

**Open source geographic information
systems: Promoting access to health
services information through a local and
participatory development methodology**

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(Applied Science)**

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Cape Town

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Synopsis

The challenges associated with the provision of health services in South Africa are immense. The South African Government aims to address some of these challenges through the decentralisation of health services management. Information sharing and dissemination is seen as a critical factor in the success of such a structure.

Geographic information systems (GIS) have been identified as a means through which information can be shared. The research aims to determine how GIS can aid the management of health related services through promoting the use and sharing of information. This is based on the premise that the GIS is developed in a participatory manner and focused at the local community level.

Three major steps make up the research being presented. The first aimed to determine the status quo of GIS use in South Africa. An online questionnaire was designed for this purpose. The second was the facilitation of the participatory development of an open source GIS prototype based on the results of the online questionnaire. The third step was the testing of the GIS prototype. Testing was completed using methodologies from case study research and human computer interaction (HCI), and included a case study of the Overstrand municipal area, in which usability testing of the GIS prototype was completed.

The research found that GIS has a significant role to play in the sharing and use of information at a local community level. The methodology employed in the research illustrated an effective manner in which to promote participation in the development of a system. Furthermore it was determined that open source software allows for the flexibility required for such system development, in that the focus of development must be for a specific group of people, and for specific tasks to be carried out by those people.

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Chapter One: Health and information requirements in South Africa

Health management in South Africa faces numerous challenges of increasing complexity and need. While a major aim of health management in South Africa is to address the disparities in the provision of health care and services caused by the apartheid government, HIV and AIDS amongst other prevalent illnesses add increasing pressure and complexity to the picture. It is within this context that the South African government is looking to implement an effective and decentralised public health care system that fulfils the requirements of its Constitution.

The South African Constitution (Republic of South Africa, 1996) makes clear provisions for health rights stating that everyone has the right to have access to health care services, food and water and social security (Section 27). Additionally everyone has the right to an environment which is not harmful to their health or well-being (Section 24). The meaning of the terms health care services, health and well-being is not well defined in policy and is debateable, to define what health services are is thus a challenge. Within the context of this research a definition is however possible as local levels of government have specific roles to play in the provision of health care services and in providing an environment that is not detrimental to the health of its population.

Health services, as seen in this research, are defined as services that contribute to the health¹ of a population and, as is concurrent with the scope of this research, within the responsibilities of local government. Examples of such services include adequate housing, electricity, sanitation, clean water, food, social security and access to clinics (TAC, 2006).

¹ Health is broadly defined within this research as "a complete state of physical, mental and social well-being, not merely the absence of disease or infirmity" World Health Organisation (1946).

Recent policy, aimed at giving effect to constitutional rights, has focused on the decentralisation of the health system, and provided guidelines for the management of health services through information gathering and dissemination.

1.1 The decentralisation of South Africa's health system

In an effort to address the challenges in the health sector the South African Government is in the process of creating a decentralised health care system (Hall et al, 2005; Andrews & Pillay, 2005). This involves the movement of responsibility for local health care delivery (in terms of planning, management and finance) away from central government, and giving the responsibility to the peripheral government structures (Hall et al, 2005; Andrews & Pillay, 2005). This aims to overcome the current fragmented state of health service delivery, as well as promoting the quality and efficiency thereof (Republic of South Africa, 1997). This has the further effect of promoting accountability of local government tiers and allowing for further community involvement in decision making.

The decentralisation of public health care services in South Africa has, unfortunately been staggered and uncoordinated (McIntyre & Klugman, 2003). Efforts to implement a decentralised health services began in the mid 1990s (McIntyre & Klugman, 2003). However these were delayed due to the need for the demarcation of municipal boundaries. Furthermore, the deconcentration² of provincial services has resulted in further confusion as health districts were created, often clashing with their local counterparts, the municipal boundaries (McIntyre & Klugman, 2003). The reality remains that the responsibility for the planning and management of health services is shared between the three tiers of South Africa's government³, with some programmes being managed by the central government in a traditional "top down" manner, and others managed by the less central government tiers (McIntyre & Klugman, 2003).

² Deconcentration is the process of giving some authority to a locally based office (such as the creation of health districts in South Africa).

³ The tiers of Government in South Africa are made up of National, Provincial and Municipal (local government).

These factors have contributed to a lack of clarity over responsibility and confusion over communications and management structures (McIntyre & Klugman, 2003; Hall et al, 2005), resulting in a lack of effective communication and information sharing. In a more positive light an increased emphasis is now being placed on the need for effective information capture and sharing (Republic of South Africa, 2003).

With the aim of promoting clarity in terms of responsibility the Health Act (2003, sections 74, 75, 76, 21, 25 & 32) emphasises the importance of the development of health information systems⁴ (aimed at providing and disseminating information) at all levels of government.

In addition to the development of health information systems, the Health Act provides guidance in terms of service provision. The services to be provided by the national and provincial levels of government are defined in the Act (Health Act, 2003, sections 21 & 25), yet the services to be provided by municipalities are decided on an ad hoc basis, and may be designated from the provincial department of health (Health Act, 2003, section 32). This allows a certain amount of flexibility, but may result in some confusion over responsibility.

1.2 Health information management

One inadequacy of South Africa's health system is the lack of accurate and available information for decision making, planning and problem identification (Mathews, 2005). The availability and sharing of such information is seen as critical for the management of health services, especially in an environment where responsibility is shared across different government structures, and cooperation between these structures is required (Gray et al, 2005). Recent policy has looked to focus on gaining and sharing relevant health information in an effort to understand the current health system and increase the coordination between the various tiers of the health service structure.

⁴ Health information systems are broadly defined as "an integrated effort to collect, process, report and use health information and knowledge to influence policy-making, programme action and research" (WHO, 2004).

The gathering of accurate information is emphasised in the recent Health Act (2003, sections 35 & 36) where guidelines are provided to classify and document the requirements of health establishments in an effort to structure the delivery of health services throughout the country. It is further described in the Act (section 12) that all national, provincial and municipal health managers must ensure that information on available health services is disseminated to the public. The inclusion of communities in the planning process of health services is another feature of recent policy (Andrews & Pillay, 2005). This is however the responsibility of the national and provincial health departments according to the Health Act (2003, sections 21 & 25).

The right of access to information for communities is embedded in the South African Constitution and supported by the Promotion of Access to Information Act (Republic of South Africa, 2000). This Act advocates that information held by the state, and information that is required in the protection or exercise of any rights must be made available to any person. The Act further provides an opportunity for people to participate rationally in decision making (Lor & Van As, 2002), through providing an understanding of decisions affecting them and their environment. Despite a number of initiatives to promote this, the translation of policy to practical implementation has lacked (Lor & Van As, 2002).

The information required for the effective management of health services is vast, and includes information on environmental health (e.g. water, sanitation), the location of health services (clinics, hospitals etc), the occurrence of disease and illness, and socio-economic information (Mathews, 2005). Equally important to the variety of types of information required for health services management is the accuracy and timeliness of the information used (Yasnoff et al, 2000). Such information is however only partially available, and as a result those responsible for the planning and management of health services (most often the local municipalities) use inaccurate and outdated information.

1.3 A role for geographic information systems

Health and health services information has a distinctive spatial nature, being connected to people, where they live and where they receive care. In addition to this, the management of public health service delivery in South Africa is delegated according to the spatial location of health districts⁵ (Hall et al, 2005). Geographic information systems (GIS) therefore provide an appropriate tool for the management and dissemination of information relating to the management of health services.

GIS has had an extraordinary influence on health care and the management thereof (Albert et al [1], 2000) within both the developing and developed world. Through its ability to manage, manipulate and analyse large amounts of data, GIS is seen as a powerful tool for health services planning and management (Albert et al [2], 2000). The use of updateable databases can keep up with the ever changing nature of health management information. GIS may also provide an opportunity to extend information across barriers potentially empowering communities and decision making authorities (Cromley & McLafferty, 1999).

There is interconnectivity between GIS and health services management, and the potential for GIS to be a highly positive and influential tool is immense. This potential has not always been realised to its full extent (Cockings et al, 2004), and GIS use in health services management remains generally centralised and immature at a local level. GIS has been criticised for its undemocratic and quantitative nature (Ghose, 2001), not allowing those working at the local level to access the tools or information potentially available. Due to similar reasons information systems (including GIS) have struggled to be accepted in health management environments (Higgs & Gould, 2001).

The relevance of GIS as a tool in promoting access to health services information is explored through this research. It aims to address some aspects of the issues raised in this

⁵ Health districts in South Africa are currently being aligned (in terms of their boundaries) with local government boundaries (Hall et al, 2005), previously these were separate entities.

chapter. The following section (1.4) introduces the exact definition of this research project

1.4 Introduction to the research

The research presented aims to illustrate a manner in which access to information and the effective communication thereof may be facilitated through the use of GIS. The research will determine the usefulness and potential for a GIS approach to the sharing of information within a health services context and at a local level by exploring and answering the following research question:

Can GIS aid the management of health service delivery at local community level in South Africa through promoting the use and sharing of relevant spatial and non-spatial information? How can this be achieved within a participatory framework?

Three research aims were developed in order to provide evidence towards, and answer the above research question. These are as follows:

- To determine the status quo of GIS use for health within South Africa
- To facilitate the participatory development of an open source and GIS for the dissemination of information
- To test the usability and functionality of the system with potential users through a case study methodology

The aims of the research play a dual role of providing a context for the research and answering the research question. This is elaborated on in Chapter 3 (Section 3.1).

The research aims were investigated through a variety of research methods. An online questionnaire was designed to fulfil the first aim, providing insight into how and by whom GIS is employed within South Africa in health related fields. This also served as a

guideline for the focus of the GIS prototype developed by the Cell-Life⁶ research team. The GIS prototype allowed for the testing of GIS as a means of sharing information and the communication thereof. The final aim of the research was completed through usability testing, stemming from Human Computer Interaction (HCI) and related fields. This predominantly tested the level of complexity and functional suitability of the GIS prototype, allowing for the measurement of the overall applicability of GIS to be established, and ultimately determining if GIS can play a role in the management of health services.

Each of the interleading steps in the research provides insight into topics that are relevant to the management of health and health services. The research acquires background and uses methodologies taken from published and primary information sources. These, along with the results of the research are detailed in the following chapters of this thesis.

1.5 Summary of the thesis

Chapter 1: Introduction considers some of the main challenges faced by South Africa in terms of health management. This is related to the research question, which is introduced along with the aims of the research.

Chapter 2: Literature review introduces the theoretical context within which the research has been carried out. The role of GIS in health is explored and issues relating to implementation strategies and an apparent lack of consideration for the end user of the system are highlighted.

This is related to GIS in general and its rapid introduction into various areas of application. A critique of GIS is provided, and participatory GIS methodologies are offered as a solution to some of the pertinent issues.

⁶ The Cell-life research team, based in the Civil Engineering department at the University of Cape Town focuses their work on finding innovative solutions to the challenges of HIV/AIDS and other health issues in South Africa.

Chapter 3: Research design and methodology formally introduces the research problems. The research question is considered in terms of the aims of the research. The selected methodologies are then explained with respect to the aims of the research. The chapter concludes by considering some of the limitations of the methodologies employed in the research.

Chapter 4: Online questionnaire results is the first of three results chapters and presents the results of an online questionnaire aimed at gaining an understanding of the use of GIS in health in South Africa. The results of this are related to the development of a GIS prototype and the gaining of an understanding of the use of GIS in South Africa. The chapter concludes by considering the variety of roles GIS currently plays in health and identifies areas where local community interaction could be promoted.

Chapter 5: GIS prototype development documents the participatory design of the GIS prototype. Open source software and web based GIS is introduced leading into the development processes and an assessment of the GIS prototype. The functional aspects of the GIS prototype are discussed as well as the data used in the prototype. This chapter concludes with consideration of the potential for the prototype's area of application and the usability of the system.

Chapter 6: Case study of the Overstrand municipal area introduces the case study and the usability testing of the GIS prototype. It includes the framework within which information is currently accessed and shared between various user groups identified. The results of the usability tests are presented and compared across a number of variables and user groups.

The chapter concludes by demonstrating the usability of the GIS prototype within the context studied. Further possibilities are considered as to future development phases of the system and to other potential user groups who may become involved in the development process.

Chapter 7: Conclusions and recommendations summarises the key results of the research. The results of the research are related to current South African policy and suggestions for further research are formulated.

Chapter Two: GIS and health: an argument for participatory methodologies

This chapter describes the theory informing this research through a review of current literature. The literature reviewed provides a conceptual background to the arguments that are prominent in this research. The use of GIS as a tool in health is considered, and reference is made to current research with an emphasis on health services management in the public sector. Through this the suitability of GIS as a tool for health management is illustrated. GIS is then considered critically in terms of its role in society, bringing to the fore issues and limitations of GIS in terms of the social implications of the technology and indicating the need for a review of current development and implementation methodologies. In response to this, participatory methodologies for the use and implementation of GIS are considered. An argument for the participatory development of GIS in a local health setting as an effective implementation solution is presented.

2.1 GIS and its role in health

The use of GIS within health is categorised according to its involvement in two distinctive areas of health (Gatrell & Senior, 1999; Kamel Boulos et al, 2001):

- epidemiology and
- health care.

Epidemiology is the study of the occurrence of disease, especially in relation to environmental features. This is an area in which the traditional analytical tools of GIS are employed a great deal (Richards et al, 1999).

The use of GIS in *health care* is concerned with factors such as hospital and clinic placement, accessibility to these and other services contributing to the health of people. It is epidemiological research however that brought health and geography together

(Richards et al, 1999), and will be considered before exploring the role of GIS in health care and management.

2.1.1 GIS and epidemiological research

The use of GIS for epidemiological research and practice is in abundance and has implications for the management of health, especially with respect to environmental factors and the provision of data on which health care may be based (Richards et al, 1999). Epidemiological research and practice will be considered briefly, limited mainly to the South African context. While there are examples of such studies in the developed world (see for example: Nuttall et al, 2005) the majority of such studies take place in, or are concerned with the developing world.

A large proportion of the articles reviewed are concerned with the occurrence of Malaria in relation to changing climate and the presence of mosquito habitats (e.g. Craig et al, 1999; Klenschmidt et al, 2000; Allison & Harphan, 2002). Others have explored cholera infections, also with respect to environmental factors such as water and climate (e.g. Ali et al, 2001). These examples illustrate of GIS's ability to combine features, and through comparison identify causal relationships.

Few epidemiological research initiatives have tackled critical issues such as HIV/AIDS. Tanser et al (2000) provide one such instance, and identify the occurrence of HIV/AIDS in relation to major trucking routes in South Africa. This is a rare instance in which epidemiology is studied and linked to health services.

The lack of attention given to health services within the developing world has been noted by some (McIntyre et al, 2000) and relates to some of the problems highlighted in the previous chapter. Allison & Harphan (2002) link the void in focus on health services to a lack of available data. The failure to take cognisance of the local context in terms of implementing such applications is also noted as a possible cause (Nemeth et al, 2005). Jacquez (2000) stresses the importance of research on health service provision in the

developing world, and suggests that it is imperative that greater focus be given to the subject. Studies relating directly to health services are explored in the following section (2.1.2). While the emphasis of this research remains on the developing world, examples from abroad are used for illustrative purposes.

2.1.2 GIS and health care research

Research focussing on health care is separated according to its focus either on the developed or developing world. Research in the developing world has a focus on accessibility to health care and services, while research in the developed world is concerned with a wider variety of topics. Examples concerned with the developing world are introduced first, followed by a fuller consideration of research based in the developed world. The argument for the GIS to play a greater role in health care and services management in a developing world context is emphasised throughout this section.

Studies related to health care planning within the developing world generally describe issues around accessibility to health services. Investigations into accessibility are provided through distance measures in relation to health care reform and the provision of services to those in need in Costa Rica (Rosero-Burby, 2004), the effects of physical accessibility in mountainous areas in Andean Bolivia (Perry & Gesler, 2000), and the identification of areas with minimal access to health services in India (Mallick & Rouray, 2001). In South Africa Tanser et al (2006) have made use of GIS in estimated travel times to clinics in South Africa, quantifying physical accessibility and providing comparisons for varying urban landscapes.

The focus on accessibility is echoed by other researchers in similar contexts (Perry & Gesler, 2000; Mallick & Rouray, 2001). Direct consideration for health services and the management thereof appears lacking within the developing world. An exception is presented by Deshpande et al (2004) illustrating the importance of effective data provision through using GIS to determine the number of private health practitioners in

India. Research based in the developed world illustrates more effectively, the potential for GIS to be used in the management of health.

Some of the most recent and advanced examples of research making use of GIS in the field of health care within a developed world context focus on the provision and management of private health care.

Accessibility to general practitioners through the bus networks of the United Kingdom is investigated by Lovett et al (2002); Shortt et al (2005) use a similar methodology in applying GIS to the development of general practitioner catchment areas in Scotland. The use of GIS in private health care and services provision is closely related to that of public health care and the foci of these sectors is similar in the developing world.

GIS has also impacted profoundly on public health care. The use of GIS in public health is an established practice in the United Kingdom. The National Health Service (NHS) of England provides a relevant and well documented example of this (e.g. Higgs & Gould, 2001). Smith et al (2003) report on the comparative use of GIS within the NHS between 1991 and 2001, indicating that nearly 86% of health authorities make use of GIS. The focus of such use is concerned with the following aspects: Assessing population health needs, health profiling, determining health catchment areas, planning health facility distribution and research.

Research has been completed on determining influences on the use of health care facilities, showing the ability of GIS to combine social and physical information. Parker and Campbell (1998) use GIS to define variables affecting this, noting the important role of GIS in health planning and analysis.

The use of GIS within such environments illustrates the potential for GIS uptake within the developing world as the responsibilities and goals of health departments show a high degree of commonality. The developing world, while in need of research concerned with health care and services management (McIntyre et al, 2000) lacks documented use

thereof. It is thus imperative that research be completed on the health services, and indeed services that add to the health of a population in general. The following section (2.1.4) illustrates the potential that GIS has for health care management.

2.1.3 The potential for GIS in health management

GIS has added profoundly to the understanding and management of health in both epidemiology and health care. This is well documented in the late 1990s into early 2000 when GIS use in health was seen to have matured to a certain degree. Olvingson et al (2003) assert that drastic changes have occurred in health care since the introduction of such technologies; Albert et al (2000[1]) relay similar sentiments within the field of medical geography, and comments on its rapid diffusion throughout all disciplines. In a less enthusiastic fashion Richards et al (1999[1]) view the incorporation of GIS technology as an important tool for health practitioners in health planning.

Simultaneously there is an emphasis on making the tools of GIS more available to health professionals through training manuals and creating an awareness of the technology (McLafferty & Cromley, 1999; Richards et al, 1999[1, 2 & 3]; McLafferty & Cromley, 1999; Bouton & Fraser, 1999). This hints at extra efforts being made to promote the effective use of GIS within health related institutions. The emphasis of much of the NHS's outputs has changed and more recently become focused on the lack of proper use of GIS within the organisation (Higgs & Gould, 2001; Smith et al, 2003). This in spite of an increasing user base within the NHS (Smith et al, 2003). Using the NHS as an example, it is clear that the use of GIS has not lived up to its expected standards (Higgs & Gould, 2001; Smith et al, 2003).

The following section (2.1.4) outlines key reasons for GIS not reaching its expected potential within health.

2.1.4 The challenge of GIS incorporation in health settings

Many reasons are offered for the lack of incorporation of GIS technologies. The majority of which are concerned with the end-users of GIS and a lack of consideration of their needs (Nemeth et al, 2005; Magruder et al, 2005). Rob (2003) suggests the reason for GIS not being implemented and used to the same extent as other application software is the time required to learn and understand its functionality. Similar sentiments are presented by other authors, who state that staff training is required (Magruder et al, 2005; Houghton, 2003), analytical skills of health workers need to be honed (Lehmann & Makhanya, 2005) and that better leadership and co-ordination (Houghton, 2004) are needed for the effective implementation of GIS in health settings.

An alternate consideration focuses on the methodologies employed in the implementation of GIS. Kukafka et al (2003) call for a behavioural approach to implementation, and claim, along with others that there is a lack of understanding of user needs (Yasnoff et al, 2000). Nemeth et al (2005) expand on this calling for a human centred approach, commenting on the difference between implementation at the management level, which is relatively simple, and implementation at the operators level which due to the complex social settings, is more challenging. Johnson et al (2005) warn against the waste of time and finances soaked up in the redesigning of systems in health settings, claiming that a large percentage of systems become redundant due to lack of use.

The complexities associated with the effective use and implementation of GIS within health institutions illustrates an important focal point. The importance of the user is stressed in this context. Those that make use of GIS to fulfil their working needs are seen as an integral part of GIS; this is expanded upon in the following section (2.2) of the literature review which focuses on this change in mind frame and introduces a critique of GIS.

2.2 The rapid introduction of GIS

GIS has been accepted into a variety of environments worldwide, described as “a climate ranging from unquestioning acceptance to a celebration about its technical capabilities and positive social impacts” (Harris and Weiner, 1998). This initial burst is often attributed to the allure of a new technology, creating excitement and a rapid increase in the use of the tool.

The introduction of GIS can be compared to that of information systems in general. Information systems have gone from being techno-centric to socio-technical (Reeve & Petch, 1999). Such a change is signified by a focus on people, not just technology, systems that have specifications designed by users, not technologists, and a demand pull, not the push of the technology (Reeve & Petch, 1999). GIS is in a stage of such transformation, and the technology is being investigated in terms of the social and political contexts in which it is being implemented.

This transformation is mimicked by the definitions provided of GIS. GIS, as a result of the rapid and diverse conception lacks a universally accepted definition. There are however certain approaches to GIS that can be classified and applied to all realms. Clarke (2001) identifies four approaches, which may be agglomerated into two areas of interest that define the changing state of the technology. GIS may be seen in terms of its functional definition, what GIS as a tool, may do to resolve a specific issue. More pertinent however, are definitions concerned with GIS as a science and as having a societal impact. Such a view points towards the changing nature of information systems in general and a focus on the societal impacts of GIS.

The general shift of focus from the technology to the user may be described as GIS having lost its initial technological “allure.” A critique of GIS based on this and other pertinent features of the technology will be considered in the following section (2.2.1).

2.2.1 Critique of GIS

The GIS and society debates can be traced back to the 80s (Obermeryer, 1998).

Obermeryer (1998) notes how the concept of GIS changed from describing it as a tool designed to solve problems, a functional definition, to seeing the development of GIS as a societal process, mirroring the development of GIS as a technology.

A critique of GIS beginning in the 1990s was based on the positivistic traits that GIS portrayed (Craig et al, 2002). This was mainly limited to theory concerning geography, where the movement away from positivism was a fairly recent affair (Mouton, 1999). The debate soon grew into one considering the external influences GIS has on society and policy, and vice versa (Elwood, 2002).

GIS was considered an undemocratic technology (Obermeryer, 1998), as it further broadened gaps between the powerful and less empowered people through differential access to data and technology and gave the people in power surveillance capabilities that the other sectors of the population did not, and do not, have access to (Craig et al, 2002). The criticism has gone as far as calling GIS an "elitist and anti-democratic technology". (Ghose, 2001). The use of GIS by certain governing institutions may disempower groups who are not adept to using computers or technology, poor communities. This extends to the forms of knowledge and input used in GIS (Elwood, 2002).

Participatory GIS (P-GIS) is a field of study and application that has emerged from the criticisms of GIS presented in this section. P-GIS aims to provide tools and accessibility for all to make use of the tools and data presentation capabilities offered by GIS. P-GIS theory and practice is reviewed in the following section (2.3).

2.3 Participatory GIS, an answer to the critique?

Participatory GIS (P-GIS) refers to a methodology that allows systems (GIS) to address the needs of people who are concerned with participation in decision making (Nyerges et al, 2002). P-GIS stems from a combination of factors, the predominant influence is seen

to be a shift in thinking relating to the social context in which GIS exists. Obermeyer (1998) notes this, stating that GIS is seen as a product of social change within the field of GIS, while previous circumstances may have also had influence. In addition to being a response to the critique of GIS, P-GIS is seen as a by-product of participatory approaches to planning (Rambaldi et al, 2005), and more generally as a product of technological advance and public expectation (Kwaku Kyem, 2004).

Three terms are predominantly used to describe this, public participation GIS (PP-GIS), community integrated GIS and participatory GIS (P-GIS).

- **P-GIS:** P-GIS is used, in most cases, as an umbrella term providing the broad context within which the other terms exist (Nyerges, 2005). P-GIS may loosely be described as a system or a process that is intended to address the needs of people (researchers, planners etc) concerned with participatory decision making and planning (Nyerges et al, 2002). McCall (2004) makes the distinction between P-GIS being the tool, and PP-GIS being the planning context.
- **PP-GIS:** The term Public Participation GIS was originally derived from the planning fraternity, used primarily because of its familiarity to planners (Obermeyer, 1998). PPGIS is concerned with providing access to GIS and thus information to people affected by or involved in official planning processes. The focus is on participatory planning and making this process participatory, involving and providing communities and people with the powerful tools of GIS and spatial analysis.
- **Community integrated GIS:** Community integrated GIS is the lesser used term of the three, and has been found to be used only as a synonym for the other terms considered (King, 2002). Craig et al (2002) consider this further, and indicate that community integrated GIS is a more general term, considering the broad process of participation.

All of the above terms imply the inclusion of local concerns and knowledge into a geographic information system in one manner or another (King, 2002). It is further implied that through the process communities are empowered by the spatial tools provided through the provision of GIS and the skills to use GIS.

McCall (2004) identifies four levels of participation in P-GIS: information sharing, consultation, involvement in decision making and initiating actions. Table 1 provides a useful summary of P-GIS practices. It is often assumed that the highest level of participation is the most effective; others however argue that this is contextually based (McCall, 2004; Ghose & Huxhold, 2001), and that such levels are appropriate only according to the context in which they are employed.

