# AN EXAMINATION OF THE APPLICATION OF A GEOGRAPHICAL INFORMATION SYSTEM TO RURAL DEVELOPMENT PLANNING IN SHIXINI LOCATION, TRANSKEI

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## ABSTRACT

Digital geographical information systems (GIS) are tools for handling spatial data. Initially developed in First World countries, the technology is fast being taken up as a tool for handling spatial information by many Third World countries. GIS has been used for any number of applications involving spatial data, one of its primary uses has been in various planning fields where the advantages offered to planners by the technology have been highlighted by a number of publications and studies. GIS has been actively used as an urban planning tool in South Africa since the mid-1980s, (Vosloo 1987) however its use as a tool for rural planning has not developed to the same extent. As early as 1986 reference was made to the possible advantages offered by GIS to rural planning in South Africa (Fincham 1986). Despite this early recognition, the use of GIS in the rural planning sphere remains negligible. This study examines the possible reasons for this by attempting to answer the question, "is GIS appropriate to rural planning in South Africa?"

A number of approaches to rural planning are practised in South Africa. This study examines the appropriateness of applying GIS to one of these approaches, rural community development planning. Components of the study included i) an examination of the issues affecting the use of GIS in the rural development field, achieved through the use of a literature and questionnaire survey and ii) a case study examining the feasibility of incorporating GIS as a tool to the Shixini Development Project, Transkei.

The study does not examine the intricacies of rural development theory, but it does acknowledge the fact that the approach employed by an organisation to rural development will have important implications concerning the use of a GIS in a project. The approach adopted to a project affects amongst others the administrative structure, the planning process, the flow of spatial data and its use, and consequently the possible role of GIS.

The Shixini Rural Development Project was classified as a community development project, and as a result the study concentrates on this approach to rural development. This may limit the study to a particular planning process, however most rural case studies will have certain aims and factors which are unique to its situation. In order to place the results of the Shixini case study in a wider context the results of the study are linked to the questionnaire and literature survey. From this basis the usefulness of GIS in the rural development sphere was examined.

Available literature on GIS indicates that the majority of problems associated with GIS rarely reside with the technology itself but rather with its supporting mechanisms. The study identified and concentrated on these support mechanisms, both at the project level and what is referred to in the study as the operating environment in South Africa. The results of the study revealed that a number of problems exist with regard to the attitude with which GIS is regarded in development organisations. It was found that these attitudes are legitimately based on a number of problems associated with incorporating the technology into project based organisations.

It was concluded that GIS was appropriate to rural community planning, but is presently limited to certain aspects of the planning process and possibly to certain applications.

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# CHAPTER ONE

## INTRODUCTION

### 1.0 - The problem

The political and social transformation of South Africa towards a non-racial, democratic society has given new impetus to the need for positive development within the country. This is especially true of the marginalised rural areas of the country, where, in comparison to urbanised areas, little development has taken place.

The majority of rural development projects in South Africa, past and present, have been relatively small scale developments facilitated by government, parastatel or non-government organisations (NGOs). The approach adopted by these organisations, especially government organisations, to rural development planning at a project level has undergone profound changes over the past decade, evolving from what was essentially a top-down, technocratic, physical planning approach such as "betterment planning", to a more bottom up, community based approach. Although both approaches differ in terms of their theoretical grounding, both use information as a basis for planning.

Information, and the data from which it is derived, is generated both as a means on which to base the planning process and as a result of the process itself. It therefore forms a critical aspect of the planning process for a number of reasons. These include identifying needs and problems, providing options for possible solutions and ensuring that resources are used as efficiently as possible. It may also be used as a means of ensuring that communities are empowered in the process. Modern information technology such as geographical information systems (GIS) are one of the tools available to help manage, integrate, model and display the often large quantities of data generated by this process. GIS, has the ability to index diverse data according to its geographical location, manipulate the data and output it as potentially useful information in a variety of formats. This has proved to be a powerful planning tool in a number of First World countries (Chorley and Buxton 1990; O'Callaghan and Garner 1991; Cocks and Walker 1987; Ottoson and Rystedt 1991; Kubo 1991; Robinette 1991; Dale 1994; Denegre 1994). Since the mid 1980s GIS has been used as a spatial and mapping tool by a number of countries throughout the world, including South Africa. In South Africa the technology is actively used in various sectors of the economy. Current applications include a strong planning aspect. GIS has been used extensively by a number of central government departments (Fincham, McDevette and Piper 1993) as well as a mapping and analysis tool by local authorities for urban land planning (Vosloo 1987,1989; McQuoid-Mason 1989; Van Den Berg 1988; Volkwyn 1995). Despite its use in central and local government and initial positive reactions to the technology, for planning in rural development (Fincham 1986) its use as a tool for rural planning has not evolved to the same extent.

Theoretically GIS could prove to be a powerful tool when applied to rural development planning in South Africa, case studies from other third world countries such as Sri-Lanka and India (Nijkamp & de Jong 1987) indicate that it can be successfully applied to rural planning problems at a number of different scales. Reasons for the limited application of the technology in the rural planning sphere of this country are unclear as few documented case studies exist. A question could therefore be asked "is GIS, which is essentially a first world technology, inappropriate as a planning tool in a South African rural planning context as the lack of documentation would suggest, or are other factors inhibiting its growth?" This study examines these questions at the project level of development planning by critically examining the appropriateness of applying GIS as a tool to a rural community development planning project in the Shixini Administrative Area of the former Transkei.

**1.1 - Research aims and objectives**

The purpose of this study is to assess whether GIS is an appropriate tool when applied to rural community development planning. The specific aims of the study are as follows:

i) to establish the theoretical case for examining GIS as a tool for rural planning.

ii) to place the wider South African operating environment in context by broadly compare the operating environments and application of GIS in the rural planning spheres of developing countries and selected first world countries.

iii) to ascertain the perceptions of selected South African organisations involved in community development planning towards the use of GIS as a planning tool.

iv) to assess the appropriateness of implementing a geographical information system as a planning and information tool to the Shixini Rural Development Project through the use of a feasibility study; including the development of a digital data base for Shixini and an pilot project.

v) to highlight the findings of the study in order to develop suitable procedures and standards for future rural planning projects in South Africa.

**1.2 - Preliminary definitions**

There are a number of terms which need to be defined in terms of their context to this study, they are: rural, rural development, rural organisations, project planning and appropriate technology. These are presented below.

The study examines the use of GIS for planning purposes in a <u>**rural**</u> area. The term rural in South Africa has become increasingly difficult to define as landscapes merge due to population pressures. Existing definitions are either very broad or tend to be narrowly defined, achieving their purpose by accentuating aspects which are thought to "characterise" the rural landscape. The definition adopted for this study is really a set of characteristics which together provide an idealised picture of what could be termed a "traditional African rural landscape". Rural is described as "a broadly understood settlement type (Hoggart 1988) characterised by small dispersed settlements, mostly lacking in infrastructure and amenities" (Erskine 1985). Often included in a definition of "rural" is the idea that the primary economic activity of these areas is based on agriculture. This perception is supported by the United Nations Development Program (UNDP 1979) which defines **rural development** as "a process of socio-economic change involving the transformation of agrarian society in order to reach a common set of development goals based on the capacities and needs of people; these goals include a nationally determined growth process that gives priority to the reduction of poverty, unemployment and inequality, and the satisfaction of minimum human needs, and stresses self-reliance and the participation of all the people, particularly those with the lowest standard of living" (Erskine 1985, p.370). The goals of rural development offered by this definition are a reflection or perhaps precursor of current thinking within South Africa as defined by the Reconstruction and Development Program (RDP) (ANC 1994). The emphasis placed on sustainable basic needs for people through facilitation and empowerment is also consistent with the concept of rural community development discussed in Chapter Five, as well as the approach to the Shixini development project.

Rural development planning can be practised at a number of spatial levels. This study concentrates on a particular planning level within rural development, that of **project planning**. Rural development planning can be undertaken at any number of planning levels which are usually defined in terms of the spatial level at which the planning is practised, these can range from an international level to that of an individual. This study concentrates on the lower end of the planning spectrum, project planning. Conyers and Hills (1984, p.11) refer to project planning as an "activity or set of related activities, which are planned and implemented as an identifiable whole." Characteristics of project planning usually include a defined geographical location and a clearly defined time span. In addition the activity or related activities boundaries are relatively clearly defined and the activities could be carried out in isolation, irrespective of any other form of planning activity. Project planning can be practised by any number of organisations or interested individuals who are in this study referred to as **rural organisations**. This term is a broad reference to those governmental, para-statal, non-government organisations/institutions (NGOs) or individuals actively involved in facilitating or helping to facilitate rural development.

One of the most important terms used in the study is that of appropriate technology (AT). AT is a commonly used term encompassing a number of meanings including intermediate technology, low cost and soft technology (for more on these concepts see Schumacher 1972; Lovins 1977 and Darrow & Pam 1978).

Appropriate technology has its roots in the 1960s through the writings of E F Schumacher who used the term 'intermediate technology', the term was coined out of the need for technology more suited to third world conditions than that used in the first world yet more productive than the traditional implements used in the third world. What constitutes 'appropriate technology' fluctuates in time and space, as it is influenced by value judgements and ideological considerations (Bhagavan 1979 in Yapa 1991, p.44). Clearly what is appropriate in one situation may not be suited to another. A number of attributes are commonly associated with AT, these include:

- low capital costs
- the use of local materials if possible
- the creation of local jobs
- can easily be understood and used by local people
- involve decentralised renewable energy sources such as wind and water.

AT also involves the concept of decreasing the local populations dependence on outside assistance for help in maintaining the technology.

It can already be seen from those characteristics of AT described above, and from earlier references to GIS and its use in First World countries, that a number of conflicts occur between GIS needs and the principles of AT. A similar conclusion was made by Yapa (1991) who concluded that GIS bears a dual relationship to AT. GIS contradicts AT principles due to its high cost and need for high levels of expertise. Yapa (1991) however argued that GIS complements AT because the tools of GIS are useful for uncovering 'local resources'. The view followed in this study is an extension of this argument. It is based on the fact that all countries have a heterogenous skills base but the composition and percentage of particular skills varies between countries. Third world countries tend to have a larger percentage of lower skilled workers than First World countries, with a result that these countries need to make the most of their expertise. Technology advances have helped increase the effectiveness of a small skills base in a number of fields, either by decreasing the time taken to do particular jobs or through the automation of others. In cases such as these, high-tech technology may be appropriate in order to make the skills base more effective. Having said this it should be apparent that 'appropriate technology' should not necessarily be associated with just the lower spectrum of technology, but has a place in the upper spectrum as well. From this the term 'appropriate technology' is taken to signify the suitability of a technology to successfully do a task(s) within the confines of the skills base, income, culture, staff and data constraints of an organisation or society. This is based on the fact that no technique or technology operates in a vacuum, and that the successful application of a technology is dependent on a number of factors including the existence of complementary technologies, suitable skills, compatible social structures and appropriate modes of thoughts and values.

### 1.3 - General Methodology

A variety of standard data gathering techniques such as a literature and questionnaire survey were used to achieve the first three objectives, which are:

i) to establish the theoretical case for examining GIS as a tool for rural planning.

ii) to place the wider South African operating environment in context by broadly comparing the operating environments and application of GIS in the rural planning spheres of Third World countries and selected First World countries

iii) To ascertain the perceptions of selected organisations involved in community development planning towards the use of GIS as a planning tool.

Clark's general model for GIS acquisition was used as a framework to establish objective (iv) which was to:

- "assess the appropriateness of implementing a geographical information system as a planning and information tool to the Shixini Rural Development Project through the use of a feasibility study and pilot project".

The use of Clark's (1991) model was restricted to the first of the four stages for reasons explained in Chapter Six. The first stage analyses the requirements of the organisations involved in the Shixini Development Project and includes a cost-benefit analysis and pilot study.

**1.4 - Location and description of study site**

Shixini is a poorly developed coastal administrative area situated in Gatyana District of what was previously South Africa's largest, most consolidated, independent homeland, the Transkei. The Transkei is located on the eastern seaboard of South Africa; its location is illustrated in Figure 1.1.

Shixini is one of thirty-nine administrative areas (Wards) which make up the Gatyana District (see Figure 1.1). Shixini and its neighbouring ward, Ntlahane, form the Jingqi Tribal Authority, chaired by the chief of Shixini. Shixini Ward is divided into ten sub-wards (see Figure 1.2), nine of which fall under the jurisdiction of a sub-headman and the tenth, the Chief. Each sub-ward is composed of a number of sub-ward sections.

Shixini occupies a peripheral position in relation to the main economic centres of the Eastern Cape Region. The only town in Gatyana District is Willowvale. The town ranges from 20 to 37 kilometres away from the ward depending on one's situation within the ward. Willowvale has a magistrates court, government offices, a post office, garage, clinic, church, schools, hotel, liquor store and a number of trading stores and small supermarkets (Andrew 1992). Services available in Shixini include two primary schools and a primary/secondary school, three trading stores, Tribal Authority buildings and a clinic.

