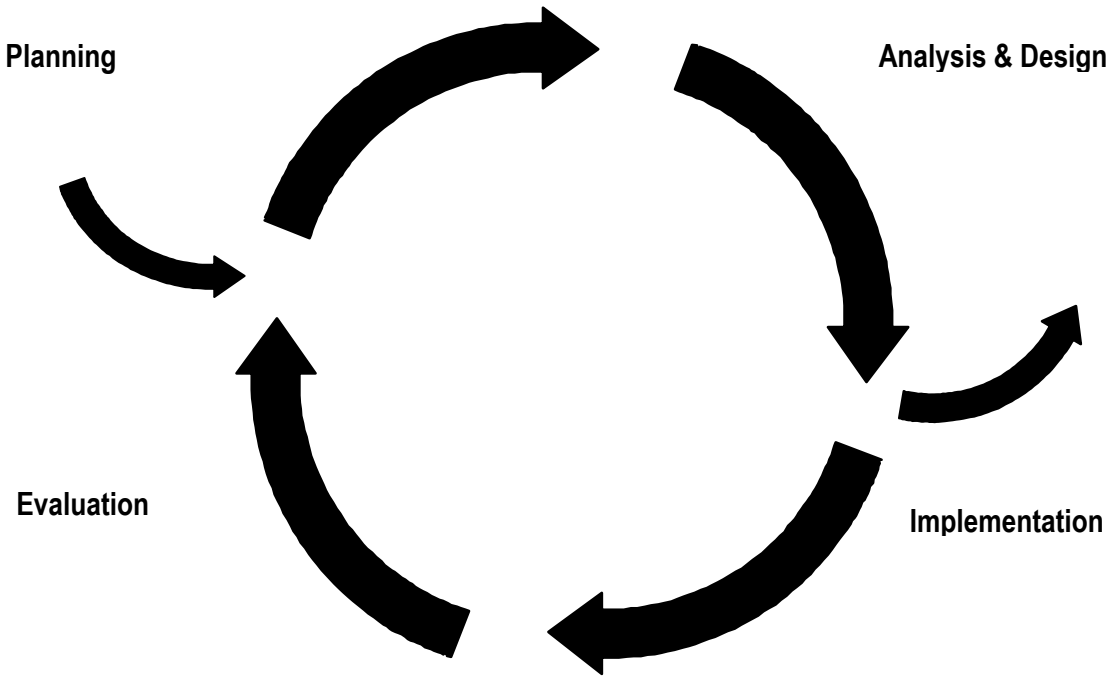
The user needs analysis process is normally followed by a GIS method of implementation. Mc Daniel and Sherman's approach (1992) recommend the following GIS implementation approach. Feasibility study; Current application Investigation; Current application analysis; Application Design Plan; System Selection; Data Capture; Customising and testing the system and Pilot Conversion and operation. Additional advantages of this model are that, it does not only focus on the deployment of a solution but also outlines maintenance and support processes i.e. optimizing the data set, catalogue source documents, quality control standards, data maintenance and copyright and data protection.

### 2.3.3. The Software Development Life Cycle (SDLC)

ICT Applications in Agriculture and Rural Development like in other public service institutions are generally used as information technology tool to ensure efficient and effective decision-making through automating manual processes. This is either done by developing or procurement of commercial-off-the-shelf software that meets the needs of the specific project. Acquiring software applications is a complex process that requires considerations such as developing the software or buying the software.

The value chain of systems development is guided by the Software Development Life Cycle (SDLC) framework. The SDLC model is coupled with elements of project management principles which is an approach recommended by most successful ICT application development managers. The objective of software development is to design, implement, configure, and sustain software systems with security being an integral part of the complete systems development life cycle and beyond, from the requirement definition to the retirement of the application (Watkins, 2012).

**Figure 7: The Software Development Life Cycle**




**Source: IBM, 2003.**

Implementation of the SDLC alone has proved to be ineffective because of its complexity. A combination of the SDLC and project management proved to meet the expectation to deliver ICT Applications projects on time, within budget and using allocated resources. Developing any ICT Application requires that the SDLC model tasks are completed. While there is general agreement on the tasks to be carried out, there is much debate about the sequence of these steps. Similarly to any ICT project, success or failure of ICT Applications projects is mostly based on successful deployment and operation of the application. There are a number of different SDLCs e.g. Waterfall Model which is criticised for lacking feedback, developing the system in a "big bang" manner, heavily "document-driven" and well-suited to contracts, but does not accurately reflect the true nature of system development. The Spiral Model is appreciated because it is iterative and incremental, there is frequent feedback, it corresponds to how systems are actually developed but sometimes difficult to manage and relate to contracts.

### 2.3.4. The Project Management Body Of Knowledge (PMBOK)

Project management addresses the need to deliver software development projects on time, within budgets and available resources. Several project management methodologies like PIMBOK and

PRINCE II etc. may be adopted for successful implementation of software development projects (van Olst, 2010). Successful management of projects requires knowledge about the project strategy, planning, organizing and controlling the human and financial resources associated with a project. In practice most GIS projects start with an idea, which later develops into a new way of doing things. Practical challenges of introducing a new way of doing things arise either during testing and piloting the application. I such circumstances the change management strategy is crucial because hardware and network infrastructure challenges may impact on successful deployment. This is an indication that application development should not be seen as a silo process from the other technologies underpinning applications development. The most critical elements to be observed in preparation for application deployment are readiness, intensity and availability which are interpreted as use, skills and access. Existing computer systems may influence the shape of proposed GIS and other computer based applications constraints may be placed on the choice of hardware and software by corporate policies about suppliers. Other constraints may arise due to the condition of existing data that needs to be converted to the new system. Such major considerations need to be reviewed as soon as possible since they will have major influence on the configuration of the proposed system (Woodcock, 1999).

The major objective of the Project Management Body of Knowledge (PMBOK) is to enable the project to succeed. With any specific evaluation process, there are associated risks and benefits. A desirable objective of any plan is to minimise risk and cost while at the same time maximizing benefits. Each organisation approaches the detail of the task differently, but there are several system development methodologies available. Identifying an appropriate methodology can be difficult but fortunately there is a number of a criteria, which may be used to assist the selection of an appropriate methodology for a particular project. Examination of the different methodologies shows that they all follow a similar path, which is to review, design and implement. The PMBOK Guide attempts to standardise project management practices and it emphasises the following characteristics of a good project; project scope, project time scale, project cost, human resources, quality management, risk management, project communications, procurement and project integration (PMBOK, 2004).

The development of a project plan or baseline plan completes the first phase of the planning and control phase. The next phase is project execution and control using the baseline plan as the means of achieving the project objectives and an outline of the required conditions. A structured approach to planning and control is recommended by experienced practitioners because through a well-disciplined system, all parties will know what is expected of them, their required performance and the reports they must generate. The project's baseline plan is the course to steer, with the tracking and monitoring functions ascertaining the project's position with respect to time,

procurement, resources and costs. If the project is off course, then control in the form of corrective action must be applied.

PMBOK (2004) standardises project management practices into the following steps;

a) project scope
b) project time scale
c) project cost
d) human resources
e) quality management
f) risk management
g) project communications
h) procurement and
i) project integration

Other authors' views about the PMBOK model are as follows:

They are of the view that the project control framework should contain at least the project level control and stage level control whereby the project steering committee meetings and formal progress reviews should be scheduled when major decision points are picked up with technical and quality tools. The project plans should be expanded to include suitable control points which will be included in the minutes of the decisions taken. The task of exercising control at a project level will generally include the production of regular reports at agreed times. These reports will provide the project with visibility and also allow problems to be communicated to the Project Steering Committee and documented (Woodcock, 1999).

Stage level control deals with the day-to-day activities of the team members. The principles are similar to those applied to project level control but deal with individual activities and associated products rather than the major deliverables shown in the project plan. It is associated with an end product such as a Team Meeting Report or minutes of meetings where decisions are recorded and actions assigned. As the project manager is the single point of responsibility, then he is responsible for everything that happens on the project (Burke, 1999).

GIS is a powerful and attractive tool, however achievement of a cost justified GIS has proved not to be easy. It can be very expensive and time consuming especially if there is no business driver against which to align this technology. What is important is to approach the problem more strategically by applying project management procedures. Successful GIS implementations dependent on the supporting technology, which if flexible, capable and open enough to provide a

sound framework upon which to base system and application development. But of equal importance are the people whose involvement will affect the project's success or otherwise. Successful projects almost always involve a significant investment in time, money and staff as it was evident during implementation of project ROSIE.

An experienced project manager will be a key member of the team and the one that will in effect deliver the first evidence that GIS can solve or address key business issues. Without this dedicated and committed resource, many small GIS pilot projects have floundered into obscurity and therefore believe that no serious GIS project can succeed without the project manager. The way to turn GIS pilots into respected and meaningful projects which have a bright, possibly corporate future clearly depends on three basic fundamental requirements: a good case to precede, experience, skill and capability, a sound technological framework. The three requirements are going to depend on the skill, capability and enthusiasm of people and people really are the key success. If GIS projects are to succeed, the right team needs to be identified at the outset (Anderson, 1992).

### 2.3.5. Control Objective For Information And Related Technology (COBIT) IT Governance

According to ITGITM (2007) IT governance integrates and institutionalises good practices to ensure that the organisation's IT supports the business objectives. IT governance enables the organisation to take full advantage of its information, thereby maximising benefits, capitalising on opportunities and gaining competitive advantage. These outcomes require a framework for control over IT that fits with and supports the Committee of Sponsoring Organisations of the Treadway Commission's (COSO's) Internal Control—Integrated Framework, the widely accepted control framework for organisation governance and risk management, and similar compliant frameworks. Organisations should satisfy the quality, fiduciary and security requirements for their information, as for all assets. Management should also optimise the use of available IT resources, including applications, information, infrastructure and people. To discharge these responsibilities, as well as to achieve its objectives, management should understand the status of its organisation architecture for IT and decide what governance and control it should provide. The ISACA has published several versions of COBIT and the recent version is COBIT 5 which was published in 2012. The key features of COBIT 5 or the major drivers for the development of COBIT 5 are;

a. Providing more stakeholders say in determining what is expected from IT.
b. Addressing the increasing dependency of organisation success on external business and its parties such as outsourcers, suppliers, consultants, clients, cloud and other service providers.
c. Dealing with the amount of information which has increased significantly.

d. How organisations should select the relevant and credible information that will lead to effective and efficient business decisions.
e. Effective management of information through an effective information model
f. Pervasive IT i.e. IT is more and more an integral part of the business
g. Further guidance in the area of innovation and emerging technologies.
h. To cover the full end-to-end business and its functional responsibilities.
i. To get better control over increasing user-initiated and user-controlled IT solutions.
j. To ensure that innovation streamlines product development, manufacturing and supply chain processes to deliver products to the market with increased efficiency, speed and quality.

The core objective of COBIT is governance and governance can simply be interpreted as being in control of the status quo. The COBIT framework has been adopted and embraced by most IT managers and organisations as a means to control the IT environment. The DPSA and the Auditor General (AG) of the Republic of South Africa (RSA) government use COBIT to assess the state of affairs within the public service. Previously, most RSA government departments used IT control mechanisms of their choice and the Auditor General did not recommend specific IT governance model. In 2012 the DPSA made COBIT a formal and compulsory framework for Government to ensure uniformity in IT governance. The application of COBIT IT governance by GDARD has proved to be successful in GDARD resulting in no matters of emphasis and unqualified audits.