Table 1 P-GIS levels of participation

Level of participation	Description
Information sharing (Least participatory)	<ul style="list-style-type: none"> • Topics pre-determined by outside agency • Communication between outside agency and local community predominantly of a technical and advisory nature • Outside agency gaining local knowledge through the community
Consultation	<ul style="list-style-type: none"> • Issues selected by outsiders before consultation with community • Analysis and knowledge controlled by outsiders
Involvement in decision making by all actors	<ul style="list-style-type: none"> • Priorities are jointly identified and defined • Joint analysis and implementation • Still externally initiated
Initiating actors (Most participatory)	<ul style="list-style-type: none"> • Initiative belongs to the community • Participation is present at all stages

(McCall, 2004)

The research being presented deals with the “least participatory” level of P-GIS as is illustrated in the table above. Within the context of the research, and according to the information gained in this research (see Chapter 4, section 4.2) this was deemed the most appropriate level. This is of relevance to such projects within the developing world

context, and it is argued that a community that has never been exposed to GIS technology cannot initiate such actions without the external help and advice that is provided at the stated level of P-GIS.

The term P-GIS will be used in the description of this research from this point forward. The following section (2.3.1) is focused on providing further insight into P-GIS as a practice. Examples from a variety of projects based both in the developing and developed worlds are investigated, aiming to illustrate P-GIS practice the theory behind it.

2.3.1 Participatory GIS research

According to McCall (2004) practices of P-GIS in the developing world are concerned predominantly with natural resource and land claims, identification and management, while the developed world is concerned with problem identification, prioritisation and participatory planning.

In the developing world the emphasis of much of this research lies in the use of GIS to document indigenous knowledge. For example, Tripathi and Battarya (2004) make use of P-GIS methodologies in community based participatory resource management, stating that indigenous knowledge is critical for sustainable development. Mbile et al (2003) provide a further example in which participatory resource mapping is used to promote forest conservation in traditional farming areas. GIS has also been used to determine a suitable strategy for the upgrading of informal settlements through the involvement of various stake holders (Abbott, 2003).

Research on the role of P-GIS within the services and planning context are also in abundance (e.g. King, 2002; Imbile et al, 2003). Scotch & Parmanto (2006) discuss the development of a system designed to monitor and assess community health. It is designed to use information from a variety of sources, and analysis is done through a simple interface. It is user friendly and thus accessible to both health analysts and the non-expert. Elwood and Leitner (1998) describe a project in which a variety of local organisations are

given access to GIS in order to facilitate community planning. Further examples include the use of GIS to promote health in various forms (Boyington et al, 2004). Theseira (2002), in a study concerned with sharing health related data over the internet, identifies the agencies involved. They include government departments at a local and national level, public health agencies, GIS organisations and the university that initiated the project. No formal assessment of the usefulness or usability of the system is available.

Many of the above mentioned research projects and initiatives show great potential for the management of health. They all however lack documentation of the manner in which they were implemented, and whether this was successful or not, especially in terms of empowerment (Elwood, 2002). This hampers development and re-use of previous research methods.

It has been argued that P-GIS projects hold many advantages for communities and such advantages are not limited to either the developed or developing world. The only limitation is the focus of the research (with respect to the developed and developing world). It is reiterated here that a focus on health services management in the developed world is of critical importance to the success of providing effective health care. The advantages of P-GIS, for the community as well as other agencies are discussed in the following section (2.3.2).

2.3.2 Advantages of participatory GIS

P-GIS is seen to have a number of advantages for communities who are involved in such projects. At this stage it is important to define two key and often misinterpreted terms: community and empowerment.

Community: Communities are defined according to a number of factors that provide for the sharing of common experiences and perspectives. This commonality is provided through physical proximity to each other, or through other forms of interaction such as professional, social or spiritual relationships (Craig et al, 2002).

Empowerment: Within P-GIS, empowerment of certain people is created through the provision of information (allowing for an improved understanding of external and internal matters). Skills are improved through P-GIS, through the creation of an understanding of mapping and specifically GIS. This is discussed further in the following paragraphs. For further consideration of this topic see Elwood (2002).

Through the use of participatory methodologies GIS communities may gain access to information about local concerns in a form that is generally understandable. For example, a map provides a means by which information can be relayed simply and effectively (McCall, 2003), allowing communities to understand decisions made by authorities. Maps also provide a means by which communities can communicate upwards (to authorities), allowing people on the ground to challenge decisions made by others. Including maps in complaints, reports or any communication adds authenticity and provides communities with a degree of bargaining power when communicating to authorities (McCall, 2003).

The potential for such use of maps illustrates that P-GIS may play a positive role in the management of any local concern. A negative factor, as noted by some researchers, is related to the nature of empowerment. Concern is expressed that while some communities are empowered, others are not to their possible detriment. Weiner et al (2002) note that P-GIS simultaneously empowers and marginalizes communities, through the inclusion of some and exclusion of others (Elwood, 2002). Additionally McCall (2004) warns against P-GIS being used to legitimise illegitimate projects, through entitling them as such without actually employing the methodologies.

2.4 Summary and conclusions

The themes that have been outlined in this chapter capture the concepts and theory that much of the research being presented is built on. The main purpose of this review has

been to illustrate the manner in which GIS has developed, how this relates to health and the social, political and technological forces that have played a role in these changes.

The value of GIS as a tool for the management of health is clear, yet this has not been fully realised due to a lack of cognisance of the end user, and of their requirements and needs in terms of a system. Additionally GIS has been argued to be an undemocratic and marginalizing technology. In response to this, participatory methodologies of GIS development and implementation have been developed, providing an opportunity to investigate this as a plausible solution for the lack of GIS uptake within health settings.

Chapter Three: Research Design and Methodology

This chapter presents the research design and methodology used to investigate whether GIS may play a role in the management of health services through the promotion of information use and sharing in South Africa. The methodologies used in the research aim to provide a participatory framework in which GIS may be developed for information sharing at a local level.

3.1 The research question and its aims

The research question considers the possibility of using GIS as a tool for the management of health in South Africa. GIS has been seen to have the potential to increase the effectiveness of health service delivery in a variety of contexts (Chapter 2, section 2.1.3). It is also apparent from the literature that participatory design and development (P-GIS) would allow for GIS to fulfil the needs of local communities most effectively.

It is however necessary to investigate the potential for the use of GIS in an environment of limited resources, such as that of South Africa. In addition to limited resources, South Africa has a variety of population groups and geographic settings, making the development of any information system a challenge. It is therefore expected that GIS would have the most positive effect by using a locally informed participatory development approach. Related to these factors, the research hypothesis is stated as follows:

Can GIS aid the management of health service delivery at local community level in South Africa through promoting the use and sharing of relevant spatial and non-spatial information? How can this be achieved within a participatory framework?

In considering the above question a number of research aims were formulated. The aims have been designed to answer the above research question while providing the necessary context for the research.

Aim 1: To determine the status quo relating to the use of GIS for health in South Africa

In order to effectively determine if GIS can aid in the management of health it was important to determine the nature and scope of GIS application in health related fields. As there is no comprehensive literature on this subject, relating specifically to South Africa, it was necessary to gather the data. This was done through the use of an online questionnaire aimed at health professionals using GIS.

Aim 2: To facilitate the development of a user friendly GIS for the dissemination of information

The research was highly dependant on the development of a GIS prototype, developed by the Cell-Life research team at UCT. The development of the prototype and the functionality given to it was based on advice given through the results from the online questionnaire. The GIS prototype was developed to be used by people with little or no GIS experience, and thus contains only basic functionality.

Aim 3: To test the usability and functionality of the GIS prototype with potential users

Testing the usability and functionality of the GIS prototype is an essential step in identifying the potential for such a system to be used and aid in the management of health. The testing of the system introduced a participatory development framework to the research by involving potential users in the development process.

3.2 Research methodologies

A number of research methodologies have been used; their interrelated nature is illustrated in Figure 1. The research methodologies, which are derived directly from the aims of the research, used include an online questionnaire, the development of a GIS prototype, and testing the usability of the GIS prototype through a case study. The methodologies displayed in Figure 1 are not as one dimensional as they appear, and there

are many sub-processes which have been added to them. The following paragraphs explain the methodologies in further detail.

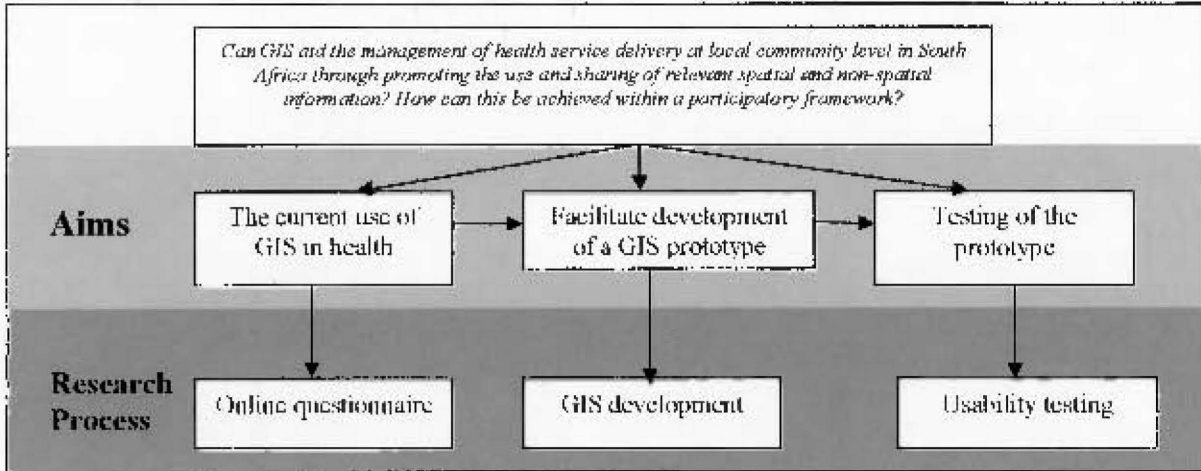


Figure 1 Research aims and methodologies

3.2.1 Online questionnaire

An online questionnaire was designed to fulfil the first aim of the research and provide an understanding of GIS use in the health sector. By identifying the various aspects of GIS use, it guides the development of a GIS prototype. The design of the questionnaire was informed by research on the use of GIS within health related institutions (Higgs & Gould, 2001; Smith et al, 2003).

The questionnaire was published on the internet. This provided a number of advantages, especially regarding access to the sample. Reips (2002) notes the practicality of using internet based questionnaires for accessing specific groups of people, who are spread over a large area amongst other advantages. The design of the questionnaire was based on simplicity, and aimed to be as brief for the respondent as possible.

The questionnaire targeted a sample group identified as being able to provide suitable insight into the use of GIS in health within South Africa. The respondents included people using GIS for health related activities in a variety of sectors in South Africa. The sample and data collection methods are explained further in Chapter 4 (section 4.1), along with the design and structure of the questionnaire and the results.

3.2.2 GIS prototype development

The development of the GIS prototype was a critical step in answering the research question, and was guided by the results of the online questionnaire. The design of the GIS prototype will be discussed (Chapter 5) following the presentation of the online questionnaire results, in Chapter 4 (section 4.2).

A number of important factors were realised through this phase of the research. It was realised that a GIS could be developed for the display and sharing of information and according to the requirements obtained from the online questionnaire. Of further relevance to this research is the usability of the GIS prototype.

3.2.3 Case study of the Overstrand and usability testing:

The usability testing of the GIS prototype was done through the use of a case study in the Overstrand municipal area, located on the South Western coast of South Africa (See Figure 2). This area was selected due mainly to the apparent focus on community participation⁷ by the municipality. Chapter 6 elaborates on the study area (6.1.2), and the dynamics of the usability testing (6.1.3).

⁷ The concept of participation is often used as a smoke screen to make projects appear to be legitimate, and is sometimes used to make unilateral decisions appear to be the choice of the public.

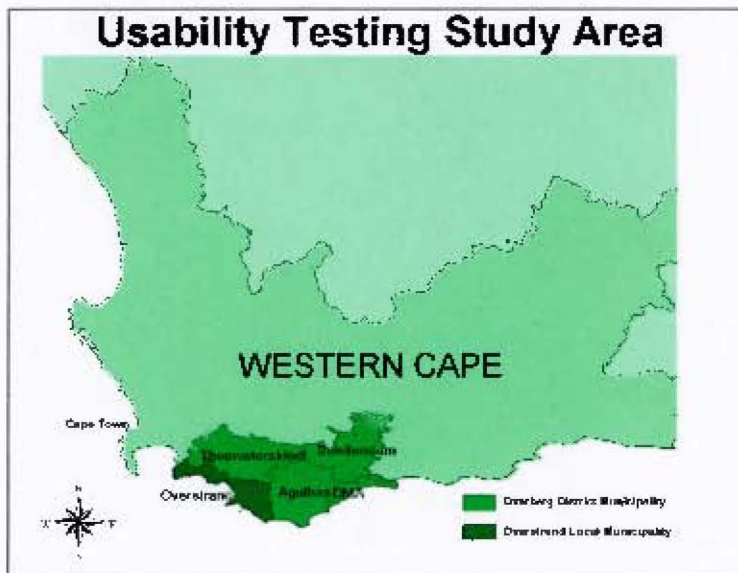


Figure 2 Map: The study area within South Africa

The following sections (3.2.3.1 & 3.2.3.2) consider the theory behind the choice of methodologies used for the testing of the GIS prototype. Case study research and usability testing are introduced and related to the aims of this research. The data collection methodologies are briefly introduced, with fuller explanations provided in Chapter 6 (section 6.1.3).

3.2.3.1 Case study research

A case study is an empirical inquiry that investigates a phenomenon within its real life context (Dube & Pare, 2003). The phenomenon being investigated in this research is the use of GIS as a tool for health services management, specifically the usability and functional specifications of the GIS prototype. The case was studied through the use of a variety of data collection methods, as is advocated for case study research (Yin, 1999), combining both qualitative and quantitative data.

Case study research has recently received revived attention and acceptance in both information systems and health services research (Yin, 1999; Dube & Pare, 2003), especially in terms of understanding the complexities that surround both these phenomena.

A case study approach to this phase of the research played an important part in understanding the role that the GIS prototype could play within a specific context. Case studies concerned with health services have focused on the use of technology, knowledge and information systems (Yin, 1999). Additionally case studies focusing on information systems generally aim to understand the organisational side of information system use (Dube & Pare, 2003), conforming to the general shift in thinking within this field. The transfer and sharing of information within health related fields are increasingly complex (Yin, 1999) due to the decentralisation of health services, and the increasing interactions between organisations, technology and individuals (Dube & Pare, 2003).

A case study was seen as a way to understand such a context, and to provide for an improved manner in which the usability of the GIS prototype could be tested.

3.2.3.2 Usability testing

Usability testing involves testing the ability of a system to allow users to complete their tasks effectively, efficiently and enjoyably (Kushniruk and Patel, 2004). Usability testing theory and practice supports the use of case study methodologies through their shared focus on a specific phenomenon within a specific context.

The compatibility between case study research and usability testing stems from the fact that the usability of a system cannot be measured in an absolute sense (Park & Lim, 1999; Brooke, 1996). Furthermore the usability of a system should be investigated within the context it will be used, and its appropriateness to that context (Brooke, 1996). A case study was seen as a way to understand such a context, and to provide for an improved manner in which the usability of the GIS prototype could be tested.

Linking usability testing to broader context of the research is the synergy between usability testing and participatory GIS (Haklay & Tobon, 2003). While P-GIS allows for non-GIS users to access GIS, usability testing, and HCI in general, studies how to better

suite systems to their users. This part of the research uses usability testing methodologies to promote the participation of potential GIS users in the development of the GIS prototype.

3.2.3.3 Data collection

Usability testing was the fundamental data collection methodology employed, with interviews, questionnaires and task analysis making up the data collection process. The following diagram (Figure 3) illustrates the research process and the tools used in the usability testing.

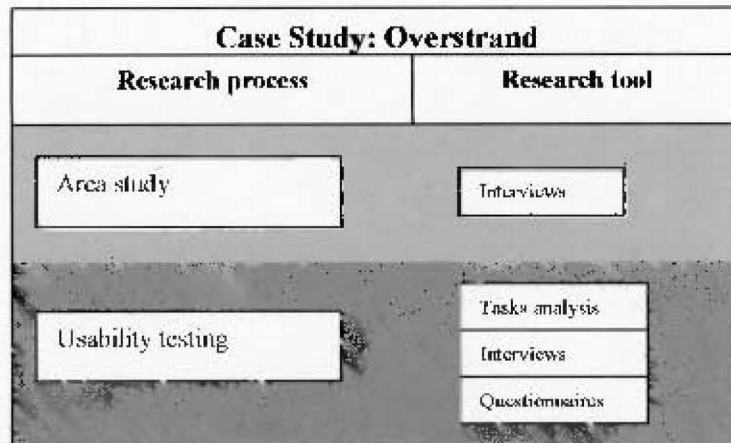


Figure 3 Simplified case study research methodology

An area study was undertaken to understand the information flow dynamics, providing for the identification of potential users and gaps in current systems. The data collected from the usability testing was used to represent two distinctive cases, that of the municipality and that of the community. The municipal case included data collected from municipal managers and ward councillors. The community is represented by clinics in the area as well as community organisations. In addition to the two cases a convenience sample was used for the testing of the usability testing process.

3.3 Conclusions and shortcomings

It is inherent in any methodology that there will be shortcomings and areas in which errors become evident. The methodologies used in this research are from varied fields of study, and thus have limitations associated with them that are derived from their respective fields. There are also limitations present that have become apparent through the combination of the methodologies used; the most pertinent limitations of the research is the lack of comparability of case study research, and the lack of quality of response of the online questionnaire.

A lack of responses to the questionnaire reduced the researcher's ability to test the responses with formal statistical relevance, yet the effect of this on the final product of this stage of the research was minimal. It is a risk using relatively new data capturing methods as they are untried and untested, online questionnaires have received some attention in this regard. Henning (2004) notes the reliability of information presented on the internet as something detracting from the use of online questionnaires, additionally noting concerns over security and misuse of information. Reips (2002) notes in response to such factors that standards should be developed through which research can be completed over the internet, thus taking advantage of the positive factors of using the internet and reducing those affecting it negatively.

Case study research has limitations in terms of its inherent nature, that of investigating something within a specific context. The result of which is that generalisation across to other contexts is difficult; this has been held as a major shortcoming of case study methodologies (Yin, 1999). Yin (1999) provides insight into remedying this feature of case studies, and suggests viewing a case study as a unit. It is felt that the research being presented is driven by theory and literature; furthermore the case study being presented was selected to be representative of South Africa in general.

The limitations are a result of using methodologies that are necessary for this research, and were unavoidable. Using an online questionnaire was necessary in order to reach the participants that were required, and although the response rate was not high the

information gained through this did prove to be highly useful to the development of the GIS prototype. In terms of the case study, an area and case of relevance to South Africa was selected, furthermore the methodologies employed for data capture and analysis are thoroughly documented allowing for repetition of research similar to this.

The methodologies used in the research represent a coming together of various fields of thought and application. This has been done in order to most effectively develop an information system suiting the needs of the potential users of it. While there are limitations associated with such methodologies, the use of them represents a step forward, and aims to introduce a manner in which effective system development and testing may be conducted.

Chapter Four: GIS and health online questionnaire

This chapter describes a questionnaire designed to gain insight into how GIS is used in health in South Africa. The design and structure of the questionnaire, the sample of respondents and the results gained are described. The results are used to produce a context in which this research resides, and helped to shape the development of a GIS prototype.

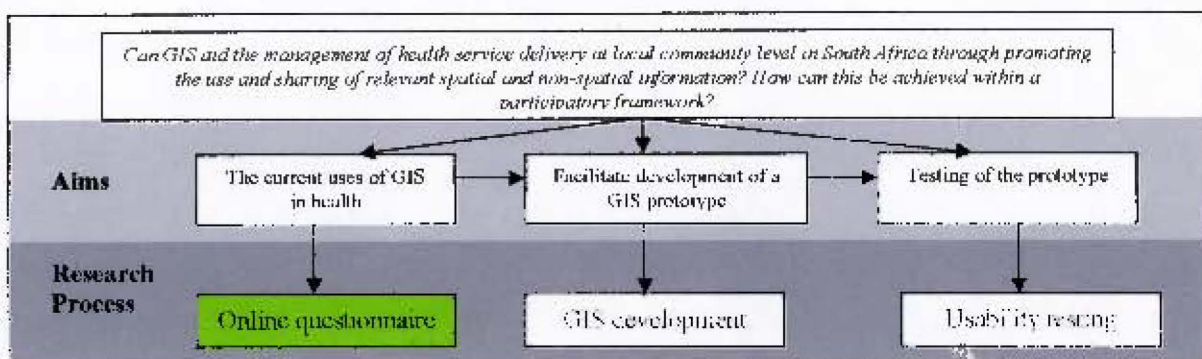


Figure 4 Research aims and processes: Online questionnaire

The results of the questionnaire also fulfil the following purposes:

- Provide a context in which this research is based and exists
- Provide insight into the manner in which communities are, and may be involved in GIS and health
- Provide a starting point for the development of a database of GIS and health activities within South Africa

4.1 Questionnaire design and structure

The questionnaire was developed using tools that enabled it to be available on the internet. It targeted those who are involved in health and work with GIS or are planning to do so. This section considers the design, content and structure of the questionnaire.

4.1.1 Questionnaire design

The use of the internet as a medium to communicate a questionnaire within health related and most areas of formal research remain in its infancy (Eysenbach & Wyatt, 2002), however the potential for its use is promising. The use of the internet for the distribution of a questionnaire provides many advantages, especially when targeting a specific sample which may be impractical to access under normal circumstances (Reips, 2002). Reips (2002) identifies the following advantages of using the internet for surveys and questionnaires:

- Reduced cost
- Less time and scheduling constraints
- Automation of data collection and entry
- Ease of access to samples

In using an online questionnaire all of the above advantages were realised, with a low response rate⁸ from the questionnaire being the only limiting factor on the outcome.

Sawicki and Peterman (2002) note some issues associated with using emails in a survey relating to the use of P-GIS, also reported a low response rate. Some mail lists do not submit surveys, and the abuse of email as a form of advertising has resulted in doubt over such a means of communication, resulting in people being less inclined to pursue such a survey.

While the number of responses does not allow for statistical tests of any significance the generalisation and comparison of the responses provides sufficient information for interpretations to be made from the data. The following section (4.1.2) explains the structure and content of the online questionnaire.

⁸ The initial response from the online questionnaire was only 17.5%. More responses were gained through phone calls and meetings with some of those initially emailed, providing for the over all response rate of 27%.

4.1.2 Content of the questionnaire

The questionnaire was structured with a view to reduce complexity and the amount of time required for participation (See Annexure A). The questionnaire was comprised of six sections with questions on the following themes:

General information regarding the respondents work, relation to health and their sector of operation (NGO, government etc).

Technical information on GIS, including software used, whether a web server is used and the method of data storage.

Information regarding the general use of GIS, the spatial analysis tools used, data sources and the outputs produced from GIS.

Information regarding future plans for GIS use, documenting specific plans to use GIS in different ways, the potential for this and also the constraints that are hindering the further use of GIS.

Information regarding community involvement, determining whether communities are involved in GIS related work, the benefits gained from this, and the respondents general impression of participatory methodologies in GIS and health.

In addition to the questions, extra information explaining some of the concepts necessary for the completion of the questionnaire were included (see Annexure B). The following information sources were included as links to other web pages:

- Information on participatory GIS
- Definition of participatory GIS
- Case study of participatory GIS
- Health applications of GIS
- General uses of GIS
- Examples of community involvement in GIS (Higgs & Gould, 2001; Smith et al, 2003)

The following diagram (Figure 5) illustrates the design of the web based questionnaire. The boxes in the drawing represent web pages present in the questionnaire; the bold arrows indicate the flow of the questionnaire from section to section (web page to web

page), with the plain arrows indicating links to additional information (included as pop-up web pages).

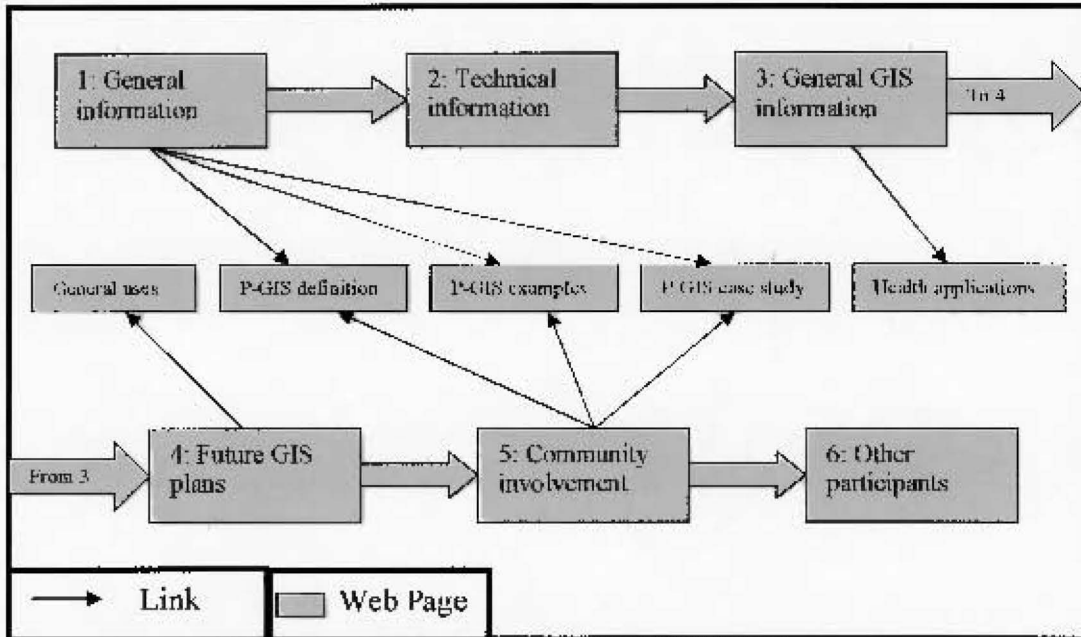


Figure 5 Online questionnaire: Web site design

4.1.3 Questionnaire sample profile

The questionnaire targeted a specific sample group. The sample was identified primarily through a database of people potentially involved in GIS and health (Martin, pers. Comm. 2005). Other participants were identified through web site searches and phone calls, mainly to government health offices. Once the questionnaire was made available online, emails were sent to all potential respondents. A total of 86 emails were sent to the potential participants, making them aware of the questionnaire and providing a link to it.