Despite the fact that agricultural activities represent only about 10 per cent of a rural households earnings, animal husbandry and subsistence agriculture form the main economic activity in the Shixini area (Heron 1990). The majority of people in the area are dependent on remittances and pensions for cash. McAllister (1989a, p.350) reported that approximately 80 per cent of all

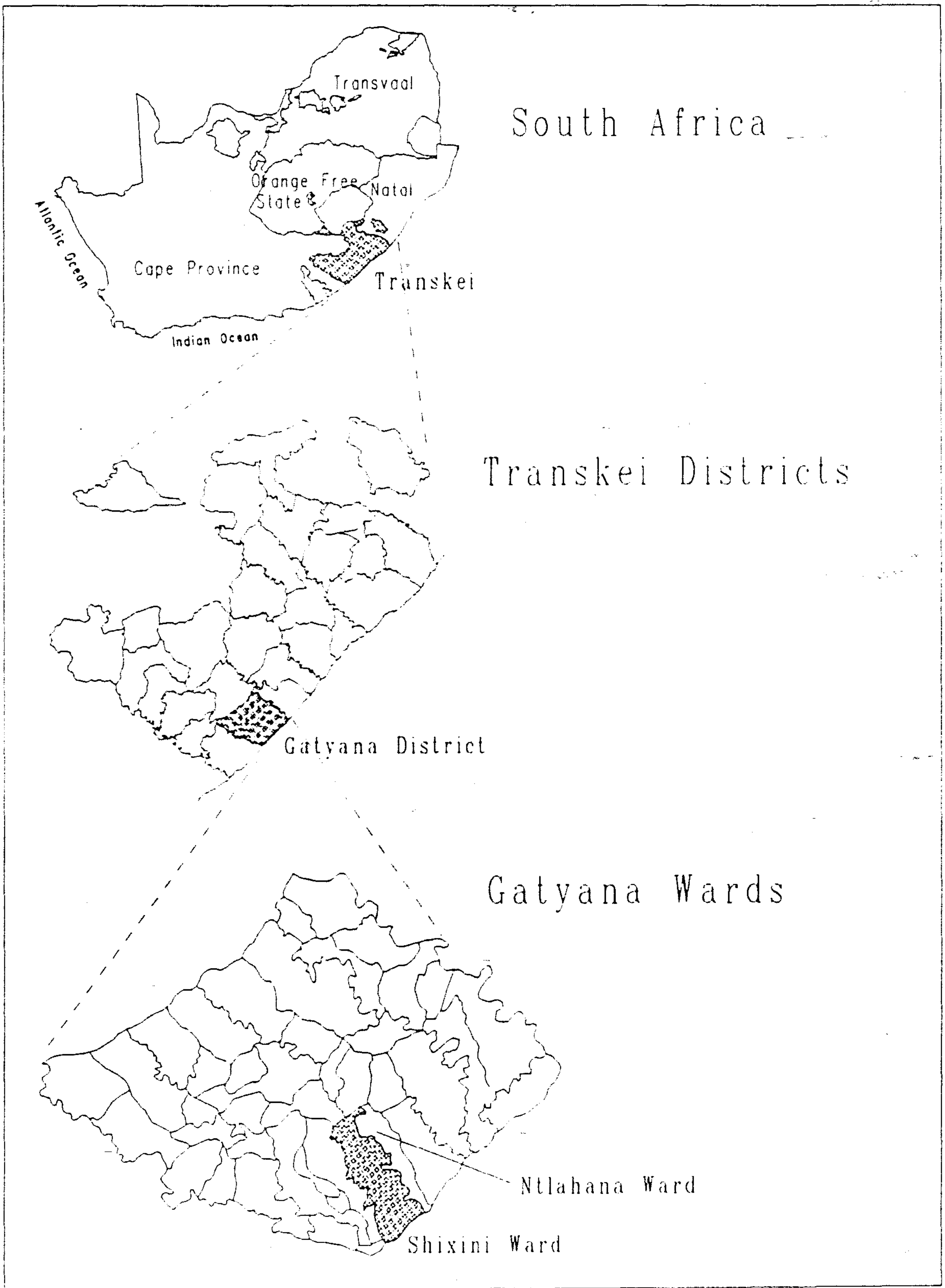



Figure 1.1 Shixini Ward Orientation map

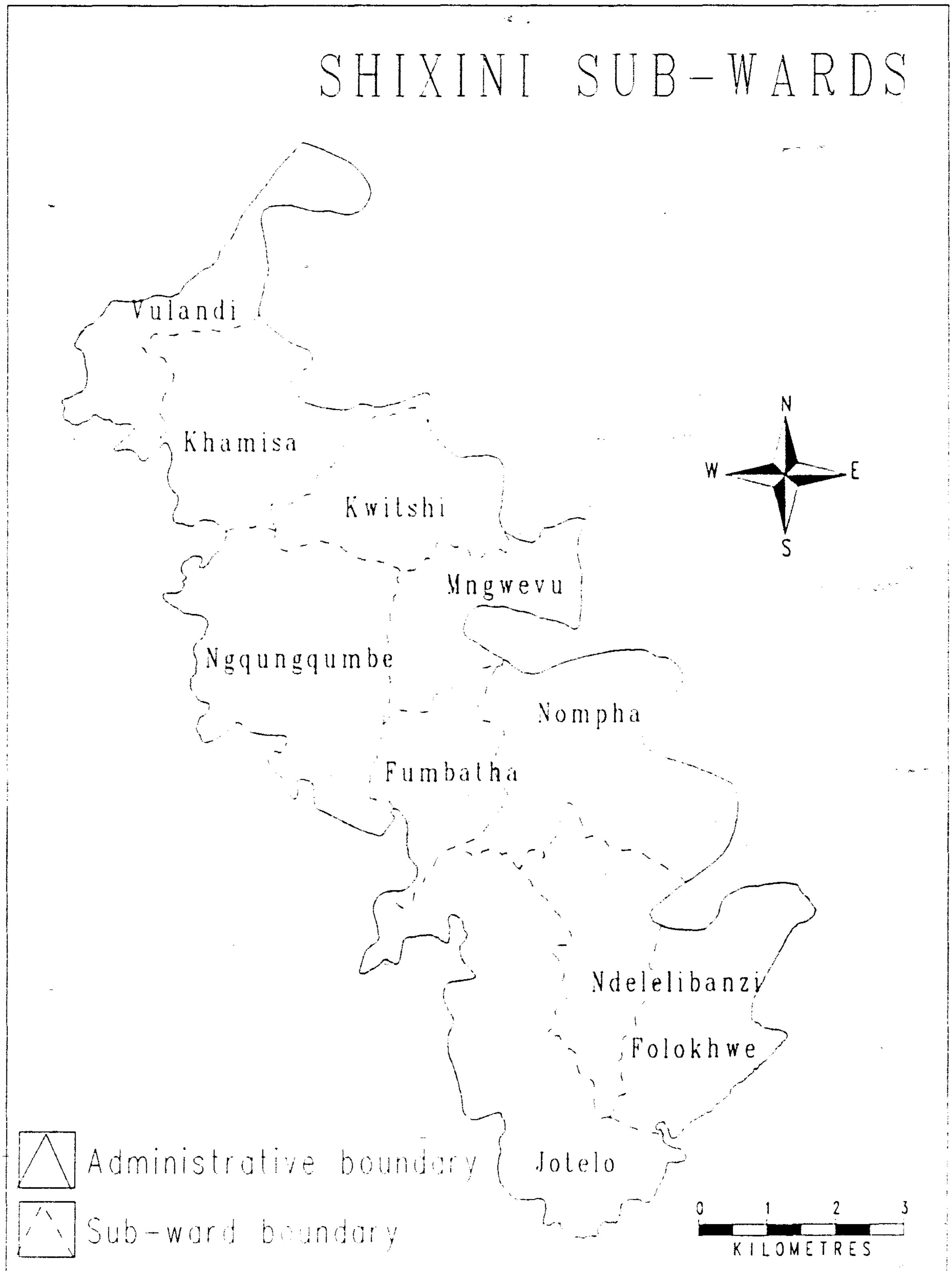



Figure 1.2 Shixini sub-ward boundaries

males over the age of sixteen were regular migrants.

Maize is the principal crop grown in fields. Garden cultivation is more diversified and includes a range of crops such as beans, tobacco and pumpkins.

The settlement pattern in the ward is scattered. Homesteads are situated along the ridges, while fields are located on the slopes and valley bottoms. An enclosed garden and a cattle kraal form the focus of the majority of homesteads. The various huts (buildings) making up the homestead are arranged in a semicircle facing these features.

Shixini falls in a warm temperate zone (Schultze & McGee 1978). Rainfall is high, averaging between 1000 to 1200 mm per anum. Seventy percent of this falls between October and March (Burchmore 1988). Spatial variation of rainfall occurs with rain decreasing from the coast inland. Due to this variation the sub-wards furthest from the coast experience water shortages in the winter months. Soils of the area are broadly defined by the Development Bank (1987) as weakly developed Glenrosa, Mispah and Swartland over shale and sandstones, while the vegetation cover is defined by Acocks (1988) as Coastal Forest and Thornveld. Soils of the area are poorly developed due to the leaching of nutrients as a result of the high rainfall.

### 1.5 - The Shixini Rural Development Project (SDP)

The Shixini Development Project was a multifaceted rural development project facilitated by the Institute of Social and Economic Research (ISER) of Rhodes University, Grahamstown and the Transkei Appropriate Technology Unit (TATU) based in Umtata, in partnership with the people of Shixini Ward, Gatyana District, Transkei (McAllister No Date ). The project was identified by the author as a rural community development project. The arguments for, and significance of this labelling are expanded in Chapter Five. The projects life extended from 1988 to 1992.

### 1.6 - Limitations placed on the study by external factors

This study was approved at the end of 1991. At this time the political situation in South Africa was relatively stable. This situation changed dramatically in the first six months of 1992. This period was characterised by increasing political turbulence and violence which persisted up to the democratisation process and elections in 1994. One of the worst affected regions was the Transkei, where the situation became such that to travel into or through the Transkei became unsafe. This state of affairs restricted the number of meetings between the ISER and TATU and affected both the ISER's and the author's ability to conduct field work in the Shixini area. A second disrupting factor was a shutout of senior personnel by junior workers at TATU for a number of months in the latter half of 1992. These factors effectively barred the ISER from continuing its work in the Shixini area and resulted in the ISER distancing itself from the project. TATU, under revised leadership, continued to maintain a presence in the Shixini area after the withdrawal of the ISER. These factors affected objective (iv) "the GIS feasibility study" in the following ways i) by restricting the information flow between TATU and the ISER, ii) by restricting the information flow between Shixini Ward and the ISER, iii) limiting field-truthing of mapped factors and iv), limiting the pilot study to a theoretical problem. More specific affects are touched on during the course of the study.

### 1.7 - Outline of the thesis

The first chapter of this thesis introduces the study problem, its aims and structure. It also provides some background information and limitations to the study.

In order to answer the question "is GIS appropriate as a rural planning tool?", the study was divided into two broad sections.

Section One consists of Chapters Two, Three and Four which address objectives i) and ii) of the study through the use of a literature survey. Chapter Two introduces GIS and the constituent components needed to successfully support it. This chapter also assess the general applicability of GIS to spatial planning and examines the operating and planning environment of GIS in selected First and Third World countries. Chapter Three examines operating and planning environment of GIS in South Africa and lays a platform for the following chapter. Chapter Four answers objective three, "to ascertain the perceptions of selected South African organisations involved in community development planning towards the use of GIS as a planning tool". This is done through the use of a questionnaire survey.

Section Two was based on a case specific GIS feasibility study and answers objectives (iv) and (v). Chapter Five introduces community development planning as well as certain aspects of the Shixini Development Project and its component parts on which the feasibility study is based. The workings of the feasibility study constitute Chapters Six. Chapter Seven is a pilot project, which answers a user defined problem.

The chapters outlined above are drawn together in a general discussion and conclusion in Chapter Eight, where, based on the results of the research, the appropriateness of GIS to the Shixini project, as well as the wider implications to rural planning are discussed. Issues raised during the study are examined and possible guidelines for its future use advanced.

# CHAPTER TWO

## A THEORETICAL ASSESSMENT OF THE ROLE OF GIS IN PLANNING

### 2.0 - Introduction

The primary purpose of Chapter Two is to lay a theoretical foundation justifying the examination of GIS as a tool for rural planning. The chapter is divided into four sections these are: 2.1 to 2.4) an introduction to the basic components of GIS and the operating environment needed to support it, 2.4 to 2.7) the theoretical role of GIS in a planning environment, and the possible advantages and disadvantages associated with this role, 2.7 to 2.9) the application of GIS to planning in selected First and Third World countries and the operating environment needed to support it, and 2.9) conclusions reached.

### 2.1 - Introduction to Geographical Information Systems

The rapid rise in popularity of digital GIS during the 1980s resulted in a large heterogenous group of users with a correspondingly wide range of applications. The different perspectives rising from this diversity has resulted in confusion over what constitutes a GIS. Reflecting on the diversity of uses, Cowan (1988) and Maguire (1991) suggest that there are four approaches to defining and separating GIS from other information systems, these being the function, application, toolbox and database approaches.

The function orientated approach emphasizes the information handling capabilities of the GIS, the provisional definition in Chapter One fits into this category. The toolbox approach is supported by Burrough (1986) and places emphasis on the tools available to capture, edit, transform and display spatial data. The database approach concentrates on the spatially referenced nature of the data stored in the database and the application approach divides the systems according to their use.

All of the above approaches, with the exception of the application approach, stress elements of GIS critical to its function. The application approach is important in its own right as it stresses a user rather than a technological approach to GIS. A GIS does not, however, operate in isolation from its human components or its operating environment. A GIS is a system. A system can be defined as a group of connected entities and activities which interact for a common purpose, therefore the inclusion of each of the above mentioned elements as an integral part of the definition appears to be logical. A fifth approach can therefore be discerned, one which Maguire (1991) refers to as a 'wide approach' to GIS. In this definition all the major elements which make up the system are represented. This view mirrors the importance of the critical elements which make up the Shixini feasibility study in Chapter Six, and therefore provides a useful working definition of a GIS. In the context of this study GIS was seen as an integrated collection of hardware, software, data and liveware which operates in an institutional context in order to efficiently capture, store, retrieve, maintain, validate, integrate, manage, manipulate, analyze and display digital geo-referenced information for a variety of purposes.

GIS is not a new concept, just a new technique (Wright 1988, p.161). The concept of manually overlaying thematic maps on a topographical base for the interpretation of geographical entities had been used long before the advent of first generation computers (NCGIA 1990, Unit 23). The method continues to be used today as a cheap method of spatial analysis. Perhaps the best known exponent of this technique was Ian McHarg who, in his classic book 'Design with Nature' (1969), used this technique as a way to avoid indiscriminate planning practices, a purpose to which many present day digital GISs are applied.

**2.2 - The components of GIS**

According to our definition in 2.1 there are five principal components of GIS. These are computer hardware, computer software, data and liveware which together operate within an institutional context. Each of the components is associated with a cost, impacting on the feasibility of using GIS within any given context. The total cost associated with a GIS can vary substantially depending on user needs and situational context.

**2.2.1 - Computer hardware**

Computer hardware and digital GIS are inexorably linked. The rise in popularity of GIS in the early 1980s can in part be directly attributed to computer hardware advances (the advent of the PC) during the same period. Benefits provided by innovation include increases in data storage space and random access memory (RAM) resulting in improved computing speed and power. These innovations have been coupled with a decrease in the physical size of the computer and lower costs. These aspects have increased access to computer technology as well as the number of environments in which computing can be undertaken.

The hardware components which make up the framework on which the GIS operates is called a hardware platform. The components making up a platform usually consist of a central processing unit (CPU) linked to a storage unit for storing data and programs, a monitor and keyboard to allow interactive communication between the user and the computer and peripherals such as digitizers, scanners and plotters which are used for the input and output of data.

GIS operate on almost any hardware platform (although GIS software are often specific to that hardware and operating system), including mainframe, mini-computers, work-stations and personal computers (PCs). Early GIS users were centralised as they were limited by the physical location of the technology. However advances in computer technology have increased the flexibility of the platforms allowing for centralised or dispersed databases and users. Camarata (1989) and Smith (1990) believe that the hardware trend in the 1990s will be towards work-stations running the UNIX operating system. These work-stations can be linked to powerful mini/mainframe computers through LANS (local area networks) or WANS (wide area networks). The advantages of linking such a system are that a number of work-stations can make use of a common set of peripherals, and that processing and other tasks such as data input, output or the responsibility for data can be spread. The cost of these platforms are however, usually too expensive for small businesses or individuals.

The Personal Computer (PC) is the first readily affordable platform that can support a GIS. The PC has a number of weaknesses and advantages when compared to other platforms. The principal weakness of using a PC as a GIS platform is the limitations imposed on program and memory size, as well as relatively low processing speeds. PCs are essentially single user systems which limits its ability to distribute large quantities of information. This limitation has been substantially reduced through increased user access to worldwide networks such as the INTERNET.