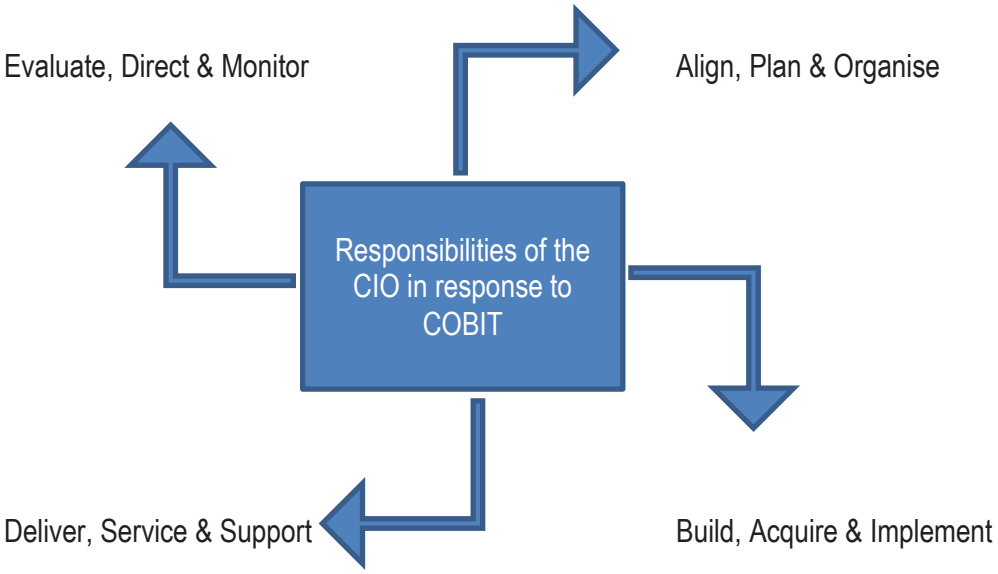
According to ISACA (2012) benefits of using COBIT framework are;

a. Maintaining high-quality information to support business decisions.
b. Generating business value from IT-enabled investments.
c. Achieving operational excellence through reliable and efficient application of technology.
d. Maintaining IT-related risks at an acceptable level.
e. Optimising the cost of IT services and technology.
f. Compliance with the ever-increasing relevant laws, regulations, contractual agreements and policies.

The key principles of governance and management of enterprise It are meeting the stakeholder needs, covering the enterprise end-to-end, applying a single integrated framework, enabling a holistic approach and separating governance from management. The COBIT framework requires management to have control objectives that define the ultimate goal of implementing policies, plans and procedures, and organisational structures designed to provide reasonable assurance that the business objectives are achieved; undesired events are prevented or detected and corrected. These challenges can be managed and contained if the model is applied correctly. Resource

management is a key factor in implementing GIS as seen during implementation of GIDS where human resources, data, software, hardware, costs are used as key indicators to determine the evolution of GIDS GIS ICT application. Similar indicators were applied during project ROSIE and this allows a consistent manner of reviewing progress although the cost aspect is reviewed in a qualitative approach as opposed to the quantitative method like the Cost Benefit Analysis (CBA). COBIT meets the IT needs through strategic alignment and ensuring the linkage of business and IT plans, defining, maintaining and validating the IT value proposition; and aligning IT operations with the Department's operations as indicated in figure 7 below.

**Figure 7: COBIT 5 Process reference model**




**Source: COBIT5 Foundation, 2015.**

The process focus of COBIT is illustrated by a process model above, that subdivides IT into four domains and 34 processes in line with the responsibility areas of plan, build, run and monitor, providing an end-to-end view of IT. Organisation architecture concepts help to identify the resources essential for process success, i.e., applications, information, infrastructure and people. In summary, to provide the information that the organisation needs to achieve its objectives, IT resources need to be managed by a set of naturally grouped processes. Control Objective for Information and Related Technology (COBIT) IT Governance structure framework is recommended for the following reasons; It was developed by the global leader promoting IT Best Practice called Information systems Audit and Control Association; It provides thought leadership and guidance on

directing and controlling organisational information technology; ISACA is responsible for developing international information systems auditing and control standards adopted by the DPSA, Auditor General and Gauteng audit Services who conduct annual monitoring of Government Department's processes and assessing internal controls. The need for assurance about the value of IT, the management of IT-related risks and increased requirements for control over information are now understood as key elements of organisation governance. Value, risk and control constitute the core of IT governance. IT governance is the responsibility of executives and the board of directors, and consists of the leadership, organisational structures and processes that ensure that the organisation's IT sustains and extends the organisation's strategies and objectives.

Value delivery is about executing the value proposition throughout the delivery cycle, ensuring that IT delivers the promised benefits against the Departmental strategy concentrating on optimising costs and proving the intrinsic value of IT. Resource management is about the optimal investment in, and the proper management of, critical IT resources: applications, information, infrastructure and people. Key issues relate to the optimisation of knowledge and infrastructure. Risk management requires risk awareness by senior managers, a clear understanding of the risks facing the Department, understanding of compliance requirements, transparency about the significant risks to the Department and embedding of risk management responsibilities into the Department. Performance measurement tracks and monitors strategy implementation, project completion, resource usage, process performance and service delivery, using, for example, balanced scorecards that translate strategy into action to achieve goals measurable beyond conventional accounting.

Control Objective for Information and Related Technology provides good practices across a domain and process framework and presents activities in a manageable and logical structure. COBIT's good practices represent the consensus of experts. They are strongly focused more on control, less on execution. These practices will help optimise IT-enabled investments, ensure service delivery and provide a measure against which to judge when things do go wrong. For IT to be successful in delivering against business requirements, management should put an internal control system or framework in place. The COBIT control framework contributes to these needs by: making a link to the business requirements; organising IT activities into a generally accepted process model; identifying the major IT resources to be leveraged; defining the management control objectives to be considered. The business orientation of COBIT consists of linking business goals to IT goals, providing metrics and maturity models to measure their achievement, and identifying the associated responsibilities of business and IT process owners.

The IT audits and risk management are carried out based on seven categories of enablers that influence how the governance and management of IT work The principles consist of policies and

frameworks, processes, organisational structures, culture ethics and behavior, information, services, infrastructure and applications, people skills and competencies (ISACA, 2012).

## 2.4. The Conceptual Framework for Reviewing the Evolution of GIDS GIS ICT Application

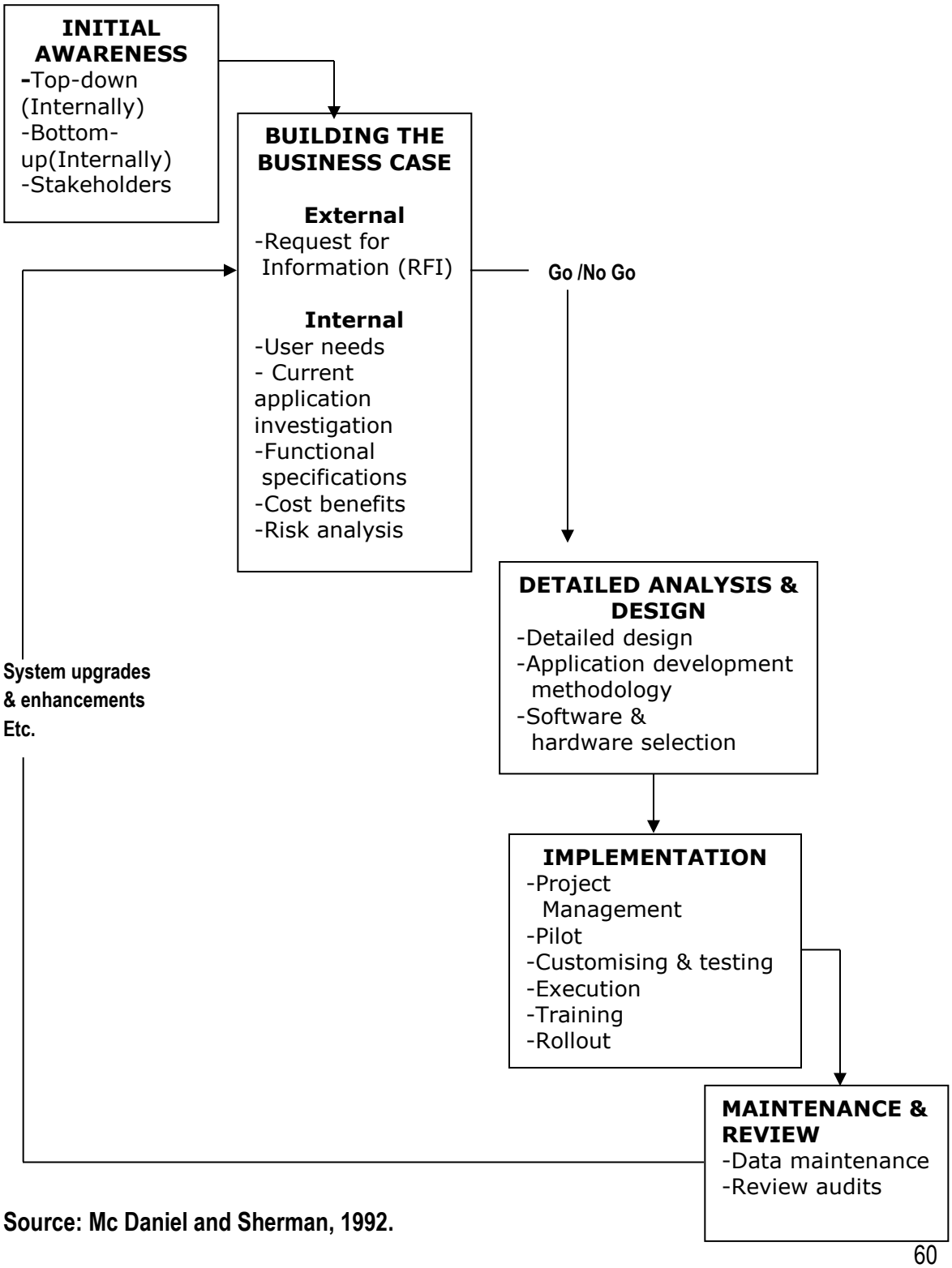
The knowledge gained from the literature review helps to conceptualise and inform the study about the qualitative indicators that are used to measure efficiency and effectiveness. The benefits of information management systems are mainly; Efficiency which is associated with costs saving and getting more from less; Effectiveness offers in greater return on assets and higher productivity. The two results in competitive advantage meaning, gaining a competitive edge over rivals and in this case responding more quickly for improved service delivery. The efficiency and effectiveness and competitive advantage benefits of knowledge management systems will be reviewed in the context of the information systems levels i.e. Executive level to resemble the policy level, management level to resemble the strategic level and operational level to resemble daily activities of the organisation.

### 2.4.1. The GIS Development Flow Diagram

The major objective of any methodology is to enable the projects to succeed and there are associated risks and benefits. A desirable objective of any methodology is to minimise risk and cost while at the same time maximizing benefits. Each organisation approaches the task for GIS development differently, depending on the challenges facing the organisation. Identifying an appropriate methodology can be difficult but fortunately there is a number of criteria which may be used to assist the selection of an appropriate methodology for a particular scenario.

The following GIS development flow diagram helps to translate how GDARD has implemented its organisational needs into appropriate Geo-Information System. The flow diagram below is designed to conceptualise a framework for analysing GDARD's processes followed to develop GIDS GIS application but the sequence would not necessarily apply in different unique circumstances. Due to different circumstances some things which should be done in sequence get done in parallel, sometimes in a backward or totally staggered manner.

**Figure 9: GDARD Composite GIS Development Flow Diagram**




**Source: Mc Daniel and Sherman, 1992.**

Initial awareness of GIS stems from different levels of information needs to be determined from different functions in an organisation and from external stakeholders. Each level of functionality has distinctive information requirements, hence distinctive kinds of information demands.

### a. Building the Business Case

Current application Investigation is a detailed investigation and fact-finding exercise of the current methods on how the data are used. This involves planning interviews with staff or conducting surveys using questionnaires. The existing applications should be re-examined and the data recorded and documented by type and application. The next step involves drawing up a flow chart showing how the data is used (Data modelling). To achieve this, business needs analysis need to be conducted. The functional requirements should be generated from the interviews with staff or survey responses. The process is designed to determine functional capabilities and should specify the functional requirements or specifications for the new system, not the technical process underlying the functions. A thorough definition project scope document produce a good functional specification and helps to set clearly defined goals for the GIS project team.

This document is sent to vendors who then respond with a proposal. The project team then evaluates these proposals. They will provide important technical and cost information and indicate the feasibility of achieving the project goals. The work of system selection and risk analysis is closely aligned. A key factor in the selection process is the job of bench making. During this process it is usual to observe what the contending systems can actually do in a controlled environment using real data to test its functional capabilities. The evaluation team will arrange for each vendor to perform series of tests on each system. Each system should be evaluated for responsiveness and user friendliness, system flexibility is also important if it will be used for a wide range of applications. The performance and functionality of each bench marked system can then be compared and evaluated.

### b. Detailed Analysis and Design

This stage is an evaluation of the current operations, the existing data and how they are used in the business process. This kind of analysis provides basic information for the new system. Observations of this analysis can be weighed against the cost of implementing the proposed system. The analysis of current applications will provide basic information to define a scope for the new system. Questions as to the physical condition of the records, accuracy of the data, maintenance difficulties and deficiencies in functionality should be raised and answered.