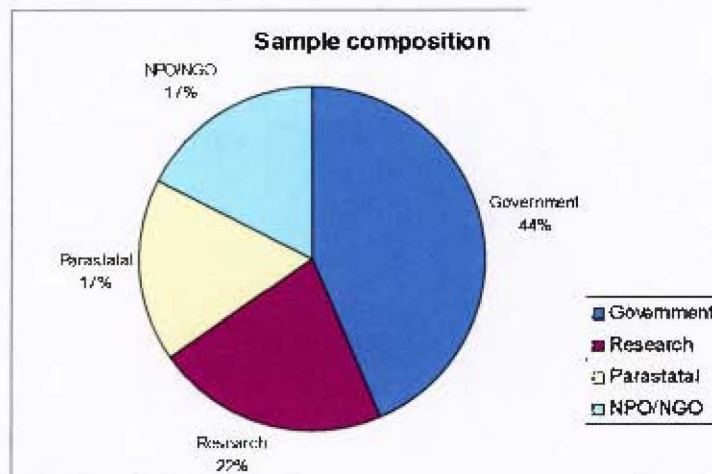


Figure 6 Online questionnaire: Sample

The sample is represented equally by most stakeholders, with an increased response from the government sector (see Figure 6). This is seen as a combination of two factors: that government is beginning to embrace GIS technology, and secondly as a result of the distribution of the questionnaire⁹.

4.2 Results of the questionnaire

The key results of the questionnaire are summarised in this section (a complete table has been included in Annexure C). The results described focus on the following:

- the manner in which GIS is being used,
- the data being used in GIS,
- outputs produced through the use of GIS,
- the potential for further GIS use
- the limitations thereof, and
- participatory GIS practice

⁹ The sample was determined through a database of people involved in health and GIS, and no means were available to determine the sector/work involvement of the entire sample.

4.2.1 Response: The use of GIS in health

A section of the questionnaire was dedicated to gaining insight what GIS is used for in health. This includes the areas of health that are impacted by GIS use and the specific GIS tools used for such work. Such information helped to provide a context for the research and through the identification of the current uses of GIS, areas of further use could be identified. This is based on the assumption that existent use in a certain field would provide the necessary infrastructure and support for further use of GIS.

The following graph (Figure 7) illustrates the areas of health that are impacted by the use of GIS within South Africa. The results show a distinctive focus on planning and the provision of health related services. Such a focus illustrates that this is an existent practice in South Africa, and provides for the opportunity to broaden the scope of application.

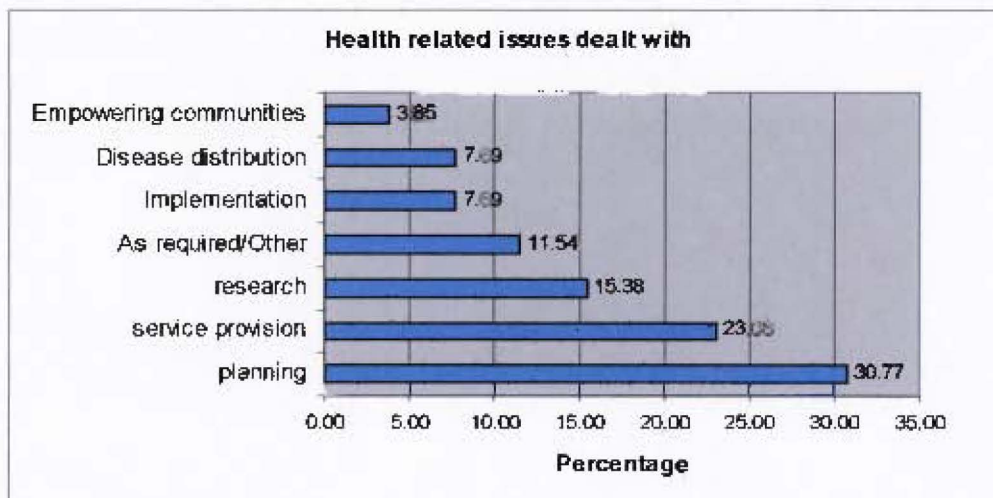


Figure 7 Online questionnaire: Health related issues

The information obtained from the questionnaire contradicts much of the literature and some of the arguments presented in Chapter 2 (section 2.1.2). A focus on the planning and provision of health services is something that has been reserved at most for research and applications focused on the developed world (McIntyre et al, 2000).

This is further reiterated by responses to a question requesting specific examples of health related work completed with the use of GIS. The following points provide some health care application examples provided by the respondents.

- Locating HIV/AIDS trials across the world
- Assessing health needs for the purchase of health services
- Determining catchments centres for local services and hospitals
- Capturing health facilities and boundaries within which these facilities are managed
- Analysing patient flows across health district boundaries

The focus of GIS use, as expected from the sample, is on high level tasks and not day to day management tasks.

To determine the level of GIS use, and the appropriateness of GIS tools to health, a question was posed on what GIS tools were used. For a large portion of the sample GIS is used for the display or production of maps (30%), the most basic function of GIS (Sawicki and Peterman, 2002; Smith et al, 2003). Other less advanced tools identified included statistical analysis and report production. A balance is created through the fact that a number of the respondents use the more advanced tools of GIS such as geographic analysis, modelling and forecasting, representing 40% of the total response (see Figure 8).

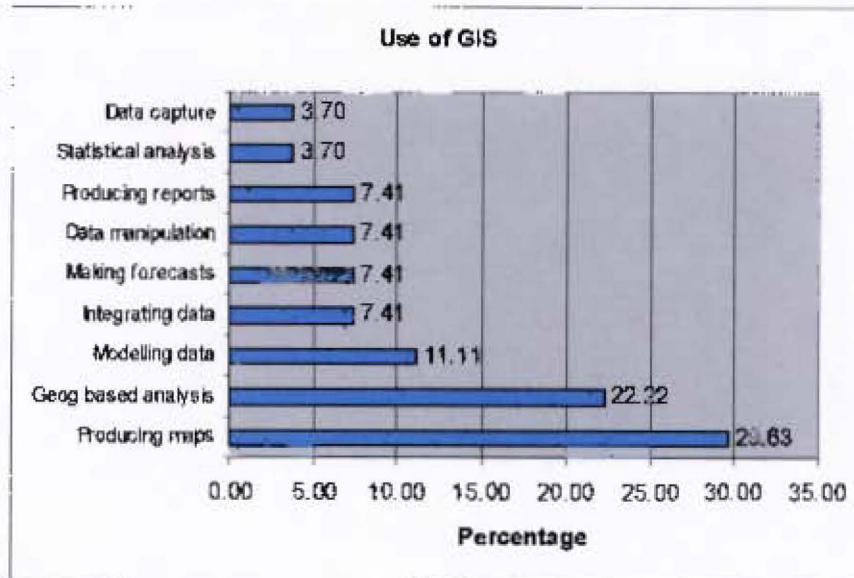


Figure 8 Online questionnaire: GIS use

The full analytical capabilities of GIS are not realised by the majority of the sample (52%). Other research has focused on the lack of analytical use of GIS, and tried to promote this (Smith et al, 2003). The focus of this research is however on the extension of GIS use for local communities, whether highly analytical or simply for the production of maps

4.2.2 Response: GIS data sources

The data sources provide interesting insight, especially in relation to the Promotion of Access to Information Act (Republic of South Africa, 2000); over half of the respondents make use of their own data, or private databases, and not publicly available information (see Figure 9).

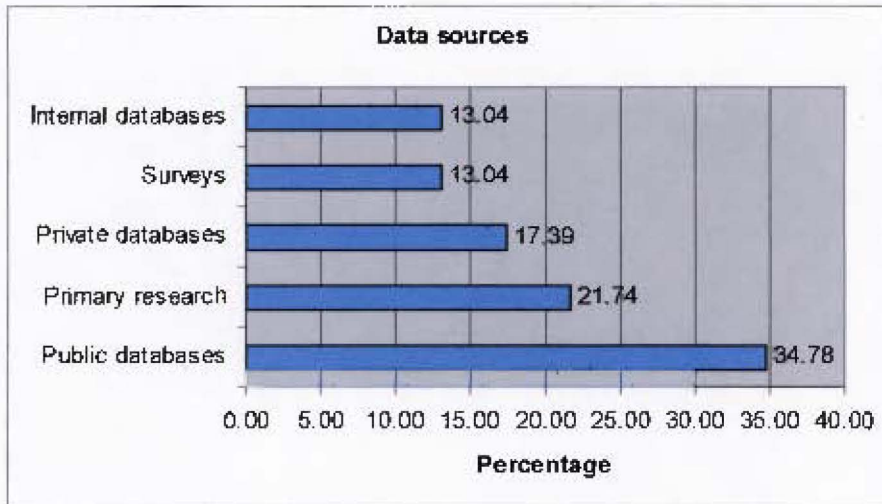


Figure 9 Online questionnaire: GIS data sources

The responses to this question clearly indicate the need for tools to make relevant spatial information available where that information exists. Thus promoting the access to, and sharing of information, providing an opportunity for certain people to monitor and understand the environment they live in.

4.2.3 Response: GIS related outputs

Nearly 70% of the respondents make use of GIS for the production of paper based maps and report related outputs (graphs and reports) indicating the use of GIS for its more basic functionality (see Figure 10).

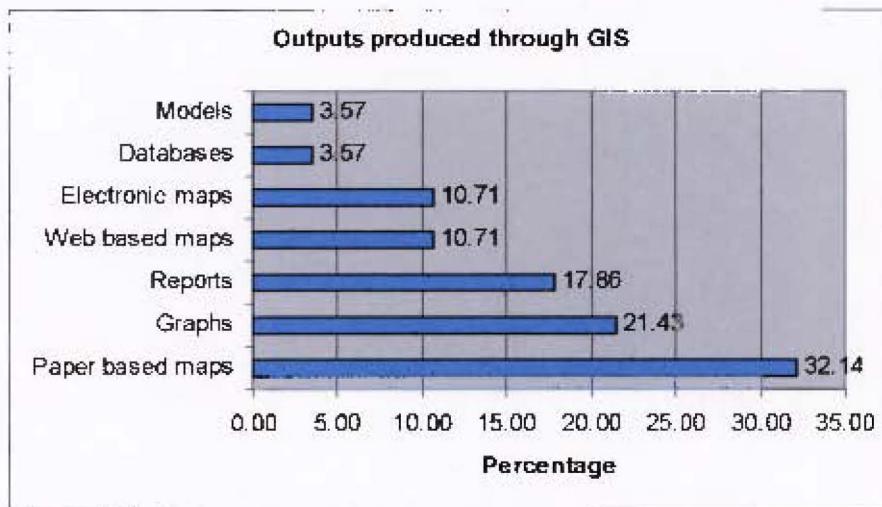


Figure 10 Online questionnaire: GIS outputs

The use of paper based maps is perhaps indicative of the lack of access to technology within South Africa. The need to communicate information held on maps is also made clear through this result.

The emphasis on the use of GIS in less advanced manners as well as the need to communicate the information held on maps to a larger audience reflects the focus of this research. And the less advanced features of GIS are advocated for the sharing of information, extending the use of GIS to new communities.

4.2.4 Response: Potential for further GIS use

The majority of respondents make use of the basic functions of GIS (60%), such as the creation and display of maps, but many see the potential for more advanced uses such as modelling, forecasting and analysis of various forms (see Figure 11). This may well be related to the allure of the technology, as described in Chapter 2 (section 2.2). Reasons for the lack of use of these tools currently are considered in the following section (4.2.5).

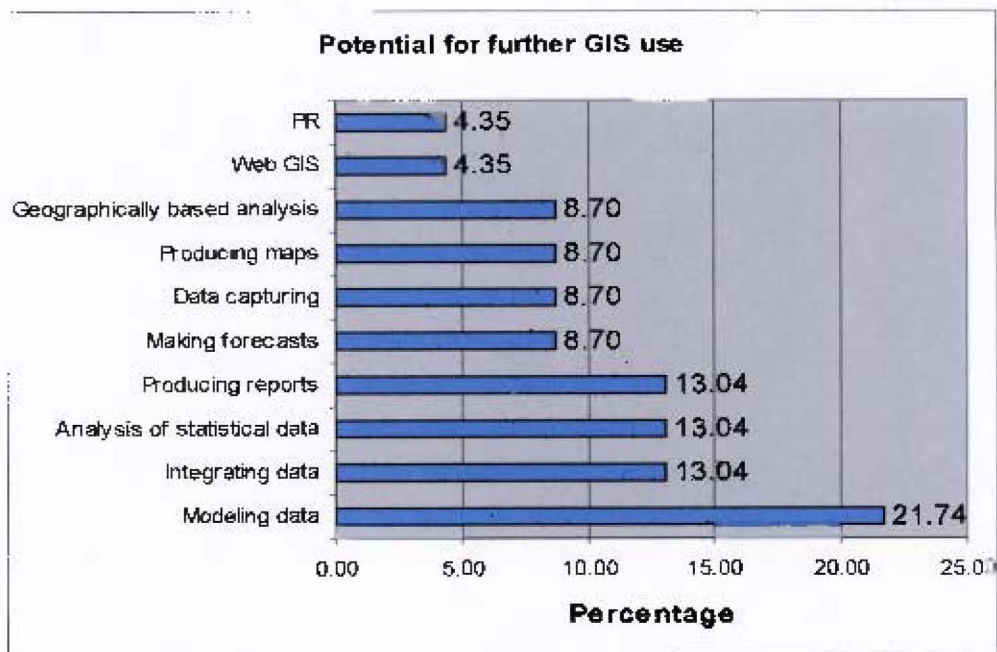


Figure 11 Online questionnaire: Potential for further GIS use

In addition to those seeing the potential for advanced features offered through GIS packages, a number of respondents see the potential for the use of GIS in a relatively basic sense, such as the analysis of statistics and the production of maps and reports. This illustrates, once again a need for the basic tools of GIS to be made available to users, with the more advanced tools not being seen as a necessity to the population at large.

4.2.5 Response: Limitations on further GIS use

Participants were asked to identify what limited them from using GIS in a more effective manner. The most prominent feature was the affordability of software, often assumed to be necessary to access a GIS. The other prominent response to this question was a matter of human skills, represented by 40% of the respondents (see Figure 12).

This supports the need for GIS to be made available in terms of cost and also in terms of usability. The GIS prototype was developed with these two factors as guiding principals.

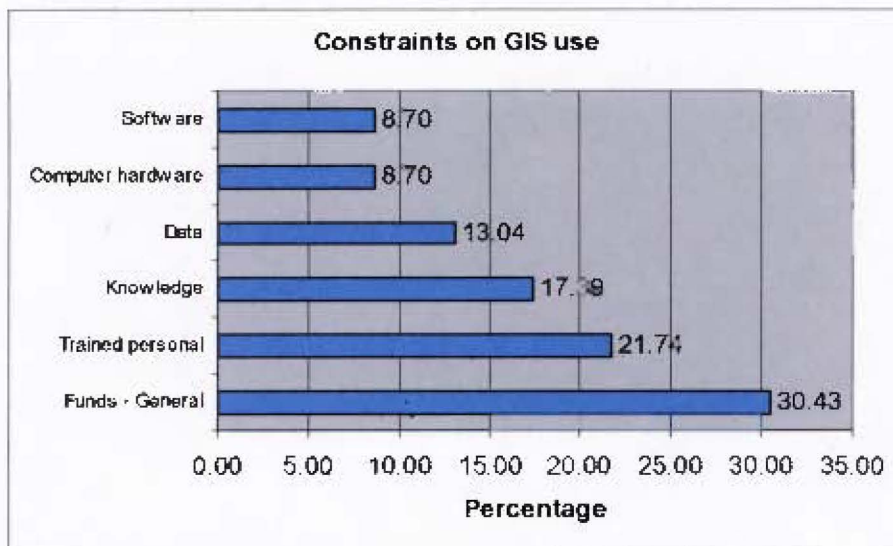


Figure 12 Online questionnaire: Constraints on GIS use

Affordability was addressed through the use of an open source development methodology¹⁰. The GIS also aimed to negate the need for human skills through the development of a basic user interface, Chapter 5 addresses these factors in further detail.

4.2.6 Response: Participatory GIS

The participatory GIS section of the questionnaire aimed to gain insight into whether communities were involved in GIS within a health context. It was designed to deduce the possibilities of such participation by gaining insight into the manner of participation, as well as gaining perceptions on the practice of P-GIS in health.

A relatively large number of participants involve communities in their GIS related work (over 25%), however in most cases merely for the provision of data (60%). The term community was defined broadly¹¹ for the purposes of the questionnaire and this may have played a role in the large number of participatory projects within the sample.

¹⁰ Open source software providing an affordable solution is a debatable topic and this is addressed further in Chapter 5.

An understanding of community participation in GIS was gained through questions regarding the potential benefits for both parties (the organisation and the community). Benefits noted for organisations vary greatly, with two contrasting sets of responses. The first being “users” of the community, gaining data from the community and surveillance thereof. Similarly the benefits for the community are seen as employment, the provision of services or it not being beneficial at all. The second group of responses reflects the use of participatory methodologies to create an understanding, forming partnerships and providing objectivity within their organisation. Furthermore Participatory GIS is seen as a methodology that can provide an opportunity for participation in decision making and enhancing perceptions. This contrast illustrates the two extremes of participation possible in participatory GIS as discussed in Chapter 2 (section 2.3).

Questions were posed on the limitations to community involvement in GIS related work, the results acting as a precautionary guide to the development of the GIS prototype. The responses emphasised the human factors in the equation, map reading, training, inexperience of technology and skills being amongst these. It is felt that these could be reduced through the use of a simpler and more user friendly GIS than the typical commercial GIS used by the majority of people and organisations. The limitations displayed in Figure 13 once again emphasise the need for a simple, user friendly GIS.

³¹ A community is defined according factors that provide for the sharing of common experiences and perspectives. This commonality is provided through physical proximity to each other, or through other forms of interaction such as professional, social or spiritual relationships (Craig et al, 2002).

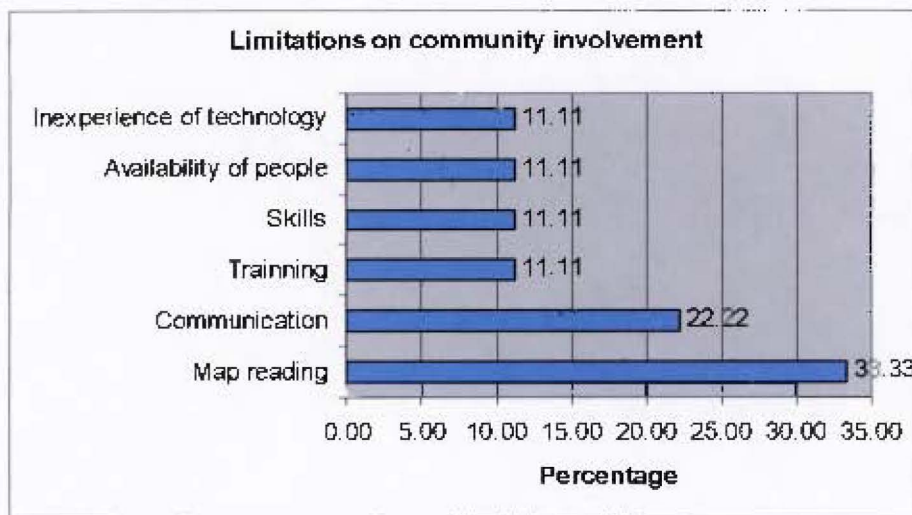


Figure 13 Online questionnaire: Limitations on community involvement in GIS

Finally, to consolidate the contextual information gained from the questionnaire, questions relating to perceptions of P-GIS in health were presented. Figure 14 illustrates the respondents' perceptions of how health may benefit from participatory GIS methodologies. Most of the respondents (85%) felt that there is a potential for P-GIS methodologies to be used in health, and that it could provide for improvements especially in the areas of disease management and service provision, once again indicating the management of health related services as a priority, and adding potential for participation in such a project.

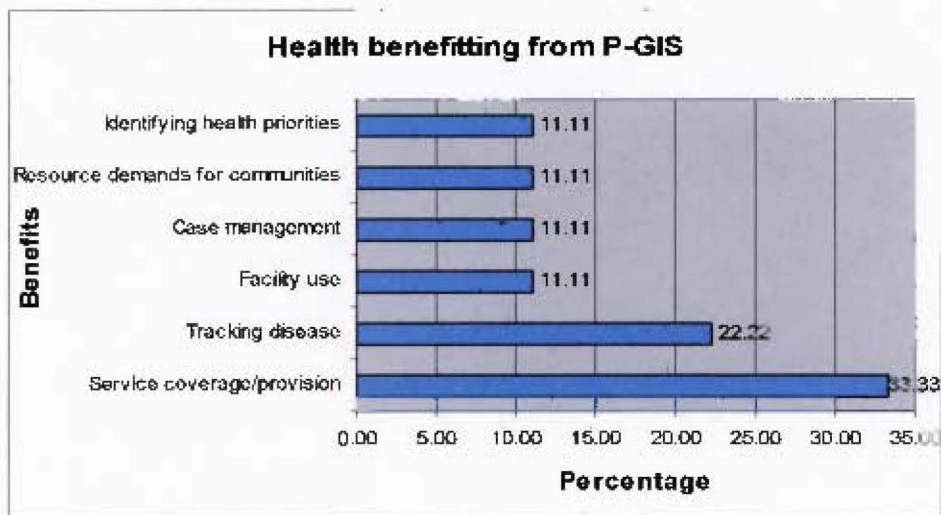


Figure 14 Online questionnaire: Health benefits from P-GIS

4.3 Discussion and implications of the results

The results presented above provide information on the use of GIS in health in South Africa, the level of use, the limitations placed on the further use and the extent to which communities are involved in such work. In terms of providing a contextual background to the use of GIS in health in South Africa the results may be summarised as follows.

- There is a focus on the use of GIS for the management and planning of health related services.
- GIS is used mainly for the display and printing of maps, while more advanced tools are used and desired in a few of the cases, the majority of users only require and use the less advanced features of GIS
- The limitations on the use of GIS are related mainly to human skills and the cost of GIS. Despite these issues 96% of the software used by the respondents is commercial and over 80% use a GIS that provides extensive functionality, and thus requires a degree of skill to operate.

The results presented are in contrast to the assumption that GIS and health in the developing world focuses on epidemiological matters (McIntyre et al, 2000), and that the

use of GIS for health services monitoring and management is limited within this context. GIS is used by the majority for health planning and services management.

Smith et al (2003) note that the full potential of GIS is yet to be realised in terms of advanced use and application. Houghton (2004) reflects similar remarks with respect to Ireland's use of GIS in health, noting that GIS is primarily used for "creating pretty pictures," and ignoring the analytical capabilities of the technology. This research aims to extend map making abilities to a larger community.

The results here show that GIS is generally used for the creation of maps, with the exception of some more advanced users. However, when considering the limitations on GIS use, human skills were the biggest problem. It is therefore suggested that the focus be on the use of less complex GIS, focusing on map making and report production. Furthermore, and with a focus on the use of GIS at a local level, the coordination of GIS use across various groups, as mentioned by Houghton (2004), may be a more appropriate focus than increasing the complexities associated with the analytical functions of GIS. These arguments are explored further in the penultimate chapter of this thesis (Chapter 6).

Chapter Five: The Development of the GIS Prototype

This chapter outlines the development of the GIS prototype, explaining what drove the design and the elements that make up the system. The design of the system is based primarily on the following results of the online questionnaire:

- Affordability, allowing the system to be available at a minimal cost to all potential users
- Accessibility, providing a system that is accessible to the broadest possible audience.
- Simplicity, providing for user friendliness for less skilled users, and those that only require basic GIS functionality

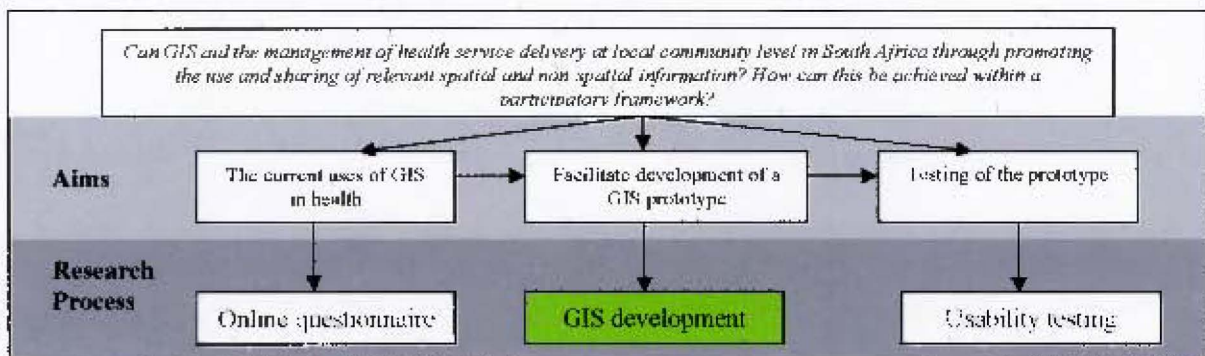


Figure 15 Research aims and processes: GIS prototype

Open source software was identified as a means to address affordability, and is discussed with respect to its prospects within South Africa. In terms of providing access to the prototype, a web-based system was deemed to be the most appropriate, and this is discussed in terms of its relevance to South Africa. Finally the functionality of the GIS prototype is introduced.