PC based GIS do have a number of advantages, especially when used for small, low cost projects where a number of the cited restrictions of PCs, such as slow processing speeds have less affect due to small data volumes. Some PCs such as laptops and notebooks are highly portable and are supplied with rechargeable batteries which are capable of keeping them running for a number of hours in areas with no fixed power supply. These technological advances have paved the way for innovative uses of the technology, especially in field research or as mobile communication tools in areas where the environment is generally unsuitable for computing.

An important issue linked to hardware is that of storage space. Technological advances have not only increased the capacity to handle larger volumes of data, but have also resulted in more data being captured. In the 1980s this represented a problem for GIS users, especially those operating large environmental databases where the volume of data can often be measured in terabytes (NCGIA 1990, Unit 66). The volume or size of the database has a direct effect on cost (space costs money, although the cost per megabyte has fallen substantially), and access speed (the ability to access the data you are looking for), with off-line archival media such as magnetic tape, CD-ROM or removable disk offering increased storage capacity coupled with reduced access speed.

In general increased performance in terms of processing power, memory, graphics capabilities, and on-line disk space means a higher price. Prices generally increase from a PC at the bottom of the range to a mainframe at the top with an overlap of computing power and price occurring between the top of the one range and the bottom of the next. The range of computing power available makes it possible to anticipate the platform required by an organisation or individual based on their requirements such as data volumes, access speed, number of users and location of users. These can be balanced against the amount of money to be invested.

### 2.2.2 - GIS software

There are a number of GIS software packages available today which can be bought of the shelf. Although software packages will differ in terms of their functionality they can usually be broken down into five basic subsystems or modules, these are:

a) a data input module which collects or processes spatial data derived from various sources into a compatible digital format;
b) a data storage and retrieval system;
c) a data manipulation and analysis module which enables the removal of errors (editing) and allows a number of operation and analysis methods to be applied to the data;
d) a data output module which can present the data in a variety of formats; and
e) the user interface, through which the user communicates with the GIS software.

GIS software differs according to their functionality (the functions they are able to perform), the operating systems on which they are able to function and the ease at which they can be driven. This last aspect is a critical and often overlooked part of the software; however it is the ease with which the user can drive the system which contributes to the appropriateness of the GIS in certain circumstances. For example a relatively 'user friendly' interface such as an icon menu driven system might be preferred over a more complex command language in a situation where computers are a novelty.

### 2.2.3 - Geographical Data

According to Cooper and Hobson (No Date p.2) "geographical referenced information consists of all information that refers to the human-environment system and that can be localised in space and time." Geographical data forms the basis of a GIS. The quality of information obtained from a GIS is usually a direct reflection of the quality of raw data input into the system (Calkins and Marble 1987). GIS data needs to be relevant and its collection should ideally be based on the geographical products required from the GIS. Estimates of data costs are typically between 60% and 70% of the cost of a GIS (Coward 1989; Maguire 1991). The database and the information it can produce therefore form a valuable asset. Unlike hardware and software the database and its information should not depreciate over time, but will become outdated and therefore needs constant revision.

In theory one of the advantages of digital data is that it provides an easy medium through which to exchange data amongst users. An advantage of this is the reduction of costs through the reduction of data duplication. The importance of this function is reflected in the emphasis placed on data standards to ensure data compatibility. A number of countries have devised these standards including Australia (the Australian data standard AS 2482; Clark, A. 1991a), the United Kingdom (National Transfer Standard; Sowton 1991), South Africa (National Exchange Standard; Cooper 1993) and the United States (Spatial Data Transfer Standard; Rossmeissl and Rugg 1991). Data standards have been compiled to try to ensure that the data and its attributes are not only transferable between different systems, but more importantly, that the data is of a known quality. Data quality usually refers to data characteristics such as currency, positional accuracy, attribute accuracy and consistency. It also tries to ensure that the elements included are adequately classified. It is this last aspect which is the hardest to achieve in a standard, as the heterogeneous nature of the data users imply a number of classifications according to user needs.

Geographical data is both expensive to collect and maintain. The acquisition of some types of data have largely been solved through remote sensed data and collective ventures (Maguire 1991). However, certain data types, especially socio-economic data, remain difficult to collect and maintain. This has resulted in the majority of GIS being resource based (Gar-On Yeh 1991).

#### 2.2.4 - Liveware (the human element)

The decision to introduce GIS in to an organisational structure is a political and not a passive process as the technology will result in different information flows, different spheres of influence and different access to data and information, all of which affect the people in the organisation.

Sommers (1987) regards a certain amount of organisational change to adapt to the new system of information flow as essential for the successful adoption of the technology. This view is paralleled by Aangeenbrug (1991, p.105) who observed that the adoption of GIS at a number of levels in the organisational structure often produced "power shifts amongst the various players" in the decision making process, with middle and lower level officials being "freed from many routine reporting and recording chores, which has often led to the perception, imagined or real, of loss of authority or actual job changes. Elkins (1991) notes that centralised information systems tend to increase the power of the administrators and technical experts who control them at the expense of those who lack the expertise to use them effectively. In some cases this streamlines the decision making process, giving weight to the fears of certain individuals. This point is especially important in the Third World where the lack of resources and skills in the outlying rural areas would tend to suggest that the skill centres and resources would be more concentrated than in First World countries. This is in direct contrast to the principals of community development.

The success of a GIS depends on the people who design, implement, maintain and use the GIS and they therefore form an important component of the system. A number of authors including Elkins (1991), Hine (1994), and Arnoff (1989), stress that the failure of a GIS is rarely attributable to technology failure but is almost always a result of people or organisational problems. This is ascribed to the fact that people are not predictable and often have multiple objectives as opposed to technical problems which can often be anticipated.

#### 2.2.5 - Institutional factors

Institutional factors have a fundamental impact on the success or failure of GIS within a country and within an organisation. Factors affecting GIS occur at two principal scales, a macro scale which equates to the nation or country and a micro scale relating to the micro organisational context.

Fox (1991) identifies a number of factors affecting Asian countries at the macro and micro levels. These are: official restrictions, culture of government organisation, accuracy and sensitivity of land ownership data, costs, legal implications and the impact of the organisational structure. Although the article is based on Asian countries, certain parallels can be seen throughout the world including South Africa. These restrictions can be summarised as follows:

a) Official restrictions, placed on the collection, distribution or possession of information. These restrictions are usually placed by the government on military sensitive issues. For example, Greece does not allow the publishing of detailed large scale maps (Mounsey 1991). The flow of government collected data is also tied up in bureaucratic red tape; this type of restriction applies to most countries and government departments unless they have a special mandate to distribute information.

b) What Fox (1991) refers to as the culture of government organisations or the attitude of the government to spatial information affects its use or adoption. Autocratic rule and management in a country inhibits the use of GIS where decisions are often taken unilaterally without any knowledge or understanding of the issues. The idea that information is a scarce resource (information is power) may also seriously retard the flow of information. The sectoral government structure used by many governments may also restrict data flow. Many government departments have a mandate for a particular task. The information gathered for these tasks are not necessarily exclusive to that department and a number of departments may require the same or similar data in order to perform their particular functions. The sectoral nature of the government makes it difficult to share this data, indeed with questions of funding and responsibility of data, the sharing of data may be bound in bureaucratic red tape or interdepartmentally rivalry, with a consequence that the data may be gathered separately by each department. GIS have the ability to cut across the sectoral approach adopted by many governments, but to successfully do so requires at the very least a little re-organisation on the part of the departments concerned.

c) Land information forms the basis or at least the base map (framework) of GIS. Land issues are complex and beset with a number of problems and therefore require a sensitive approach for a number of reasons. In First World countries land rights and issues are usually well defined, this is not always so in developing nations where customary and 'tribal' law provide a complex web of land types and associated land rights. In these cases the attribute data associated with the land is in doubt, restricting the accuracy of the GIS for purposes such as land use planning. Where the legal rights and ownership of the land are established, the information system has to be spatially accurate if it is to stand as a definitive spatial reference system for land use data. Land issues may be sensitive in other regards. Large land owners may not want either the government or public to know how much land they own for tax related reasons. In Third World countries it is often the government officials themselves who are large land owners! In these cases pressure may be brought on departments to restrict this information.

d) Spatial information systems require skilled individuals to handle the development, maintenance and application of the systems. Many developing countries do not possess the necessary skills and, depending on the government's attitude, may not see this as a necessity. Even developed countries are said to suffer from a lack of skills in certain areas.

e) Cost is an important factor in the development of a technology. In many Third world countries, the technology, often imported and associated with uncertain benefits, competes with other needs seen as more basic/or essential.

f) Legal implications are inherent in spatial data if the data is used for practical applications. There are two aspects of information which have important legal consequences, access to information and liability arising out of error, negligence or misuse bridging copyright and breach of contract. Legal implications differ according to countries, although certain factors such as breaching the secrecy of information act or the equivalent are serious charges in any country (Epstein 1991; Epstein and Roitman 1990). Sufficient checks and balances should be in place to ensure that an acceptable amount of care has been taken to ensure that error within the data has been minimised.

g) The organisational context plays a crucial role in maximising the effectiveness of GIS by institutionalising the process through investments in hardware and software and liveware such as training. The organisational context also has an important role to play in the smooth running of the GIS by delegating tasks, ensuring that relevant skills are available and that sufficient procedures exist to ensure that the system and the data are current, useful and conform to user set standards.

**2.3 - Data structures**

This study does not examine the technical aspects of GIS *per se*, however a brief discussion on data structures is necessary due to the impact of underlying data structures on geographical data representation and GIS functionality.

Data structures form a framework for the collection, representation and storage of geographically referenced data and their attributes. GIS are normally classified into three generic data structures of which two, the tessellation (raster) and vector database structures are considered. In the context of this thesis these data structures will be referred to simply as raster or vector.

Rasters consist of a grid made up of what Maguire (1991) refers to as "polygonal units of space", and which are commonly referred to as pixels. Spatial information is represented by X, Y and Z coordinates, where X and Y relate the geographical position of the pixel and Z the attribute. A set of pixels make up a cover or layer.

Vector representation of phenomenological objects is achieved through the use of areas, lines and points. This type of representation of the real world has been traditionally used by cartographers for map making. Vector based GIS represent geographically referenced data as a xy or xyz coordinate. A line is represented by a series of these coordinates.

Raster can be referred to as a data dependent system, as the geography represented in the image is only present in the data (Bracken & Webster, 1990). In practical terms this means that each pixel in a layer needs to be classified whether superfluous to the desired operations or not. The recording of information for each pixel adds unnecessary data volume. In small raster images with limited rows and columns this is not a problem, however in larger digital images this can represent a sizable waste of space.

Raster locational precision is limited to the size of a pixel. Pixel size also places a limit on the minimum size of phenomenological objects which can be represented. An example of this is the representation of a critical water feature such as a borehole. If the borehole occupied an area of 4 $m^2$ on the ground and a pixel had a resolution of 100 $m^2$ that pixel would have to be used to represent the borehole. This problem is not unique to raster. Vector representation, especially at the smaller scales, is limited when representing small or narrow but important features where the width of a line on a map may be wider than the feature it is representing. For example at a scale of 1:250000, a line width of 0.25 of a millimetre would represent 62.5 meters. In reality features such as roads may be substantially narrower than this.

Raster representation assumes that geographical space can be treated as though it were a flat cartesian surface (Burrough 1986). A pixel is located through the use of a single cartesian coordinate which can, depending on the product, be placed either on one of the corners or in the centre of the cell. This procedure limits coordinate precision and often confuses the user as to the exact location of the reference point.

Representation of phenomenological objects in raster format are often highly abstract depending on the raster's resolution. Inaccurate raster coordinate precision and the often abstract nature of the raster image are offset by the fact that natural phenomenological objects seldom have straight lines and precise boundaries, but rather have an area of transition between them. This is often not true of man made objects or definitions where a definitive boundary line is often required, such as land parcels.

The advantages associated with raster include a simple data structure which enables quick computation times when performing certain analytical operations, such as overlaying different themes, as no calculations are required to determine relative position among layers. In addition, certain operations such as viewshed algorithms, the generation of friction layers and least cost lines can only be achieved using this structure (NCGIA 1990, Unit 21). The structured nature of the pixel does however adversely affect other operations such as area, perimeter and distance calculations.

Vector is able to supply accurate graphics to a high degree of precision. The danger inherent in this statement is the assumption that such precision is achieved. Data source inaccuracies, however, and the processes of data capture and performing analytical operations on data are generally error prone and reduce relative precision. It can therefore be argued that the " true comparison in terms of precision is between raster cell size and the positional uncertainty of a vector object, not the coordinate precision" (NCGIA 1990, Unit 21, p.21.5).

Vector requires complex mathematical algorithms to perform spatial operations such as overlaying. Operations such as these are memory intensive, require free space to perform the computations and result in comparatively lengthy computation times. Despite these problems certain operations such as network analysis are quicker and more efficiently performed on vector.

Both raster and vector based GIS are capable of analyzing, displaying and manipulating geo-referenced data. Each model has traditionally been linked with certain application areas which are guided by the advantages and disadvantages inherent in the different data models. Vector systems tend to dominate in transport, cadastral and utility marketing applications while raster is often utilised with land and resource planning at a regional level or small scale mapping where satellite imagery is a major source of data (NCGIA 1990, Units 4,5,13 and 21).

Mitchell and Stuart (1991) point out that either data structure can conceivably carry out the same spatial operation, although at present the systems available are not able to offer complete functionality in either model. Technological advances have, however, reduced the distinctiveness of the data structures through algorithms which allows the exchange of data from one format to the other and vice-versa.

Vector appears to be the dominant GIS data structure at the present time, although certain authors such Mitchell and Stuart (1991) predict that this dominance will be eroded in the future as software and hardware capabilities continue to improve. The decision over whether to choose either a raster or vector model or both should, in the end, be dictated by practical considerations such as the source of data for the system, the dominant functionality required and the types of output needed.

**2.4 - The generic case for including GIS as a planning tool**

The nature of planning is essentially spatial in nature! Although the planning process in different countries may differ according to political system, administrative structure, development policies and objectives, the underlying nature of the data are spatial in nature. This statement has important connotations in terms of this study as it links generic planning issues to all types of planning. It is this relationship between the planner and spatial data which prompted Cowan and Shirley (1991, p.297) to assert "that the planning community have been greatly influenced by developments in GIS." While this statement understandably has some truth in it as borne out by the surge in GIS sales over the last decade for purposes including planning and management, it is tempered by Aangeenbrug (1991, p.101) who in a critique of GIS warned that GIS had been operating in a "booster type environment" where critics and reported failures had been few. Aangeenbrug (1991) stressed that GIS was still a relatively young discipline with technical, organisational and procedural problems which had yet to be resolved.

This section examines the advantages that could be offered by GIS in a planning and organisational environment as well as the disadvantages and problems associated with the technology, concentrating on a general framework necessary for the incorporation of the technology in a planning environment.