The answers to these questions will affect the scope and the ultimate cost of GIS in an organisation. All this work forms the foundation for generating the Functional Requirements Document (FRD) which will be used in defining the overall project scope. These requirements become the basis for analysing the feasibility of the project. The project cost will include all the costs of developing and implementing the system. This stage should provide sufficient data to make a go or no go decision, or revalidate the proposals.

### c. Implementation

The pilot is the last step before full implementation of system. The purpose the pilot is to evaluate the operational performance of the system using a production database. In the pilot, the daily operations of the system are evaluated. It should test the efficiency of any interfaces, translators, or special applications that are developed. During the test, the effectiveness of any training on system use can also be evaluated. Pilot test data should be a logical sub-division of data used in the department's operations. This data may have to be converted by in-house staff or by a conversion service before it can be loaded into the system, using a portion of real data will also provide the opportunity to evaluate the conversion process. The pilot is the last decision point in the technical and financial analysis. If the pilot meets the requirements defined in the project scope in a cost justifiable manner, then a documented, well-supported decision to proceed may be made. During implementation, conversion and operations continue to change as new data and applications are introduced, the organisation will need to adapt to such changes.

An application plan includes the outputs of the new GIS based application, the inputs and the transformation of these. In this case, the product flow diagram has been used to define the interdependence between the various products and the sequence in which they will be produced. It is of critical importance when defining the sequence of products that the diagram demonstrates the progression from the current situation to the final delivered system. Implementation of the system completes the first phase of the system. The next phase is execution and control of the system using the baseline plan as the means to achieving the system objectives and an outline of the required condition. A structured approach to planning and control is recommended because through a well-disciplined system, all parties will know what is expected of them, their required performance and the reports they must generate. The system application plan is the course to steer, with the tracking and monitoring functions ascertaining the system application plan position with respect to time, procurement, resources and costs. If the system application plan is off course, then control in the form of corrective action must be applied.

**Data Capture**

Planning and preparation before the data capture stage of a GIS project starts is just as important as the actual data conversion itself. Data capture linked to a particular line function should continue to be performed within the component responsible for that function, i.e. where the subject expertise lies (e.g. the collection of statistics on animal vaccinations or biodiversity data). A data co-ordinator should be designated within Strategic Information Management unit. The co-ordinator will be responsible for collating, capturing, maintaining and distributing data internally and externally.

**Customising and testing the systems**

A detailed design document that defines the database graphics specifications interfaces, calculations and any specific GIS application is required after implementation of each system. The graphical characteristics will typically include properties such as colour, weight, font and line code level and symbol number. Any textual data that is to be displayed will need specifying as to format placement and symbology. The various products such as the network record and index map generated by the system must be specified in terms of the scale, geographical area, and frequency of use and response time. A GIS is an information management tool that has a database definitions for the items of plans, attribute associated with each item dates validation procedures, and security processes need to be specified. Interface with other data sets and applications to communicate with each other should be documented. This will involve identifying the particular application programs and database that will be used. The system software may need to be customized to preserve the graphic symbols currently used by the organisation, for example the Organisation's emblem. Application software may need to be written to replace the manual tasks identified for computerization. Finally the acceptance criteria will need to be determined along with details of who is responsible for delivery of what.

**d. Maintenance and Review**

**Data maintenance**

Data maintenance involves planning for the long-term maintenance of the GIS data sets once they are converted and the system is up and running. It is important to develop this plan prior to starting the conversion stage. Woodcock (1999) states that too often GIS projects eventually fall because the human and financial resources required for data management and maintenance effort were overlooked at the project costing and planning stages. The cost of maintenance must be assessed and budgets must be allocated. The higher the accuracy the higher the cost.

**Optimising the data sets**

The main task here will involve identifying the database entities and defining the relationships between them. In addition an exhaustive review of each entity needs to be undertaken to add to each attribute, in turn to the Data Dictionary. At the conversions stage the data Dictionary becomes the prime source of reference for all attributes which are to be entered into the data base. Where data is being captured from existing records, much of the attribute information may not have been recorded. It is therefore important during the data conversion planning stage that special attention is given to identifying those attributes which are available in the existing data and need to be added to the GIS database. The next stage will be to compare the existing data formats and descriptions with the format as defined in the data Dictionary and prepare a list of acceptable formats for each attribute to be captured. Such information need to be included in the data conversion manual which is issued to the conversion team. The manual will therefore require constant updating as new knowledge is gained.

**Catalogue of Source documents**

Another task in preparing for data conversation is a detailed examination and inventory of all the source documents that will be used in the conversion. A thorough inventory of the source documents will provide answers to most frequently asked questions about the available data. Data conversion is one stage in an organisations life, when the past record-keeping shortcoming can be identified and improved. The examination and inventory of source documents is something that should be started before the data conversion stage of the GIS.

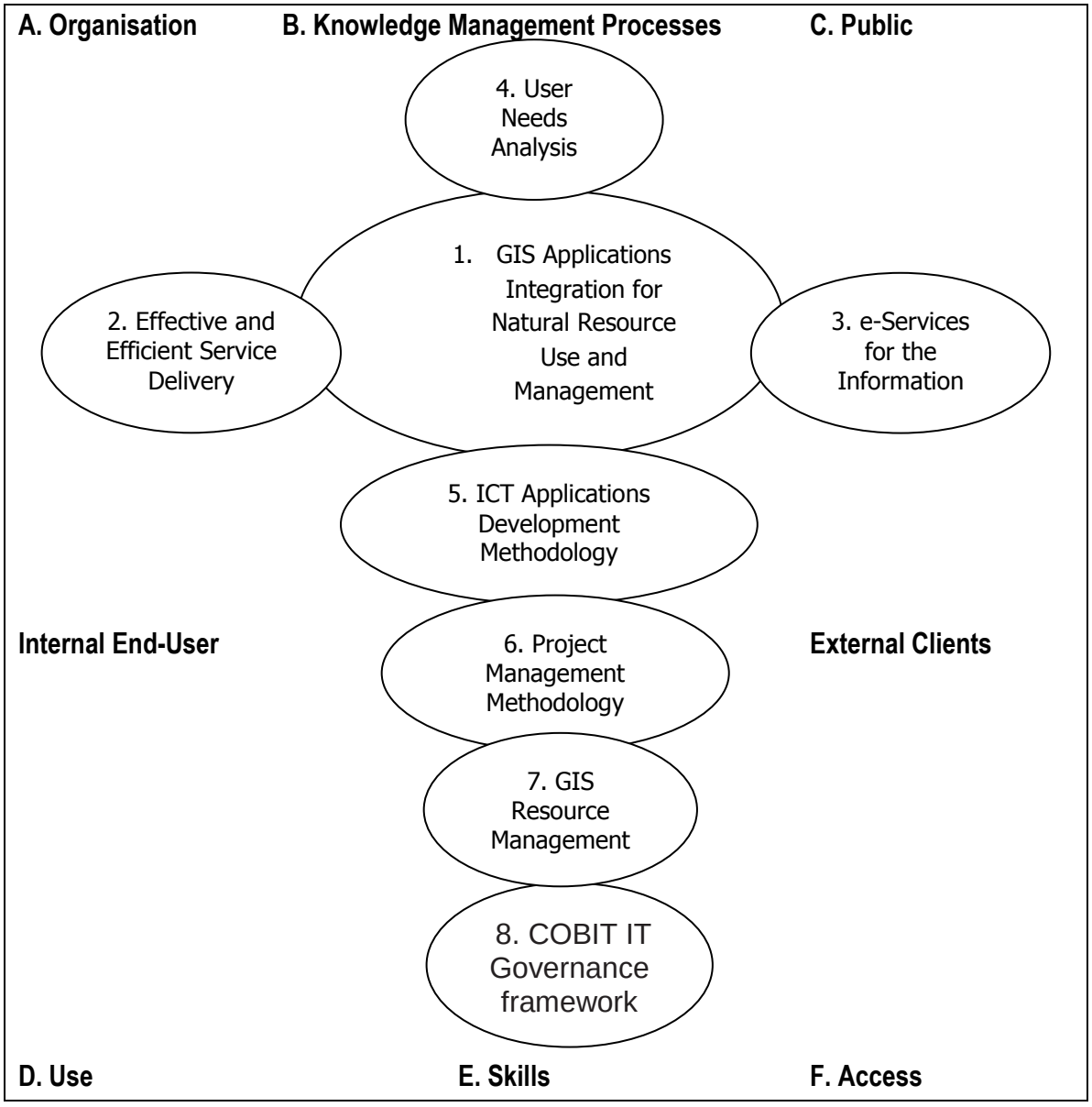
**Quality control standards**

The next task in preparing for data conversion is to establish data quality standards. Any conversion effort is going to produce errors of various sorts in addition to errors which already exit in data. Before starting the conversion stage, each category of error needs to be planned for, along with tests to identify the errors developed. Procedures for error correction need to be established. The more straight forward the functional specification, the lower the error rate will occur. The development and use of software tools will increase efficiency for quality control acceptance testing. However it is important to develop and test this software before the full data conversion starts. It is a good idea to assign experienced and knowledgeable employees to the quality control effect: Quality control is the last chance to get it right before the GIS project goes live. Where an outside vendor is used for data conversion, it is also important to involve them in setting up the quality control standards and development of the quality control software.

**Copyright and Data protection**

Information held by other departments or companies may be regarded as the sole property of the company. Inappropriate use and maintenance of copyrighted data and other proprietary material may incur penalties and heavy fines for the department. The department need to develop policies to ensure compliance with copyright and other information management policies.

**Figure 10: The Conceptual Framework**



The conceptual framework above is generated from the literature review chapter two to address the challenges of providing an integrated management system for sustainable utilisation and management of natural resources in the public service through ICT Applications development and integration of business processes. The framework is summarised as follows;

The framework applies to three broad areas which are the A. organisation, B. the GIS knowledge management processes and C. the public. At the center of the framework lies circle no. 1 (GIS Applications Integration for Natural Resource Use and Management) which falls under the knowledge management area and is derived from Gauteng Department of Agriculture and Rural Development (GDARD) constitutional mandate which stipulates the policy objective regarding natural resource use and management. The next circle no.2 (Effective and Efficient Service Delivery) which falls under the organisation area is based on the need identified by the project ROSIE to improve effectiveness and efficient service delivery to GDARD officials (Gavin, 2005) and the vision is to be "leaders in Agriculture and Rural Development" (GDARD, 2009) because to be in a leading position means to gain a competitive advantage over rivals and to respond more quickly to service delivery. Circle 3 of the framework is e-Services for the Information Society representing the requirement to meet the information society need to use ICT as a fundamental tool for acquiring knowledge and creativity, improving the standards of living through productive participation in Agriculture and Rural Development. This need is similar to project ROSIE recommendation for the need to provide wider access to information.

The circles 4 – 8 i.e.; User Needs Analysis, ICT Applications Development Methodology, Project Management Methodology, GIS Resource Management and COBIT IT Governance framework fall under the knowledge management processes are the salient features for the successful implementation and integration of knowledge management tools for effective and efficient service delivery improvement within the public service and to deliver e-services to the public. The bottom left, center and right D. Use – reflects the organisational usage of ICT Applications, E. Skills – represents the importance of both software development and end-user skills while F. Access - indicates the dependency of ICT Applications on other underpinning ICT technologies like Local Area Networks (LANs), Wide Area Networks (WANs) and the Internet for the purpose of improving the delivery of services to the public using e-Services.

# 3. Chapter Three: Interpretive Qualitative Research Methodology of Exploring Rationalisation of Spatial Information in the Public Service

The following chapter outlines the research methodology followed to address the problem statement, purpose statement, research questions, the data collection tool, the method of sampling, data validation, reliability, tools for conducting the research, data analysis and limitations to the study. An interpretive approach is adopted to explore the knowledge about the evolution of GIDS in order to understand the processes and the patterns that were undertaken to develop and deploy it. The section also covers the research approach which is three simple steps that follows i.e. data collection, report on findings and data analysis. The process of determining efficiency and effectiveness for improved service delivery is similar to performance review. Performance review is achieved by establishing a quantitative or qualitative method which leads to determination of success or failure (Gichoya, 2005).