The system described in this chapter is a prototype. Prototyping is the process of putting a working model of a product together, in order to test various aspects of the design to gain feedback from potential users of the system (Argent & Grayson, 2001). The advantage of

using prototyping is that the system can be easily changed, and it encourages participation from both potential users and the developers of the system.

5.1 Open source software in South Africa

The use of open source software in the development of the GIS prototype addresses cost for the end user, and also promotes participation. These features are addressed in this section in light of the advances of open source GIS.

Open source is a software development methodology (Christl, 2006) relating to the freedoms associated with accessing to source code and being able to alter this in any way to suite ones needs (or the needs of a specific community), and does not directly relate to free (as in cost) software. While this may seem contradictory, the use of open source software has been seen to have long term financial benefits.

The definition of open source software is based on the freedom of accessing to the source code and the licensing of open source programmes. The Open source initiative (2005) defines open source software according to the following characteristics.

- The source code of the product must be made available
- The license must allow unlimited redistribution of the product
- The license must permit the creation of license free derived works
- The license may not limit how, where or by whom the product can be used

Certain departments within the South African Government have been actively trying to promote the use of open source software, and there are a handful of organisations making use of this software methodology in South Africa¹² (Levin et al, 2005).

While there are instances of its use in South Africa, until recently there has been no direct policy concerning the use, or standards of use of open source software in government, or

¹² These include: The Department of communications, the CSIR (Council for scientific and industrial research) the National, and some Provincial Departments of Health.

any other institutions (South African Government, 2005). 2007 has seen the approval of the first formal policy within Government promoting the use of open source software (Fleming, 2007)

The new policy states that FOSS (Free and Open Source Software¹³) will be implemented in all government departments, unless a proprietary counterpart is demonstrated to be significantly superior. Furthermore all future software development to be completed for, or by government departments will be done in accordance with open standards and a FOSS license. (Republic of South Africa, 2007).

The approval of the policy is a result of the realisation of a number of advantages open source software has to offer, especially within the South African context. Fleming (2007) notes a number of these:

- All GIS data formats can be read and written by FOSS GIS software (interoperability)
- Open source software is cross-platform (not dependant on a specific operating system)
- Free as in cost (no license fees)
- Free as in freedom to modify the programme (through the availability of the source code)
- Money previously spent outside South Africa on license fees, is spent on developing local skills

The interoperability (ability to interact with other programmes) of open source GIS software is an aspect that is particularly advanced, while proprietary systems remain essentially closed to sharing information with other software (Dunfey et al, 2006), open source standards have allowed for greater sharing of information to a wider audience.

¹³ FOSS is a synonym for OSS, the only difference being what is emphasised by the acronym (freedom as in libre (OSS), or freedom as in gratis (FOSS)).

There is some debate over the cost of open source software. There are no costs for the implementation or use of open source software (Mitchell, 2005). The only costs that are associated with it are for software developers (if modifications or further development is required). It is generally accepted that open source software will be more affordable than its proprietary counterpart in the long run (Ismail & SAPA, 2007), this in addition to other advantages of open source.

The final advantage noted is of particular relevance to South Africa. It concerns the development of local skills through the implementation and continuous use of open source software. Open source software, through allowing access to its source code provides for the development and honing of local skills (Fleming, 2007) which in turn will enhance the software and support for it (Ismail & SAPA, 2007).

While open source software provides a number of advantages, there are some prerequisites for the effective use and implementation thereof. The main factor is that of user buy in and interest, and the skills of those responsible for the technical side of software development (Lin, 2007). Open source software, in comparison to proprietary software, does not guarantee formal user support, and without technologically savvy staff projects run the risk of failure. The participatory process in which the GIS prototype is being developed hopes to nullify these limitations through creating enough interest to sustain the use and further development of the system.

Open source GIS software has developed to such an extent that it is said to have equalled, and possibly exceeded some of the functional abilities of proprietary GIS in terms of web-based capabilities (Kamel Boulos & Hondam, 2006).

5.2 Web based GIS

The influence of the internet and the World Wide Web (www) has had a profound impact on all information technologies. The influence on geographic information systems is no different (Dunfey et al, 2006). The internet has changed and revolutionised the manner in which data, and specifically spatial data and processing abilities are accessed, shared and

manipulated (Peng & Tsou, 2003). The influence of the internet on GIS is so immense that it is stated that one of the most important features of GIS is its ability to share information across the internet (Kamel Boulos & Hondom, 2006). The sharing of information for health management is a key component of this research and the GIS prototype.

In terms of providing accessibility, the internet is seen by some as the most egalitarian method of sharing software and information (Leitner et al, 2002). While this statement may be questionable in the South African context, the potential users of the GIS prototype all have access to the internet (See Chapter 6, section 6.3) The internet furthermore provides a means through which the results of GIS analysis results and spatial information can be shared with a wide audience (Peng & Tsou, 2003), without the prerequisite of having GIS experience. This allows access for communities, and not only professional or experienced GIS users, providing a means to reach another goal of the GIS prototype.

5.3 The potential users of the GIS prototype

The GIS prototype was developed to be used by community members who can benefit from having access to information. While it is assumed that a large portion of the population could benefit from such access (and the indirect benefits), access to the GIS is limited by some factors. The users of the GIS prototype require:

- Access to the internet
- Some form of computer experience (the level thereof is determined in the usability testing phase of the research)
- The ability to read a map (map literacy)

The following diagram (Figure 16) represents GIS users within South Africa. The current GIS users (top tier) have established GIS skills, access to GIS software of their choice and data. The second tier “potential GIS users” represent people who do not currently use

GIS, but have basic computer skills and access to the internet, allowing them access to the GIS prototype being described.



Figure 16 GIS prototype potential users

5.4 GIS prototype functionality

The functionality of the GIS prototype was based on a premise of simplicity, addressing the issue of users skills. The data displayed through the prototype was based on the responses of the questionnaire, and focused on basic health services, such as the availability of water, electricity and sanitation. A technical description of the development of the GIS prototype has been appended in Annexure D.

The GIS prototype displays a choropleth map, a map that illustrates the rate of a phenomenon over a certain area. Choropleth mapping is an effective tool for viewing patterns within a data set and are commonly used for visualizing socio-economic patterns, disease and various other human geographic variables. In addition to these characteristics choropleth maps have the added advantage that they are familiar to a wide audience (Boscoe & Pickle, 2003), increasing the appeal and usability of the GIS prototype.

Boscoe and Pickle (2003) identify a number of desired characteristics of choropleth maps, including a high degree of spatial resolution, allowing for more details and potentially more patterns to be presented on the map. A second desirable feature of choropleth maps is that the population and area sizes are homogenous, so that the number

of observations is equally spread over equal areas on the map. Failing this, the areas with the smallest populations, and the smallest areas will show extreme values. In order to reduce this, the areas were identified through the use of wards, which have approximately the same population size.

It is unfortunate, but integrating all the desirable features of a choropleth map on one map is not a possibility (Boscoe & Pickle, 2003), and it is thus one of the aims of the case study to determine which features are priorities to the users of the GIS prototype. The initial aim of the prototype was one of simplicity, and thus a low spatial resolution was selected, as well as areas that would be familiar to the users.

The prototype allows for the display, editing and updating of data through a relatively simple user interface. The processes that would take place in a typical situation are explained with the aid of screenshots of the GIS prototype's user interface in the following paragraphs.

Screen 1:

The first page (Figure 17) presents a map of South Africa with aggregated data for the entire country. On the right hand side there is an option to change the indicator being displayed (Water, sanitation, electricity), the user may also view this information in table form at the bottom of the page being displayed (Figure 21). On the top left hand side the user may select the province to be viewed (only Western Cape available in prototype). Once the user selects the appropriate province Screen 2 appears.

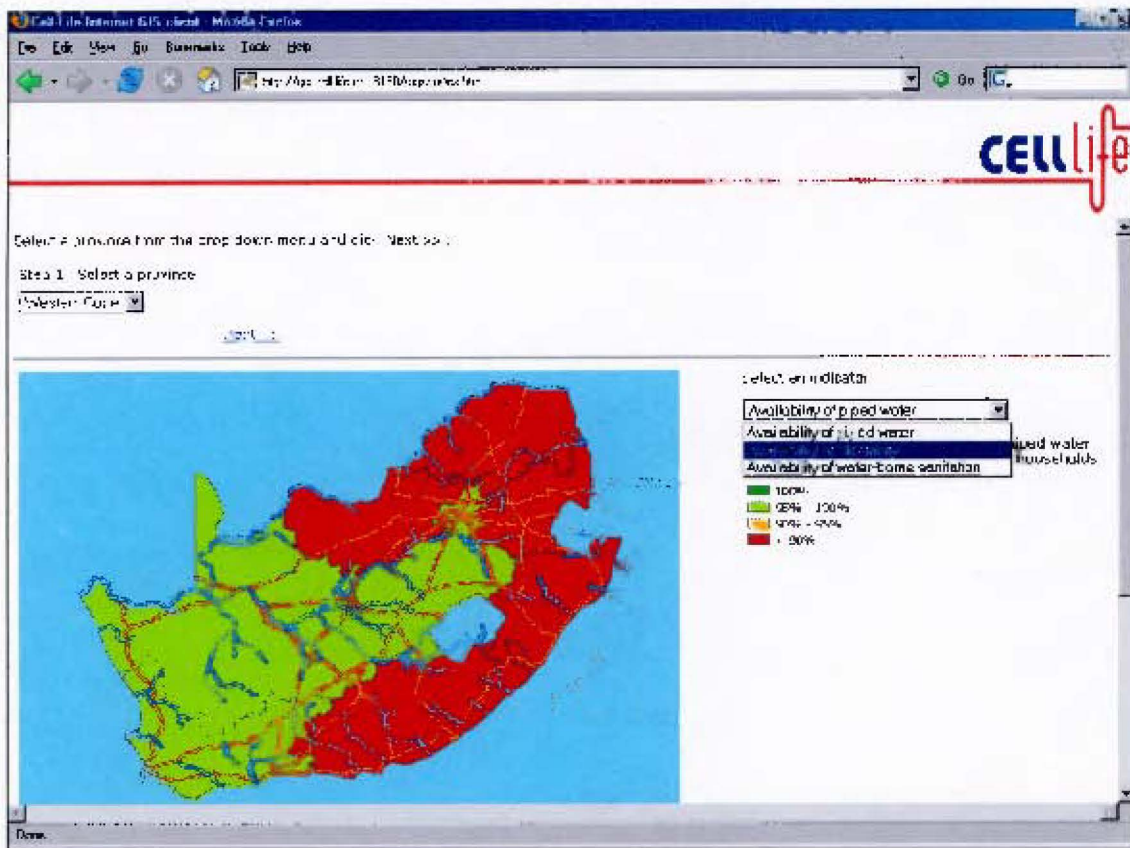


Figure 17 GIS prototype: Screen 1

Screen 2:

Figure 18 displays the map zoomed into the selected province, the same functionality is available as was for Screen 1 (Changing indicators, viewing tables). The scale of the map allows for data to appear aggregated at the district level. The user is prompted to select a municipal area to view, once this is done Screen 3 is loaded.

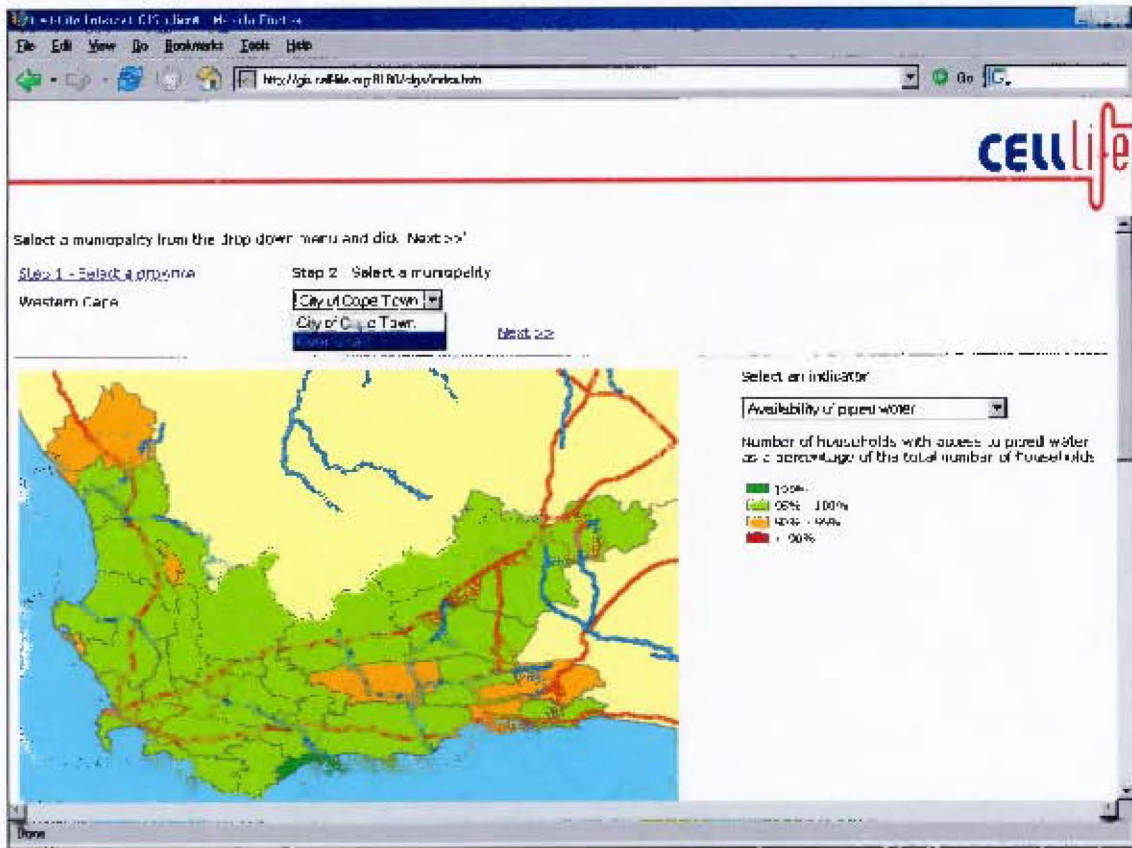


Figure 18 GIS prototype: Screen 2

Screen 3:

This screen (Figure 19) once again provides the same functionality as the previous ones (indicators, viewing tables). It is zoomed to the extent that the municipal area is visible within the screen, and the data is aggregated as such. Once again the user would select either a ward (in the case of selecting Overstrand on the previous page), or a sub-council (if Cape Metropolitan was selected). Once this has been selected Screen 4 is loaded and displayed.

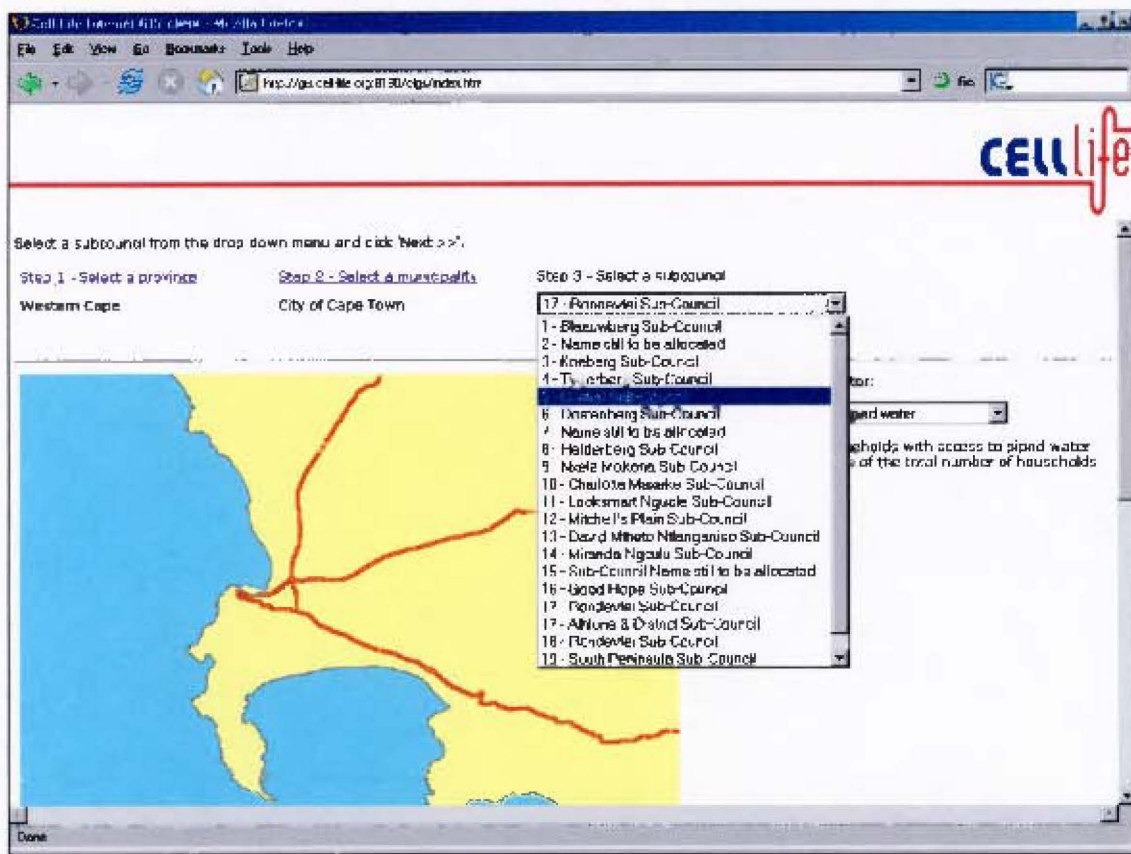


Figure 19 GIS prototype: Screen 3

Screen 4:

This is the final extremity to which the data included in the GIS prototype can be viewed (Figure 20), at the ward (or sub-council level). It is at this scale that the potential users of the GIS prototype operate, and were expected to use the data. While this level of spatial resolution may be less than what is desired it is based on what data was publicly available. It also expected that the potential users of this system would have access to, or be in a position to generate their own data, providing the opportunity for them to enter it into the system, thus making it available to other stakeholders, Screen 5 displays the manner in which this may be done.

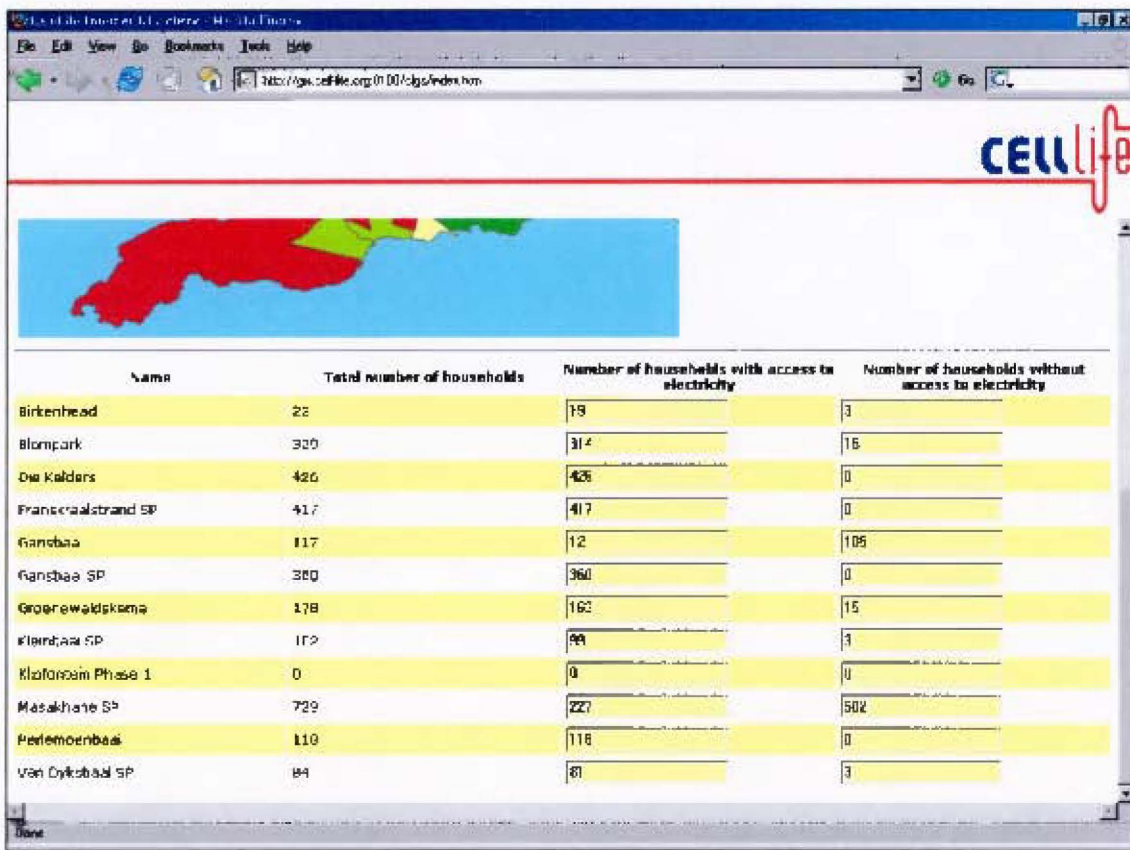


Figure 21 GIS prototype: Screen 5

The functionality provided by the GIS prototype is simple yet allows for the display, sharing and gaining of information. The data currently presented through the GIS is of the basic health services as are provided by municipalities across the country, and serves to provide an example of what information can be displayed through the system. The following section (5.4.1) explains the data made available through the prototype in more detail.

5.4.1 Data available in the prototype

The data displayed by the prototype is based entirely on that gained from the South African census of 2001 (Statistics South Africa, 2003), and consists of three different categories: the availability of water, availability of water borne sanitation and the availability of electricity. The categories displayed are aligned with the health related services that municipalities are responsible for (TAC, 2006), they are furthermore

features that are understood by, and relevant to most people, ensuring that all those involved in the testing of the GIS prototype understand what is displayed on the map.

The spatial level of the data displayed in the GIS prototype is that of the “sub-place.” Sub places are categorized and named according to the name of the suburb, electoral ward, village, farm or informal settlement (Statistics South Africa, 2003), covering populations of at least 500 people (Grobelaar, 2005). The sub-places are displayed within the borders of the wards, or sub-councils, as defined by the municipality responsible for the area. Figure 22 illustrates the spatial tiers of the South African census.

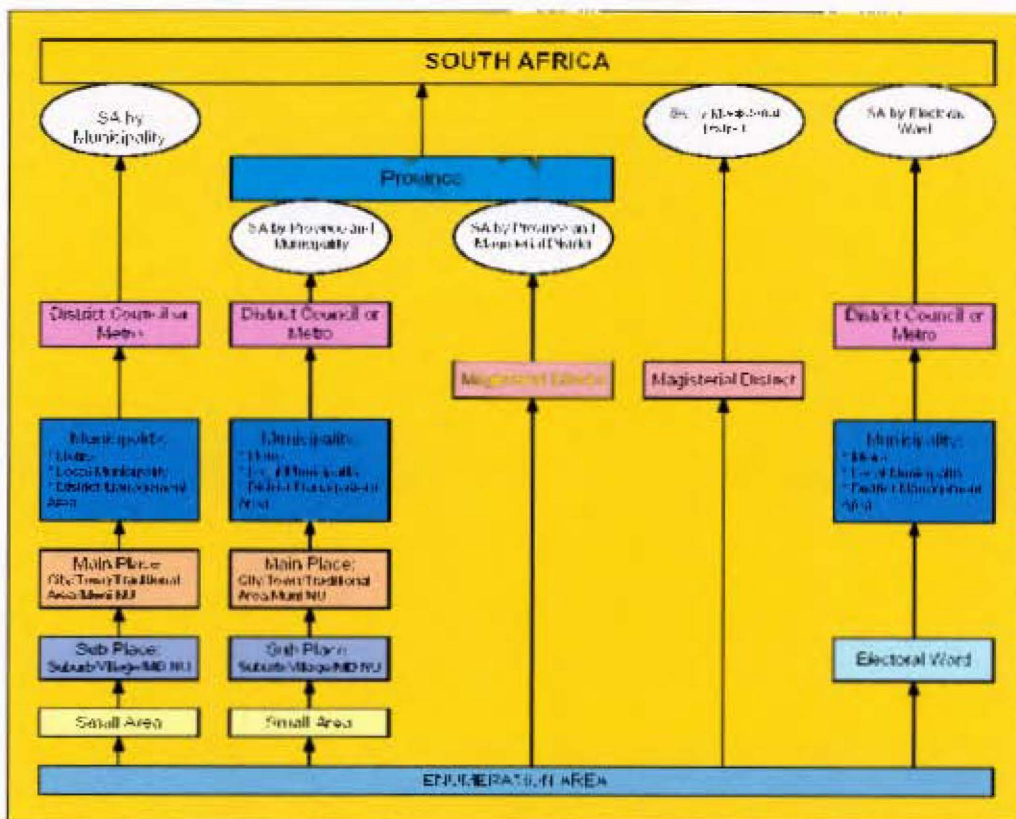


Figure 22 GIS prototype: Census data hierarchy (Statistics South Africa, 2003)

The spatial hierarchy of the census 2001 consists of nine levels (as displayed in Figure 22), with one level in the process of being developed (Grobelaar, 2005) at the time of the GIS prototype’s development, that of the “small area.” Therefore the lowest level of data available publicly is that of the “sub-place” level, the second tier of spatial hierarchy and

therefore aggregated from the first tier, the enumerator area (Grobbelaar, 2005). The reason for only this level being made available is to prevent the possibility of identifying individual households, which is possible when the data is available at the enumeration area level.