It is essential to understand the planning process in order to understand the possible role of GIS in that process. Planning can be described as the formulation of short and long range goals for an organisation or objective, including the policies, procedures and standards necessary to achieve them. Planning is also concerned with identifying opportunities, problems and alternative courses of action to achieve a desired goal. Cowan and Shirley (1991, p.297) report that despite disparate planning processes, information requirements and the legal basis under which they operate, there are more similarities than differences in the planning process. This assertion is based on a study completed by Dangermond and Friedman (1986) who developed a list of 21 common procedural and 12 managerial tasks based on their findings of several local governments in the United States. Cowan and Shirely (1991, pp.297-298) generalise these activities into a set of five planning functions, each of which require a set of procedures which enable the planner to combine diverse amounts of spatial data into the type of information needed to support spatial planning. These functions consist of five different components.

1) A "central intelligence function" where organisations require a wide variety of often disparate information which may occur in a number of forms and formats. GIS operates in this context as an integrating tool by combining different forms of information within a single system. Shepherd (1991, p.337) recognises three main benefits resulting from integrating data;

a) it imposes spatial consistency on data,
b) it enables a wider range of operations to be carried out
c) in the long run it can save time and effort by reducing duplication. In a scenario where government departments or organisations with differing mandates integrate data or provide facilities for data exchange the benefits of the technology are even greater, reducing acquisition costs through the elimination of data duplication. In addition, the increase in database variables provides a broader base from which to access conditions, providing access to information initially beyond those of the individual organisation or government department. These activities need to be carried out within a controlling framework to ensure proper utilisation of these facilities and for the maintenance of adequate data integrity and data standards.

2) 'Pulse taking function' where often miscellaneous data are aggregated or converted into meaningful patterns and trends. The census data can be considered an example of this. Collected in small areas (enumerator districts, EAs) the data can be aggregated up to national level to show inequality between districts or regions.

3) 'Policy clarification' where the different routes used to solve a problem can be analyzed and compared in order to find the best solution for the problem. This is especially important where an issue is contentious. In this context GIS is used tc examine each of the scenarios and possibly of modelling their outcomes in order to provide role players with a more informed view of the possible outcome if certain decisions are made.

4) Development planning which utilises a wide variety of spatial and tabular data pertaining to the landuse pattern of a community or area. Planners try to optimise the landuse pattern, directing its development through the use of zoning maps.

5) Feedback and review functions; a critical and under-utilised function in a democracy, where citizens should be able to view the way in which taxes are being spent and are able to object or add to developments affecting them and suggest alternative ways (similar to policy clarification). A distributed GIS is able to enhance this process, making the planning data available at selected points for the public.

Langendorf (1985) notes that over the past 25 years planners have been promised a lot from computer technology but have not always received the goods. Complaints from planners using computer technology for planning purposes vary. Common complaints are:

1) a mistrust of information from the models due to factors such as model complexity beyond the grasp of the potential user;
2) an intuitive sense that the models do not suit the required purpose;
3) the lack of suitable models;
4) inadequate flexibility for changing needs;
5) the fact that many planning problems are ill or semi structured (ie either the nature of the problem, the possible courses of action or the criteria for choice are unclear or uncertain) whilst automated procedures are ideal for structured problems.

GIS may be able to provide a solution to some of these problems. GIS are able to enhance or support the decision making process at all four traditional decision making levels in an organisation. These are the strategic, tactical, operational and project planning levels (Robinette 1991).

At the strategic and, to a certain extent the tactical levels, the overall direction of the organisation or project is decided through long term planning. GIS can enhance the decision making process for ill-or semi-structured problems which characterise this planning level by providing a framework for the incorporation of database management, spatial analysis and textual and tabular outputs enabling the identification of trends and their subsequent analysis.

Decision making at the tactical level is fairly structured and is primarily concerned with assessing alternative strategies for implementing decisions made at the strategic level, which Robinette (1991) refers to as the "what to do" level. GIS makes an ideal tool for this task, providing the functionality and flexibility to produce and assess a number of scenarios.

The operational level uses GIS for structured decision and solution finding where the solutions to the problem can be found in a logical set of sequences. At the operational level, concerns revolve around the more practical aspects of how to meet an objective, while project planning deals with the actual design and physical placement of the objective.

Information needs for each of these decision levels differs. Each planning level usually requires a higher level of abstraction from the base data. Therefore the operational and project planning level require detailed data reflecting the day to day operational environment while, at the strategic level, information requirements are refined in order to provide as little 'noise' in the information as possible.

The purpose of any information system is to support a user in his/her decision making environment and will effectively constitute a Decision Support System (DSS) or contribute towards a DSS. Densham (1991 p.406) considers DSS to have six distinguishing characteristics:

1) they are designed to solve ill-or semi-structured problems,
2) they have a powerful easy to use, user interface,
3) the system "enables the user to combine analytical models and data in a flexible manner",
4) they are able to generate alternatives,
5) they "support a variety of decision making styles and are easily adapted to provide new capabilities"
6) they allow problem solving to be both interactive and recursive (process in which decision making proceeds by multiple paths, perhaps involving different routes rather than a single linear path).

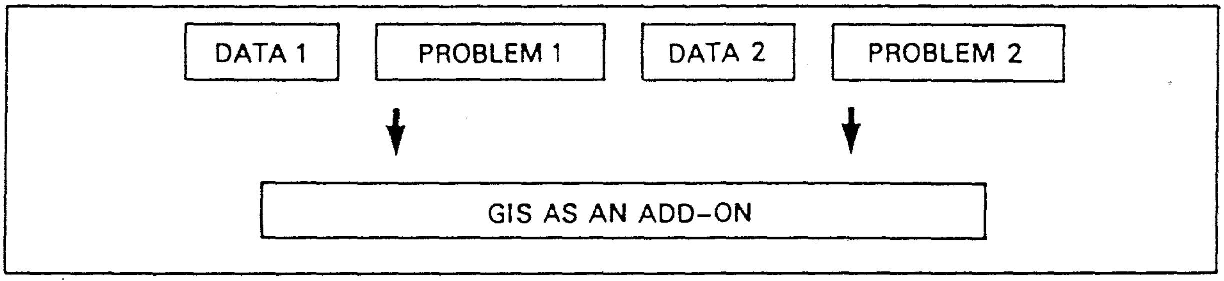
Spatial decision support systems (SDSS) are spatial analogues of DSS (Densham 1991). SDSS are primarily designed to provide the user with a flexible decision making environment for the analysis of geo-referenced data. DSS and SDSS provide similar products, however, due to SDSS concern with geo-referenced data and the complexity of spatial data, SDSS possess four additional capabilities and functions (Densham 1991). These are:

1) mechanisms for the input of spatial data,
2) the ability to represent spatial data, and their relationships,

3) analytical techniques that are unique to spatial and geographical analysis and,
4) facilities for the output of spatial data.

Fincham and Berjak (1990) stress that to be effectively utilised in an organisational structure the GIS needs to be incorporated into the organisation's DSS. This is an important concept linking the GIS with the planning environment.

In Figure 2.1 the GIS functions as an 'add on coordinator' of data, as illustrated in Piper *et al.* (1990) and reproduced in Fincham and Berjack (1990, p.336).




Although GIS can make an important contribution in this model, as far as information needs are concerned, data needs were not properly articulated before the introduction of the GIS which resulted in problem specific data being utilised. This type of scenario often produces a disjointed database with disparate geo-referencing and differing data integrity. The practical consequences of this are that the user may not be able to take full advantage of the available data sets, therefore decreasing the potential value of the GIS in that situation. Figure 2.2 illustrates a GIS incorporated as an integral part of the decision making process for project work. The GIS database has been planned and fully geo-referenced to provide a platform for the integration of data which would have a wider base of variables from which to address problems, and as a result, increase the potential range of problems that could be addressed.

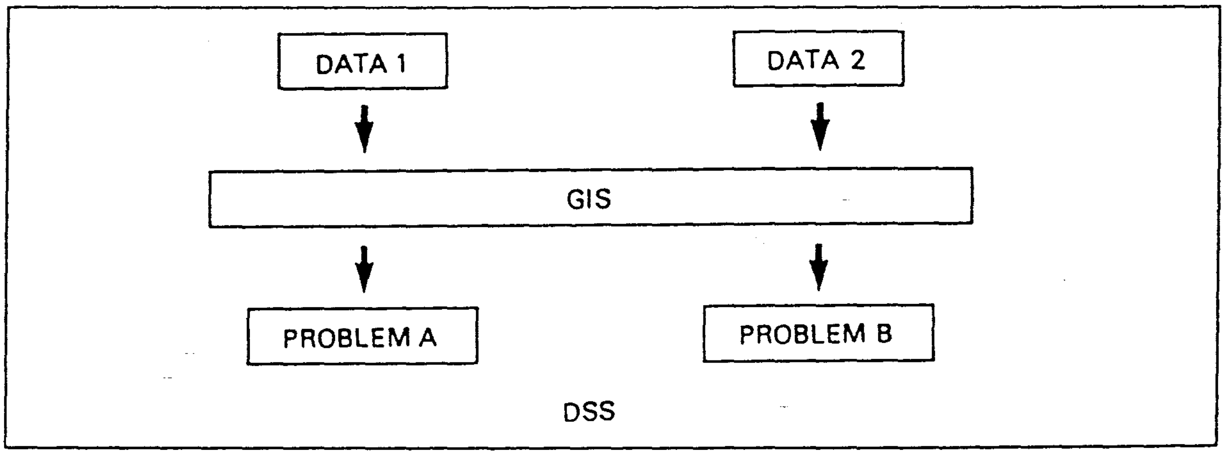



Figure 2.2: A GIS incorporated as an integral part of the decision making process (Piper *et al.* 1990, in Fincham & Berjack (1990, p.336)

In order to illustrate this point they provide a number of mental models illustrating the role GIS might play in different project situations.

Figure 2.3 illustrates a third model, that of a GIS which has been fully incorporated into the DSS. The needs of the users in this scenario have been articulated to form a well designed database, constructed on the needs of the users.

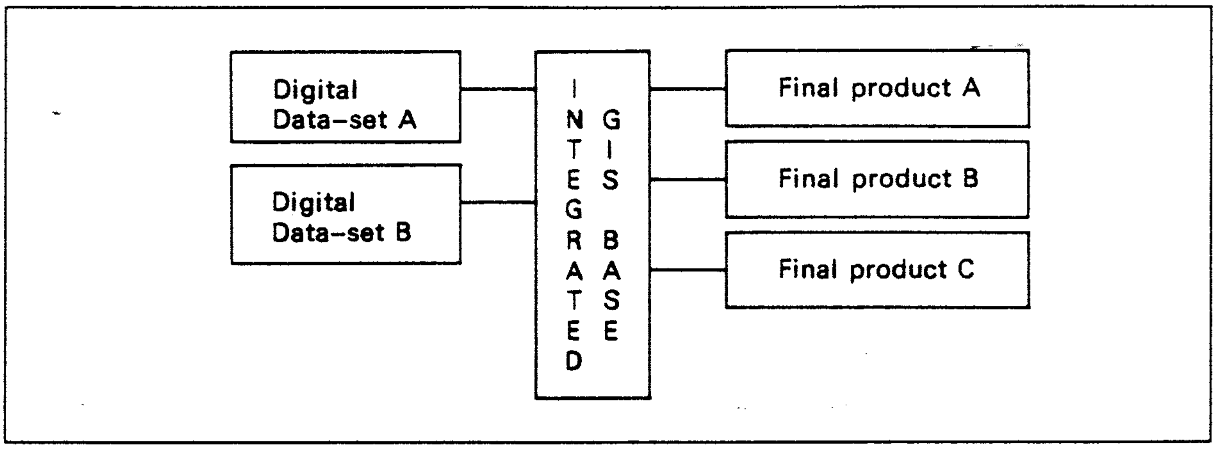



Figure 2.3: A decision making process dictating data collection and GIS structure, in Piper *et al.* (1990).

The advantages of a GIS which has been fully conceptualised is that organisational issues, needs, and procedures regarding maintenance, access, finance and data acquisition, integrity and standards have been examined before the purchase. This model decreases the chances of failure by taking 'liveware' into account. It is this last model which is closest to the approach adopted to this study.

At present there appears to be a discrepancy between the functionality of a SDSS and present day GIS. Cowen and Shirley (1991, 301) view data problems and "an inability to support the type of decision making process that characterises the planning environment" as critical problems. Goodchild (1987) claimed that the set of tools available for spatial analysis fell far short of those needed for the extensive modelling needed to support a SDSS. As a response to user needs, increasingly sophisticated spatial analysis packages have become commercially available in the 1990s; GIS are also becoming more flexible, bringing them closer to fulfilling the role of a SDSS.

**2.5 - Designing the database**

Cowan and Shirley (1991, p.302) report that the fundamental building block of a planning GIS must be an appropriate database, that can;

a) describe the real world in abstract, physical, social and economic terms in an appropriate format and

b) enables the elementary display, analysis and query of data.

The cost of building and maintaining a comprehensive database for planning purposes can be prohibitively expensive, the formation of such a database is ideally compiled over a few years in a logical way. The problem with this method is the limiting effect that the lack of data has, reducing functions such as spatial analysis and consequently reducing the amount of information available for holistic planning in the short term. Estimates of the time needed to create a mature database vary, depending on the area under study, the nature of the available data, and the variables needed. Fincham and Berjack (1990) estimate that the average length of a GIS to mature in the United States ranged from three to five years, Crain and McDonald (1984) suggest an even longer maturation period.

The value of any information system rises out of the usefulness of its resultant information products (De Man 1990). The value of the GIS in turn can only be gauged when compared with the timeliness, efficiency acceptability and costs of an organisation's present information system and other compatible systems. GIS should only be considered if it is seen as improving one or more of these factors. What this implies is that information systems can be quantified, their value ascertained and can therefore be compared with other information systems.

A number of authors have applied different methods to the problem of selecting and institutionalising a GIS system. Clark (1991) provides a detailed four stage plan each with a number of sub-points for implementing GIS. His model identifies a) the organisational requirements which are translated into, b) GIS functional specifications, these specifications are given to GIS vendors, who try and match these requirements, c) systems are compared for functionality and cost effectiveness and compared with the present system and, d) selection or rejection of the system. Incorporated in this method are a number of checks and balances to insure acceptability within the organisation, including a cost/benefit analysis and benchmarking. Other models trying to reduce the risk of failure of GIS in the organisational structure have concentrated on reducing the uncertainty of the recipient through economic evaluation of the proposed GIS (Dickson and Calkins 1988), performance evaluation and workload estimation (Goodchild and Rizzo 1990) and the establishment of a GIS in relation to its use (De Man 1990). The advantages of following a number of set procedures when purchasing a GIS are:

1) user needs and required functionality are established and matched with a suitable system;
2) procedures for the functioning of the system are established before the actual acceptance of the system, for example lines of communications and fields of influence within the organisation;
3) installation, data and running costs and reoccurring costs are identified and can be catered for;
4) benefits which the organisation will accrue from the purchase of a new information system, both tangible and intangible, are known and can be used to convince those

opposed to the system;

5) a well thought out and well designed functioning database forms the basis of the information system;
6) less chance of organisational and technical problems and a subsequent reduction of failure, under-utilisation or disappointment with the system;
7) the technology would be application and not technology driven;
8) the human component such as skills and staff training needs can be addressed and;
9) the technology can be incorporated into the organisational DSS.