## 3.1. The Qualitative Research Approach

Three of the six qualitative steps outlined by Neuman (2011) will be adopted to carry out this research i.e.

a. Collecting data/ Data collection
b. Interpreting data/report on findings
c. Analysing data/ Data analysis

## 3.2. The Problem Statement

The challenges of providing an integrated provincial management system for sustainable utilisation of natural resources through ICT Applications development and integration of business processes cannot be underestimated. These challenges need to be better understood by assessing the relevant frameworks that guide ICT Applications needs analysis, the ICT Applications development life cycle, as well as ICT Applications compliance to the IT governance and project management frameworks. Through exploration of how GIS applications are developed, managed and implemented to ensure effective and efficient information dissemination, it is possible to identify certain characteristics (e.g. data sets, resources) that influence the successful implementation and integration of knowledge management tools to deliver e-services.

The project report on Rationalisation and Optimisation of Spatial Information Exploration (ROSIE), exploring rationalisation of spatial information in GDARD, reflects the issues of duplication, unconsolidated information resources and non-provision of wider access to information to officials

within the department as examples of the challenges of ICT Applications development and integration. The perspective of the conceptual framework for this study is that, the gap in knowledge represents the extent to which the identified challenges of applications integration were resolved and which new challenges have emerged.

The research problem being investigated in this study is the complexity of introducing integrated ICT Applications in the public service to deliver services effectively and efficiently. GIS applications are an example of the integrated spatial planning tools available for improved decision making in government and improved service delivery to meet the needs of the stakeholders. This study therefore focuses on the integration of GIS applications in the field of Agriculture and Rural Development of Gauteng.

### 3.3. The Purpose Statement

This research aims to explore how Gauteng Department of Agriculture and Rural Development's ICT Applications have evolved to provide an integrated provincial management system for sustainable utilisation and management of natural resources that will make information available to citizens in an open, innovative, responsive and smart way. It seeks to understand the value added by such tools to farmers, ecologists and environmentalists of Gauteng in interacting with government in the areas of agriculture, conservation and environment. The purpose of this study therefore is to review effectiveness and efficiency of the GIDS GIS ICT application and the advances in the integration of this application into the GDARD business processes over the period 2003 to 2013.

The process of exploring how Gauteng Department of Agriculture and Rural Development's ICT Applications have evolved to make information available to citizens in an open, innovative, responsive and smart way is done through looking at ICT Applications integration for delivering e-services in an information society, applications development methodologies, It seeks to understand the value added by such tools to farmers, ecologists and environmentalists of Gauteng in interacting with government in the areas of agriculture, conservation and environment.

The conceptual framework above is generated from the literature review in chapter two to address the challenges of providing an integrated management system for sustainable utilisation and management of natural resources in the public service through ICT Applications development and integration of business processes. The framework is summarised as follows;

The research questions to provide answers to the research problem statement and purpose for Reviewing the Evolution of GIDS GIS ICT application for natural resources use and management

in Agriculture and Rural Development of Gauteng will be framed by applying the conceptual framework of to three broad areas A. organisation, B. the GIS knowledge management processes and C. the public.

### 3.4. The Research Questions

The main research question is: How did the GIDS GIS ICT application for agriculture and rural development in Gauteng evolve to make information available to citizens in an open, innovative, responsive and smart way?

Based on the conceptual framework, the following research sub questions are aimed at reviewing effectiveness and efficiency of the GIDS GIS ICT application and the advances in the integration of this application into the GDARD business processes over the period 2003 to 2013:

a. How did various ICT frameworks and methodologies influence quality of ICT applications planning?
b. How did ICT organisational resources influence ICT applications development and implementation?
c. How did relevant GIS data sets foster knowledge management?
d. How did improved knowledge through GIS utilisation enhance efficiency and effectiveness of ICT service delivery and support?
e. How did the use of GIS ICT applications for GDARD contribute towards attainment of sustainable utilisation and management of natural resources in Gauteng Province?

### 3.5. Collecting Data

The qualitative primary data for this research is obtained by means of a desktop review of the project about Rationalisation and Optimisation of Spatial Information Exploration (ROSIE). The methodology followed to collect data during project ROSIE involved the following steps: Gathering information from individual components through: face-to-face interviews with staff within individual components, which could provide both strategic and technical insights into the current usage of GIS and future requirements for spatial information. A semi-structured approach was used during the interviews, all relevant information was captured and follow-ups through e-mail, further meetings and telephone discussions.

### 3.6. Data Collection Tool

The secondary data is collected through targeted semi-structured interview guide with the aim to capture qualitative opinions on how GIDS GIS ICT application evolved inside and outside Gauteng Department of Agriculture and Rural Development. The data on the status quo of GIS resources was collected through a joint interview of five GDARD staff members from the IT section of Knowledge and project management branch. This interview focused on reporting about the status quo of the five components of GIS that were previously reported about during project ROSIE to benchmark progress on the status quo in 2013, i.e. human resources, software, hardware and costs. Additional data aimed at reflecting the perceptions of advances of GIS from 2003 until 2013 is also collected. The focus of those interviews is according to the different functions levels in an organisation. Each level of functionality has distinctive information requirements, hence the following distinctive kinds of information demands as indicated below;

a. Policy level: Need for GIS applications integration for natural resource use and management, this is intended to illustrate achievement of organisational policy, mission and vision for sustainable use of natural resource management.
b. Strategic level: This process allows identification of planning processes, frameworks and legislative prescripts for Knowledge Management processes at management level.
c. Operational level: This level reflects the strengths and weaknesses towards achieving effective and efficient service delivery targets for improved knowledge management and enhanced efficiency and effectiveness of service delivery.
d. Costs: The cost element indicates resource management of GIS investments in the organisation and their influence on ICT applications development.
e. Service delivery improvement level: reflects e-Services for the information society through enabling e-services.

### 3.7. Sampling

The data collection sample consists of 20 GDARD staff members (i.e. 5 from the IT section of Knowledge and project management branch, 5 from Agriculture branch, 5 from Environment branch, and 5 from the conservation branch), 5 respondents from other GPG departments that use GIS and 5 Agriculture and Rural Development stakeholders.The sample size is categorised as follows;

a. GPG spatial planning departments
b. GDARD IT directorate

c. GDARD business units (Agriculture, Conservation, Environment, Veterinary services and rural development)
d. System end-users (GDARD, stakeholders and clients)

### 3.8. The Method of Sampling

The simple random sampling method is adopted and done by means face-to-face interviews, telephonic interviews and in some instances questionnaires responses via e-mail.

### 3.9. Validity

The verification and documenting of the collected data was done with GDARD GIS team. Data is validated by measuring the degree to which perceptions of effectiveness and efficiency of service delivery are achieved.

### 3.10. Reliability

Quality assurance and data cleaning was conducted jointly with the GIS team to ensure reliability.

### 3.11. Data Analysis

Project ROSIE data is summarised and packaged to reflect the situation with respect to GIS resources usage and management in the former DACEL, i.e. human resources, software, hardware and costs. The secondary data collected through targeted semi-structured interview guide and desktop review of progress reports about the evolution of GIDS application for Agriculture and Rural Development between 2003 and 2013, is analysed and interpreted in line with the interview guide themes and in line with the adopted and adapted conceptual framework. Those themes are also used as the subheadings for analysing data, they are:

a. Policy level: GIS Applications Integration for Natural Resource Use and Management, this will illustrate achievement of organisational policy, mission and vision for sustainable use of natural resource management
b. Strategic level: Identification of planning processes, frameworks and legislative prescripts for Knowledge Management Processes, this will identify planning processes, frameworks and legislative prescripts for knowledge management processes
c. Operational level: Strengths, weaknesses, opportunities and threats towards achieving effective and efficient service delivery indicates improved knowledge through GIS utilisation and enhanced efficiency and effectiveness of services

d. Costs: GIS resource management indicates investment on organisational resources and influence on ICT Applications development
e. Service delivery improvement level reflects e-Services for the information society through enabling e-services

The analysis is done in the context of the best knowledge management practices of GIS needs analysis, ICT applications development methodologies like SDLC, GIS resources management, COBIT and PMBOK project management. Technology readiness at the inception of GIDS is reviewed to determine the network infrastructure access, server and desk top processing capacity against the user demand and data standards. Usage levels reflects the demand and supply of capabilities and skills, GIDS distribution and access to GDARD clients like farmers, environmentalists and ecologists.Skills assessment matrix is used to determine the applications integration skills and usage of GIDS. The analysis and interpretation of data illustrates whether the problem statement, purpose statement and the research questions are answered. Recommendations and conclusions are drawn in line with the problem statement, purpose and research question.

### 3.12. Limitations to the study

There has been difficulty of obtaining information from certain respondents especially external stakeholders not honouring interview appointments. This led to resorting to structuring questionnaires based on the initial semi-structured interview guide. Another limitation to the study is that there were no external agricultural stakeholders to interview because they do not use the GIDS tool directly but they get farming advice from extension farmer services from GDARD staff based on GIDS GIS tool.

# 4. Chapter Four : Report on findings about the evolution of GIDS GIS ICT Application

The following chapter is subdivided into three sections (section A, B and C) of which section A reports on findings based on a desktop review of the project about Rationalisation and Optimisation of Spatial Information Exploration (ROSIE) which marks the inception of GIDS GIS ICT application for Agriculture and Rural Development in Gauteng Province of the Republic of South Africa prior 2003. Section B reports on findings on advances of GIDS application for Agriculture and Rural Development between 2003 and 2013. Section C reports on findings of targeted semi-structured interviews about the evolution of GIDS application for Agriculture and Rural Development in 2013.

## 4.1. Section A: Report on Findings Based on the Desktop Review of the Project about Rationalisation and Optimisation of Spatial Information Exploration (ROSIE)

The findings of section A are based on a desktop review of the project about Rationalisation and Optimisation of Spatial Information Exploration (ROSIE) presented in 2001. The year 2003 marks the inception of implementing project recommendations to; eliminate a large degree of duplication through rationalization; consolidate the information resources within the department; and providing wider access to information to officials within DACEL, in order to increase effectiveness and efficiency in performing their work". The main objective of reporting the status quo about the GIS ICT Applications portfolio in 2003 is in order to benchmark the technology readiness to increase the effectiveness and efficiency of service delivery in Agriculture and Rural Development. Project ROSIE data is packaged to reflect the situation with respect to GIS usage in the former DACEL using the following components of GIS User Needs Analysis; human resources, data, software, hardware, GIS costs and recommendations concerning the future GIS strategy.

### 4.1.1. Human resources

There were 10 people within DACEL who have significant experience or have had some degree of formal training in GIS. There were also around 30 additional users of the GOSP system, who have received in-house training to use the Gauteng Open Space Project (GOSP) GIS system. There has, however, been an ongoing loss of trained people, including people who had been trained during their time at DACEL. Also noted is the "underutilisation" of existing resources, i.e. the use of trained people for routine map production, as opposed to the use of their skills in information management and manipulation for the purposes of spatial analysis.

### 4.1.2. Data

A comprehensive inventory of DACEL's spatial data holdings and spatially referenced information has been compiled and this was available through the Spatial Data Discovery Facility (SDDF) administered by the National Spatial Information Framework (NSIF), see http://www.nsif.org.za/spatial.htm. Commonly used "base" data sets, carried by most components were topographical information at a 1:50 000 scale, as well as the boundaries of land parcels in Gauteng, especially farm boundaries, including their sub-divisions.

Because "desk-top" GIS software was used, rather than an intranet-based system, there was duplication of storage of data sets. Once the same dataset was stored separately, there would almost inevitably have been some duplication with respect to its management and maintenance, either through receipt of updated information from the datasets originator, or through updating or editing as errors in the base dataset were discovered by the user. A considerable amount of data collected routinely was not being integrated regularly into a GIS, and consequently not being used to any significant degree within DACEL.

### 4.1.3. Software

There were 13 ArcView licences within the Department, varying in version. Some kind of software maintenance agreement (SMA) was associated with some of the licences, although all the SMAs in place were with the same software vendor. In addition, there was also one licence of Image, Analyst, Spatial Analyst and 3-D Analyst, modules linked to ArcView. There was also one IDRISI and one ENTAC software licences.