The aerial units of the GIS prototype are fixed, but it is envisaged that these would be altered according to the users needs as they become apparent through the participatory design process. The same applies for the data displayed in the GIS prototype, and as networks develop and participation in terms of data collection increases a variety of data could be made available through the GIS.

5.5 Conclusions and discussion

This chapter outlined the development of the GIS prototype, introducing the components and tools that it is based on, as well as the functionality of the system.

The development of the GIS prototype represents a product of the online questionnaire presented in the previous chapter (Chapter 5). It combines the development tools available to provide a system that is accessible and affordable. The potential for the use of open source and web-based information systems is being realised growingly, and the GIS prototype aims to provide an example of an application that may fulfil the needs of local administrators and communities.

Chapter Six Case Study: Overstrand Municipality

The case study of the Overstrand Municipal area was used to measure features associated with the usability of the GIS prototype. This allowed for information to be gained on the role that the prototype could play in the management of health services within a specific context.

This chapter begins by considering the study area and the research methodologies used. The results are then described in terms of the information flow and communication between the samples (municipality and community) studied. The results of the usability testing are summarised in terms of the usability, learnability and the functional and data requirements of the GIS prototype. The cases and the convenience sample are used as comparative measures of the GIS prototype, allowing for the relative measure of the usability of the system to taken¹⁴.

The chapter concludes by summarising and interpreting the results, drawing conclusions on the usability of the prototype and the methodologies used in the testing.

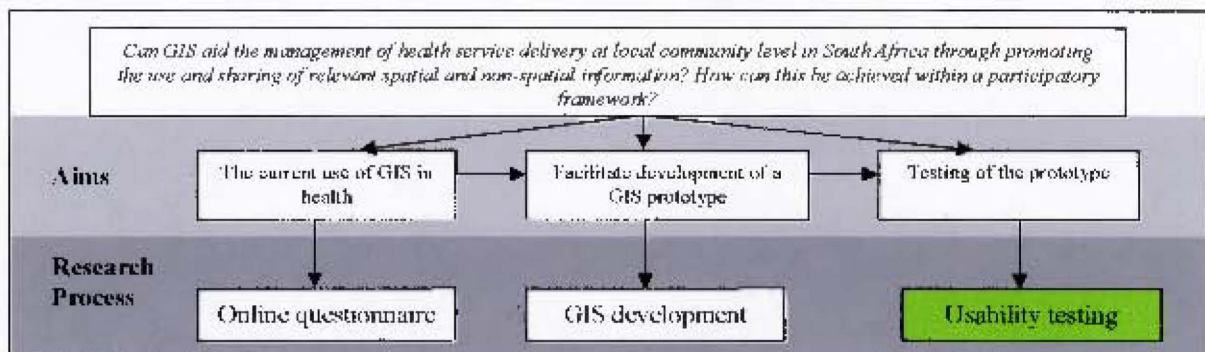


Figure 23 Research aims and processes: Usability testing

¹⁴ The usability of a system is highly dependant on the context and purpose of use and thus cannot be compared to other systems in other environments; the usability of the system has therefore been measured for two different cases within the same context, providing comparable usability results.

6.1 Background

This section introduces the study area, providing insight into the municipalities and community structures. Consideration is given to the data collection methodologies used in the case study.

6.1.1 Local government structure in South Africa

The structure of local government in South Africa is defined in the Municipal Structures Act (Republic of South Africa, 1998). The municipal system consists of three tiers, and municipalities are categorised as either A, B or C, explained in Table 2.

Table 2 Municipal categories

Category A (Local municipality)	A municipality that has exclusive municipal executive and legislative authority in its area
Category B (Local municipality)	A municipality that shares municipal executive and legislative authority in its area with a category C municipality with whose area it falls
Category C (District municipality)	A municipality that has municipal executive and legislative authority in an area that includes more than one municipality

(Municipal Structures Act, 1998)

The role of the local government at district municipality level is to work together with the local municipalities within the district in order to ensure that all have access to equal services and resources. The local municipality is responsible for the provision of services at a local level, amongst other administrative duties. Services include water, electricity, sewage, sanitation, refuse removal, fire fighting, public transport, local tourism and health services amongst others.

6.1.2 The study area

The Overstrand is situated in the Western Cape Province and is the central authority for the Overberg district municipal area. The Overberg District municipality (Category C) is the highest level of local authority that governs the study area and surrounds. The district municipality governs the following local municipalities: Theewaterskloof, Agulhas,

Swellendam and the Overstrand local municipalities (Category B) see Figure 24. Within the Overstrand local municipality further tier of local municipalities (Category B) exist in the towns of Gansbaai, Kleinmond, Stanford and Hermanus from which the Overstrand municipality operates.

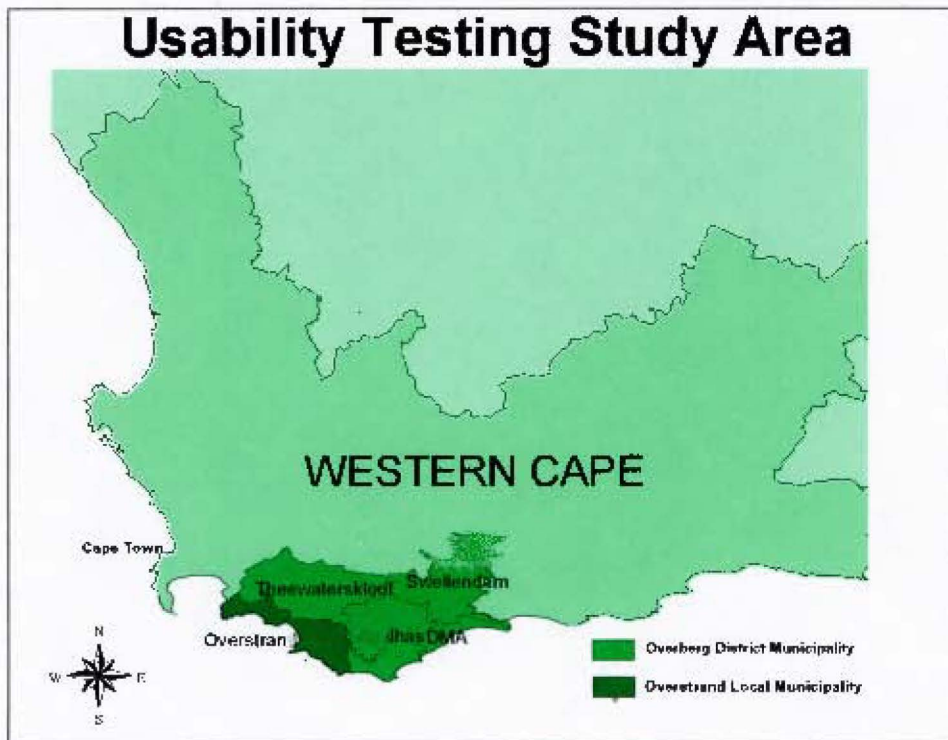


Figure 24 Study area

The Overstrand Municipality is the administrative and developmental centre of the Overberg District. Driven by mainly by tourism, the area boasts the fastest economic growth in the Overberg District (Overstrand Municipality, 2006). The Overstrand area also boasts a population with education levels and skills that exceed the average for the district as well as that of the Western Cape Province (Overstrand Municipality, 2006). While the area stands out in terms of economic performance, education and skills, the social development of the area is generally on par with the surrounding municipal areas and the Western Cape Province (see Overstrand Municipality, 2007 for more details).

The representation of a broader area as well as the potential to influence other areas were key factors in using the Overstrand as a study area. A further factor that adds relevance to

the area is a focus on community participation from the Overstrand Municipality. The municipality has a ward committee structure in place, allowing for, and promoting participatory decision making within the area (explained further in the following paragraphs).

The Overstrand district municipality is separated into political and administrative sectors, these are illustrated in Figure 25. The political structure is concerned primarily with developing policies and by-laws, and implementing strategies to implement and monitor these. The administrative structures serve as the operational side of the municipality and are in place to implement and manage policies brought down from the political structures. Service provision and other functions mentioned under the duties of local municipalities are also carried out by the administrative sector of the municipality.

A part of the political structure of the municipality is the ward committees, these serve as a tool for participatory planning and involvement in the municipality. The ward committees are made up of community members and ward councillors, who act as a link between the community and the municipality (see Figure 25). Ward committees are unique to the Overstrand municipality, at least within the Overberg district, and provide an opportunity for participatory and self governance. This is the area in which this research aims to have impact, using information to increase the communication and collaboration between the community and local government.

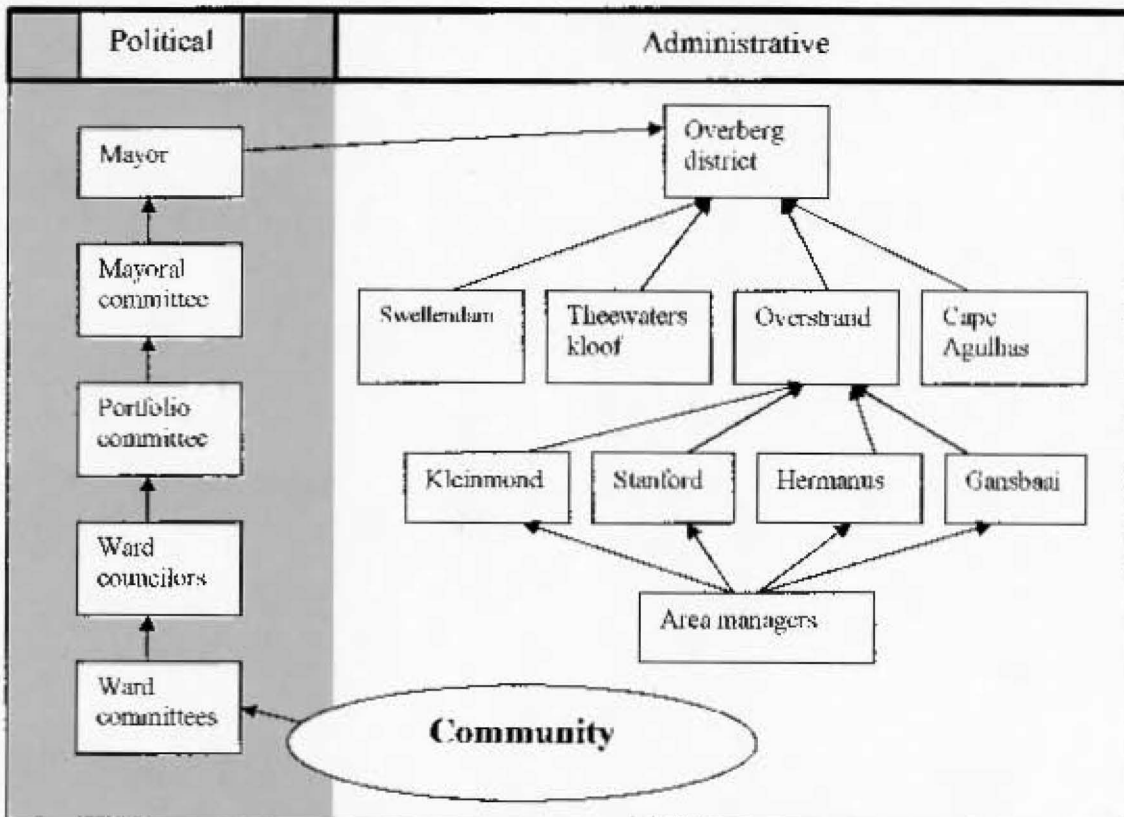


Figure 25 Overberg municipal communication structure

6.1.3 Data collection

The data collection for the usability testing of the GIS prototype included the use of interviews, questionnaires and task analysis. All of these processes were completed in one sitting with a participant of the research (See photographs in Annexure E).

The participants have been grouped to represent two cases within the case study (see Table 3)

- Case of municipality using the GIS prototype as an information tool. The municipality is case is represented by a number of municipal officials including those who deal with planning of services and service provision, those who deal

with community involvement in decision making and those responsible for the ward committees.

- Case of the community using the GIS prototype as an information tool. The community is represented by, and limited to clinic personnel, those responsible for the management of clinics and sisters at the clinics, the community is further represented by community organisation members and members of ward councils within the study area.

The participants of the research represent potential users of the GIS prototype. The following table (Table 3) further explains the composition of the groups (municipal staff, ward councillors, clinic staff and the convenience sample). Each of the groups represents one of the cases being studied; the Table indicates this in the final column.

Table 3 Usability testing and case study research participants

Participating group	Number	Area	Case
Municipal staff	4	Hermanus	Municipality
Ward councillors	5	Hermanus, Gans Bay, Stanford, Kleinmond	
Clinic staff	7	Hermanus, Stanford, Kleinmond, Zweihle, Onrus, Hawston	Community
Community members	4	Hermanus	
Convenience sample	10	Cape Town	Only included in usability testing

Municipal staff includes area managers of the municipality and those responsible for promoting community participation in decision making.

Ward councillors provide a link between the community and the municipality, they are responsible for providing a means through which communities can participate in decision making within a certain area.

Clinic staff consists of sisters and clinic managers working at clinics within the study area, clinic managers are involved in decision making in the clinic and community.

Community members were sourced from community organisations within the Overstrand, this group also includes members of ward councils within the area.

The **convenience sample** includes students and professionals who were not involved in the research or development of the GIS prototype (included only in the results of the usability tests). The convenience sample has been included in the analysis of the results, providing important comparative values for the usability testing. Figure 27 illustrates the usability testing process in the order in which they took place (from 1 to 5); these are further explained in the following paragraphs.

All of the participants were located within the Overstrand municipal area representing those within Hermanus town and the surrounding areas, indicated in Figure 26.



Figure 26 Case study: Towns and areas surveyed

The usability testing process is summarised by the following diagram (Figure 27). Each of the processes followed on from each other as indicated by the numbers in the diagram. The usability testing process is further explained in the following paragraphs.

Research process		Information gained	Outcomes
1	Structured Interview	Information flow Information system use	Current systems Information needs
2	Participant Questionnaire	User details Computer experience Education	Comparative usability measures
3	Task 1 and Questionnaire	Task times Insight into usability	Usability test measures HFS data
	Usability Task Analysis Task 2 and Questionnaire	Task times Insight into usability	Usability test measures HFS data
4	Post Test Questionnaire	SUS Test Map relevance	System rating Map relevance
5	Post Testing Interview	System usability Functionality Information sharing Participatory GIS	Perception of the system

Figure 27 Case study and usability testing data collection methodologies

1. Structured interview (Annexure F)

Interviews were designed to gain insight into the manner in which information is shared and gained between the municipality and the community. The information gained from these interviews is presented as a beginning to the case study of the Overstrand, illustrating current information and communication flow between the cases.

2. Participant questionnaire (Annexure G)

The general information questionnaire was concerned with gathering the participants level of computer use, age gender and area of work. Providing a measure through which

the usability of the GIS prototype could be compared. The information gained from the questionnaire has been combined with that of the usability task analysis.

3. Usability task analysis (Annexure H)

The task analysis allowed for the identification of specific problems the users may have with using the system's interface. The issues identified aim to guide any further development of the GIS prototype. The tasks also allowed for the measurement of time required for the user groups to complete the tasks. This measurement was compared to the users' level of computer use and education and other variables.

The task rating questionnaires were completed after each of the tasks. The users rated the GIS prototype in terms of its consistency, simplicity, effectiveness and their overall satisfaction. These are a direct measure of the users perceptions of the systems usability and ability to suite their needs. These measurements have been combined and used to represent the overall human influence on the GIS prototypes ability to perform a task, this is called the Human Factor Score (HFS). This measurement was compared across the variables gained from step 2 of the data collection, and also across the two cases.

4. Post test questionnaire (Annexure I)

The final questionnaire used was a SUS (System Usability Scale) questionnaire. This is a Likert scale (Brooke, 1996), in which the participants rate the system according to a broad set of questions. This is a measure of the overall usefulness, ease of use and appropriateness of the system. This measurement was compared across the variables gained from step 2 and the cases.

5. Post test interview (Annexure J)

The final interview of the testing process was aimed at determining the functional and data requirements of the GIS prototype as well as the potential users' perceptions of the system and testing process. The functional requirements and data needs are documented according to user group (case), guiding further development of the GIS prototype for

each group. The overall perceptions of the system are documented in the final paragraphs of the results section (6.2.7) of this chapter.

6.2 Research results

The results of this phase of the research have been divided into three separate processes; the identification of information is accessed and shared, the testing of the usability of the GIS prototype and an assessment of the functional needs and data requirements that would be required to increase the effectiveness of the GIS prototype. Figure 28 illustrates these processes, and shows the research tools used for each step as well as the participants in each of the research processes.

Usability testing case study: Hermanus		
Research process	Research tool	Participants
Information flow	Interviews	Municipal managers Ward councillors Clinic staff Community
Usability testing	Tasks analysis Interviews Questionnaire	Ward councillors Clinic staff Community Convenience sample
Functional and data needs assessment	Questionnaire Interviews	Ward councillors Clinic staff Community

Figure 28 Case study and usability testing methodologies

6.2.1 Information flow

This section outlines the manner in which communities and municipalities share and communicate information. It serves to provide a context to the case study being presented. Through this it is possible to identify areas in which the GIS prototype may play a role in increasing the access to information.

A comparative analysis of the information flow structures between the two cases (the community and the municipality) is presented. The raw data that contributed to this analysis is in Annexure K.

Figure 29 shows how health related information is shared between the municipality and the community. The diagram illustrates the tools available for communication, and whether they are used or not (an arrow indicates the use of the tool).

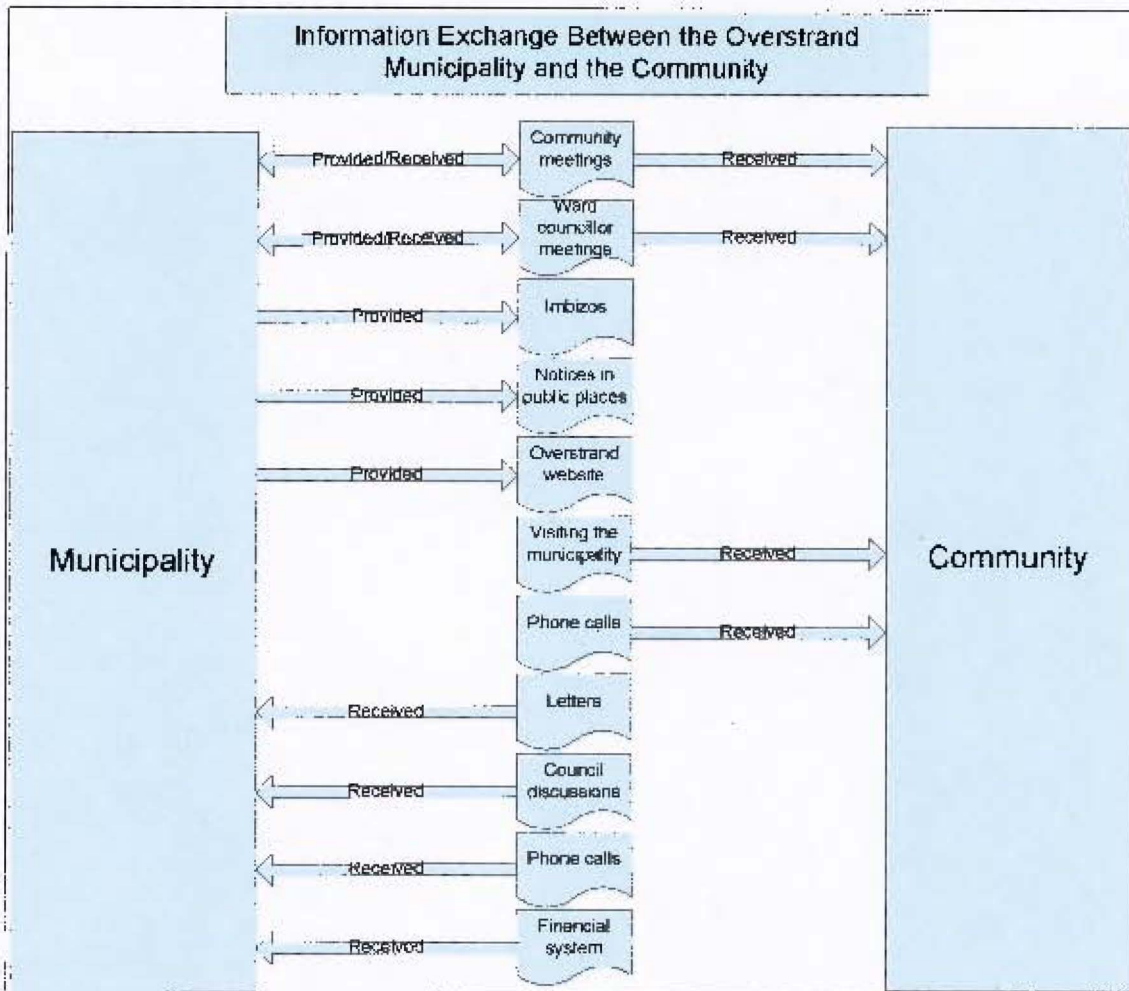


Figure 29 Case study: Information flow between the municipality and the community

The municipality identified a number of ways in which information is provided for and received from the community (indicated with arrows connected to the municipality). Some of these methods of information transfer were noted by the community (such as community and ward council meetings); however no other formal ways of receiving information from, or providing information to the municipality were noted. The only ways in which information could be gained were through phone calls or visits to the municipality.

The communities did not mention any structure whereby information held could be shared with the municipality. This is in contrast to the municipality's perspective as they identified a number of informal manners in which this is done (see the "received" arrows in Figure 29). A number of the community members noted the lack of provision for information to be "fed up" to the municipality. Additionally a number of the community members felt that the information that is available from the municipality could of more relevance and up to date than what is received.

The responses gained illustrate the lack of (or perceived lack of) ways in which the community can offer information to the municipality. This research aims to fill this gap by providing a tool (the GIS prototype) for the management of information, and also a sense of ownership through a participatory design process.

Identifying the current information systems used by the cases formed a part of this phase of the research. The municipality make use of a number of systems, however these remain closed to other users and are concerned with specific tasks, mostly related to operations management and engineering. In contrast those in the community do not make use of information systems for their day to day tasks.

The only common system noted by the two cases was the use of the internet. The municipality noted their website as a source of information for the community, and also make use of the internet for ad hoc searches depending on need. The community did not note the use of the Overstrand website¹⁵, but do make use of the internet for ad hoc searches.

¹⁵ The information provided on the website (www.overstrand.gov.za) is limited and centred around recent news and events within the area. The municipality's web site includes links to services and documents, however many such links end without producing any meaningful information, and the site is a work in progress (Accessed August, 2006).

6.2.3 Usability tests

Usability tests of the GIS prototype provide measures of the system's ability to fulfil the needs of the potential users. Factors that influence the usability of the GIS prototype have been measured and are discussed. The usability of the prototype is then considered through a comparison of the cases (and the convenience sample). The functional requirements and data needs of the cases are considered, illustrating possible avenues for the further development of the GIS prototype. Finally the participant's views on the use of GIS for community participation are considered. Tables with raw data gained from the task analysis part of the usability testing are appended in Annexure L.

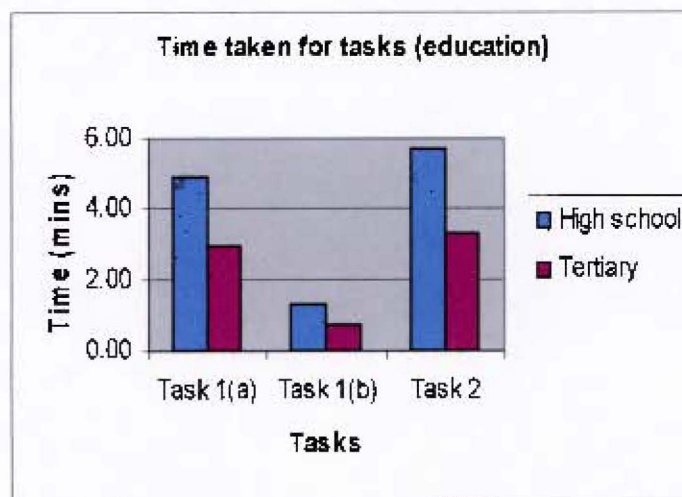


Figure 30 Usability testing: Time taken for tasks (education)

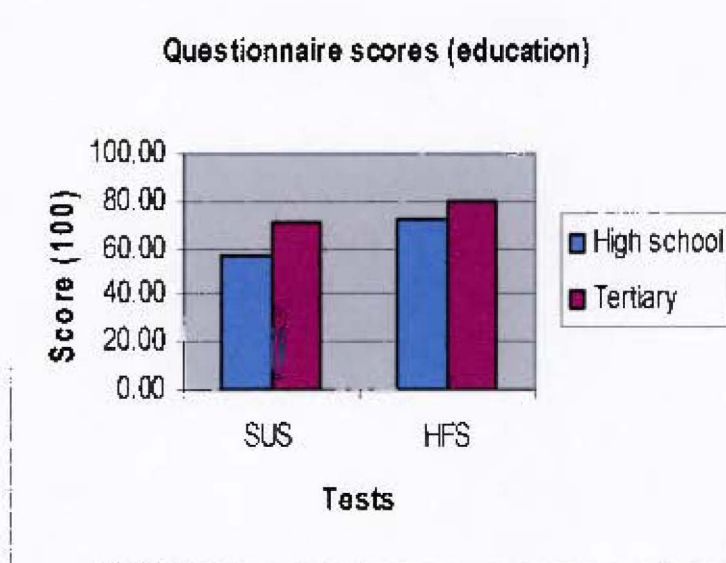


Figure 31 Usability testing: SUS and HFS indicators (education)

Education level (see Figure 30 and Figure 31) does seem to influence the user's performance on the system, as well as the user's perception of the system, with time taken for the task generally longer for the high school graduates than those with a tertiary education, and the SUS and HFS being lower. This is a result of the general skills gained through education and is an expected outcome.