**2.6 - The benefits of using GIS**

Assuming that the needs of a GIS are met there are a number of benefits that the user or organisation can derive from its use. These benefits can be divided into two main categories, 'quantifiable' and 'non-quantifiable'. Antenucci *et al.* (1991) further divides these categories into five types as follows they are:

Type 1) The most obvious quantifiable benefits is improvement to existing practices through the automation of certain procedures. Antenucci *et al.* (1991) observes that these benefits are usually the easiest to identify and quantify. A number of the benefits that would occur in this category have been discussed, such as time saved through being able to obtain, update, index and distribute digital data to other users.

Type 2) Other quantifiable benefits include increased functionality. GIS may offer functions which enable a user to undertake tasks not previously considered either because it was not possible with the tools available, or the effort required to achieve the task was greater than the benefits derived from the process. Examples of this may include relatively complicated planning exercises such as scheduling new public/school bus services. This task requires a number of factors to derive a suitable solution. Even if available, to manually work them out may require more manpower than warranted by the exercise. Typically in this situation planning would be reactive, in this example probably responding to complaints from irate citizens. GIS has the ability to match these needs in a routine way with a minimum of time lost. Antenucci *et al.* (1991) considers this type of benefit to be the equivalent of additional staff.

Type 3) These are benefits which cannot be measured or anticipated in advance but in reflection are perceived as benefits and can then be measured. An example of this is the establishment of a GIS to monitor an organisations community planning requirements in a district. The advent of famine in the area gives the organisation the opportunity to provide useful data, produced by the GIS. For example, identifying those families below the poverty datum line in the area. This could result in a number of possible benefits such as contracts with government or increased cooperation from other organisations who benefitted from the information.

Type 4) These benefits are referred to as intangibles (cannot be quantified) such as 'better' decision making, resulting from an improved understanding of the issues involved. The timeliness of information resulting from the use of a GIS may also provide certain intangible benefits. In Chapter Five it is stressed that timeliness is critical to maintain public participation in community development, the failure to produce or implement a plan may have a critical affect on the project such as reducing participant confidence.

Type 5) The last type of benefits are those linked to the geographical product and are therefore tangible. These benefits may be derived from the sale or release of geographical products. An example of this are the sale of digital products by certain South African government departments such as the Surveyor General and the Central Statistics Service. The release of data or products to other users may induce the benefit of increased cooperation and savings, for example through combined data collection strategies.

## 2.7 - The application of GIS to planning in selected First and Third World countries, and the operating environment needed to support it.

The following section broadly examines GIS in planning and the operating environment (factors needed to support the technology) in First and Third world countries. Two First World countries are examined: the United Kingdom and the United States, a number of countries are looked at in the Third World due to the lack of available literature on any one country

### 2.7.1 - GIS in the First World

Both the United States and United Kingdom have had a long association with GIS, starting in the 1960s. Despite this the technology has only started to become significant in terms of the number of users from the early 1980s, a fact which must be attributed to technological advancements in computer hardware and the commercially available GIS.

**GIS in central and local government**

Central government involvement in GIS development has been essential to the growth of GIS but, where as the Federal Government of the United States nurtured GIS development and the development of spatial technologies, early involvement by the British government was not as positive. The lack of sustained government funding curtailed early developments in ventures such as the National Resources Committee who, in 1964, proposed a prototype GIS. The British government only started to realise the importance of computers as an aid to land use planning in the early 1970s, leading to representatives of central and local government publishing a report in 1972 entitled General Information Systems for planning (DoE 1972). Early government support for GIS was possibly not forthcoming in the United Kingdom due in part to the private ownership of land which resulted in the government having little responsibility for land management, one of the traditional bastions of geographic information. The centralised nature of the government and the small size of the country may also have retarded the realisation of the need for computer based information systems (Coppock and Rhind 1991). It was not until the early 1980s that far reaching government investigations started to take place such as the House of Lords Select

Committee on Science and Technology which convened in 1983 to investigate remote sensing and digital mapping and a committee of enquiry into the Handling of Geographic Information chaired by Lord Chorley (Chorley Committee).

These government commissioned committees advanced tremendously the cause of spatial technologies in the United Kingdom. Recommendations included increased government participation and funding, the acceleration of the digital conversion of maps at the Ordnance Survey (OS), and the need for government departments to make non-sensitive information available to interested parties. A further recommendation was the establishment of a central body to coordinate geographical information (Chorley 1988). However the major contribution of the Chorley Committee was making the public and private sector more aware of GIS (Chorley and Buxton 1991).

Central government departments and agencies of both the UK and the US are mandated to collect data to support policy making and other applications in their respective countries. The mapping of topographic data in the United States falls on the United States Geological Survey (USGS) and in the UK, the Ordnance Survey. Although performing essentially similar roles their policy regarding data needs and data distribution differ markedly.

The purpose of the two organisations are remarkably similar. The USGS is a national earth science agency with responsibility for gathering, analyzing and presenting information on the US geology, water resources and topography. The Survey has a mandate to meet all the topographic mapping needs of the federal and state governments, as well as commercial interests and those of individual citizens (Starr and Anderson 1991). The OS has a mandate to supply mapping and survey services, with responsibility for keeping the topographic mapping of England, Scotland and Wales up to date (Sowton 1991a, p.25).

The USGS has an external user dictated philosophy; each year federal and state agencies report on data and map needs to the USGS which, to a certain extent, allows the survey to be user driven. The products produced by the organisations include a number of digital mapping series and a Digital Elevation Model (DEM). The OS produces a range of digital maps at scales ranging from 1:1250 to 1:625000 while the principal topographic map series in the United States is the 1:24000 scale series of which certain categories of information are in digital format.

Despite the OS's and USGS's long association with digital data, few digital map series had been completed by 1991. Strategies such as joint ventures have been evolved to speed up the digitisation process. The OS has allowed utility companies to digitise certain areas of the country to OS specified standards while the USGS has a cooperative agreement with the Census Bureau over the digitising and coding of certain features of the USGS 1:100000 scale map series which form the basis of the TIGER system. Cooperative ventures may be seen as a sign of maturation in the GIS field as it reduces data duplication and consequently the costs involved.

Where the two organisations differ considerably is in their approach to information dissemination. Data are not in the public domain in the United Kingdom, while the opposite is true in the United States. This means that certain data such as census data are more freely available in the United States for planning purposes. These policies are evident in their respective mapping agencies, the OS and the corresponding division in the USGS. Before the privatisation of the OS the British Government maintained a policy which made digital data produced by the OS, expensive. The OS expected an expenditure recovery rate of 59 per cent in 1991, a large proportion of which was expected to be recovered through the sale of digital products (Sowton 1991a). The information generated by the USGS is not subject to copyright, the data is also distributed at a minimal cost which covers the transfer of the data. As a major GIS user, the USGS is also involved in the dissemination of information and joint ventures with other state departments.

There were differing opinions concerning the OS's pricing structure before privatisation. Certain authorities regarded the high cost of data as suppressing its free flow and restricting entry into GIS. Bromley and Coulson (1991) observed that there is a ten times differential in the cost of digital data as compared to paper maps, a fact not looked on favourably by many local authorities, while Cane (1991) observed that local authorities have become aware that OS digital maps are expensive to acquire and maintain. It could be expected that cost might constrain the use of GIS but Sowton (1991a) regards the lack of digital data rather than the cost as constraining GIS growth. This statement is borne out by an increasing demand for digital data from utilities and a number of local authorities, however the cost of procuring data may have the affect of retarding the growth of the smaller GIS user in the United Kingdom.

The period from the late 1980s to the early 1990s has seen a significant increase in the use of GIS for planning purposes at the local government level of both countries, with support being provided at a federal or central government level. The increased involvement of governments in GIS and geographical data is not surprising as the various departments which constitute these bodies are usually amongst the largest collectors and users of information. Antenucci *et al.* (1991) contends that in 1990 at least sixty-two federal organisations used or intended to use GIS. At the state level a research study by French and Wiggans (1991) indicated a dramatic increase in the number of agencies in California involved in urban or regional planning purchasing a mapping system, from ten in 1986 to twenty-one in 1989.

The majority of these users apply the technology to the mapping of land parcels, plan preparation and zoning reviews. French and Wiggans (1991) observed that the "traditional" applications of GIS such as environmental and natural resource planning have declined and that the technology is being used to make plans and support administrative functions. Local Authorities in the United Kingdom administer and manage a number of local services and many are large land owners. Many local authorities have invested in GIS to better manage these services and land. Bromley and Coulson (1991) observe that the influence of public utilities on local authorities to go 'digital' has also played a part in this trend. Local authorities are organised departmentally and Campbell (1990) has noted that information technology (IT), including GIS, has enabled interdepartmental cooperation. The benefits derived by GIS for local authorities were summarised by Bromley and Coulson (1991) into map benefits (currentness), data benefits (quicker access to a number of types of data), operations benefits (forward planning) and general (better working conditions, better service).

The products produced by the respective mapping agencies underpin many GIS, forming a common base map for the addition of attribute data. The scale at which the maps have been digitised have implication for their use in planning. According to Robinette (1991) the large scale series < 1:10000 available in the United Kingdom are suitable for project planning, while the largest scale available in the United States 1:24000 are suitable for operational planning (as discussed earlier in this chapter), although it was indicated that the US census have used the 1:100000 series as their cartographic base. The 1:1250 series available in the United Kingdom only covers urban areas and by 1991 it appeared that the rural areas had little detailed coverage. Indications are that both mapping agencies cater to demand. The relative absence of digital coverage of the rural areas would seem to signify that there is not sufficient demand for digital data from these areas as compared to the urban areas or, alternatively, other methods of obtaining data for these areas are used. Planning of the rural areas occurs in both countries, but available literature consulted indicates that this is more likely to occur at a regional level (small scale mapping). This is probably due to the fact that farmers, estate managers and other landowners plan at the local scale while local authorities provide longer term planning for areas larger than the single property. It is also unlikely that the rural areas would require large scale maps as is required for urban planning as land management need not be as accurate and there are usually less man made features in the rural areas. Planning also tends to concentrate on physical or environmental issues at the regional level. Literature found concerning the use of GIS in the rural areas of Britain appears to be limited to the use of small experimental GIS at universities or large national databases. A number of rural related GIS projects have concentrated on certain aspects of GIS such as the use of digital elevation models (DEMs) which have proved effective in the visualisation of planning impacts on areas (Duffield & Coppock 1975; Selman *et al.* 1991). The application of GIS to rural planning may include large scale planning such as site selection, however, it is more likely to be used as a regional planning tool (Curtis 1989; Gould 1992).

Socio-economic and other data are available to varying degrees in both countries. The availability of socio-economic data for planning purposes are underpinned by a relatively efficient information collection system. In the United Kingdom this data is obtained from a number of government departments as well as the national census. The census is carried out by enumerators who personally canvass every household in Britain. In the United States census are delivered by post which accounts for the interest in automotive features for this activity. The US census is taken every ten years and forms a major source of socio-economic information. The census includes a number of questions pertaining to the individuals (families) demographic, social and economic characteristics, although by all accounts it is not as wide ranging as that held in the United Kingdom. The data is available for small areas or can be aggregated to a national level and forms the basis of a number of GIS related activities such as market analysis.

In the united Kingdom the Online Manpower Information System was set up to provide socio-economic data. The database, which is located at the University of Durham, represents a collusion between government (the Department of Employment and Training Agency) and academics. The resultant reliance of the government on academic sector skills has increased the accessibility of government data for academic purposes. The information held in NOMIS is divided into five sections: demographics, projections, employment, unemployment and vacancies (Blakemore 1991). The system can be described as a 'small area information system' due to the relatively detailed and geographic specific nature of the data. The information available in the system can be accessed from any of 120 visual display units around Great Britain (Townsend *et al.* 1987). NOMIS users are spread relatively evenly amongst the central and local government's, commercial agencies and academics (Blakemore (1991). Local authorities and academics are not charged for the use of the data, but commercial users are charged commercial rates (Blakemore 1991).

A data base which is primarily aimed at the rural areas in the United Kingdom and for which the United States does not have an equivalent, is the Rural Areas Database (RAD). The database was established by the foundation RAD Unit in conjunction with the Economic and Social Science Research Council (ESRC), various government departments and agencies. The purpose of the database was to create a centralised source of data of the United Kingdoms rural areas (Walford, Lane and Shearman 1989, p.222). The factors contributing to the establishment of the database are the growth in data concerning the rural areas and an increased focus on rural problems. The database is able to incorporate a wide range of variables from a wide variety of sources and has left the definition of what constitutes a rural area to other organisations in order to meet the varying demands of users. The database integrates a wide variety of public and private data to increase the database's utility to diverse users. In so doing the database is a tacit acknowledgement of the complexity of rural problems. There are a number of problems associated with the database, the most important being the lack of control over the agencies contributing data, leading to different standards. Walford, Lane and Shearman (1989) stress that the RAD council would have more control over this aspect in the future, with data sets from these sources being built around national core data sets which would provide a framework to which data could be attached.

**GIS in the commercial sector**

The United States has a well developed commercial sector both in the development of GIS and its support services. Dangermond (1991) estimated annual sales of GIS technology in the region of 500 million US dollars. Equally active are commercial organisations applying GIS technology in a number of fields such as utilities, forestry, civil engineering, regional planning and many more (Dangermond 1991; Tomlinson 1987). The United Kingdom also has a growing market in GIS; its use for the utilities has already been mentioned. Hinton (1994) observes that GIS in the country is increasingly viewed as a corporate information system capable of meeting a number of needs in business. This view is supported by Winters (1994) who notes a growth in the non-traditional users of the technology such as retailers and financial institutions. Commercial activity in the GIS field contributes both to the growth and development of the technology through the need to be competitive. GIS related businesses such as GIS education services, database distributers and publishing all provide services which contribute to the awareness and in some case the effectiveness of the technology.

**GIS in tertiary education and national organisations**

GIS users are well represented in the tertiary education system of both the US and UK (Coppock and Rhind 1991). Academics have played a leading role in the establishment, development and propagation of the technology. Mention has already been made of academics and the government colluding on the NOMIS database in the UK in addition a number of state GIS in the US were originally established at universities; one of the best known is the Minnesota Land Management Information System (MLMIS) which was originally established in 1976 at the University of Minnesota. Other government and tertiary initiatives include the government supported Regional Research Laboratories (RRL) in the UK (Morrison 1991). The preliminary aims of the RRL during their formative years in the late 1980s was to establish an integrated data resource strategy, develop centres of expertise and examine methodological issues arising from database management. The RRL have also provided bursaries for the study of GIS at graduate and post-graduate level (Chorley and Buxton 1990; Morrison 1991). The RRL have to all accounts been extremely successful in terms of research outputs and their attempts to develop collaborative ventures with both public and private sector agencies (Masser 1991).