### 4.1.4. Hardware

There were effectively five PCs across DACEL used dedicatedly for GIS. Users generally used their standard issued desktop for GIS work when required. The adequacy of the specifications for these desktop PCs were questioned by users, specifically the RAM allocation, and size of monitor screen. There were three plotters within DACEL, one A0 and two A1s, although these were not dedicated to GIS use; likewise an A3 printer. There was only 1 colour A4 printer used for map printing. Otherwise, black-and-white printers were used predominantly for the production of maps. There was also one A1 roll-up digitizer. DACEL had approximately 30 hand held GPS receivers of varying kinds.

### 4.1.5. GIS costs

To add a quantitative component to the study of the situation then, an attempt was made to estimate the scale of investment which has been made into developing GIS for DACEL.

## 4.2. Section B: Report of Findings on Advances of GIDS Application for Agriculture and Rural Development between 2003 and 2013.

The data on the status quo of GIS resources was collected through a joint interview of 5 staff members from the IT section of Knowledge and project management branch and verified through a desktop review of progress reports about the evolution of GIDS application for Agriculture and Rural Development. The data is summarised and packaged to reflect the situation with respect to the GIS usage between 2003 and 2013 in GDARD using the same method of GIS components for User Needs Analysis; human resources, data, software, hardware, GIS costs.

### 4.2.1. Human resources

It was proposed to integrate the ten people who had significant experience or some degree of formal training in GIS in various core business branches within the organisation into the established central GIS unit but due to resistance and change management challenges, the idea did not materialise. The number of GIS end users increased proportionally as the organisation expanded and the demand for in-house training to use the GIS system raised. The ongoing loss of trained people increased as GIS skilled people are in demand in the country to an extent that GIS is identified as a critical skill. With effective from 1 July 2009, the Occupation Specific Dispensation (post and salary structures) is applicable to employees who are appointed in terms of the Public Service Act, 1994. OSD has been implemented in other Branches with exception to GIS subcomponent pending clarification on segregation of duties to HR and implemented to the GIS subcomponent. As opposed to the “underutilisation” of existing resources prior 2003, the use of trained people for routine map production evolved to use of their skills in information management and manipulation for the purposes of spatial analysis.

The central GIS component is constituted by four positions of which only one middle management and junior management positions were filled and the two operational positions were vacant. The organisation identified a capacity shortfall for the component to perform all its functions effectively and efficiently. Additional technical positions were identified in order to fulfil the specialised GIS functions recommended to be in line with the COBIT framework aspect of segregation of functions but budget constraints prevented the initiative to be considered.

### 4.2.2. Data

The core branches are required to capture data and provide it to the central GIS component on a regular basis, for integration into the central database. Data management involves procurement and storage of data sets centrally as co-ordinated in the GIS coordination committee (GISCO),

quality checked and standardised by the GIS unit. A central inventory of all spatial data sets held, or under construction or in planning, data maintenance, i.e. a metadata database exists. The GIS unit co-ordinate the distribution of such data internally and externally.

A comprehensive inventory of DACEL's spatial data holdings and spatially referenced information continued to be compiled and made available through the Spatial Data Discovery Facility (SDDF) administered by the National Spatial Information Framework (NSIF) but the NSIF ceased to request updates and attempts to update the inventory database via the Internet ended in vain to date due to the challenges regarding standardisation of metadata requirements and the development of the spatial information bill which was eventually enacted as the Spatial Data Infrastructure Act in 2003 (SDIA).

The commonly used "base" data sets, as well as the boundaries of land parcels in Gauteng, especially farm boundaries, including their sub-divisions are still in use with additional electronic satellite imagery instead topographical maps. This brought about the demand for server based GIS as compared to "desk-top" GIS software that was used. Due to budget constraints and network speed challenges, the central GIS system cannot be accessed externally via the Internet and the GIS subcomponent co-ordinates the central distribution of such data manually both internally and externally through external media like CDs.

### 4.2.3. Software management

GIS software for the organisation is standardised to the ESRI suite of products allocated to limited "power" users with expert GIS skills whilst GIS output products like general purpose maps to "non-power" users with limited GIS skills are accessed through the GIS viewer that is a freeware software supplied by ESRI called Arc explorer. Web-based intranet GIS system was introduced and still in use. Upgrades and software maintenance agreements (SMA) are centrally coordinated.

### 4.2.4. Hardware management

A dedicated server and ArcSDE geodatabase link for multi-users for storing corporate data centrally and to cater for the provision of the web-based GIS were acquired together with large colour graphics monitors for GIS power users. The high RAM processing power requirements of officials performing spatial analysis and the spatial editing of data sets were acquired for such work. GIS input and output devices like colour plotters, printers, scanners, CD writers and external mobile memory are also standard requirements for each GIS intensive unit.

### 4.2.5. GIS costs

GIS investments within the Department are currently centralised and is more cost effective resulting in less operating budget dedicated to salaries, software maintenance and data procurement for regular periodic updates. GIS budget has been consistent based on inflation rate adjustments. Budget mainly covers salaries, Annual ESRI SMA renewal, GIDS SLA and Data Sourcing.

## 4.3. Section C: Report on Findings Based on the Targeted Semi-Structured Interviews About the Evolution of GIDS GIS Application.

This section reports the status quo of findings on the GIS components of human resources, data, software, hardware, GIS costs to reflect how Gauteng Integrated Decision Support (GIDS) has evolved until 2013. The findings will help to determine usage levels, usage skills to reflect the demand and supply of GIDS distribution or access options of GIDS to GDARD clients like farmers, environmentalists and ecologists. They will also be useful to inform the overall contribution of GIDS towards achieving the desired organisational objectives at policy level, strategic level, operational level, budget level and service delivery improvement level.

### 4.3.1. Human Resources

The human resources capacity challenge still exists due to prolonged processes for filling vacancies and scarcity of PLATO registered candidates. The GIS skills assessment findings reflect that GIS end-users skills range between appropriate training only and limited practical experience, power-users have solid-extensive to extensive skills and the GIS professionals and technicians have expert experience. Internal training needs for end-users with limited practical experience is still required on an on-going basis and the existing limited capacity is intensively involved on other critical central Geo-data management and support functions. An internal indicative training needs plan ensures that GIS professionals and technicians are effectively trained to carry out their duties.

### 4.3.2. Data

GIDS data is mainly used for re-site inspection by internal Environmental Officers for scoping EIA applications and externally by Consultants to inform their applications for development, capturing of Veterinary Technical Services (VETS) related projects during site inspections, protection of

endangered species by conservation officials and ecologists. There was no respondents to report on GIDS data usage from Agriculture external stakeholders. GIS data is now integrated and available at Head Office but no access at regional and satellite offices due to slow network connectivity. There were reports of data layers that are outdated.

#### 4.3.3. Software

The enterprise GIS approach ensures that GIS software is standardised, managed centrally and allocated to power-users. End users access GIDS via the Intranet and external stakeholders obtain GIDS on various external media like CDs, Memory sticks and external hard drives. Software Maintenance Agreement (SMA) is done centrally and renewed annually. The software categories are client desktop software, Geo-database software, web-GIS software and satellite imagery processing software. The web enabled GIS software is currently accessible on LAN and serves internal needs only. There are needs to access it on the Internet even by internal officials while on site using mobile devices technology.

#### 4.3.4. Hardware

Additional innovative fieldwork hardware tools are acquired for example advanced GPS with high accuracy levels and low error rate, advanced latest plotters, GIS staff computers are standardised with high specifications for RAM processing, CPUs and graphics. There is a dedicated virtual ArcGIS server but storage capacity is becoming depleted.

#### 4.3.5. Costs

Cost saving on Software Maintenance Agreement is evident due to a reduction of GIS Software licences. There is a new cost component for Web-GIS Service Level Agreement to ensure maintenance and support. There is under expenditure on Compensation of employees budget due to high staff-turnover. Training budget is sufficient for internal training needs. Data procurement budget is made available annually to update the Geo-database.

### 4.4. Section D: Report on Findings Based on the Information Needs at Different Levels.

**Policy level: Determining how well mission and vision are met and which policies are working**

GDARD ICT section agrees that GIDS contributes to meeting the Department's business policy objective for sustainable use of natural resource management. This is evident during the section's interaction with all core branches or line functions when either carrying out strategic planning sessions or during support and maintenance interaction.

Agriculture section respondents have realised eminent achievement of policy objective through coordination of agricultural activities jointly with local municipalities by demarcating and declaring agricultural hubs which are zones of high agricultural potential and thus promoting suitable agricultural practices within the hubs.
Objectives of the natural conservation act are met through the conservation plan which is widely acquired by developers for EIA process to ensure that endangered fauna and flora are preserved for future generations. VETS uses GIDS to inform management to make policy decisions on diseases outbreak strategies and future plans for example, Rabies and African horse sickness.

At a provincial level, the Gauteng Planning Commission find that the GIDS application is contributing to achievement of access to relevant and accurate data sets that feed into provincial infrastructure planning policy development processes. GIDS relevance result in its data sets about exploring the urban metabolism of the Gauteng City Region (GCR) as well as analysis of the state of green infrastructure in the Gauteng City Region. The Gauteng City Region Observatory outreach and partnership programme resulted in entering into agreement with GDARD to use GIDS data as part of collaboration and sharing of information.

**Strategic level: Identification of planning processes, frameworks and legislative prescripts**

Identified strategies which drove the implementation of GIDS applications in GDARD are Project Rosie, core branches strategies, and other ICT implementation frameworks like Control Objective Based Information Technology (COBIT), Systems Development Life Cycle (SDLC), Rational Rose, ITIL and Prince 2.

GDF is the key role player in providing the provincial ICT guidelines, strategy and policies for common ICT infrastructure hosting platforms like e-Government, transversal systems in Finance and Human resources with exception to GIS. Gauteng Department of Agriculture and Rural

Development IT strategy recommended implementation of a centralised integrated system due to the following problems experienced and negatively affecting the farmer Agriculture Information Systems Directorate, Farmer support and Economics and Marketing line functions; Management information systems required to report on how much resource is allocated per farmer, by whom and where, to auditors, legislature etc. The C-plan which is a data set within GIDS is regularly updated and approved by the EXCO and Gauteng legislature to ensure that there is regulated percentage of conserved land in consideration of the provincial spatial development plan. Disease surveillance and monitoring strategies also necessitated the implementation or use of GIDS application within veterinary services and it is reported that there are eminent strategic benefits brought by GIDS.

The field workers in the organisation value the innovation of the GPS technology because it assists them in saving time and petrol to navigate to remote areas like farms. The digital pen solution tool is a new technology used for field data capturing and is recommended for saving substantial time spent in consolidating media data like pictures, GPS coordinates and field reports which are directly sent on site to the central database and accessed by decision makers though GIDS. Maintenance of such tools become problematic in the long run e.g. Cell phones not replaced and software cannot be loaded on another device by any service provider except the original service provider.

Provincial planning commission strategies that necessitated the implementation or use of GIDS include Gauteng Economic Growth and Development Strategy (GEGDS), Gauteng Spatial Development Framework and Gauteng Planning and Development Bill. Future innovation considerations derived from using GIDS is establishment of a Provincial GIS portal to inform Gauteng infrastructure planning like for example, the GCRO's integrated GIDS with their research portal to provide research support to provincial and local Government in Gauteng, the Green Strategy Programme of 2012 in support of the long term planning strategy of the province referred to as "G2055".

The GCRO is an independent, university based research centre at the University of Johannesburg and University of Witwatersrand as an innovative response to the socio-economic, cultural, governance, political, growth and other challenges related to the cluster of cities that make up the Gauteng City Region, the economic engine of South and Southern Africa. It also provides research and support to the Gauteng Departments like Economic Development; Roads and Transport; and Sports, Arts, Culture and Recreation; the City of Johannesburg; Mogale City and Tshwane Municipality among others, as well as certain national sphere of Government. In 2011/12 the organisation undertook applied research projects such as the Organisation for Economic cooperation and Development (OECD) territorial review of the GCR, the 2011 quality of life survey,

2010 FIFA world cup survey undertaken in June, November and July 2011. Forthcoming multiyear projects include research which will help to build an environmentally sustainable city region.

**Operational level: Strengths, weaknesses, opportunities and threats**

The operational purpose of the GIDS application is to visualise GIS base data and themed layers offering different perspectives, such as the conservation plan which shows reserved, protected and irreplaceable areas, agricultural potential plan which indicates the areas with high agricultural potential and Wetlands. The application serves as a screening tool used by environmental officers when processing application for development proposals mainly from developers and environmental practitioners. It is also used for screening and searching of location of the proposed development. The environmental officers will use cadastral data (farms, agricultural holdings, portions, erf, suburbs, etc.) and overlay it with environmental sensitivity data. The application also provides basic GIS analysis tools for the users to make better informed decisions and policies regarding GDARD operations.