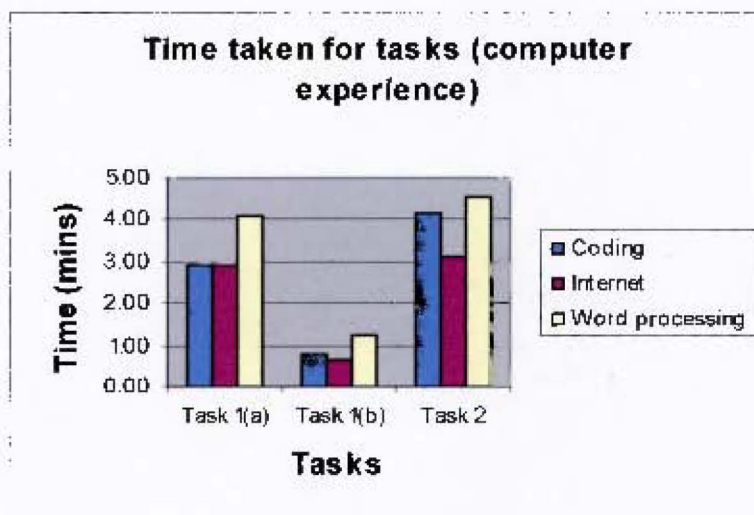


Figure 32 Usability testing: Time taken for tasks (computer experience)

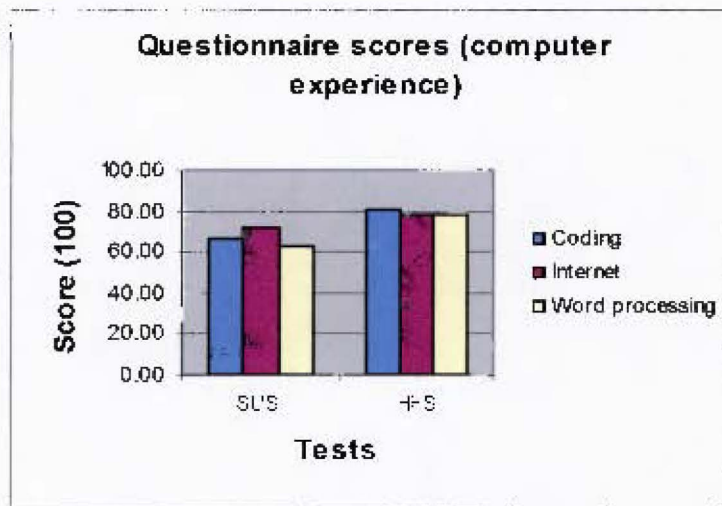


Figure 33 Usability testing: SUS and HFS indicators (computer experience)

Previous experience in computer use (see Figure 32 and Figure 33) has a minimal effect on the system's usability, with those experienced in coding and internet use performing better than those with word-processing experience only. It is interesting that those with experience in using the internet slightly outperformed those with programming experience. This illustrates that minimal computer skills are required for the use of the GIS prototype.

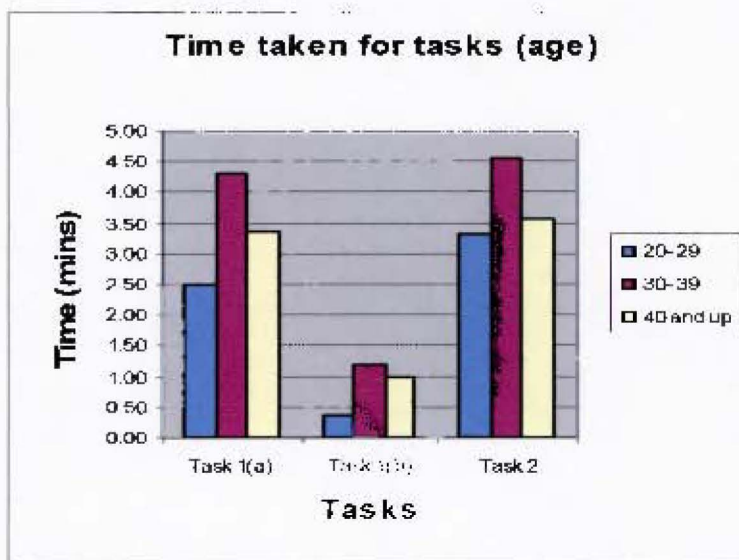


Figure 34 Usability testing: Time taken for tasks (age)

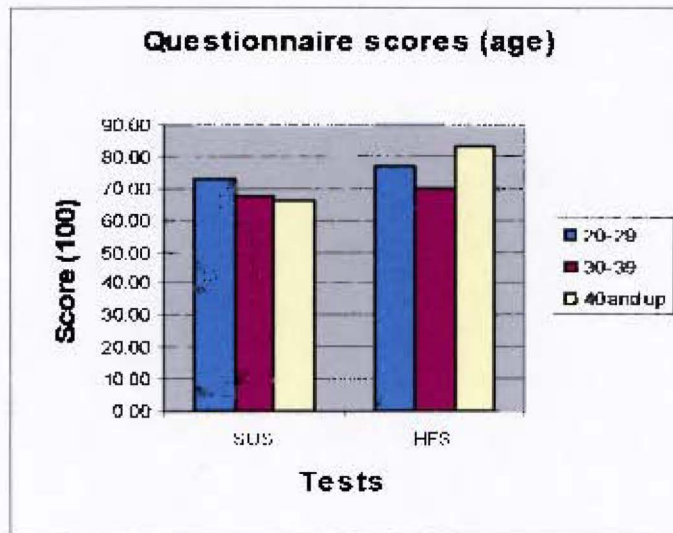


Figure 35 Usability testing: SUS and HFS indicators (age)

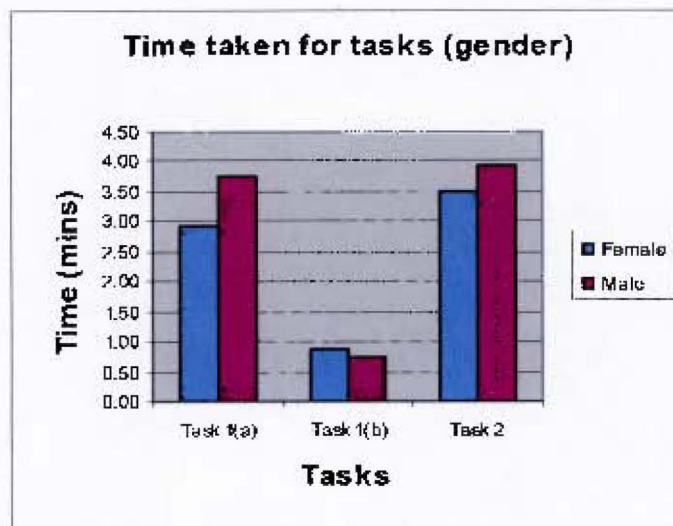


Figure 36 Usability testing: Time taken for tasks (gender)

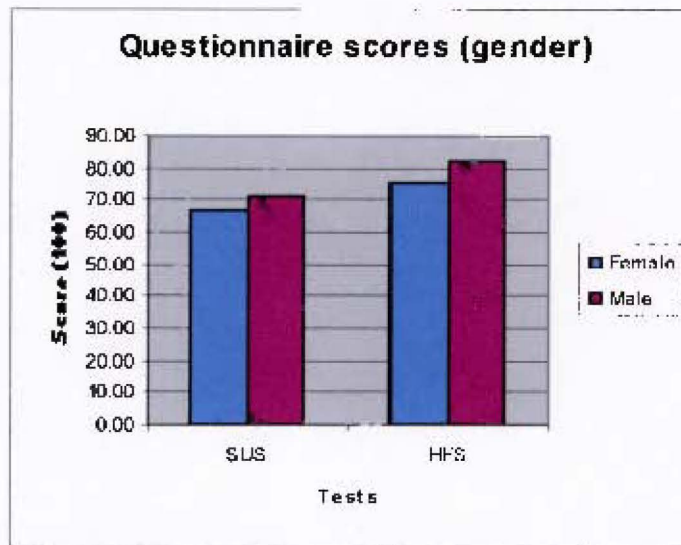


Figure 37 Usability testing: SUS and HFS indicators (gender)

Age and gender (see Figure 34, Figure 35, Figure 36 and Figure 37) show minimal variations, those at the two extremities of the age groups performed most effectively, illustrating that age is non influential in the usability of the system. The female user group performed generally better than the male counterparts, however perceived the system to be less valuable, both measures are however minimal and insignificant.

The measures illustrate that the usability of the system is generally high, and is not influenced by user characteristics in any significant way. The most influential factors are education and experience in using the internet, which indicate that basic computer experience provides an advantage in using the GIS prototype.

6.2.4 System short term learning

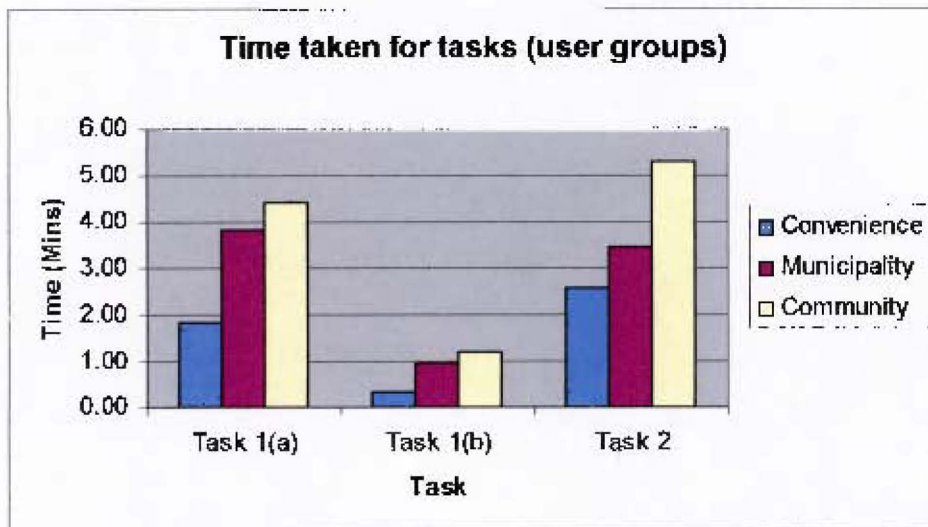
What influences the usability of the system is of interest, yet more valuable is a measure of the ability of the users to learn the system. The first task involved the identification of two areas, effectively repeating the same task twice and providing a measure of how easy it is to learn the system.

Table 4 Usability testing: Average time for tasks and indicator scores

	Task 1(a)	Task 1(b)	Difference	Task 2	SUS	HFS
Time/Score	(Mins.)	(Mins.)	(Mins.)	(Mins.)		
	3.27	0.83	2.44	3.67	68.50	78.33

The difference between task 1(a), finding area 1, and task 1(b), finding area 2, is monumental (over two and a half minutes difference), and shows that the system is highly conducive to easy learning (see Table 4 and Figure 38).

The SUS score is nearly 70, showing a generally high regard for the systems usability. The scores for the user groups are displayed in the Figure 39 and Table 4. The convenience sample giving the system the highest SUS score, and the municipalities the highest HFS. The scores do not vary greatly except for that of the community example, which scored the lowest on both the SUS and HFS.

**Figure 38 Usability testing: Time taken for tasks (samples)**

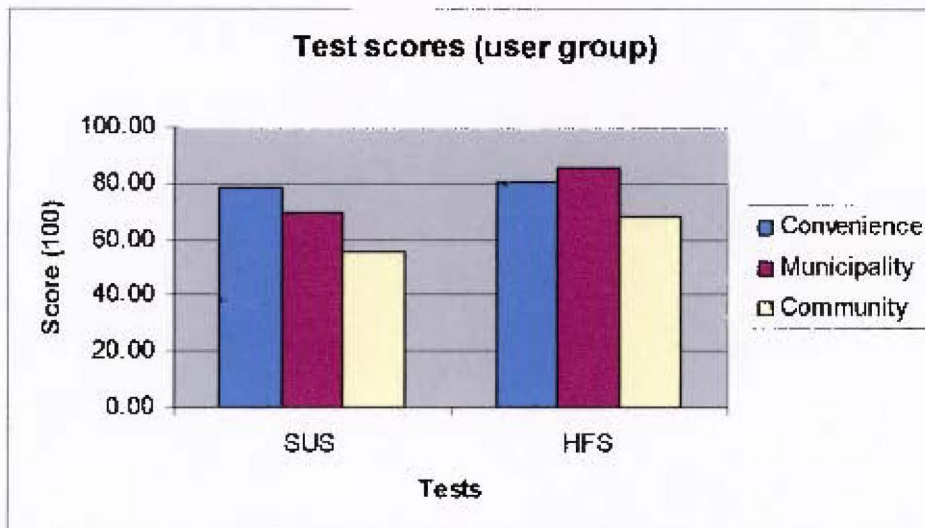


Figure 39 Usability testing: SUS and HFS indicators (samples)

The results of this phase of the research may be compared to external measures for the initial measurement of the systems performance, it must be noted that this would be ill advised if this was a continuous assessment of the GIS prototype. Results of SUS tests performed within contexts that may be related to this research illustrate an average score of 68.5 (Anand, 2005; Hvannberg et al, 2007). With an average score of approximately 70, the GIS prototype shows great potential, even in its early development stages. For further comparisons in terms of such measurements future testing of the prototype is required using the methodology provided by this research.

Most importantly, and relevant to this research are the comparisons of the scores within this research and between the various user groups. Once again a high level of consistency is noted, showing a degree of compatibility between the user groups.

6.2.5 Functionality and data needs assessment

The functional requirements and data needs of the potential users were gained through interviews held with the participants after the testing of the GIS prototype (full responses are available in Annexure M). This aimed to shed light on the appropriateness of the system, potential for the system to be used by the different user groups as well as what

could improve the system. The functional and data requirements highlighted by the user groups were highly individual (see Figure 40 and Figure 41), and in many cases illustrated the general lack of implementation of effective information systems.

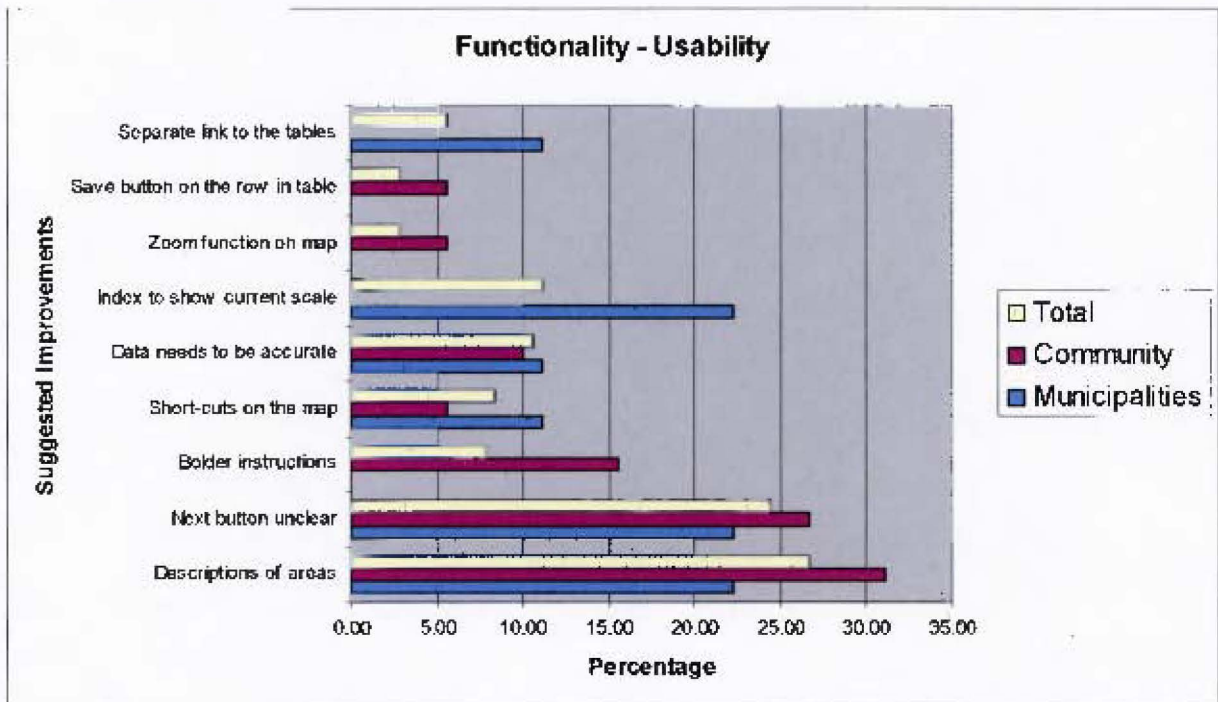


Figure 40 Usability testing: System functionality

The above graph (Figure 40) shows the responses to questions relating to the design of the prototype's interface and functions that should be present there. It indicates clearly what areas are in need of improvement and alteration. These are mostly related to instructions on the use of the system, and the buttons used in order to change the data displayed on the map. The following graph (Figure 41) describes further possible uses for the system, and thus implies the data requirements that are required to fulfil these.

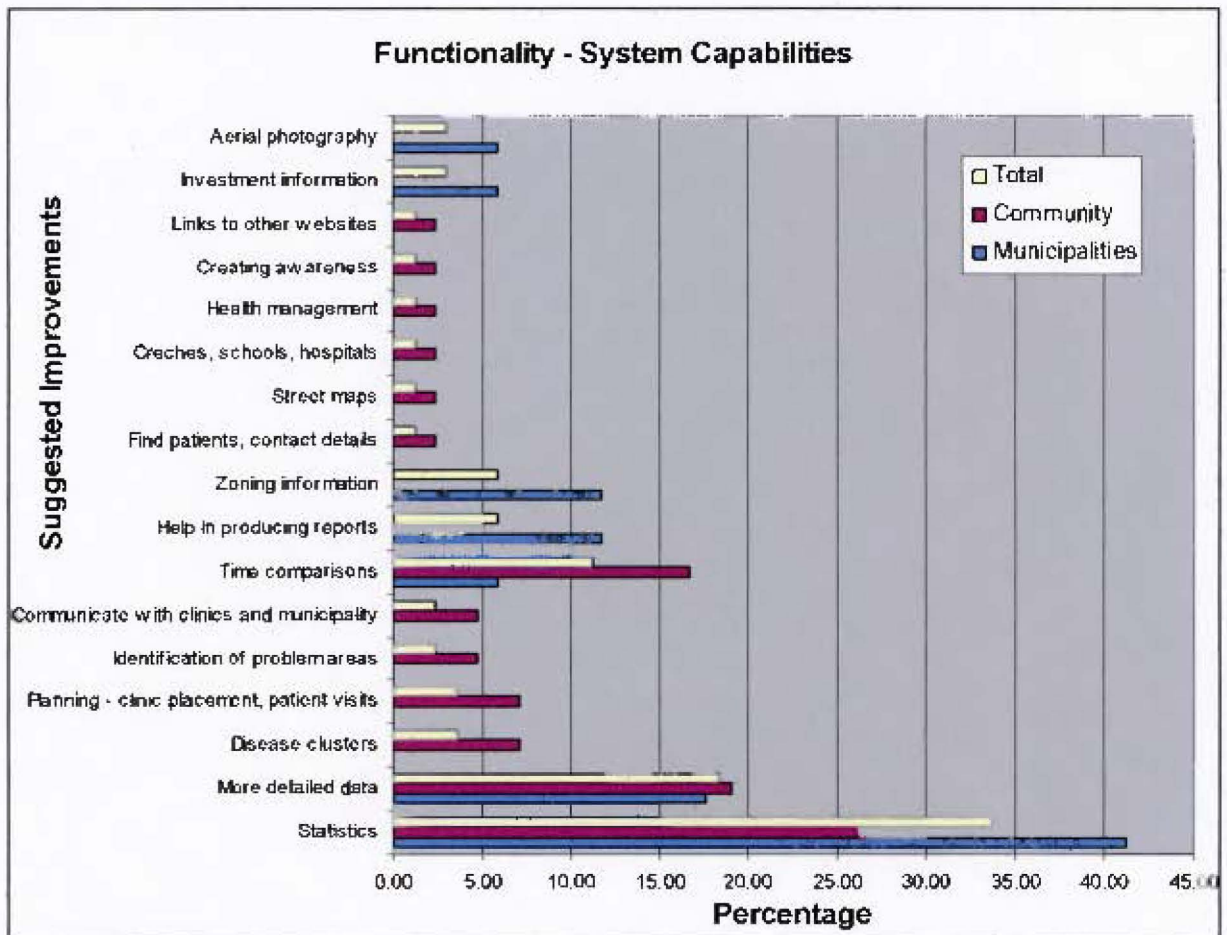


Figure 41 Usability testing: GIS prototype capabilities

The GIS prototype is heading in the right direction in terms of delivering statistical information; however more detailed data would be needed to fulfil the requirements of the potential users. The community were the most active in terms of identifying possible uses of the prototype and illustrated a number of possible uses for the system in health related activities. The results clearly show the disparate perceptions of the possible uses of the GIS prototype, and emphasise the use and development of such tools in specific ways.

The fact that such a number of potential uses were identified is positive for the development of the GIS prototype. This shows interest in the system from the potential users, and a great potential for the system to be used across a broad base of users. The uses identified by the users also correlate with conclusions drawn from the online

questionnaire results. Illustrating that the use of GIS for complex analysis and modelling is not what is required, rather the use of GIS for the display of data and basic analysis.

The information displayed in Figure 40 and Figure 41 are considered in terms of the two cases (the community and the municipality). The following improvements to the GIS prototype were indicated by the participants:

Community:

- A save button after changes to the table have been made
- An interactive zoom in button on the map
- Bolder instructions are needed

Municipality:

- A separate link should be provided to the tables
- An index showing the map scale should be included

Both cases:

- The next button should be changed
- Descriptions of the areas on the map should be provided
- Accurate data must be displayed
- Short-cuts should be provided on the map (click and go)

The following suggestions were made by the participants in terms of functionality and data on the GIS prototype:

Community:

- Links should be provided to other websites
- Tools for creating awareness within the community should be available
- Health management tools should be available (find patient, patient details etc)
- Communication channels between clinics and with the municipality should be provided

- Disease cluster identification/information should be included
- Identification of problem areas (clusters)
- Street maps should be included
- Health services planning capabilities such as clinic placement and catchment areas should be included

Municipality:

- Report production tools
- Aerial photography
- Investment information
- Zoning data

Both cases:

- Time comparisons (then and now)
- More detailed data should be available
- Relevant and updated statistics should be displayed

6.2.6 Map use and appropriateness

In order to measure the effectiveness of the map display of the GIS, questions regarding this were designed in a Likert style questionnaire, similar to the SUS questionnaire.

These responses have been manipulated to form a similar score. The score represents the ease at which the map was understood, the data displayed on the map and the suitability of using maps for the purposes of the respondents. The following table (Table 5) summarises the results for the three user groups.

Table 5 Map relevance score

User group	Map Score
Clinics	72.14
Municipality	61.67
Community	52.50

The scores above can not be compared to external examples; however they aim to provide a benchmark from which future measures of this nature can draw on.

6.2.7 Impressions made on participants

The final series of questions in the case study and usability testing process were used to gain an impression of providing information access to communities through a GIS (included in Annexure M). The impressions gained from the participants in this part of the research answer the research question¹⁶ in a subjective way.

The impressions left after the usability testing of the GIS prototype are best described through considering responses received in the interviews directly.

Should GIS be used by communities?

All of the responses in this respect were positive, with one of the community participants commenting that “they (community members) need all the help they can get.” The municipalities were positive, but with reservations as to their involvement, indicating that the GIS prototype should be implemented by and for NGOs (Non-Government Organisations), libraries and even real estate agencies.

Are there any benefits for the municipality?

Further insight was gained from the municipality case through the question above. Once again the overall response was positive, and benefits identified include: increased access to information; updated data; better informed voters; increased communication and increased self governance.

Are there benefits for the community?

¹⁶ Can GIS aid the management of health service delivery at local community level in South Africa through promoting the use and sharing of relevant spatial and non-spatial information? How can this be achieved within a participatory framework?

The benefits that could be reaped for communities using GIS to access information were varied, and included, on a broad scale: better living conditions, service improvements, community upliftment and providing for a better perception of transparency within government. The more practical benefits identified by the municipality and community included: engaging with the municipality and challenging decisions; the ability to articulate their needs, improving contributions to planning and development, understanding of municipal decisions.

What might hinder the use of GIS by communities?

The respondents from the municipality and the community provided similar answers to this question, and were mostly related to skills and resources. Concern was expressed over both computer and map literacy of the community at large. In terms of resources, the main concern was over providing facilities whereby community members can gain access to a computer to view the information available.

It can be said that the GIS prototype left a positive impression on all those that participated in the testing. Overall those who represented the community showed a positive attitude, and were pleased to be involved in the development of a system that could benefit them, and their community at large. The municipality also showed a great interest while having some reservations in terms of the facilitation and management of the system.

6.3 Summary and conclusions

The Overstrand is a municipality that has mechanisms to ensure community participation. Information is a key to participative decision making, and it is clear that communities have little access to this as the mechanisms for this are undeveloped and under utilised. A large amount of information was gained through the research presented in this chapter. The following points summarise and discuss some of the key results.