Despite these advances the education system has been reactive rather than proactive in the GIS field (Unwin 1991). Tomlinson (1987) observed that there was no central coordination in what was taught in the education field in 1987, although this position may have changed since the establishment of the National Centre for Geographic Information and Analysis (NCGIA) in the same year. The position of tertiary education in relation to GIS could be attributed to the rapid development of the technology, which means that the education system is always behind. Another problem is the expense associated with the hardware and software. A more fundamental problem is the place of GIS in the education system, is it a discipline of its own or relegated as an application tool to a number of departments?

Academics together with other interested parties have been instrumental in forming associations to address spatial data needs. In the UK the Association for Geographic Information (AGI) was established in 1989. Independent of government, the AGI was established to act as a coordinating body for geographical information issues as well as a centre for geographical Information. One of the responsibilities of the association is the handling of the National Transfer Format which was formerly controlled by the OS. The AGI forms an important link between the government, academics and private sector users of GIS.

There are five professional organisations which have some claim to GIS in the US including the

NCGIA which was established in 1987 (Morrison 1991). The NCGIA has four principal goals, these are: 1) "to advance the theory, methods and techniques of geographic analysis based on GIS" (Morrison 1991, p.95) to help ensure the supply of GIS experts, 3) to promote the use of GIS through the scientific community and 4) to act as a central source and disseminator of information concerning various aspects of GIS. The establishment of the NCGIA has had a number of effects on GIS education in the United States. Morrison (1991) reports that GIS related positions were established at a number of universities, and that a number of top academics were enticed to other universities in order to form strong nodal points of expertise. A bi-product of the NCGIA was the establishment of a Core Curriculum for GIS educators, the use of this curriculum has extended past the boundaries of the United States and forms a substantial part of courses in other countries including South Africa. As in the United Kingdom the associations provide the link between the three sectors discussed, ie the government, commercial and academic sectors.

### 2.7.2 - GIS in Third World Countries

There has been a steady increase in the availability and use of geographical information and GIS in Third World countries since the mid 1980s. This is evident in the increase in the literature documenting the application of GIS in different areas of the Third World (Fox 1991; Hedburg 1991; Hastings and Clark 1991; Gar-On Yeh 1991; Sundaram 1987; Calhoun *et al.* 1987; Nkambwe 1991; Fincham, McDevette and Piper 1991, 1993; Henstock 1989; Rix and Markham 1994; Price 1994 and Bujakiewicz and Mulolwa 1994). Due to the relatively recent appearance of the technology in these countries this literature tends to discuss experimental, pilot or project related GIS, as opposed to mature systems. The problems and focus of GIS in the Third World differ to those of the First World due to different factors in its promotion.

#### Government and local government

The commitment shown by developing countries regarding the acquisition of spatial technologies and GIS varies considerably. Countries such as China and India have developed their own GIS, whereas the governments of other countries such as Indonesia, Singapore and Malaysia have invested large amounts of capital in acquiring the technology (Fox, 1991). Like their First World counterparts it is those departments with a mandate to produce a definite product such as mapping agencies which have been among the first to adopt the technology. In Malaysia this department is the Department of Surveys and Mapping which uses GIS for small scale mapping and cadastral mapping. In Indonesia this role is fulfilled by the National Coordination Agency for Surveys and Mapping (NCASM). The primary use of GIS by this department is for mapping, however the technology is also used for physical planning and land resource inventory (Gar-On Yeh 1991). The incorporation of first world technology has not however been limited to the relatively affluent developing countries. Calhoun *et al.* (1987) reports on the use of GIS in the systems poor environment of the Sudan, and Hedburg (1991) has examined the use of GIS efforts in both Zambia and Uganda. In these countries however the interest in GIS seems to have been generated outside the country rather than through the efforts of their respective government.

The use of GIS as a tool for certain types of planning has been a prominent feature of GIS in Third World countries. The interest in the technology for this purpose was expressed succinctly in Asia at the Visakhapatham seminar in India, 1985. Organised by UNESCO, the seminar brought together a number of development planners and information specialists from developed and developing countries alike in an endeavour to stimulate sub-national development planning (through GIS) and coordinate an Asian cooperation programme (Sundaram 1987).

Although the Visakhapatham seminar indicated a willingness by developing nations to examine the possible advantages of the technology, its subsequent use depends on the individual countries motivation and ability to supply the prerequisites for its introduction. Sundaram (1987) regards the following four factors as essential for the establishment of the technology: 1) a reliable source of data collection, b) a viable communication network, c) a knowledgeable human resource base, with a variety of expertise in the various facets of the technology and d) competent government officials who are able to evaluate and use the information in order to enhance the decision making process. Although some of these factors are being addressed in a number of countries it is evident from the problems addressed later in this chapter that there is still a lot of work to be done to achieve these goals.

The majority of GIS in the Third World are focused on resource based applications although there are examples of GIS being developed for integrated rural planning. These include the Natural Resource Data Management System (NRDIS) in India (Sundaram 1987) and the Resource Utilisation and Regional Planning Information System (RURPIS) in Botswana (Nkambwe 1991). The latter has been developed to provide information to planners at a local level and to help co-ordinate the national programme. RURPIS consists of four sub-GIS which incorporate a wide range of variables including environmental resource data, economic and cultural data, census data and land use data. Many of the uses envisaged for the completed system are rural development based and will address a number of primary issues such as health care, agricultural services and famine detection.

A feature of a number of GIS programmes in developing countries is the presence of donor assistance. Calhoun *et al.* (1987) stresses that there is an national mandate for national economic development planning and concomitant of national accounts. This attitude, he says, is implicit in the activities of the world bank and IMF where evidence of development planning is sought by both public and private donors. This approach requires an enormous range and complexity of information which many of the governments of the developing countries are ill equipped to handle. The basis to this approach is the idea that computer hardware and software are seen (by the donor) as an efficient and cost effective way of improving accountability and information flow in these countries, a view which is often not shared by the receiving country.

Hastings and Clark (1991) stress that the development of GIS in developing countries with donor assistance is not a one way process. Donors often supply the technology, training and financial assistance while the host country (organisation) might supply staff, office space, finances and infrastructure. An example of donor assistance is RURPIS which is being developed in conjunction with Stockholm University and Kansas State University. Another example is the Global Resource Information database (GRID) run under the auspices of the United Nations Environmental program (UNEP). Situated in Kenya, the database underwent a pilot phase between 1985 and 1987, becoming operational in the early 1990s. The purpose of GRID is to supply users with access to harmonised and integrated geographical data sets of a known quality (Hastings and Clark 1991). Run by a small fulltime compliment of staff out of Nairobi, the project personnel are augmented and guided by visiting experts, colleagues and an advisory panel (Hastings and Clark, 1991). The advantages of these arrangements are that the staff stationed in Nairobi provide a node of expertise to surrounding countries. Despite this expertise basic problems have been experienced; for example the development of a natural resource database for Uganda. The development of this database was undertaken in 1987 by GRID in cooperation with the Ugandan Ministry of environmental Protection (MEP) in Nairobi (Hedburg 1991). The database proved a success in that it has been used by GRID as a demonstration model, however practically speaking the database at a scale of 1:1.5 million proved to coarse to be useful to the MEP as an operational system. In addition no strategy for the future utilisation or implementation of the database at the MEP was planned. By 1989 the database was still in Nairobi and no data for transferral had yet been set (Hedburg 1991).

The failure of this system in practical terms and the consequent disillusionment with the technology has been a common feature of GIS in both the developed and developing world. Hedburg (1991, p.106) stresses that 75% of all systems development undertaken is either never completed or not used if completed. It has been noted a number of times that the organisational and institutional problems far outweigh technical ones. The question which is important at this stage is have the developing countries who lag behind in the computerisation process been able to take advantage of the experience gained in the developed countries? On the basis of three case studies in Africa Hedburg (1991) concludes that "mainstream Western system development strategy and practices were unaltered being transferred to developing countries and that the difference in outcome was mainly a question of degree" (Hedburg 1991, p.110). Gar-On Yeh (1991) observes that Third World countries appear to have adopted the technology and the problems directly from the First World countries, the only difference being in the acuteness of these problems which appear many times greater than in the developed countries. A few of these problems are discussed briefly below.

1) The provision of suitable geographical data and their attributes has remained a problem in both developing and developed countries alike. These problems are concerned not only with the acquisition of data but also with the conversion of existing data into a format in which it can be effectively used. Available data is often not complete, varying in currency, precision, accuracy, verifiability, clarity, comprehensiveness, scale, projection and appropriateness. The European developers of the CORINE GIS (Briggs and Mounsey 1989) experienced a number of problems developing a European database for environmental purposes, notably the uneven coverage of factors, the existence of mapped and digital data at different scales and projections, the

unavailability of certain existing map series due to legal restrictions in certain countries such as Greece. Lack of environmental data can to a certain extent be remedied through the use of remote sensed data. Natural resource based GIS databases are not usually entirely environmentally based, other factors such as political boundaries, management unit boundaries and transport networks are also needed in order to be able to address a range of issues (NCGIA 1990, Unit 9). The acquisition of certain socio-economic data such as demographic, migration and economic data is often more problematic than physical data, which requires expensive and time consuming surveys. The traditional detailed indicator of socio-economic conditions in a country, the census, is often not of a suitable quality or current enough to be used with any degree of confidence by planners. Government departments often hamper the flow of socio-economic data due to their lack of coordination in the collection, exchange and dissemination of data and to the low priority govemments often assigned to the collection of socio-economic data, a point which needs to be addressed in the developing countries (Gar-On Yeh 1991). A parallel problem with the paucity of data in the developing countries is the lack of suitable data standards to ensure that what digital data is available can be exchanged and used with a certain degree of confidence. A number of developing countries are not oblivious to this problem. Threshold countries such as China and India have each been developing suitable data standards.

2) In some Third World countries planning has not advanced to the point to warrant the use of GIS, in such cases the information that GIS is capable of producing may be superfluous in the current planning system. Many planners are also not yet aware of the tools or potential applications which are offered by the technology. This process is slowly being remedied through education, but even in the developed countries this remains a problem (see Chorley 1988).

3) The shortage of trained personnel is a common problem in both developed and developing countries alike, although it is especially critical in the latter.

Hardware and software developments often leave the education system behind even in developed countries. Universities and centres for learning in a number of the developed countries are however often at the forefront of GIS research, and make important contributions in the form of manpower and expertise to local GIS initiatives as discussed earlier in this chapter. In Third World countries, educational institutions also form important nodes of expertise, however, they are invariably less sophisticated in the technologies use than their counterparts in First World countries.

The need for suitable skills in developing countries is one of the most important factors constraining the use of GIS. Sundaram (1987) stresses that there is an urgent need to command the socioeconomic development of science and technology through large scale training of the relevant target groups. Sundaram recognised four main target groups in planning. They are designers, survey and data collection specialists, analysts and policy planners and decision makers. Despite this recognition, training of these groups has been extremely slow, and a number of authors (Fox 1991; Hedburg 1991; Gar-On Yeh 1991; Sundaram 1987; and Tayler and

Clark 1991) consider the lack of suitable skills one of the most serious limiting factors confronting the incorporation of GIS in developing countries.

4) GIS technology is more often than not imported from developed countries using needed foreign currency. A number of Third World countries including India and South Africa have developed indigenous software, whilst China has developed both hardware and software. Gar-On Yeh (1991) noted that the software packages developed in the Third World were for small projects with a microcomputer base. The South African developed package ReGIS runs against this trend. The package can operate on a variety of hardware platforms. Problems with these packages often include glitches in the systems and insufficient reference manuals and training programmes. Imported GIS manuals are usually more complete but the manuals and software commands are usually written in the langauge of the originating country, or in English, a feature which often leads to bottlenecks and frustration for users who do not speak the langauge. GIS users who wish to query systems operations or whose programs require alteration are often frustrated by the lack of vendor or program support in Third World countries, a facility which is usually available in developed countries. Lack of support facilities in a developing country require a hardware and software configuration consistent with the conditions, the hardware configuration requires some stand alone work-stations to ensure that hardware problems in part of the system do not bring the operation to a standstill.

5) The organisational home of the GIS needs to be established before its inception; this includes the need for a long term plan on its growth with regards to upgrading, increasing its application areas or incorporating it as a DSS. Gar-On Yeh (1991) notes that a number of GIS projects in the developing countries are geared to serve the needs of specific development projects with little or no long term objective with other GIS or databases. Most GIS are not institutionalised at all but are small experimental or pilot projects which are run by universities with little or no input from practitioners. In cases such as this, without institutional arrangements, and long term funding the completion of the project often means a reduction in the GISs complexity and operation. In contrast, the small number of national or urban GIS in the developing countries are expensive and require coordination, institutionalising, a large database and steady financial backing to support it.

**2.8 - Characterisation of GIS in First and Third World Countries**

First world countries are characterised by:

Strong Government interest in information technology expressed through:

- a well developed national digital mapping system providing useful physical data and access to socio-economic data;
- the development of geographical information systems, improved data collection, dissemination and information handling
    - through investigative committees

- the establishment of centres of expertise
- investment in education
- funding for system development/improvements in the technology.

- a strong academic sector interested in the development of all aspects of the technology;

- dynamic and committed education component to ensure skilled graduates as well as opportunities for study such as bursaries and opportunities;

- the existence of national interest groups dedicated to the advancement and coordination of the use of geographically related information;

- a maturation of GIS systems and policy with increasing cooperation and joint ventures between government departments and between government and other sectors of the economy;

- a vigourous commercial sector active in the sale of GIS, the provision of associated services and a correspondingly large user sector;

- application diversification from the more traditional physical environment based application to involve socio-economic and business related applications as well.

Problems include: the lack of current data, a lack of user awareness, little adherence to digital standards, a lack of trained personnel, organisational problems and a shortage of capital.

Third World Countries are generally characterised by:

- increasing government involvement and funding in countries capable of supporting GIS, increasing interest generated through conferences and by other means such as vendors and international organisations;

- governments which sometimes vigorously control data and information availability;

- few governmental organisational structures capable of successfully supporting the technology;

- competition with other products such as basic necessities for limited monies, shortage of money for education and facilities;

- a limited pool of expertise capable of supporting the technology.

- a limited amount of data collection takes place in a number of countries; few data are available in the form of maps and tables, especially socio-economic data, little or no digital data is available;

- a preponderance of external funding and bilateral agreements, with the external partner often supplying the expertise needed;

- few established large installations, the majority are either establishing , experimental or pilot project GIS. Those installations which do exist are often run by ex-patriots;

- GIS is still based firmly on the more traditional environmental based application, little diversification has occurred to include socio-economic and business related applications;

**2.9 - Conclusion**

This chapter identified the elements which make up a GIS and discussed each of those features identified as critical for the application of the technology. It was indicated that the hardware and software components of the system were less likely than the human, institutional and data components to result in the failure of the system. It was pointed out that the use of a structured approach to GIS implementation would decrease the chance of failure of a GIS.

There appears to be a strong generic case for the use of GIS in planning with a number of attendant advantages of applying the technology for this purpose. There are a number of disadvantages as well for Third World countries, these include the cost of the technology and the relatively slow maturation of the system which tends to limit results in the short term. In these cases the advantages of the system have to be visible to compete with the seemingly more pressing matters such as the provision of health and education facilities which provide more visible, immediate and practical results.