The main users of the application are environmental officers, agricultural officers, veterinary officers, etc. These users are responsible for planning the future developments and direction of the GDARD operations and are mainly operational officials with little or no mapping or GIS experience. The current priority business need of the application is to make it available to the general public through web access, to ensure that the public users access the site to get a quick overview of the main GIS data influencing GDARD decisions. Hence the focus on a simple “Google maps”- like design. The site will also be publically accessible through the Internet providing open access to the GCRO GIS website. The benefit of providing open access of the Web-GIS application through the Internet is to ensure dynamic interactive usage.

**Strengths and weaknesses**

Gauteng Department of Provincial Local Government (DPLG) attempted to centrally coordinate GIS activities between 2003 and 2005 but due to lack of continuity the efforts didn’t materialise, the former GSSC’s project management office also initiated a similar venture and later moved to the provincial department of Transport. GDARD and Gauteng Department of Housing continued to co-ordinate GIS activities through a committee named e-Land which also disbanded due to mandatory challenges.

The Department of Economic Development (DED) then commissioned a provincial spatial development Framework. All provincial GIS initiatives were then centrally coordinated by DED which in late 2012 was merged with the provincial planning commission which according to

GDARD GIS unit, is not seen to be proactive in coordinating provincial GIS matters. Another initiative for corporate governance of GIS in Gauteng was introduced by the office of the Premier through appointment of GCRO which has a memorandum of agreement with GDARD on sharing GIS data.

GDARD ICT directorate is of the opinion that, because of the successes of GIDS, there is buy-in from the Department executives and as such the Department's ICT environment with regards to ICT budget, infrastructure, technology and skills is conducive for innovation but could be improved. There were several silo precursor GIS applications in the conservation field than other branches because GIS has been considered a powerful tool to deal with the conservation challenges. Individuals in conservation possessed a multitude of GIS software and data which a particular employee undertook to maintain in an ad hoc manner as and when new knowledge was received from various sources.

Agriculture operational challenges result in the non-functional centralised farmer systems because farmer information and projects could not be consolidated Agriculture sections operate in silos and there is no skills transfer to enable continuous use of applications. Data retrieval is difficult and time consuming. There are no records for production inputs offered to farmers and there are unintegrated business processes and systems. Project information is stored in personal computers and not backed up resulting in data loss. Uncoordinated extension services result in poor service delivery. The uptake of new systems is not optimal due to technology resistance and fear of unknown upon introduction of new systems. There are also findings of un-renewed SLAs resulting in poor maintenance at service centres. The GIDS ICT application strength is that it integrates the agriculture databank and the agriculture decision support system (ADSS) but it is not optimally used because of lack of skills to use the system and insufficient server processing capacity, data storage capacity and slow bandwidth to carry the heavy GIS data traffic.

Agriculture work is dependent on spatial information and would improve service delivery if the challenges that have been raised are resolved. The provincial agriculture hubs decisions for agriculture potential land are informed by GIDS and used for daily agricultural decision-making together with the innovative tools like laptops, 3 G cards, mobile phones, digital pen system, agriculture extension suite online application and national department of agriculture and forestry (NDAF) monitoring tool that is forthcoming. The C-plan data set is one of the most requested data set in GDARD. It gained its popularity due to EIA scoping compliance requirement linked to the conservation act adding great value and popularity to the GIDS because it is an integral part of GIDS, thus a demand for wider access in the near future. The GIDS tool is highly recognized strengths include consistency in ensuring that similar software, hardware platforms and data

standards. These resulted in no more duplication because data is centrally managed and the system is user friendly. Hardware is regularly provided and upgraded to meet the needs.

Weaknesses identified by VETS are data conversion errors, certain data not up to date e.g. cadastral data and certain roads data are not updated immediately. Bandwidth at service stations is poor and this pose a risk of decentralizing data to desktops for faster access and processing by certain users. User needs are not updated ever since the first time and GIDS support capacity not enough at regional offices due to high GIS staff turnover. VETS have won several awards and systems approach made it possible. There are limited number of GIS power users and end users in VETS. Basic GIS training has been offered by institutions like the University of Pretoria (UP) but the results are not eminent because there is still dependency on key limited GIS resources.

The Knowledge Management branch only receives the annual budget increment based on annual inflation rate, they ensure that they optimise the budget usage to yield improved service delivery. Branch Agriculture's budget is supplemented by most innovative initiatives funded by NDAF including application and data hosting which should be transferred to GDARD and internal GDARD IT should be skilled to support and administer such innovative agricultural systems and tools. The nature conservation branch reported that they face budget challenges which result in them focusing on conservation function than hospitality which was unsuccessfully outsourced and remain a challenge for the organisation. VETS feel that GIDS is a good investment but not ideal for each user to have full package GIS with all extensions cost recovery money should be used to improve GIS usage at service centres.

**Service Delivery Improvement level: e-Services**

The introduction of e-Services to date includes centralisation, corporate approach to GIS operations, policies and standard operating procedures. The following table summarises the Service Delivery Improvements (SDI) in GDARD from a technology, infrastructure and skills point of view:

**Table 1: Summary of GDARD Technology, Infrastructure and Skills Background**

| Technology | Infrastructure | Skills |
|---|---|---|
| Standardisation to ESRI software (Shape files) | WAN upgrades | Scarce GIS skills i.e. Plato registration |
| SQL database<br>ArcSDE Geo-database | Virtual environment | Limited Practical Experience for end-user skills |

| | | |
|---|---|---|
| Image processing software | Standardising to MS AD platforms | Solid Practical- Extensive Experience for power users |
| Web applications | Broadband, LTE, VSAT | |
| Mobile tools e.g. cell, digital pen cameras etc. | Good at HQ and poor at satellite/regional offices (Digital divide). | Expert for GIS technicians |

Agriculture branch states that a precursor ICT application known as the Agriculture databank was used to capture and store farmers information and different agricultural extension services offered by the department like chicken and piggery infrastructure, production inputs. However, the system is not directly accessed by farmers because the extension farmer programme aims at imparting the information through the programme. The value add that could be derived from direct access is seen as potential future innovation.

The Conservation Plan (C-plan) has proved to effectively impact on service delivery. There has been a high demand to prototype the initiative at other provincial departments and among the GIS community, seminars and workshops. Service delivery is facilitated by printing maps for animal health technicians to plan daily operations like site visits data used for import and export of animal produce and products at the permit office external clients don't directly benefit but private VETS would to be informed of diseases and outbreaks and export and import consultants.

In terms of perceived value of the GIDS interoperability, standards and quality of content, convenience and flexibility, reduced environmental impact, affordability, user-friendliness, availability and accessibility. The GIDS data is standardised, which makes it easy to share with key stakeholders, users of this system find it user-friendly and say it contains the relevant information which is needed on a daily basis to inform service delivery practices. Most clients like Government, business, labour, civil society and residents of the city region find GIDS easy to use. The GCRO focus areas in GIS is data collection, surveys, development of new data sources mapping and analysis work which results into innovative data products and interactive website launched in September 2010. The GCRO web GIS portal which is accessible via the Internet indicates fair access levels and usage continues to grow significantly from an average of 189 visits in April 2011 to 561 in March 2012 as per Google Analytics stats. Most non-academic stakeholders are unaware of the GCRO Internet portal and are currently dependant on the current arrangement to travel and collect the data with cost recovery of the media used to distribute data.

# 5. Chapter Five: Data Analysis of The Findings About the Evolution of GIS ICT Applications for Sustainable Utilisation and Management of Natural Resources in Agriculture and Rural Development of Gauteng

This chapter analyses and interprets the reported findings of the qualitative data collected using the semi-structured interview guide and questionnaire. The findings are analysed and interpreted in line with the interview guide themes and in line with the adopted and adapted conceptual framework. The data analysis and interpretation illustrates whether the problem statement, purpose statement and the research questions are answered. Recommendations and conclusions are drawn with regard to achievement of the five key elements of GIS, composite GIS methodology and the various levels of information in an organisation. The overall summary of findings should indicate whether the mandate, organisational policies are effective and efficient.

## 5.1. Data Analysis in the Context of the Five Key GIS Elements

### a. Human resources

Before 2003 there were few people within the organisation who had GIS experience or formal training in GIS. The same trend had proved to be eminent throughout until 2013. This proves that GIS is still a scarce skill. The strategy to integrate people who had experience or some degree of formal training in GIS from various core business branches within the organisation is relevant to the circumstances but can't be relied upon as this is temporary and not sustainable to capacitate the central GIS unit. The human resources capacity is still reported as a challenge and made worse by the requirement to register with the PLATO professional body which seem to also face capacity challenges.

The GIS skills assessment findings reflect that there is a great need for GIS professionals, GIS technologists and GIS technicians with expert experience. The GIS users level of skills seems to be adequate for functional and not technical purposes although on-going training will still be required since there has been an ongoing loss of trained people. The organisation's GIS user base is higher than the support and maintenance capacity contrary to "underutilisation" of GIS resources experienced before 2003. The ongoing loss of trained people will continue as the problem seem to be attributed to the high demand of GIS skilled people for as long as GIS is still a critical skill. This situation reflects that there is a great need to introduce GIS at school level to attract new entrants into the field and resolve the problem in future. Capacity building initiatives are restricted by budget limitations. The right control measure for this problem is to avoid the delays in filling critical vacancy post. Inadequate process to training IT staff, i.e. There was no evidence that training was aligned with development plans and IT strategy.

### b. Data

IT is reported that a comprehensive inventory of DACEL's spatial data holdings and spatially referenced information was compiled and made available through the Spatial Data Discovery Facility (SDDF) administered by the National Spatial Information Framework (NSIF) early prior 2003. There is a finding that the NSIF ceased to request updates and attempts to update the inventory database via the Internet and this is a draw back against good practice. Unavailability of metadata has implications for duplicity leading to inefficiency. Because "desk-top" GIS software was used, rather than an intranet-based system, the duplication of storage of data sets continued at the early stages of GIDS evolution. This challenge was later addressed between 2003 and 2013 by ensuring that core branches capture data and provide it to the central GIS component on a regular basis, for integration into the central database, however the GIS coordination committee (GISCO) meeting take time to take place due to capacity problems. The user needs methodology supports the quality checking and standardisation processes carried out by the GIS unit. The GIS data distribution is seamless internally and cumbersome externally due to network access challenges discussed earlier. Additional electronic satellite imagery which replaced topographical information brought about the demand for server based GIS as compared to "desk-top" GIS software that was used. Web-based intranet GIS system was introduced and still in use but budget constraints and network speed challenges still prevents it to be accessed externally via the Internet. Maintenance of Web-GIS software licence is not used to capacity and results into wasteful expenditure. COBIT controls require management of third party services to be done at all times including regular SLA meetings.

### c. Software

The number of 13 ArcView licences within the Department which varied in versions is reduced to 10 licenses of standardised versions. Full package GIS software is only issued to limited "power" users with expert GIS skills whilst non-power users of GIS who only require the output products like general purpose are accessed through the intranet web-based GIDS. The reduced licenses are well managed to ensure that they are used effectively. This is a positive achievement because the reduction is looked at in proportion to the growth of the department and demands. This is a good example that change management skills for introducing new applications to avoid application uptake resistance are introduced and ongoing refresher training is carried out routinely.

### d. Hardware

GIS hardware specifications are standardised and the slow processing challenge is eradicated. The plotters are increased for the production of maps. A dedicated server and ArcSDE

geodatabase link for multi-users for storing corporate data centrally and to cater for the provision of the web-based GIS were acquired together with large colour graphics monitors for GIS power users. High desktop and server processing power is required to use GIS efficiently.

### e. Costs

The GIS expenditure was previously very high due to duplication and uncoordinated activities and it is reduced. This is a sign that GIS investment within the Department is now centralised and is more cost effective resulting in less operating budget dedicated to salaries, software maintenance and data procurement for regular periodic updates. According to best practice experience, ongoing data procurement and maintenance costs are a normal GIS maturity practice.