The following is noted with respect to information flow and communication with the study area:

- The community is limited to receiving information held by the municipality via telephone calls or visits to the municipality.
- The community has no possibility of providing information to the municipality
- All of the participants saw potential for GIS to play a role in the sharing of information
- All of the potential users of the GIS prototype potentially¹⁷ have access to the internet

The following results were gained from the analysis of data gained from the usability testing of the GIS prototype:

- Characteristics, such as education level, computer experience, age and gender, have minimal effect on the usability of the system.
- The GIS prototype's functionality is easily learnt
- The results of the usability tests are consistent for various user groups (community, municipality and convenience), showing no favour for either of the cases.
- The results of the usability tests provide a standard for the GIS prototype. They should be used as a comparison if testing on a future version of the systems is undertaken.

Further insight into the usability of the GIS prototype was gained through interviews and questionnaires:

- That different potential user groups have varying needs in terms of an information system, and thus the functional and data requirements vary greatly between user groups.

Interface improvements/suggestions

¹⁷ The potential users have access to computers and have telephone lines, yet some are not connected to the internet

The interface improvements suggested by the cases were generic. This means that further development of the GIS prototype in accordance with these changes should increase the usability of the system for both the municipality and the community.

Functional improvements/suggestions

The functional and data related suggestions were however disparate, indicating a lack of a unified vision between the two cases, as well as a seemingly misled view on health services management by some.

The community participants envisaged a number of opportunities for the GIS prototype. These were concerned with making general information available, creating communication lines with other communities (clinics), completing tasks related to their day to day work and also fulfilling high level tasks such as identifying clinic catchment areas.

The municipality took a different perspective and saw the need for zoning and even investment information. More relevant suggestions included report production, time comparisons and statistics (identified by both cases).

The suggestions made by the various potential user groups may be easily produced, however increasing the functional capabilities of the system has an effect of the ease of use of the system in the end, and it is important to consider this as a trade off between increased functionality and decreased usability.

Further development and testing of the GIS prototype are suggested, the methods used to get to this stage of the design provide a template through which further development may take place for the GIS prototype and also for the development of other community based information systems.

Chapter Seven: Conclusions and discussion

The research presented here aimed to answer the following research question:

Can GIS aid the management of health service delivery at local community level in South Africa through promoting the use and sharing of relevant spatial and non-spatial information? How can this be achieved within a participatory framework?

The research has illustrated that GIS has the ability to fulfil the needs of local communities through the provision of information, allowing for participation and an opportunity for more effective management of health services delivery. The methodologies used to test the GIS prototype illustrated how participation from potential users of a system could be achieved.

7.1 Conclusions and summary of main findings

The following conclusions relate to the three aims of the research and are presented as such:

To determine the status quo relating to the use of GIS for health in South Africa

These results directed the scope and focus of the research and provided insight into how a participatory framework may be created. The following contributions were gained from this research

- GIS use focuses mainly on the management and planning of health related services
- The majority of respondents only use GIS for the display and printing of maps, and while some use or aim to use more advanced GIS functionality, the majority are content to use GIS for the fulfilment of basic tasks.
- Limitations associated with the use of GIS were identified as being the cost of GIS and the human skills required to use GIS.

To facilitate the development of a user friendly GIS for the dissemination of information

A GIS prototype was developed based on some of the principal findings of the online questionnaire, providing an opportunity to measure how effective GIS could be in promoting the use and sharing of information, and thus aiding the management of health service delivery. The following points highlight the conclusions of this part of the research.

- The development of the GIS prototype illustrated the ability to combine people's views and opinions with available development tools to produce a geographic information system.
- Open source and web based technologies are able to provide GIS solutions that are highly applicable and appropriate to the local community level within the South African context

To test the usability and functionality of the GIS prototype with potential users

The research question was directly tackled through a case study of the Overstrand municipal area and usability testing of the GIS prototype. The following are the conclusions from the ultimate phase of the research.

- The GIS prototype has the ability to increase the flow of information at a local community level
- The GIS prototype is usable by the sample population, regardless of computer experience, education or any other recorded variable
- The different potential user groups have varying needs in terms of an information system

Addressing the research question and looking at the results of the research from a broader perspective the following conclusions can be drawn:

- GIS has the ability to provide information for local communities, thus providing an opportunity for the more effective management of health related services.

This is however dependent on the following points:

- The GIS development must be focused on fulfilling the requirements of a specific user group
- The tasks that the GIS aims to fulfil must be strictly defined, and within the requirements of the prospective user group

The research has illustrated the following with respect to the above requirements, and it may be concluded that:

- Open source software provides a suitable solution to the various functional requirements of communities. This is offered through the fact that open source software is generally interoperable, and also that the source code of any programme is available. It is therefore possible to customise existing applications to suit the needs of specific groups
- A participatory development methodology has a number of advantages for both the community and the development of the system.

7.2 Recommendations for further research

The research has a number of implications for further research. This section discusses recommendations for further research in terms of the development of the GIS prototype and the methodologies used for usability testing.

- The development of the GIS prototype should be continued. The findings of the usability test indicate that the prototype will be effective in meeting the needs of local communities in terms of providing access to information. The further development of the GIS must however take into consideration the points discussed in Section 7.1.
- The usability testing methodology developed in this research was well received by the potential users of the system, and provided insightful information into the GIS prototypes usability, as well as the potential areas of impact the system may have on its users. The methodology has been documented, and thus provides an

opportunity for replication of this research in other contexts and with other information systems.

- As the decentralisation of health services becomes more of a reality in South Africa, systems such as the GIS prototype will be required to work together to promote the sharing of information. Further research should focus on the areas in which systems such as the one described in this research could impact most.
- The information gained from the online questionnaire was used as a basic guide to the development of the GIS prototype. The information gained may however extend past that in terms of its scope, and it should be used to guide further research into the applications of GIS in health.
- It was observed that the focus of GIS and health research in the developing (on epidemiology) contrasted to the focus of practical GIS and health work in South Africa (as obtained from the online questionnaire). This provides an opportunity to study the disparities between research and practice within the field of GIS and health.
- The case study of the Overstrand municipal area highlighted the lack of information sharing and dissemination, despite a number of mechanisms to promote this. Research into the effectiveness of such mechanisms should be undertaken.

The research lends itself to further research possibilities, yet also adds substantially to the knowledge base of GIS use as well as its potential to play a role in the use and sharing of information in South Africa. The realisation of progressive health and information related policies in South Africa requires participation and access to information at all levels. This research illustrates the potential that open source geographic information systems hold in the promotion and realisation of these goals.

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Annexure A: Online questionnaire

Introduction

This questionnaire forms part of a Masters research project attempting to identify the use of Geographic Information Systems (GIS) within the health sector, and the potential for this use to be extended to communities through a process called Participatory GIS. This survey aims to establish the extent to which GIS is used for health related purposes, and more specifically if and how communities are benefiting from GIS applications. Participatory GIS for a range of purposes is being recognised as an important initiative world wide. For more information on Participatory GIS visit www.ppgis.com

This survey is intended for anyone using, or planning to use GIS in a health related field. While the World Health Organisation defines health as the 'complete physical, mental and social well being of people, not merely the absence of disease or infirmity,' for the purposes of this study it will be restricted to two areas:

1. **Health service provision** - planning, research, analysis, monitoring, management, implementation, etc.
2. **Disease prevention** - treatment, research, control, analysis, etc.

You have been identified as working within one or both of these fields. **If however you are not involved in GIS and health please do not continue any further.**

This survey is open and thus may be forwarded to other relevant people interested in participating in this study. The results of the survey will be circulated to all participants and through relevant channels.

The questionnaire aims, initially to determine the use of GIS for health purposes, and then focuses on Participatory GIS. **The Questionnaire is set out as follows:**

1. General organisational information
2. Technical specifications
3. The use (current or anticipated) of GIS in your organisation
4. Future plans for the use of GIS in your organisation

5. Community involvement and participatory GIS

6. Thank you

Please try to answer all the questions. If you are not currently using GIS please answer the questions with respect to how you anticipate using it. Please type your answers into the boxes provided, drop down menus are available for some of the questions. **The questionnaire should not take longer than 15 minutes to complete.**

The links and drop down lists throughout the questionnaire provide extra information specific to that section.

Please do not hesitate to contact me regarding any questions or queries: rckada001@mail.uct.ac.za.

Thank you for your participation in this research.
Adam Ricketts

The links at the top of the following page provide further information on the subject matter of this survey.

1.	2.	3.	4.	5.	6.

Extra information:

Definition and examples of participatory GIS
Extra information on participatory GIS
Case study of participatory GIS - The Klapersol Project

Section 1: General information

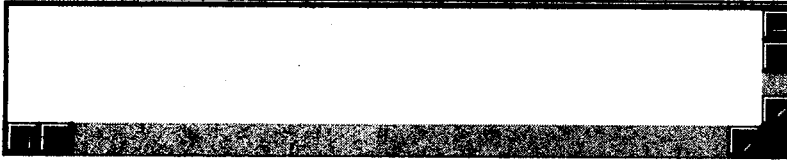
1.1. Please enter your name

1.2. Please enter your email address

1.3. Please enter the name of the organisation you work for?

1.4. In what field of work is your organisation primarily involved?

**1.5. What health related issues does your organisation deal with?
(eg. Health care, health service provision, planning, healing etc)**

A rectangular box with a black border, completely redacted with a solid black fill.

1.6. Within which sector would your organisation be classed? (eg. NGO, government etc)

A rectangular box with a black border, completely redacted with a solid black fill.

1.	2.	3.	4.	5.	6.

Section 2: Technical specifications

2.1 Is your organisation using GIS?

- Yes
- No

2.2 What GIS software does your organisation use?

2.3 Is your GIS supported by a web server?

- Yes
- No

2.4 How is your data stored: File format or database? Please specify if possible.

1.	2.	3.	4.	5.	6.

Section 3: GIS use within your organisation

3.1 For what general purposes is your GIS used?

More than one option may be chosen

—SELECT—	—SELECT—
—SELECT—	

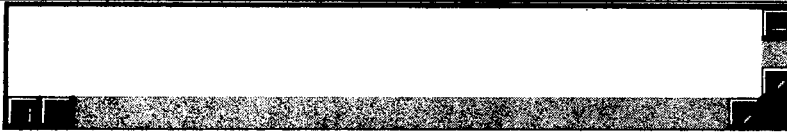
other:

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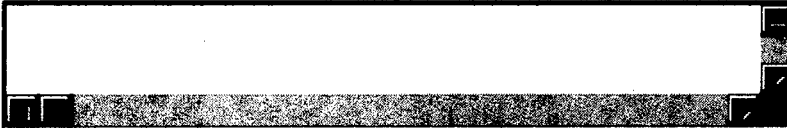
3.2 For what applications is GIS used for in your organisation?

Examples:

- Assessing health needs for the purchase of health services
- Epidemiological research
- Producing health profiles of local populations
- Determining catchment centres for local services
- Planning the location of health facilities
- Targeting resources towards local population groups
- Analysing GP referral patterns
- Evaluating demand for hospital services
- Evaluating demand for other services
- Analysing patient flows across health district boundaries

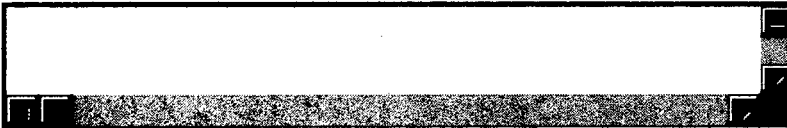


3.3 From where is your data obtained?

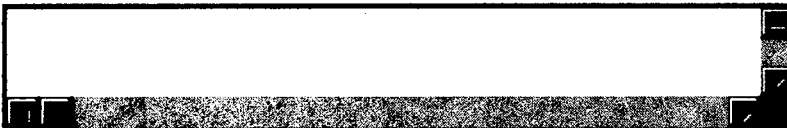


3.4 Do you use any spatial analysis tools of GIS?

Please specify



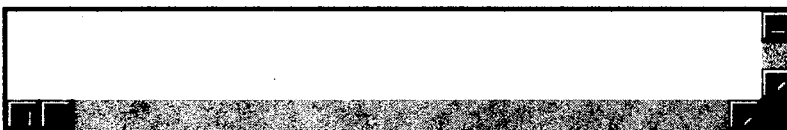
3.5 What outputs are produced? (eg. Web based maps, paper based maps, graphs, reports etc)



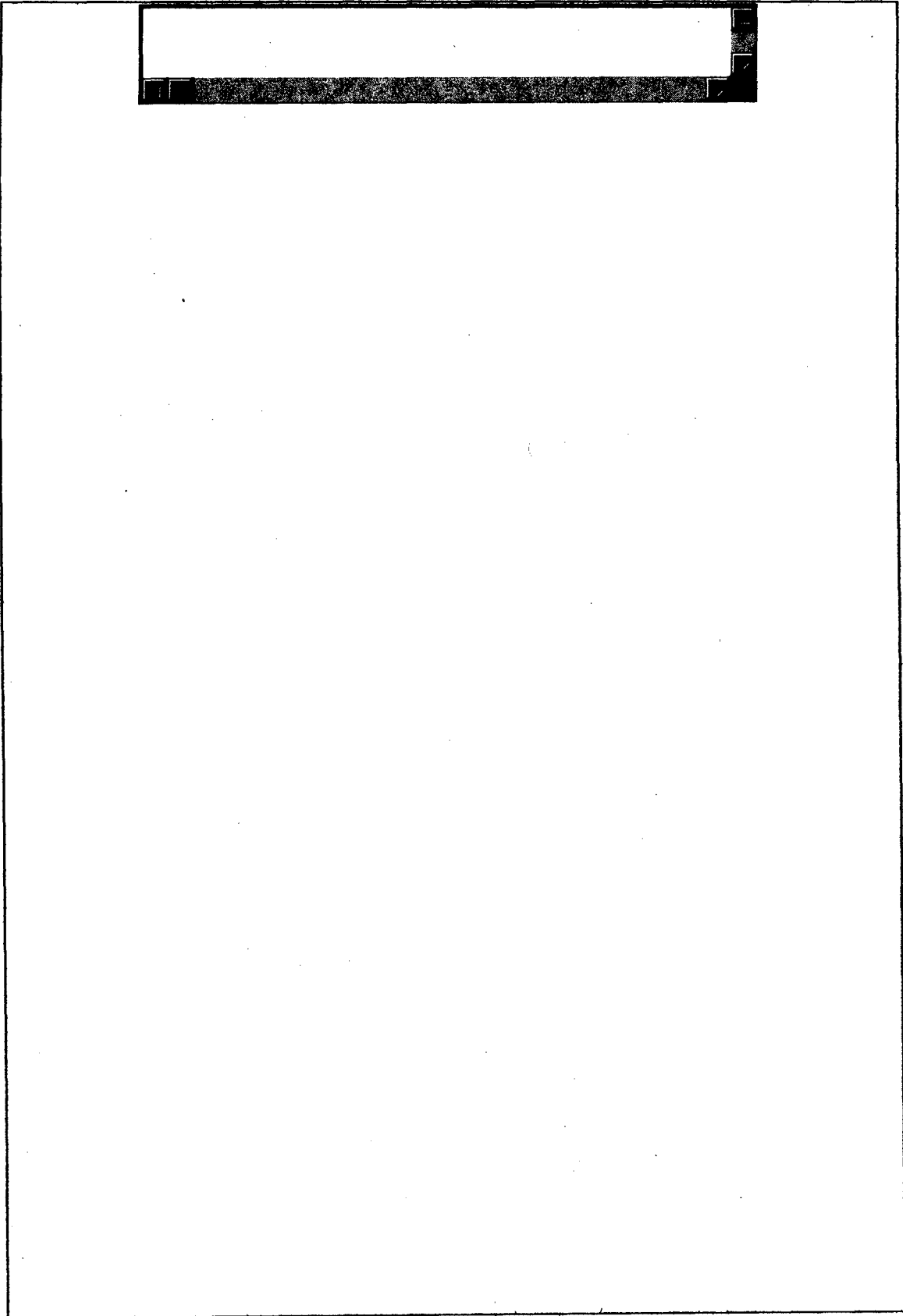
3.6 Are your outputs designed for analysis of features, for presentation purposes, or for both?

- Analysis
- Presentation
- Both

3.7 For whom is your output developed or aimed? (e.g. For your own use, for use by community members, for field staff etc)



3.8 For what purposes will your output be used? (e.g. Creating awareness, planning, educating, analysis, communication etc)



1	2	3	4	5	6
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Section 4: Future plans for GIS use

4.1 Does your organisation have any specific plans for the further use of GIS in ways that it is not currently used?
More than one option may be chosen

—SELECT—	<input type="checkbox"/>	—SELECT—
—SELECT—		<input type="checkbox"/>

other:

4.2 Do you feel there is potential for any other applications and functions of GIS to be used within your organisation?
More than one option may be chosen

—SELECT—	<input type="checkbox"/>	—SELECT—
—SELECT—		<input type="checkbox"/>

other:

4.3 Are there any constraints on the further use of GIS within your organisation? Please specify
More than one option may be chosen

—SELECT—	<input type="checkbox"/>	—SELECT—
----------	--------------------------	----------

other:

1.	2.	3.	4.	5.	6.
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Section 5: Participatory GIS and community involvement

Extra information on Participatory GIS:

Definition of participatory GIS

Examples of participatory GIS

Case study of participatory GIS - The Klepersol Project

5.1 Does your organisation involve the community in any way?

- Yes
 No

If you answered NO, please continue to question 5.7. If you answered YES, please answer the following questions

5.2 Do you feel there are any possibilities to extend the use of GIS to communities? Please specify.

Examples

- Empowering local communities through the the use of GIS for their managerial needs
- Mapping community space
- Analysing resource conflicts
- Participatory land use planning
- Raising awareness
- Educating people on their health needs

• **Identifying perceptions of service requirements**

5.3 How did the community become involved in GIS

5.4 Please explain the benefits gained for:

Your organisation

The community

5.5 Was the community involved in a once off partnership, or is the community still involved?

- Once off
- Still involved

5.6 What limitations were/are being experienced in community involvement?

If you have answered questions 5.2 to 5.6 please continue to question 5.11

5.7. Do you feel there are any possibilities to extend the use of GIS to communities for their own purposes or joint purposes? Please specify

Examples

- Empowering local communities through the use of GIS for their managerial needs
- Mapping community space
- Analysing resource conflicts
- Participatory land use planning
- Raising awareness
- Educating people on their health needs
- Identifying perceptions of service requirements

5.8 What positive factors could be gained through providing communities with access to and use of GIS resources for:

Your organisation

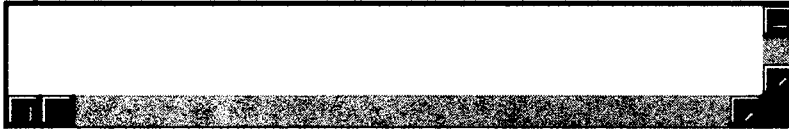
The community

5.9 What limitations are hindering community involvement? (If it is not desired, simply state that)

5.10 Were you aware of Participatory GIS before receiving this questionnaire?

- Yes
- No

5.11 What area of health do you feel could benefit from Participatory GIS most?



5.12 What is your general impression of Participatory GIS within the health sector?



1.

2.

3.

4.

5.

6.

**You are
here**

Section 6: Thank you

Thank you for your participation, the results of this survey will be sent to you.

This research will hopefully play a role in promoting the involvement and representation of communities in GIS and its affiliated areas of expertise. Further more this questionnaire forms the beginnings of a needs assessment for the use of Participatory GIS, hopefully providing some valuable information to this interesting field of study and application. Your participation is greatly appreciated.

6. Are you aware of any other potential participants for this research?

Please provide their names and email addresses:

Name(s)

Email address(es)

Annexure B: Online questionnaire – extra information

Examples of applications of GIS in health

- Assessing health needs for the purchase of health services
- Epidemiological research
- Producing health profiles of local populations
- Determining catchment centres for local services
- Planning the location of health facilities
- Targeting resources towards local population groups
- Analysing GP referral patterns
- Evaluating demand for hospital services
- Evaluating demand for other services
- Analysing patient flows across health district boundaries

Examples of general uses of GIS

- Data capturing (digitizing)
- Integrating data
- Data manipulation
- Producing maps
- Producing graphs/tables
- Producing reports
- Geographically based analysis
- Analysis of statistical data
- Modeling data
- Making forecasts

Definition:

Participatory GIS: The use of GIS by non-experts and occasional users with a diverse range of computer literacy, world views, cultural background and knowledge. Within this context it is implied that community involvement is paramount and includes the use of local knowledge for the bettering of local conditions and empowering previously disadvantaged people.

Examples of participatory GIS

- Empowering local communities through the use of GIS for their managerial needs
- Mapping community space
- Analysing resource conflicts
- Participatory land use planning
- Raising awareness
- Educating people on their health needs
- Identifying perceptions of service requirements

Case study of participatory GIS – The Kiepersol Project

Kiepersol is the site of a participatory GIS project. It is a rural location in the Mpumalanga Province of South Africa. The area has a history of contested resources and forced removals, the demand for land in the region remains high.

The project used mental maps to gain local information on the land and the issues surrounding it. The local knowledge was integrated with traditional spatial knowledge using GIS. From this exercise a number of issues and opportunities for development arose. The following points illustrate some of the data sources and outputs produced through the project.

- Data was obtained on the historical geography of forced removals, as well as information regarding farming techniques of the past.
- Information was gained on the potential for farming through a comparison between the perceptions of where the good land is, and the land type data.
- Information was gained on the changing nature of boundaries affecting the people at Kiepersol, this could not have been produced through a GIS without the use of local knowledge.
- The GIS enabled people to express their ideas on land use through the universal methods made available by the GIS.

(Abbot et al, 1998)

Extra information

Participatory GIS: Participatory GIS for the purposes of this questionnaire is defined simply as any involvement of the community in the use of GIS, including the identification of the need for spatial mapping, the collection of data for themselves or for others, the generation of outputs by using a GIS, and the use of maps. This survey relates specifically to its use in the field of health, as defined in the introduction. There are varying levels of involvement and many debates around the subject of participatory GIS, but for the purposes of this survey a broad definition is employed, as is described above.

The following points provide examples of participatory GIS as it is defined for the purposes of this survey.

- Community members collect spatially referenced data for use and analysis by a researcher or professional.
- Community members help in the creation of maps (mind maps etc) which are then compared to 'traditional' maps by a researcher or professional using a GIS.
- Community members are taught how to do basic data collection for their own use which is incorporated into a GIS by a professional, who analyses the data for the community.
- Community members are taught how to do basic data analysis and display for their own purposes using a GIS.
- Community members identify local problems, and possible solutions to these problems using analysis and display functions of a GIS.

Annexure C: Online questionnaire results

Table 6: Online questionnaire results

Field of work	No.	Percent	Health related issues	No.	Percent	Organisation type	No.	Percent
Research	7	30.43	planning	8	30.77	Government	10	43.48
General	4	17.39	service provision	6	23.08	Research	5	21.74
Public health	3	13.04	research	4	15.38	Parastatal	4	17.39
Data provision	4	17.39	As required/Other	3	11.54	NPO/NGO	4	17.39
Primary health care	3	13.04	Implementation	2	7.69			
Surveillance	2	8.70	Empowering communities	1	3.85			
			Disease distribution	2	7.69			
Total	23			26			23	

Using GIS	No.	Percent	Software	No.	Percent	Web server	No.	Percent
Yes	23	100	Arcview	8	33.33	Yes	9	53.33
No	0	0	ArcGIS	4	16.67	No	8	26.67
			ArcMIS (IMS)	2	8.33	Unsure	6	20.00
			Arc Explorer	1	4.17			
			MapInfo	5	20.83			
			Idrisi	3	12.50			
			Autodesk Mapguide	1	4.17			
	23			24			23	

Output target	No.	Percent	Outputs purpose	No.	Percent	GIS plans	No.	Percent
Internal	6	28.57	Planning	8	30.77	Analysis of statistical data	3	21.43
NGOs	1	4.76	Monitoring trends	1	3.85	Web based GIS	2	14.29
Government departments	5	23.81	Analysis	5	19.23	Integrating data	3	21.43
Funders	4	19.05	Communication	3	11.54	Producing maps	1	7.14
Field work/Research/reports	5	23.81	Coordinating targeted responses	1	3.85	Producing reports	1	7.14
			Advocacy	2	7.69	Modeling data	2	14.29
			Creating awareness	3	11.54	Making forecasts	2	14.29
			Education	2	7.69			
			Field work	1	3.85			
	21			26			14	

Potential for further use	No.	Percent	Constraints	No.	Percent	Community involvement	No.	Percent
Modeling data	5	21.74	Funds	7	30.43	Yes	6	26.09
Integrating data	3	13.04	Trained personal	5	21.74	No	17	73.91
Making forecasts	2	8.70	Knowledge	4	17.39			
Analysis of statistical data	3	13.04	Data	3	13.04			
Web GIS	1	4.35	Computer hardware	2	8.70			
Data capturing	2	8.70	Software	2	8.70			
Producing maps	2	8.70						
Producing reports	3	13.04						
PR	1	4.35						
Geographically based analysis	2	8.70						
	23			23			23	

Possibility to extend	No.	Percent	How community got involved	No.	Percent	Benefits for organisation	No.	Percent
Mapping community space	2	22.22	To provide data	3	60.00	Data	2	22.22
Mapping facility use	2	22.22	Surveys	1	20.00	Objectivity	1	11.11
Empowering local communities	1	11.11	Employed	1	20.00	Planning and evaluation	1	11.11
Raising awareness	2	22.22				Relationships	1	11.11
Educating	2	22.22				Understanding of community	1	11.11
						Surveillance	1	11.11
						Improved analysis	1	11.11
						Research	1	11.11
	9			5			9	

Benefits for community	No.	Percent	time span	No.	Percent	Limitations	No.	Percent
Provision of services	2	33.33	Once off	1	20.00	Map reading	3	33.33
Enhances perceptions	1	16.67	Still involved	4	80.00	Communication	2	22.22
Employment	1	16.67				Training	1	11.11
Opportunity to participate in decision making	1	16.67				Skills	1	11.11
Minimal influence	1	16.67				Availability of people	1	11.11
						Inexperience of technology	1	11.11
	6			5			9	

Possibilities to extend	No.	Percent	Positive for organisation	No.	Percent	Positive for community	No.	Percent
Empowering local communities	1	25.00	Improve service delivery	1	25.00	Improve service delivery	2	40.00
Raising awareness	1	25.00	Save resources	1	25.00	Empower communities	1	20.00
Educating	1	25.00	Improve data	1	25.00	Provide access to information	1	20.00
Not possible in health	1	25.00	Provide understanding	1	25.00	Improve decision making	1	20.00
	4			4			5	

Limitations	No.	Percent	Awareness of P-GIS	No.	Percent	Health benefiting from P-GIS	No.	Percent
Resources	2	33.33	Yes	2	50.00	Service coverage/provision	3	33.33
Knowledge	2	33.33	No	2	50.00	Tracking disease	2	22.22
Empowerment	1	16.67				Facility use	1	11.11
Funds	1	16.67				Case management	1	11.11
						Resource demands for communities	1	11.11
						Identifying health priorities	1	11.11
	6			4			9	

Impression	No.	Percent
Limited use	2	33.33
Growing tool	1	16.67
Poor	1	16.67
Positive	1	16.67
Essential for health management	1	16.67
	6	

Annexure D: GIS prototype description

The GIS prototype was developed using the following development tools and environments illustrated in the following table.