Although GIS has only been used in the Third World countries for approximately ten years the problems experienced by users in these countries appears to mirror those of the First World. Third World countries problems however appear magnified in this regard. The reasons for this are what have been referred to in this study as the operating environment which are elements at the national level that contribute to the advancement of the technology. These elements are principally related to government involvement, which are reflected in terms of data availability (institutional constraints), financial constraints, infrastructure and most importantly suitable skills.

The use of GIS for addressing problems in the rural areas has tended to occur at a regional level in First and Third World countries alike. The rural areas have not received as much attention in both the United States and Britain as the more populated urban and peri-urban areas as evidenced by their respective mapping programs. This would appear to be logical as both mapping agencies ultimately cater to demand. Most of the rural planning carried out in the

United States appears to be environmentally orientated, although the emphasis on the physical environment is changing. In Third World countries there is still an emphasis on environmental issues, reflecting perhaps the greater reliance on the land for the majority of their people. In addition many of the bilateral programs running in the these countries tend to have an environmental emphasis, perhaps reflecting the concerns of the host country. Socio-economic data is scarce in these countries due in part to the land systems, a highly transient population and the fact that few houses have formal addresses which increases the difficulty of keeping track of the population. Most countries rely on their census for socio-economic data, however, the high illiteracy rates in many Third World countries make the accuracy this source of data unreliable.

Most GIS used in rural planning and development in both the First and Third World have been located in the urban areas where they can achieve economy of scale by sharing hardware and software. Infrastructure capable of supporting computer systems as well as the required skills is also more likely to be available in these areas. This may also suggest a reason why the technology has been used at a regional scale rather than at a local scale. Another possible reason that the technology is not often used during large scale planning such as at the project level are the attendant costs which accompany such planning such as personnel, hardware and software. The planning process is usually not a long term process with the result that when the planning is finished the source of funding for the GIS ceases. Most GIS employed at this level of planning are therefore likely to be pilot projects or experimental GIS run either by universities or the private sector.

The following chapter examines the application of GIS to planning as well as the operating environment of GIS in South Africa.

## CHAPTER THREE

### GIS DEVELOPMENT IN SOUTH AFRICA

#### 3.0 - Introduction

In parallel with other developing countries, the use of GIS technology in South Africa began in the early to mid 1980s. Initial growth of the technology in the country was slow, however the late 1980s and early 1990s saw both a steady increase in the number of GIS users and applications. A number of sectors of the South African economy make use of GIS. The most active sectors applying GIS are various departments of central and local government, educational institutions and increasingly the business sector and GIS support industry.

#### 3.1 - GIS in central government

It was indicated in Chapter Two that First World governments have had an important role to play in stimulating development of GIS technology. Government interest in the technology is probably based on the fact that many of their primary functions are information related, in this regard they have three main roles, these are as: 1) data gatherers, 2) data users and 3), as data disseminators. These roles are also apparent with regards to the South Africa government.

The increased use of GIS by South African government departments has helped GIS development by:

1) stimulating the private sector, principally vendors and data contractors;
2) increasing public and private sector awareness of the technology;
3) making spatial digital data available;
4) making money available for the development of data standards and central data repositories.

A number of government departments in South Africa have developed GIS capabilities, these include the Department of Water Affairs and Forestry (DWAF); the various Surveyors General; the Chief Directorate of Surveys and Land Information (CDSLI); the Council for Geoscience; the Department of Housing; and the Department of Environmental Affairs and Tourism (DEA) (Fincham, McDevette and Piper 1991; Division of Building Technology 1995). Other departments developing systems include the departments of: Health, Education and Culture Services, Regional and Land Affairs and Central Statistical Services.

A number of these departments are important collectors and disseminators of data, including rural related data and therefore have an important role to play in terms of making data available for rural planning.

**The Department of Water Affairs and Forestry (DWAF)**

The DWAF developed in-house GIS capabilities during the early 1980s. They enhanced these capabilities in 1987 with the installation of commercially available GIS software.

The department collects a wide variety of data including that relating to rural communities and their environment. These data are used at a number of scales and planning levels. The largest of these scales are at a basin level (Polton and Brown, 1989).

GIS is used by DWAF for holistic and long term planning as well as the development of hydrological and water quality models. The extent to which the GIS fulfils these functions is not clear, however DWAF has made an important contribution towards increasing public and user awareness of GIS and its capabilities through the use of a demonstration model which has been shown around the country. The DWAF have also encouraged data sharing by making their data available to other GIS users free of charge.

**The office of the Chief Directorate of Surveys and Land Information (CDSLI)**

The Chief Directorate of Surveys and Land Information (CDSLI) is the custodian of geographic feature data in South Africa. The CDSLI consists of four parts:

1) the various Surveyors General: who are the custodians of cadastral data (properties and their ownership),
2) the Directorate of Mapping: who produce amongst others the 1:500000 and 1:50000 digital national mapping series,
3) the Directorate of Control Surveys: who control survey networks, including the trigonometric beacons,
4) the National Land Information Services (NLIS).

The CDSLI initiated a move towards obtaining GIS functionality in 1986, when a pilot project for a cadastral information system was initiated (Henstock, 1989). By the end of 1994 a large portion of the country's cadastral features such as original farm boundaries had been completed. The CDSLI through the Directorate of Mapping had by this date also completed the digital 1:500000 topographic series of the country and had completed approximately 30% of the 1:50000 map series. Other digital data available from the directorate included a digital elevation model (DEM) which varies in resolution from 400 to 50 meters across the country. The directorate presently faces an important task in maintaining an accurate and current record of the various political boundaries in South Africa which have undergone a number of changes over the past five years.

The CDSLI have also played a leading role in national efforts to coordinate GIS activities. These initiatives have focused on the Coordinating Committee for the National Land Information System (NLIS) which is chaired by the Chief Directorate of Surveys and Land Information (Fincham *et al.* 1991). The objective of the NLIS is, according to Clark, D. (1989, p.1), to provide a meaningful, coordinated and integrated computer based land information system on a national basis. It is envisioned that the databases maintained by the NLIS will include a wide variety of factors, including: cadastral land parcels, areas and boundaries, deeds, zoning, socio-economic and various data on the environment. Approved in May 1988, progression of the NLIS has to date been slow. Fincham *et al.* (1991), considers the NLIS to lack national legitimacy, which, according to McDevette (1991), may be due to the fact that the LIS/GIS community is still fairly young and lacks full financial commitment by the government.

The directorate also plays a significant role in the country's National Exchange Standard (NES). Established by a project team of the CSIR's National Committee for remote sensing in 1987, the standard is managed through the Coordinating Committee of the NLIS (Clarke, D. 1989; Cooper 1988). The committee is assisted in this task by a National Exchange Standard Committee (NESC) who were formed to promote and maintain the use of the NES. Although favourably received in principle by the government and private sector, the NES is not widely used. According to Fincham *et al.* (1993) this may be due to inexperienced GIS users and the premature development of many GIS. Another factor contributing to this situation is the relative paucity of digital data in South Africa which has resulted in organisations establishing their own standards to fulfil their immediate needs. This was the case with the DWAF. Presently in South Africa a number of industry standards prevail, but with the increasing availability of data from the Surveyor General an increase in the use of the NES could be expected.

**The National Information Management Project (NIMP) of the RDP**

In addition to the coordinating attempts of the CDSLI through the NLIS the development of an integrated data model for the RDP is being undertaken by the office of the minister without portfolio. The primary objective of NIMP is to develop a data model that will allow the seamless use of data across government departments (Division of Building Technology, *et al.* 1995). The project will also endeavour to make the various players in the RDP more aware of data management and data issues relating to the RDP.

**Department of Environmental Affairs and Tourism (DEA)**

The DEA has a strong association with GIS as one of the 'traditional' application areas of the technology. The various provincial Parks boards have strong GIS capabilities, using the GIS to monitor migratory patterns, record animal counts and other environmentally related studies (Colvin and Fincham 1987). The department, through the National Parks, has often been in conflict with the rural peoples that populate the boundaries of these parks. The parks are often seen as a source of natural resources by these people which brings them into direct conflict with the Parks Boards. Whether GIS are being used to try and resolve these conflicts is not clear from the available literature, however, the potential to apply this technology as a tool to help resolve the ongoing conflict is a possibility.

**The Department of Health**

The Department of Health is moving towards a geo-referenced digital database and are presently involved in a number of initiatives aimed at achieving this goal (Dr K. Herbst, pers. comm. 1995). Projects are presently being funded through bodies such as the Medical Research Council (MRC). Ongoing projects include the development of a Malaria Information System in Northern Kwa-Zulu Natal. This project is presently being extended by the MRC to include other areas of South Africa (Sharp *et al.* 1988). Primary data collection for this project in the rural areas of Kwa-Zulu Natal has been achieved with the help of a global positioning system (GPS). GIS are also being used to locate health resources in order to ascertain the resource base for primary health planning (Stead, 1995). It is possible that these initiatives will pave the way to a more encompassing rural health information system in South Africa.

**Geological Survey**

The extent to which GIS is used at the Geological Survey could not be ascertained, but the Survey has made available a 1:1000000 geological mapping series of the country.

**Central Statistical Services (CSS)**

CSS is the only mandated data collection organisation in South Africa. One of the important tasks conducted by the CSS is the national population census which is performed every five years. At present the maps used to define the base geographical unit of the census, the enumerator area (EA), are paper based. A project was initiated in March 1995 to be completed by the end of May in the same year to digitise these areas for the 1995 local elections as well as the next census, in 1996. The project will not only record the 42000 existing EAs in South Africa but will also define approximately 40000 new EAs in the former TBVC states.

**The Human Science Research Council (HSRC)**

The HSRC, a Government funded research institute, has built up an extensive human and environment related data base and has coupled this with a GIS unit capable of sophisticated analysis. Involved in both environmental and social research the GIS unit seems set to revolutionise the data market by supplying cheap socio-economic data at the level of the enumerator area (Schwabe 1994, pers comm). The unit already has extensive data sets of the Kwa-Zulu Natal region including demographic data down to enumerator level, and was instrumental in helping site polling stations for the 1994 National elections (Illing, Pillay and Scott 1995).

**CSIR**

The CSIR, formerly the Centre for Scientific and Industrial Research, is a partially funded government research institution which in the past fulfilled the scientific and research needs of the Government. As a result of a decreasing government grant the emphasis of the CSIR has changed from a research driven to a market driven approach (Pryjomko 1994). The CSIR has had a long association with GIS and image processing technology having developed their own sophisticated mapping system in the early 1980s (Cooper pers comm. 1995) as well as housing the Satellite Application Centre. The CSIR presently maintains the necessary expertise to provide consulting services in both the technical aspects of the technology as well as specific application fields such as forestry and environmental services. A move has been made by the CSIR to provide the RDP with technical support and expertise, including the development of grass-roots information systems. A number of projects involving GIS supporting this objective were active at the beginning of 1995, including a grass-roots water related data base for the Northern Province and the National Housing Database in the Division of Building Technology.

### 3.2 - GIS related problems at a national level

Although the importance of spatial information and spatial information systems are recognised by the South African government a number of problems are apparent at a national level.

1: The first problem, is a lack of government backing of spatial technology, especially at an educational level. This may have been influenced by the fact that at a national level a number of issues are competing for limited funds. GIS is often seen as having a high cost coupled with a slow maturation period. These factors conflict with the need to produce results in as short a period as possible, a feature on which future funding often depends.

2: The second problem concerns the institutionalisation of the technology within government departments. It was stressed in Chapter Two that the acquisition and use of a GIS often requires organisational change in order for the technology to be effectively applied. Fincham *et al.* (1991, p.457) observed that although the decision may have been taken by various government departments to accept the technology, the many layered hierarchial system which characterises the management structure in the South African Government has remained, limiting its effectiveness.

3: There are a number of data related problems at a national level which affects both public and private sector GIS.

- a:) The coverage of digital geo-referenced data is uneven, with the 'old South African' areas being better covered than the apartheid created TBVC states. Urban areas are also better covered than rural areas.
- b:) The data collected by government, although sometimes fairly detailed, is often patchy, and is rarely used at a finer resolution than that of the magisterial district. This places a limit on the data and consequently the planning level at which it can be used effectively.
- c:) Data related to the physical environment is more readily available than socio-economic and demographic data. Detailed socio-economic and demographic data are available in digital format from the 1991 census. These data can however only be displayed at a magisterial district level as a complete digital dataset of the EAs has yet to be completed.
- d:) Existing digital data occurs at different scales, accuracy and currency.
- e:) Existing digital data occurs in different formats, making it hard to relate data sets. Spatial

data are complex and the internal structures of GISs vary significantly which complicates the exchange of data from one GIS to another. Although South Africa has its own exchange standard it is not extensively used. This is due in part to the complexity of the NES and the fact that software has to be obtained to interpret the NES. More common is the use of internal formats such as DXF.

f:) Although the transference of geo-referenced data is often difficult it is still understood. It is the attribute data which is more problematic as it often has several meanings. This problem is compounded in South Africa which has more than one official langauge. As yet a definitive data dictionary of entities, standard names for features and terminology data has not yet been completed for South Africa.

4:) Probably the most contentious issue of the past few years concerns the copyrighting and cost of spatial analogue and digital data produced by (CDSLI) and other government departments: not all the data generated by government departments are in the public domain. Data produced by the CDSLI such as maps and digital data are under copyright, which may be infringed if digitised or used for commercial purposes (SAGIS Panel Discussion 1989). CDSLI used the copyright laws to protect their data as there had been cases where private companies sold bastardised versions of their data. CDSLI copyright policy, coupled with the high cost of data, hampered the free flow of information in South Africa, an issue which prompted Fincham, *et al.* (1993) to stress that these problems, unless resolved could cripple innovative planning and development in South Africa. At the end of 1994, CDSLI changed their policy. They realised that it was critical that their data be used as widely as possible to provide a common framework on which to hang digital data and to support the Reconstruction and Development Programme (RDP). To achieve this goal they have reduced the price of their data to the cost of reproduction and will only enforce copyright if an individual or organisation tries to use their data to make a profit.

5:) There is still no clear pricing structure evident between government departments, individual departments appear to determine their own policy in this regard. Some, such as the Geological Survey are still charging high prices for what is essentially public information.

### 3.3 - Local government (municipalities)

A number of municipalities have GIS capabilities, including most major cities and metropolitan areas: Cape Town (van der Merwe and Reyneke 1989; van der Merwe 1989 and Genanews 1994), Durban (McGivergan 1995), Pretoria, Johannesburg (Vosloo 1987), East London (Lawless 1995) and Pietermaritzburg (van den Berg 1989). The role of GIS in these urban areas may differ substantially. However many are orientated towards fulfilling an automated land information system, as well as the management of utilities such as electricity and water networks. Data of primary interest in these systems usually includes cadastral data such as erven and data associated with individual erfs, utility networks such as electricity, roads, water and sewerage pipes, land use and zoning. Whether these systems are being used purely as automated mapping or as GIS is not clear from the literature. What is apparent is that a number of municipalities, especially the smaller ones, are using CAD to display the above information rather than GIS. These municipalities should be able to upgrade to full GIS functionality in the future without a problem.