## 5.2. Data Analysis in the Context of the GDARD Composite GIS Flow Diagram

### a. GIS Initial Awareness

Initial awareness of GIS stems from different levels of information needs determined by different functions in an organisation. Each level of functionality has distinctive information requirements, hence distinctive kinds of information demands . The research proves that there is adequate GIS awareness at the lower levels of the staff and external stakeholders but inadequate awareness at the higher levels of the organisation. This scenario proves that there is a high risk of uninformed decision making because GIS is a powerful tool to support decision making. On the other hand it could mean that the operational people and the organisation's clients are adequately informed and thus no pressure for decision making at the higher levels.

### b. Building the Case

**External Request for Information**

External Request for Information (RFI) from GDARD is reported high and it is a positive sign that the organisation is serving its stakeholders effectively. The negative side of the matter is that, most of the external clients that request GIS information from GDARD is consultants, municipalities and academic institutions. This proves that the ordinary citizens of Gauteng may not be aware of such a powerful tool to inform their daily practices.

**User Needs Analysis**

GIS needs analysis in GDARD has been conducted during inception of GIDS and updated once since the inception. User requirements specifications should be reviewed periodically rather than

in an unstructured manner because user needs are dynamic and subject to change which require the application to be adapted. Un adapted systems have a reputation of becoming redundant and resulting in wasteful expenditure. User needs are also important to enhance an existing application.

**Current Application Investigation**

There was no mention of current application investigation by all technical respondents to assess the as is situation in order to identify gaps. Current application investigation is a detailed investigation and fact-finding exercise of the current methods on how the data are used. This involve planning interviews with staff to understand their perceptions about the system.

**Written functional specifications**

The written functional specifications of GIDS were available. It is important to generally file the system specifications as they are important for a number of reasons like for example when there system experience failure, a solution may be based on reverse engineering of the application code based on specification. The specifications are also important for succession when new people join the organisation and others resign.

**c. Detailed Analysis and Design**

**Detailed design**

A detailed GIDS application design document defines that the database graphics specifications interfaces, calculations was available. The design document is required during and after implementation of each system. The graphical characteristics includes properties of the map such as colour, weight, font, line code level and symbol number. Any textual data that is to be displayed will need is specified as to format placement including symbology. The various map qualities such as the scale, geographical area were specified. The output of this process is the GIS application model.

**Development Methodology**

There are two methods of acquiring software, i.e. Build or Buy. GIS software is mostly bought as opposed to being developed. GDARD buys GIS software and thus do not apply the SDLC methodology in the GIS context. The SDLC is applied on non-spatial ICT applications for the organisation. The organisation is dependent on software maintenance renewal and service level agreements which is best practice but costly because of monopolistic behavior of GIS software

vendors. The SDLC is not meant to be only implemented in a situation where a system is being developed in-house because the life cycle doesn't have a definite starting and ending point. In a situation where analysis and design of the application is not relevant, other stages of the SDLC may be relevant, like planning the GIS application infrastructure, implementation of the off-shelve software and ongoing evaluation of the application performance. A structured approach to planning and control is recommended because through a well-disciplined system, all parties will know what is expected of them, their required performance and the reports they must generate. The system application plan is the course to steer, with the tracking and monitoring functions ascertaining the system application plan position with respect to time, procurement, resources and costs. If the system application plan is off course, then control in the form of corrective action must be applied. An application plan includes the outputs of the new GIS based application, the inputs and the transformation of these.

**Software and Hardware Selection**

The functional requirements are also useful to inform the minimum and maximum specifications of the software and hardware. GDARD's software choices are informed by the compatibility with sister departments in the province, national departments and municipalities. This tendency only strengthens the monopoly of software vendors. Open source strategy has been introduced many years ago, but not implemented or recommended. It would be ideal to give the functional specification document to vendors who then respond with a proposals that meet the specification than just going with the flow. The project team would then evaluates these proposals. They will provide important technical and cost information and indicate the feasibility of achieving the project goals. The work of system selection and risk analysis is closely aligned. A key factor in the selection process is the job of bench making. During this process it is usual to observe what the contending systems can actually do in a controlled environment using real data to test its functional capabilities. The evaluation team would arrange for each vendor to perform series of tests on each system. Each system should be evaluated for responsiveness and user friendliness, system flexibility is also important if it will be used for a wide range of applications. The performance and functionality of each bench marked system can then be compared and evaluated.

### d. Implementation

**Project Management Methodology**

GDARD has adopted a project management methodology within the principles of PMBOK and Prince II project management methodologies. The organisation has invested in developing a custom web enabled project management system but its uptake is below average and resulting in

wasteful expenditure which is not required by the PFMA. The main reason for the poor uptake is change management and human resources, skills and capacity challenges. An SLA for supporting and maintaining the system had expired and not renewed by during the time of this study. Project management addresses the need to deliver software development projects on time, within budgets and available resources.

**Customising and Testing**

Since GIDS data was unique to GDARD, customisation had to be carried for the database definitions, attribute data, and security processes. However, GIDS was not designed to interface with any other applications so identifying the particular application programs and database that would will be integrated was not necessary. This finding is a shortfall because the need to integrate GIDS in the future may arise and unfortunately be impossible or costly to adapt GIDS to future needs. The system software may need to be customized to preserve the graphic symbols currently used by the organisation, for example the organisation's emblem. The system test reports were available to prove that the application met the user requirements specified and the application design.

**e. Maintenance and review**

Data conversion and operations continue to change as new data and applications are introduced, the organisation needs to adapt to such changes.

**Data maintenance**

Data maintenance for GIDS is done both internally, other government departments and also sourced from data vendors. During the time of the research, budget constraints impacted on out sourced data maintenance like imagery. The organisation's contingency is to enter into memorandum of agreement with national departments. The contingency contained the challenge but created a dependency which did not necessarily support the user needs due to inconsistencies of such arrangements. The high staff turnover of skilled GIS personnel resulted into some internal data sets outdated and posing the department to litigation risks on EIA applications for development. Woodcock (1999) states that too often GIS projects eventually fall because the human and financial resources required for data management and maintenance effort were overlooked at the project costing and planning stages. The cost of maintenance must be assessed and budgets must be allocated. The higher the accuracy the higher the cost.

In summary, the findings of the report suggest that in order for ICT Applications to contribute towards saving costs, getting more from less, achieving greater return on assets and increasing productivity, the successful implementation of User Needs Analysis, application development methodology, project management, and IT governance are salient. Determined IT governance weaknesses are due to operating in silos, unstandardised GIS platforms i.e. software, hardware and procedures, dependency on consultants, non-existence of Operational Level Agreements (OLAs) between technical support units and business units, poor records of Service Level management interactions and insufficient change management processes.

### 5.3. Data Analysis in the Context of Different Organisational Levels

Policy level: GIS Applications Integration for Natural Resource Use and Management, this will Illustrate achievement of organisational policy, mission and vision for sustainable use of natural resource management. The major finding of the study reflects that GIDS GIS ICT application contributes to achievement organisation policy aims and objectives. This finding is shared also supported by other GPG Provincial departments that are within the scope of this study. This response together with GDARD experience for using ICT Applications shows that ICT Applications enables effective and efficient service delivery for GDARD staff and the organisation by attainment of mandate for sustainable use and management of natural resources. GIDS GIS application has improved decision making processes by reducing turnaround times for the following areas of work; crop suitability, encroachment on conservancies, illegal activities and applications for Development.

Strategic level: Identification of planning processes, frameworks and legislative prescripts for Knowledge Management Processes, this will identify planning processes, frameworks and legislative prescripts for knowledge management processes.

Operational level: Strengths, weaknesses, opportunities and threats towards achieving effective and efficient service delivery indicates improved knowledge through GIS utilisation and enhanced efficiency and effectiveness of services.

Costs: GIS resource management indicates investment on organisational resources and influence on ICT Applications development.

Service delivery improvement level: reflects e-Services for the information society through enabling e-services.

# 6. Chapter Six: Recommendations and Conclusions for Knowledge Management, Future GIS Strategy, Policy and Regulation Implications

This last chapter of the report presents the recommendations and conclusions knowledge management, future GIS strategy, policy and regulation implications. The policy and regulation implications are drawn about GIS ICT Applications integration for natural resource use and management. This is done in order to determine how well mission and vision are met and which policies are working. Conclusions and recommendations at the strategic level are done in order to identify planning processes, frameworks and legislative prescripts that influence deployment of ICT Applications. The operational level strengths, weaknesses, opportunities and threats of utilising GIS ICT Applications are done to determine the costs associated with GIS resource management, the service delivery improvements required, the perceptions about GDARD's level of providing e-Services to Gauteng Citizens. The challenges of providing an integrated management system for sustainable utilisation and management of natural resources in the public service through GIS ICT Applications are identified together with the factors that influence the successful implementation and integration of knowledge management tools for effective and efficient service delivery.

## 6.1. Recommendations

### 6.1.1. Recommendations for a Knowledge Management Strategy

The strategic information management requires management of two main information categories. The spatial information (corporate GIS) and non-spatial information (corporate databases). This scenario depicts a subdivision of the Information systems Management Component into two subcomponents, i.e. the GIS subcomponent and the Applications subcomponent. In addition to the two subcomponents, there is a responsibility to collaborate corporate GIS and databases with all line functions. Therefore, the situation necessitates co-ordination and management of activities across the department's branches and directorates through a dedicated ICT Project Manager.

**The knowledge management processes** include managing the users' access to the system in order to add, modify or erase data, as well as to consult, and manage the information system itself. The different information recipients are information producers, information consumers and system managers. This functions require dedicated information recipients to;

- Integrate the information into the system. Information producers will give the original data for this activity. This process can lead to an earlier processing of such data. It can be processed before it have been stored in the system.

- Distribute information to both the internal users and external stakeholders. This process requires enablement of access to GIDS ICT Application on a web-portal.
- Manage the system, to enrol and withdraw, to modify new information producers and consumers, establishing permissions regarding their activity. It is essential that GDARD GIS subcomponent is capacitated to ensure proper administration and timeous updating of the Geo-database warehouse.

The advantages and disadvantages of the above knowledge management processes are as follows;

**Advantages**

- Different systems representing different business processes will more effectively form a holistic picture and representation of the departmental objectives and vision.
- The establishment of an effective geo-database warehouse (one version of the truth) becomes much more viable and reliable.
- *Scalability* is the ease with which a system or component can be modified to fit the problem area. The update of systems to reflect the most current business process and spatial data will be much more efficient and cost effective.
- Ad hoc queries and reports can easily be generated by both the internal staff and external stakeholders.
- *Interoperability* is the ability of two or more systems or components to exchange information and to use the information that has been exchanged. Systems can be linked more effectively and become efficient.
- *Flexibility* is the ease with which a system or component can be modified for use in applications or environments other than those for which it was specifically designed. The geo-database enables central content contribution and management.
- *Maintainability is t*he ease with which a software system or component can be modified to correct faults, improve performance, other attributes and adapt to a changed environment. This will improve the turnaround times to effectively maintain the system.

**Disadvantages**

- Systems design is a highly specialized field, which needs adequately trained and experienced developers to produce effective and efficient systems – training is therefore costly.
- To keep personnel within a development team is sometimes difficult as the market for good developers and designers are very competitive.

### 6.1.2. Policy level: GIS Applications Integration for Natural Resource Use and Management

Achievement of the policy objective for sustainable use of natural resource management internally, the focus should shift to accommodate external clients and stakeholders for enhanced service delivery.

### 6.1.3. Strategic level: Identification of planning processes, frameworks and legislative prescripts

After conducting and implementing user needs, COBIT and project management principles of strategically directing and redirecting resources, reviewing, monitoring and evaluating progress should be applied complied with in order to ensure consistence progress.

### 6.1.4. Operational level: Strengths, weaknesses, opportunities and threats of utilising GIS ICT Applications for enhanced efficiency and effectiveness of services

The key operational strengths for application of GIDS GIS ICT application is for field work planning and execution, identification and protection of agriculture hubs or zones with high agricultural potential for food security in Gauteng, conservation of important, reserved and irreplaceable sites (e.g. National monuments, Nature reserves, Wetlands), protection of bio-diversity (e.g. Protected species), environmental planning and impact assessment (e.g. environmental authorisations), air quality monitoring compliance and enforcement (e.g. illegal developments) and waste management (e.g. management of waste disposal and land fill sites).

The innovation of the GPS technology assists in saving time and petrol to navigate to remote areas like farms. The digital pen solution tool is a new technology used for field data capturing and is recommended for saving substantial time spent in consolidating media data like pictures, GPS coordinates and field reports which are directly sent on site to the central database and accessed by decision makers though GIDS.