Table 7: GIS prototype development tools

Tool/environment	Description
JavaScript	An object-oriented development language. Known for its platform independence and internet capabilities.
Mapserver	An open source internet map server developed by the University of Minnesota. Originally developed in conjunction with NASA to make satellite imagery available to the public
Mapscript	The scripting language for Mapserver, thus making Mapserver features available to other applications.

The tools used in the development of the GIS prototype are provided through the open source community, for a more detailed description of Mapserver see University of Minnesota (2006). The following diagram illustrates the architecture of the prototype, including each component thereof, and the manner in which they communicate with one another.

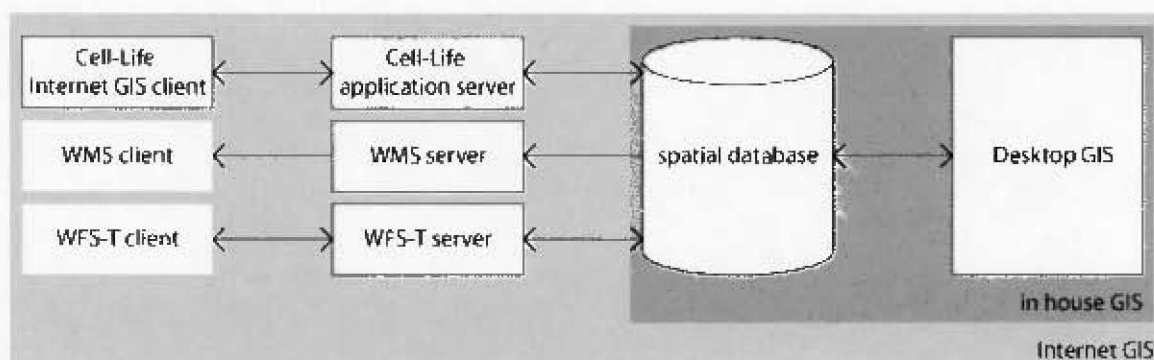


Figure 42: GIS prototype components (Vanmeulbrouk & Rivett, 2006)

The internet GIS client consists of plain HTML (Hyper-Text Mark-up Language) which is output by the Internet GIS server (the Cell-Life application server), which

handles the requests from the client. The result of which is an HTML page displaying the requested map. WMS (Web Map Service) and WFS (Web Feature Service) play a major role in the production and display of the maps as well as the retention of open source standards.

WMS (Web Map Service) produces maps of spatially referenced data, the maps produced are not the data, but a representation of the data usually rendered as an image, in this case a GIF image file is produced. This is in contrast with the WFS, which returns the actual data.

WFS (Web Feature Service) allows for requests directly to the data, allowing for the querying and retrieval of features from the database. WFS-T allows for data manipulation through the creation, deletion and updating of features.

(University of Minnesota, 2006)

The Web Feature Service (WFS) requests are handled by GeoServer. GeoServer aims to enable greater geographic interoperability by enforcing OGC standards (GeoServer documentation 2005). To achieve this goal, GeoServer has implemented both the Open Geospatial Consortium WFS and WMS standards. MapServer has also been used to handle Web Map Service requests. For more information on these aspects of the GIS prototype please see: Cell-Life (2006) and University of Minnesota (2006).

The data required to render a map are stored in a spatially enabled relational database. PostgreSQL was used for this purpose, with the PostGIS extension, which enables the database to handle spatial data (PostGIS, 2007). The most important advantage of storage of geographical data in a database management system over storage in a proprietary file format is that of data independence. Users interact with a representation of the data independently of the actual physical storage of the data (Rigeaux *et al.* 2002).

The components introduced here combined to form the GIS prototype, an online and open source GIS. It is important to note that all the tools and components described here are available over the internet and at no cost.

Annexure E: Case study photos

Research participants work through the task analysis section of the usability testing



Figure 43: Usability testing participant 1



Figure 44: Usability testing participant 2

Health service delivery poster at one of the clinics

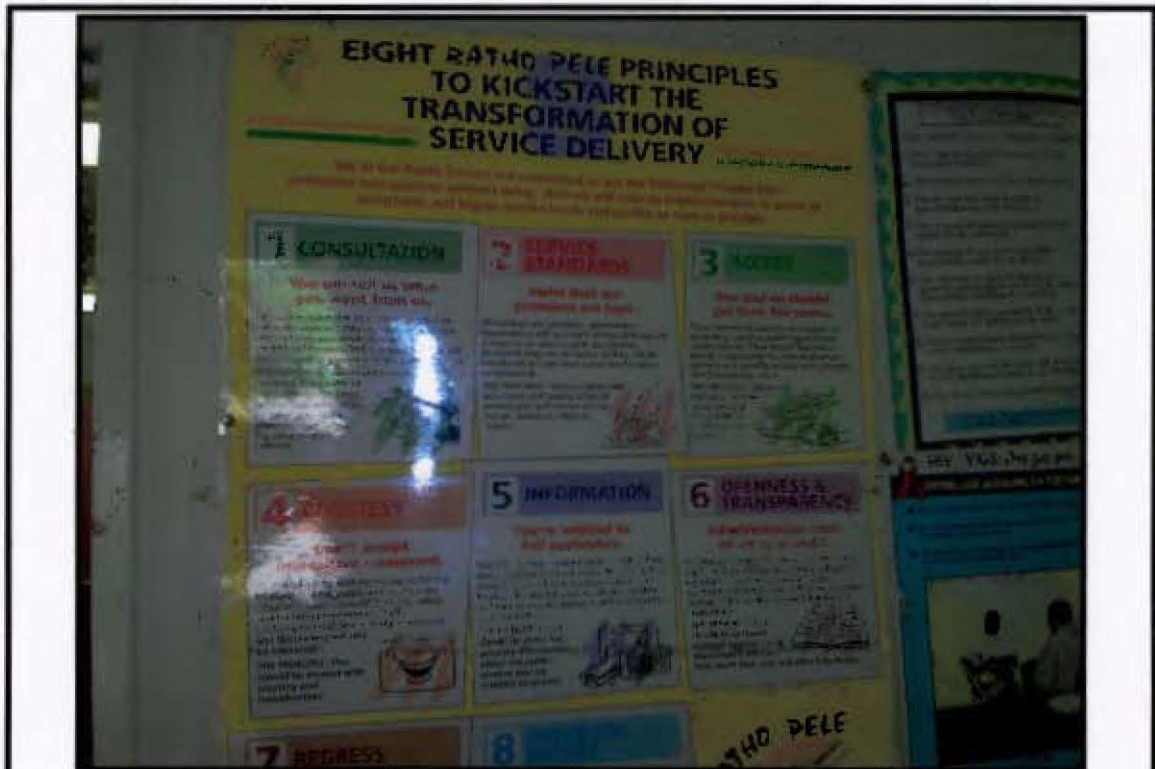


Figure 45: Poster in one of the clinics

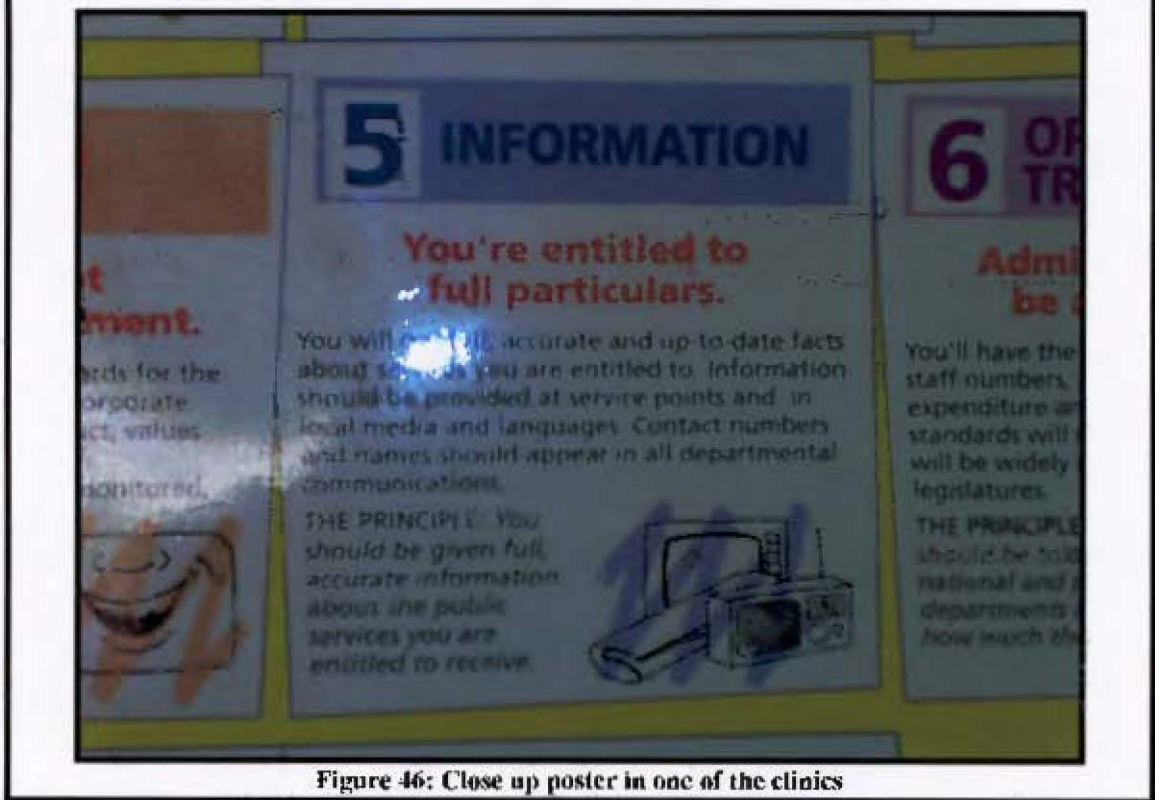


Figure 46: Close up poster in one of the clinics

The use of hardcopy maps in one of the clinics, a need for GIS?



Figure 47: Map use in one of the clinics

Annexure F: Usability testing pre-test interview

Pre test interview

I would like to talk to you about your information needs, and also how information is gained and shared with other institutions. After this I would like you to test the system with a simple usability test, and following that a short questionnaire and brief discussion.

1. General description of work

2. Information flow

- What information is required to fulfill your needs?

- What information would improve your ability to service your community and needs?

- How is information fed up to local or provincial authorities?

- How do you access information held by other institutions?

3. Information system (GIS) use

- What systems do you use to monitor service provision and health stats?

- Problems/ compliments on the systems?

- Potential for the use of systems

- Problems with implementation?

Annexure G: Usability testing participant questionnaire

Usability testing of Cell-Life GIS development for health and health related services management

Introduction

Cell-Life is a research group at the University of Cape Town as well as a not for profit organisation. The main aim of the organisation is to use technological innovation to promote health management in South Africa. The research team is in the process of developing an online GIS in order to add to community health and increase information flow between people and organisations involved in planning. The usability tests being completed form a part of this development, and are critical to the production of an effective and user friendly system.

This is a test of an online GIS prototype (a system in the beginning of its development) developed by Cell-Life. The aim of these tests is to identify improvements that can be made to the system, as well as additional functionality that may be added to the system. **It is important to note that the system is the subject of the test, and you are not being tested.**

The system has been designed in order to provide a method whereby community members can communicate more effectively with the municipality and vice versa. Beyond this it may act as a method whereby information gathered by communities and local authorities can be posted and accessed through a common interface by a variety of users.

While completing the tasks you are requested to "think aloud," this will allow the researcher to note problems with the systems interface, and make usability easier in the final product. You may ask questions throughout completing the tasks, and these will also aid in the identification of problems.

Thank you for your participation in this research

Consent

Dear participant,

Kindly please note the following points and complete the requested details followed by your signature.

Usability Testing Participant Details and Consent

- I am NOT being tested but the system (menus and software) is being tested.
- I have freely volunteered to participate in this experiment.
- I have been informed in advance what my tasks(s) will be and what procedures will be followed.
- I have been given the opportunity to ask questions and have had my questions answered to my satisfaction.
- I am aware that I have the right to withdraw consent and to discontinue participation at any time, without prejudice to my future treatment.

My signature below may be taken as affirmation of all the above statements. It was given prior to my participation in this study.

Date

Signature

Participant Questionnaire

User no.	1					
Age						
Gender	F	M				
Highest education level	Primary School	High School	Batchelor degree	Honours degree	Higher	
Have you used a computer before?	Y	N				
What is the level of your computer experience?	0 None	1 Word processing	2 Excel Internet	3 Access Macros	4 Program ming	5 Expert
Position held in your organisation						
Responsibilities in your organisation						

Annexure H: Usability testing task analysis

Task 1: Identify a requested wards and indicator, and display it in the map window

USER EVALUATION TEST		
Cell-Life GIS development		
Task: Find a ward on the map		
Username		test1
Password		test1
Ward number		1
Ward number		2
Indicator		Availability of piped water
Complete after identifying the area and the indicator		
Were you able to redo/correct actions?	Y/N/NA	Y or N or NA
Are menus/displays consistent?	1 = not at all 5 = very	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
Are menus/displays simple?	1 = complex 5 = simple	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
Was the map display affective?	1 = not at all 5 = very	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
O/All subjective satisfaction	1 = low 5 = high	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
Please provide at least one critical comment:		

Task 2: Change the data for an indicator of an area within a selected ward

USER EVALUATION TEST		
Cell-Life GIS development		
Task: Change the data of an area		
Ward number	7	
Area to be changed	Silvers Sands	
Indicator to be changed	Availability of piped water	
Number of households having access to piped water	193	
Number of households not having access to piped water	0	
Complete After new map has been displayed		
Were you able to redo/correct actions?	Y/N/NA	Y or N or NA
Are menus/displays consistent?	1 = low 5 = high	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
Are menus/displays simple?	1 = complex 5 = simple	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
Was the map display affective?	1 = not at all 5 = very	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
O/All subjective satisfaction	1 = low 5 = high	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
Please provide at least one critical comment:		

Username:

Time (seconds)	Current task	Thought/Question	Comments/solution

Annexure I: Usability testing SUS

Section 1: System usability

1. I would like to use this website frequently

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

2. I found the website unnecessarily complex

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

3. The website was easy to use

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

4. I would need technical support to be able to use this website

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

5. I found the various functions in this website were well integrated

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

6. There was too much inconsistency in this website

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

7. Most people would learn to use this website very quickly

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

8. I found the website very cumbersome to use

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

9. I felt very confident using the website

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

10. I need to learn a lot about this website before I could affectively use it

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

Adapted from: Brooke, J. (1996) SUS: a "quick and dirty" usability scale. In P W Jordan, B Thomas, B A Weerdmeester & A L McClelland (eds.) Usability Evaluation in Industry. London: Taylor and Francis.

11. I felt that the map was easy to understand

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

12. I feel that the map displays too much information

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

13. To my knowledge the information on the map was accurate

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

14. The scale of the map is suitable for my purposes

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

15. Using maps is unnecessary for my work

Strongly Disagree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Agree	<input type="checkbox"/>	Strongly Agree	<input type="checkbox"/>
-------------------	--------------------------	----------	--------------------------	---------	--------------------------	-------	--------------------------	----------------	--------------------------

Annexure J: Usability testing post-test interview

Post test interview

1. System usability

- What would make the system easier to use?
Eg, placement of buttons, display etc
-

- What features would make the system easier to use
Eg, shortcuts to tables, report generators etc
-

2. System functionality

- What normal tasks could the system help you with?
-

- What information would be the most useful to display on the map
-

- What other functions do you feel the system should include?
Eg, overlays, routes etc
-

- Are you using systems that offer similar functionality?
-

3. Participatory GIS**Question 1** Do you use GIS for decision making and planning**Question 2** Have you ever been involved in decision making involving your community?**Question 3** Do you feel that GIS and decision making should be extended to community members?**Question 4** What benefits could be gained for your organisation?**Question 5** What benefits could be gained for the community?**Question 6** What would hinder community involvement in GIS?**Question 7** What is your general impression of community involvement in GIS and planning?

Annexure K: Case study information flow structures

MUNICIPALITY	Information shared with community	Information gained from community	Limitations of current system	Potential for new systems
	Community meetings	Community meetings	Security	Community tool
	Ward councilor meetings	Ward councilor meetings	None	Libraries
	Imbizos	Imbizos	Access limited to location	For housing
	Ward committee meetings	Letters	None	Community tool
	Community meetings	Phone calls	None	Maybe
	notices at taxi ranks	Committee meetings	None	Yes
	Notices at shops	Through council	Communities have no access	Email system
	Notice at schools	Financial system		Huge
	Notices in newspapers	Within municipality		
	Paper based communication	Within municipality		
	Through ward committees			
	Website			
	Limited exchange			

COMMUNITY	Information gained from municipality	Information Fed up to municipality	Limitations of current system	Potential for new systems
	No system in place	Paper based	No follow through on implementation	Information on talks/conferences
	Antagonism exists between clinics and municipality	Nothing really		tracking patients
	Irrelevant stats			tracking patients
	Outdated data			needed a long time ago
	Information from Province			decreasing errors in information
	Visit municipality			
	Phone calls			
	Meetings			
	Ward committee meetings			

Annexure L: Usability task analysis results

Test site	ID	Age	Gender	Education level	Used computer	Level of computer use	Test number	Time for area 1	Time for area 2	Redo actions	Combined measure
Clinics	28	34	female	tertiary	TRUE	Internet	1	1.6	1.4	TRUE	80.00
Clinics	27	41	female	High school	TRUE	word-processing	2	3.5	1.5	TRUE	100.00
Clinics	26	42	female	High school	TRUE	word-processing	2	4	1	TRUE	100.00
Clinics	25	45	female	tertiary	TRUE	Internet	2	5	0.8	TRUE	75.00
Clinics	29	47	female	tertiary	TRUE	word-processing	1	1.6	1.4	TRUE	80.00
Clinics	24	57	female	tertiary	TRUE	Internet	1	5	1	TRUE	75.00
Clinics	30	57	female	tertiary	TRUE	Internet	1	2	1	TRUE	85.00
Community	21	36	female	High school	TRUE	word-processing	1	7	2	TRUE	45.00
Community	23	44	female	tertiary	TRUE	coding	2	5	1	FALSE	70.00
Community	20	26	male	High school	TRUE	word-processing	1	8	1	TRUE	45.00
Community	22	41	male	tertiary	TRUE	coding	2	2.5	0.9	TRUE	90.00
Convenience	5	22	female	tertiary	TRUE	internet	4	3	0.4	TRUE	80.00
Convenience	8	23	female	tertiary	TRUE	internet	2	0.47	0.3	TRUE	90.00
Convenience	10	23	female	tertiary	TRUE	internet	5	2.25	0.15	TRUE	85.00
Convenience	7	24	female	tertiary	TRUE	internet	1	1.3	0.18	TRUE	55.00
Convenience	6	26	female	tertiary	TRUE	coding	4	1.16	0.1	TRUE	90.00
Convenience	1	30	female	tertiary	TRUE	Internet	1	2.15	0.25	TRUE	80.00
Convenience	9	47	female	High school	TRUE	word-processing	3	2	1.2	TRUE	100.00
Convenience	4	24	male	tertiary	TRUE	internet	5	0.5	0.2	TRUE	90.00
Convenience	3	25	male	tertiary	TRUE	Internet	3	2.5	0.25	TRUE	75.00
Convenience	2	27	male	tertiary	TRUE	Internet	2	3	0.25	TRUE	95.00
Municipality	19	34	female	tertiary	TRUE	Internet	2	4	1	TRUE	80.00
Municipality	13	53	female	tertiary	TRUE	word-processing	1	2	1	TRUE	100.00
Municipality	15	23	male	tertiary	TRUE	coding	1	3	1	TRUE	95.00

Municipality	18	39	male	tertiary	TRUE	Internet	2	5	1	TRUE	75.00
Municipality	12	39	male	tertiary	TRUE	word-processing	1	6	1.5	TRUE	85.00
Municipality	17	44	male	tertiary	TRUE	Internet	2	4	1	TRUE	85.00
Municipality	16	48	male	tertiary	TRUE	Internet	2	5	1	TRUE	80.00
Municipality	11	48	male	tertiary	TRUE	word-processing	1	2.5	0.45	TRUE	100.00
Municipality	14	58	male	tertiary	TRUE	Internet	2	3	0.5	TRUE	80.00

Time to display	Redo actions 2	Consistency2	Simplicity 2	Affectiveness 2	Satisfaction 2	Combined measure	SUS Score	Combined measure over 2 tasks	Map 1	Map 2	Map 3	Map 4	Map 5
3	TRUE	2	2	2	2	40	65	60	4	2	4	2	1
4	TRUE	5	5	2	5	85	65	92.5	4	2	4	4	2
4	TRUE	5	5	2	5	65	72.5	92.5	4	1	4	4	1
5	TRUE	4	4	4	4	80	57.5	77.5	4	2	3	4	2
3	TRUE	2	2	2	2	40	72.5	60	4	2	2	2	2
4	TRUE	4	4	4	3	75	65	75	4	2	4	4	2
2	TRUE	4	4	4	4	60	55	82.5	4	2	4	4	2
9	TRUE	3	2	2	2	45	35	45	4	2	2	3	2
5	TRUE	4	2	3	3	60	35	65	4	2	2	2	2
9	FALSE	3	2	2	1	40	42.5	42.5	2	3	3	3	2
5	TRUE	4	3	4	4	75	75	82.5	4	2	3	4	2
4.6	TRUE	3	3	4	3	65	55	62.5	4	1	4	4	1
1.4	TRUE	5	4	3	4	80	92.5	85	4	2	2	2	4
1.5	TRUE	5	5	4	5	95	87.5	90	4	2	4	4	2
2.15	TRUE	2	2	2	2	40	45	47.5					
1.5	TRUE	5	4	5	4	90	95	90	4	2	4	4	2
4.2	TRUE	4	4	4	3	75	97.5	77.5	4	2	4	2	1
2.5	TRUE	4	4	4	3	75	67.5	87.5	4	2	4	4	2
2.1	TRUE	5	5	5	5	100	80	95	4	2	2	4	2
4.2	TRUE	4	3	4	4	75	75	75					
1.7	TRUE	5	5	5	5	100	92.5	97.5					
3	TRUE	3	3	4	4	70	62.5	75	2	2	4	4	2
3	TRUE	5	5	5	5	100	72.5	100					
5	TRUE	4	4	4	3	75	62.5	85	4	2	1	4	2
4	TRUE	4	5	5	4	90	80	82.5					
4	TRUE	4	4	3	4	75	65	80	5	1	1	3	5
3	TRUE	3	4	4	4	75	62.5	80	4	2	2	3	3
3	TRUE	4	4	4	4	80	67.5	80	4	4	4	2	2
2.15	TRUE	5	5	5	5	100	70	100					
4	TRUE	5	5	4	4	90	85	85	4	1	3	3	1

Annexure M: Usability testing post test interview results

COMMUNITIES

Should GIS be used by communities	Benefits - organisation	Benefits - community	Hinder	General impression
Yes	Planning	Better living conditions	Computer literacy	Good, happy to be involved in the development
knowledge about local conditions	Knowledge of facilities	Service improvements	No access to internet	Promising
they need all the help they can get	Understanding of services by community	Insight	Knowledge	Good, Creating awareness and sharing knowledge
	Understanding of local conditions	Engage with municipalities, and challenge their decisions	Understanding	Good, but needs to be simplified
	identification of problems	upliftment	misuse	Positive
	home based carer management	upliftment	skills	
		education	resources	
			map reading	
			computer literacy	

Repetitive responses have been omitted

MUNICIPALITIES

Should GIS be used by communities	Benefits - municipality	Benefits - community	Hinder	General impression
Yes, but concerns over how it may work	Budgeting	Information availability	Skills	Positive, but with reservations
Yes, if resources are made available	Information	Transparency of government information	Political parties	Positive, but will need facilitation
Yes, through NGOs	Better informed voters	Improved contribution to planning and development	Resources	Could be of benefit
	Awareness	Understanding of planning and priorities	Cost	Positive, there is a need for mechanisms such as this
Yes, very interested	May pose problems, but should be beneficial	Better informed	Facilities	Positive, understanding and awareness
Yes, in libraries	Less phone calls	Information accessibility	access to resources	Generally positive
Yes, real estate	Relief on municipal staff	knowledge	resources	
	updated data	ability to articulate needs	Distribution	
	communication with municipalities	prep for community meetings	accessibility	
	informed decisions	Feedback from community	management	
	co-operation			
	local knowledge			
	self governance			

Repetitive responses have been omitted