The software versions, hardware platforms and data standards are key to GIS and as such keeping with the trends and maintaining consistency in this areas is important. Interoperability, standards and quality of content, convenience and flexibility, reduced environmental impact, affordability, user-friendliness, availability and accessibility are needs should be reviewed periodically.

A database of clients and stakeholders must be maintained to ensure involvement and consideration of external user needs when planning e-services. The importance of provincial integrated planning cannot be underestimated because of the efficiency and effectiveness benefit prospects that can be realised by utilisation of GIS ICT Applications.

Operational challenges identified (silo mentality, training, skills transfer, slow technology uptake, change management slow bandwidth) impacts negatively towards the system usage.

The priority business need is to make GIDS available to the general public through web access, to ensure that the public users access the site to get a quick overview of the main GIS data influencing GDARD decisions.

#### 6.1.5. Costs: GIS resource management

Budget constraints are a key factor that limits most identified weaknesses, involvement of the organisation's executives especially the Chief Financial Officer (CFO) with regard to ICT strategic planning is key for the resolution of such threats.

#### 6.1.6. Service delivery improvement level reflects e-Services for the information society through enabling e-services

**Usage**

Software and hardware standardisation are critical but adequate currently. Web applications and Internet solutions need to be explored. Mobile tools e.g. GPS, cell phones, digital pen and cameras are recommended innovative technology tools

**Access**

Virtual environment, fully managed data centre, single domain approach and broadband networks are recommended. LAN and WAN upgrades are also at the core of the main problems identified. Future ICT strategy needs to prioritise these issues.

**Skills**

There is a threat for continuous high staff turn-over despite the available staff retention strategies. The fact is that GIS is a scarce skill and the organisation must comply with the OSD

recommendations it is also important to note that according to the SDIA act registration with the PLATO authority is compulsory for OSD implementation.

### 6.2. Conclusions

Based on the above recommendations, the following conclusions are made in the context of the adopted and adapted stages of the conceptual framework. The challenges of providing an integrated management system for sustainable utilisation and management of natural resources in the public service through ICT Applications development and integration of business processes are better understood and factors that influence the successful implementation and integration of knowledge management tools for effective and efficient service delivery improvement within the public service to deliver e-services to the public are outlined in the report's analysis section. The study gives a perspective that GIS ICT Applications are valued as fundamental tools for acquiring knowledge, improving the standards of living through productive participation in Agriculture and Rural Development. The dependency on other ICT technologies like Local Area Networks (LANs), Wide Area Networks (WANs) and the Internet is proven to underpin the successful deployment of ICT Applications to meet the need of providing wider access to information.

The objectives of IT governance are to create business value by determining the business benefits, optimising the risks and resources of an organisation. The CIO play a critical role of aligning, planning and organising resources but he/she needs commitment of the CEO and CFO to ensure that there is evaluation, directing and monitoring of ICT projects. In order to establish the CIO performance, the following should be addressed; stakeholder needs, achievement of goals, managing the enabler life cycle and applying good practice methodologies (COBIT5 Foundation). GDARD's experience of conducting User Needs Analysis through project ROSIE and successful implementation of GIDS GIS ICT application if proof that GIS technology really has the power to integrate knowledge to serve the purpose of consolidating the information resources within an organisation. Although there are limitations in providing wider access of GIS information to external clients and stakeholders, GDARD officials notably achieved the benefits of GIS to increase their effectiveness and efficiency in performing their work. As it was the case with project ROSIE, the next ten years (2014 – 2024) GIS strategy for GDARD should take lessons learned in this study's recommendations especially the focus on e-Services and content management because GIDS has approached the maturity level of ICT Applications development where maintenance and support are critical.

In view of the above, it is evident that GDARD geographic information systems (GIS) is a crucial tool for carrying out Agriculture and Rural Development policy objective for natural resources use and management and there is room for further improving service delivery objectives at policy level,

strategic level and operational level to address the competing and conflicting land use prioritisation challenges. There is again an opportunity for other provincial government departments that make use of spatial information for decision support to apply the tested solutions. Besides the GIDS data layers of which GDARD is the custodian, there are base data layers which can be shared for orientation on Gauteng Province spatial layout. GIDS is also used by other Gauteng Provincial Departments such as Human Settlements, Economic Development, Education, Sports, Health and Social Development, Infrastructure Development, Roads and Transport as an input for integrated and coordinated Provincial Spatial Development Planning Framework.

The strengths and weaknesses of the relevant public service institutional framework, policies, regulations, strategies and structures identified common elements that are causing a disjuncture between Agriculture and Rural Development business policies and the relevant ICT policies. Due to the fact that Gauteng Provincial Government share the ICT infrastructure, the ICT access challenges experienced by GDARD obviously has the same implications to GDARD's sister departments and they can adopt and adjust the recommendations of this report in their own environments. The remaining challenge is optimization of storage space and costs. GPG noticed this challenge and issued a moratorium for GPG departments not establish nor contract for new data centre services, as the GPG's data centre initiative by the GDF will have sufficient capacity to service the needs of the GPG as a whole. This includes data back-up and disaster recovery system. The innovation will lead to new and improved business processes enabling multidisciplinary knowledge sharing, communication and collaboration. The policy lesson learnt is that ICT governance is part of the executive function and the Public Service Regulations need to be reviewed and updated to ensure mandatory compliance of state organs through SITA and DPSA, hence there is a disjuncture between organisational policy objectives, strategies, operations and budgets to achieve e-service delivery, skills development and network infrastructure access to public services.

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# 8. Appendices

## 8.1. Appendix A: Documents Reviewed


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## 8.2. Appendix B: Interview Guide

| Data Objective | Illustration | Questions: |
|---|---|---|
| 1. Policy level: GIS Applications Integration for Natural Resource Use and Management | Achievement of organisation policy, mission and vision for sustainable use of natural resource management | How and to what extent have GIDS application contributed to achievement of your organisation policy aims and objectives? |
| 2. Strategic level: Identification of planning processes, frameworks and legislative prescripts for Knowledge Management Processes | Identification of planning processes, frameworks and legislative prescripts for Knowledge Management Processes | Which strategies necessitated the implementation or use of GIDS application in your organisation? How does your strategy support innovation for GIDS current and future development? |
| 3. Operational level: Strengths, weaknesses, opportunities and threats towards achieving effective and efficient service Delivery | Improved knowledge through GIS utilisation Enhanced efficiency and effectiveness of services | What are pre-cursor GIS applications in your organisation?<br><br>What is the status and value of the GIDS application today?<br><br>Were user needs/requirement specifications in terms of usability and content considered?<br><br>Were the right processes for system development and project management followed?<br><br>Which ICT application development frameworks have been most effective in guiding successful implementation? |
| Costs: GIS Resource Management | Investment on organisational resources & influence on ICT applications development | How do you understand the balance between investment in application innovation and service efficiency and effectiveness? |
| Service delivery improvement level: e-Services for the Information | Enabling e-services | What are the access levels of GIDS ICT application? |

| | | |
|---|---|---|
| Society | | How does your stakeholders value GIDS in terms of interoperability, standards and quality of content, convenience and flexibility, reduced environmental impact, affordability, user-friendliness, availability and accessibility<br>How do farmers, developers and nursery owners experience improvements in GDARD service delivery from the period 2003 to 2013 in relation to GIDS? |

## 8.3. Appendix C: Research Information Sheet

Title: The evolution of ICT applications for agriculture and rural development in Gauteng

**Request:** You are invited to participate in this study by responding to only six (6) questions for the purposes of Masters research. You have been selected as a key informant because you have been captured in the client database for Gauteng Department of Agriculture and Rural Development after your previous requests for GIDS. The interviewer would like you to respond by objectively answering the attached questionnaire and e-mailing it back to Mike.malema@gauteng.gov.za or to conduct a one-on-one interview which should take a maximum of thirty (30) minutes. Please read the following outline in order to consider your participation. An informed consent form is attached for your signature.

**Overview of the study:** This study's focus is on reviewing the evolution of ICT applications for agriculture and rural development in Gauteng, specifically Gauteng Integrated Decision Support (GIDS) application for the Department of Agriculture and Rural development, to determine if the Gauteng Provincial Government ICT strategy and Gauteng Department of Agriculture and Rural Development ICT strategy are contributing in addressing key concerns of economic and social development of enhancing the quality of life and sustainable utilization of agricultural and natural resources through the use of modern ICT applications technology platforms like e-Administration, e-Government and e-Services .

In view of the above, a qualitative research is fundamental to determine reasons why there is a disjuncture between agriculture and rural development business policies and the relevant ICT policies. There is also a need to determine the benefits of introducing Gauteng Integrated Decision Support (GIDS) ICT application to the organisation, determination of user experience of the GIDS ICT application because public awareness and usage of this modern agriculture practice tool is considered critical to address the organisation's key service delivery concerns. This can be achieved through examination of how the GIDS users value the importance of GIDS ICT application for improved service delivery quality and access in supporting internal agriculture and rural development decision-making, citizens perceptions of agriculture and rural development e-Service delivery quality and lastly the value derived from GIDS ICT application tool to address the organisation's business vision.

**Deciding to participate:** Participation is entirely voluntary. You are free to withdraw at any stage without giving a reason. There are no risks to participation. The study may have several beneficial outcomes, as the researcher publishes and contributes to the public discourse on universities, in South Africa and internationally. A few quotations from selected interviews will be included in the final report. The examined report will be published on WITS open access repository.

**Anonymity and confidentiality:** Any limited personal information collected about you will be kept confidential. Names will not be listed in the published report, unless specifically agreed to. Please note that it may be possible to identify the interviewee where reference is made to a particular area of research or research administration, but this will be implicit rather than explicit in the report. The anonymised data generated in the course of the research will be kept securely in paper or electronic format for a period of five years after completion of the study.

### 8.4. Appendix D: Structured Questionnaire

Name and Surname :_____
Organisation (If applicable):_____
Occupation (If applicable):_____
Date :_____

1. What necessitated your requirement(s) to use GIDS?
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2. Which specific purpose do you use GIDS for?
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3. Which pre-cursor GIS applications did you use before acquiring GIDS?
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4. Has GIDS improved your efficiency and effectiveness? If so, describe how?
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   ……
5. How do you value GIDS in terms of interoperability, standards and quality of content, convenience and flexibility, reduced environmental impact, affordability, user-friendliness, availability and accessibility?
   ……
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   ……

……
……

6. How do you rate your skills for using web-based GIS applications? Please **tick with an X** on the appropriate level of skills below.

| LEVEL | DESCRIPTION |
|---|---|
| 1 | Appropriate Training Only |
| 2 | Limited Practical Experience |
| 3 | Solid Practical Experience |
| 4 | Extensive Experience |
| 5 | Expert |

### 8.5. Appendix E: Informed Consent Form

Title: The evolution of ICT applications for agriculture and rural development in Gauteng
**Please initial box**

1. I confirm that I have read and understand the information sheet for the above study. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason. ☐
3. I understand that the researcher will not identify me by name in any reports using information obtained from this interview and that the views I express will remain confidential; or ☐
4. I agree to my name being listed as a participant in this study in the annexure to the report. ☐
5. I agree to the use of anonymised quotes in the dissertation. ☐
6. I agree that my data gathered in this study may be stored (after it has been anonymised) and may be used for future research. ☐

Name of Research Participant Date Signature

Name of Researcher Date Signature

## 8.6. Appendix F: Interviews Schedule

| Interview category | Name & Surname | Occupation |
|---|---|---|
| GDARD ICT Branch | Anonymised | Info Systems<br>GIS<br>ICT Infrastructure<br>ICT Support<br>GIS Technician<br>GIS Technician |
| Core line functions | Anonymised | DIR Agric<br>Agric<br>Complience enforcement<br>Conservation<br>Nature Conservation<br>DIR Environment<br>DIR Environment<br>SUE<br>SUE<br>Conservation<br>Conservation<br>VETS<br>VETS<br>VETS |
| External Stakeholders | Anonymised | Spatial Research<br>Spatial Planning<br>Spatial Planning<br>Spatial Planning |
| GDARD Clients/stakeholders | Anonymised | Environmental consultant<br>Environmental consultant<br>GIS consultant<br>Ecologist<br>Ecologist<br>Environmental officer<br>Nature conservation<br>GIS specialist<br>Environmental consultant |