### 3.4 - GIS in educational institutions

The use of GIS at universities for teaching and research purposes has gathered momentum since 1988. In that year the South African Geographical Society observed that of 200 academic staff in geography departments in South Africa only 3 had listed GIS as a field of interest (Wills 1989). By 1991 the geography departments of the Universities of Cape Town, Stellenbosch, RAU, Rhodes, Pretoria and Natal offered some type of GIS course (Fincham, *et al.* 1991). Despite this progress, Fincham, *et al.* (1991, p.458) observed that "the lack of a national programme for developing the training, research and applications agenda for GIS poses a serious threat to its long term viability and institutionalisation." In addition the universities are not catering for all the skills required by the marketplace. It could be argued that a university education trains a student to think, rather than providing the student with a particular skill, and that this training should be provided by technikons. However, few if any, technikons were providing GIS training in South Africa by the end of 1994. Although GIS skills are taught in a variety of university departments including geology, landscape architecture and town planning, the majority of GIS versed graduates are products of geography departments; these students often lack sufficient computer science skills to utilise the technology effectively. Computer science graduates in turn lack the application based background to become more than GIS technicians. In countries such as the United Kingdom and the United States, students can, together with another major, major in GIS. A similar concept is perhaps needed in South Africa in order to produce students familiar with the different aspects of the technology and the capability of using it. Ultimately a range of GIS skills are required for the business sector, including GIS managers, GIS specialists, analysts, system administrators, database administrators, programmers, cartographers and operators (Hine 1994). A factor limiting this development in GIS at the moment are that many of the better known GIS "experts" have been attracted to the private sector and that many of the university staff teaching GIS courses are self taught, and possibly lack the experience and expertise of first world educators who have had more time to develop their expertise, or who are themselves products of a more developed GIS training system.

Universities and institutes in South Africa have made important contributions to fostering the use of GIS in the country. One such institute is that of the Institute of Natural Resources (INR). Attached to the University of Natal, Pietermaritzburg, the INR was a major force in GIS during the mid-1980s to early 1990s. The INR officially initiated their GIS program in 1986 (Fincham and Berjak 1990). The INR developed their GIS capabilities around practical issues, focusing on environmental issues and rural upliftment in Natal. The INR's importance rested on the fact that their learning curve together with the problems experienced while institutionalising GIS at the institute was made transparent through extensive documentation (Berjak and Frankland 1989; Schwabe and Johnson 1990; Fincham and Berjak 1990, 1990a; Fincham and Martin 1991 and Fincham and Wolff 1991). Individual members of the INR also played a role in fostering development among other GIS users and contributed to exposing the potential of the technology both in the Natal region and South Africa as a whole.

### 3.5 - South African GIS interest groups

Interest in GIS technology and issues in South Africa are reflected in the establishment and growth of regional GIS bodies such as the Traansvaal Association GIS, Natal Association GIS and the Eastern Cape Association GIS. These bodies could play a central role in addressing GIS issues and coordinating and developing data standards. As yet they tend to lack national legitimacy being based at a provincial level. There are moves to unify these regional structures at a regional structure (Kotze 1994), an occurrence which should take place during 1996. Despite their lack of national legitimacy GIS interest groups have managed to stimulate interest in GIS and mobilise the GIS community through conferences and workshops.

The first conference dedicated entirely to GIS was held in Pietermaritzburg in 1987 (EDIS, 1987). Since then a number of GIS conferences have been held in Southern Africa these include amongst others SAGIS (1989), and the Third Seminar on LIS/GIS held in Zimbabwe in 1991. GIS articles and papers have also featured strongly in user interest groups such as the Conference of Southern African Surveyors (CONSAS 1989). GIS development in South Africa has also featured for the last four years in GIS World, a book reflecting annual hardware and software developments as well as providing a synopsis of GIS development in individual countries (Fincham, *et al* 1991, 1993).

Although the number of GIS users have continued to grow, the number of people producing papers either for publication and/or conferences appears to consist of a relatively small but enthusiastic nucleus of people. As the sophistication of GIS users grow there is an ever increasing need for GIS users to share their experiences in order to make other users aware of the possibilities that exist within the technology.

### 3.6 - Private sector involvement

Private sector involvement could, for convenience, be divided into two categories. The first category is comprised of those companies selling and maintaining GIS, included in this category are those in the business of data provision. The second category are businesses using GIS as a tool to help increase their decision making capabilities or manage their resources. These categories are not necessarily exclusive as overlap does occur.

A limited number of the larger and better known GISs have been sold by vendors in South Africa since the mid 1980s. Local GISs such as ReGIS and AllyMap were also successfully developed during the late 1980s, possibly as a result of sanctions during the apartheid era. The end of the apartheid era has seen the GIS market flooded by a number of GIS. Most GIS vendors are involved in a number of facets of the GIS market including GIS training and the provision of certain data.

A discussion of the role of the private sector during the (1989) SAGIS conference concluded at that time that the sector was limited in extent. Application areas identified during this discussion included consulting services, data subcontracting and the provision of sophisticated modelling and analysis expertise. By the end of 1994 a number of these niches were being filled, with the emphasis being on the provision of data. There still appears to be a need for GIS consultants not attached to any particular GIS product or vendor, however, at the moment the market does not appear to perceive this as a necessary service, with the majority of GIS users opting to do the planning in-house.

During the late 1980s the private sector maintained a fairly low key position as far as the use of GIS was concerned. Lees (1995) attributed this to six factors, these are:

- a lack of understanding by vendors of the business clients needs,
- the lack of business in spatial data and its attributes,
- the lack of data standards and an effective means to disseminate data,
- the fact that clients databases were not geared for geo-coding,
- a shortage of expertise within the country to manage the process.

This position has slowly been changing. A number of companies, especially those involved in utilities and marketing, have recognised the advantages that GIS can offer their business. Utilities giants such as TELCOM and ESCOM have stimulated the GIS sector in a number of ways (Computer Graphics 1994). Both companies are currently developing databases that, due to their size and data resolution, will have important connotations for other GIS users. Both organisations are collecting data at household level for the entire country. This fact, combined with their commitment to extending their services to the rural areas, augers well for increased data availability for these areas. In addition the search for and development of suitable data standards for Telkom's database has resulted in renewed interest in data standards in South Africa. Telkom has been instrumental in stimulating both the NLIS and the NES through financial investment in these institutions.

Other large companies developing GIS, or with GIS capabilities, include: First National Bank (Lees 1995) and a number of the mining houses such as Anglo American. GIS capabilities are not limited to large companies, the advent of cheap, functional GIS such as MapInfo and Atlas have put GIS within range of small businesses and the public, and it is this market which appears to be rapidly expanding.

### 3.7 - Issues surrounding data availability in South Africa

The availability of geo-referenced data in South Africa differs according to geographical location and theme. The largest complete digital map series covering the country is the 1: 500 000 topographic series. Certain features such as provincial boundaries are complete and available at a scale of 1: 50000, however the digital 1: 50000 topographic series was only 40% complete at the beginning of 1995. Large parts of the country are also covered by a 1: 10000 orthophoto map series, although the currency of this information differs widely. In general the former TBVC states are substantially less well covered than the rest of South Africa, having taken responsibility for their own mapping program. For example the latest orthophoto maps of the Transkei are from 1982, but for some areas of South Africa are 1993. The availability of theme specific data such as soils maps, geology, vegetation and ground-water differ according to location and the importance of the theme to the area. Satellite imagery is also available for the country but is relatively expensive.

Current socio-economic data is hard to obtain in the country. Generally speaking the best socio-economic data available is still the 1991 census data or projections of this data. Problems however exist in that there is as yet no dynamic way to spatially represent this data at a scale larger than that of the magisterial district for most of South Africa's provinces.

South Africa still faces problems with regards to the acquisition of accurate socio-economic data in the face of rapidly shifting populations in the urban and peri-urban areas of the country. Shifting squatter settlements and the ongoing influx of people from the rural areas make this task difficult. There have been attempts to address this problem in the greater Durban area where aerial photography and ground surveys have been shown to be fairly accurate and updatable (Eekhout *et al.* 1987). There is a need for accurate socio-economic data if development planning is to move past "physical planning" and address the development needs of the people of a region.

### 3.8 - GIS in rural planning in South Africa

Very little documentation exists concerning the use of GIS in the rural planning sphere of South Africa, although there is evidence of increased interest, especially from foreign interest groups (Pryjomoko 1994)

The application of GIS to rural development to date has been conducted mainly at a regional or small scale and has tended to concentrate on resource assessment or environmental matters at project level (Schwabe and Johnson 1990, Fincham and Wolff 1990).

Experienced GIS users have indicated that the incorporation of the technology at the project level has been difficult for a number of reasons.

The first reason concerns the dichotomy that exists between South Africa's urban and rural areas, with the latter being poorly equipped to incorporate GIS technology in terms of infrastructure and human resources. This has resulted in GIS work principally being carried out in towns or cities where the infrastructure and expertise are more likely to exist.

Secondly, there has been little interaction with people at ground level due in part to the unsuitability of a basic GIS to interact with the grass roots. Advancements in technology however appear to be making this perception increasingly redundant as discussed further in this chapter.

Thirdly, although some interest has been expressed by NGOs to incorporating GIS at this level, the difficulties involved in such ventures appear to have limited their involvement (see Chapter Four).

Technological advances have to a certain extent helped to make computers and GIS more mobile. Hand held positioning systems such as the global positioning system (GPS) have also helped to increase both the mobility and applicability of GIS to the rural area's of South Africa, by providing an easy means to undertake primary data collection for areas where data is not available.

The development of innovative software has done much to bridge the communication gap between technology users such as planners and the community. An example of such software is the 3-D visualisation technology (3DVT) used during the Chatty River Project (McKay , 1994). The technology has enabled the community to interact fully with the planners and guide the planning process with an understanding of the issues and consequences of their decisions. The software bridges the gap between the community world view and the shortcomings of their visualisation of the traditional paper map by producing a realistic 3-D image of the area. This was achieved by incorporating a 3-D image with photographs of the area draped over it, the image enabled community orientation through the recognition of local features. The image can be combined with computer modelling and graphics allowing manipulation of the image for interactive planning purposes (McKay No Date). A possible drawback to innovative systems such as these are the skills and equipment needed to produce the images and guide the process. This factor would probably limit the use of the technique, a fact noted by the development team involved in the Chatty River Project who indicated that they would probably market the technology as a service (McKay 1994).

### 3.9 Conclusion

South Africa fits the profile of a threshold country such as China, in that it possesses the technology and skills to develop its own GIS software and has some indigenous expertise to utilise the technology. However South Africa, like other third world countries, has been a relatively late starter in the use of GIS when compared to certain first world countries and is still experiencing a number of the teething problems which were experienced by the first world countries. The majority of these problems are related to the mechanisms needed to successfully support a GIS, such as suitable data, personnel and organisational structure.

Central and local governments are the largest users of GIS in South Africa. Although the importance of GIS and other technologies which handle spatial data was not initially supported by the government (Fincham *et al* 1991). This attitude has been changing. The democratisation process has focused attention on the need for reliable spatial information to help address past imbalances in the country. This attitude has meant an increased drive towards the capturing and provision of spatial data for previously data impoverished areas. It has also opened the doors towards government collected information becoming public domain. However the government is still not supporting GIS in tertiary education in the way that both the United States and the United Kingdom have by providing the money for special facilities and research in GIS. The lack of suitable skills is still perceived to be a problem in the commercial sector, although the situation is improving. Application diversification is occurring rapidly in South Africa, the business sector representing one of the fastest growing markets in South Africa.

The use of GIS in rural planning has to date been negligible. The use of the technology for rural planning has tended to focus on small experimental GIS which have not inspired other organisations to invest in the technology. These GIS have also tended to be based in the urban areas of the country. This is not surprising as South Africa has a fragmented infrastructure and skills base with existing expertise limited to certain areas of the country such as the metropolitan areas. The rural areas of the country are also usually poorly supplied with infrastructure such as roads, electricity and telecommunications networks. There is also little or no backup should hardware or software problems be experienced, these areas must therefore be regarded as systems poor environments. The advent of the laptop and notebook computers have to a certain extent negated a number of these problems and have enabled computers to be used in the most systems poor environments. These situations are not ideal however as any problem experienced with the equipment can render the GIS useless.

The following chapter examines the attitude to GIS of some of the organisations involved in the facilitation of rural development in South Africa.

# CHAPTER FOUR

## QUESTIONNAIRE SURVEY OF SELECTED RURAL ORGANISATIONS: ATTITUDES TO GIS

### 4.0 - Introduction

A brief description of the GIS operating environment in South Africa was described in Chapter Three. A questionnaire study substituted in a couple of cases by a semi-structured interview was perceived as an ideal way to verify this information's relevance to the operating environment of selected rural organisations, as well as to ensure that perceptions formed, and problems encountered with the Shixini GIS pilot study which are described in Chapters Six, and Seven are not viewed in isolation.

The questionnaire survey consisted of two separate questionnaires. The first questionnaire which served as a precursor for the second questionnaire was initially sent to 26 organisations actively involved in planning/facilitating rural development in South Africa. The objective of the questionnaire survey was to establish whether the selected organisations considered GIS an appropriate/inappropriate tool to aid in the rural development process.

### 4.1 - Relevance of the questionnaire and interview survey to the study

Questionnaires and interviews are both self report techniques. Self completion questionnaires as used in this study are based on a fixed sequence of open and/or closed-ended questions which the respondent is asked to answer. Closed-ended questions offer a set of answers for a respondent to choose from, while open ended questions allows the respondent to determine his/her own answer and respond to the question in full. The main advantages of closed-ended questions are that they are easier to answer; requiring less effort by the respondent. They are also easier to classify and encode as they will fit into a set response group. Behr (1988) points out that the use of fixed questions may lead to considerable bias by predetermining answers. Open ended questions do not confine the respondent answer and may therefore probe deeper than the closed alternative, however the answers are more subjective and harder to classify.

The choice between open and closed questions depends on the purpose of the survey. Lazarsfeld in Nachmias and Nachmias (1981, p.212) claims that closed-ended questions are suitable when the objective of the research is to lead the respondent to express agreement or disagreement with a particular point of view. An open-ended format is more appropriate when the researcher wishes to learn about the process by which the respondent arrived at a particular point of view. Researchers may combine the advantages of both types of questions in a questionnaire.

Cannell and Kahn (1968) in Chadwick *et al.* (1984, 103) define the research interview as a "two person conversation, initiated by the interviewer for the specific purpose of obtaining research-relevant information and focused by him on research objectives of systematic description, prediction or explanation.

Interviews differ along a continuum from structured, to unstructured. A semi-structured interview forms the middle point and consists of a set of predetermined questions, which the interviewer delivers as he/she sees fit. Robson (1993, 231) observes that the interviewer is free to modify the order of the questions, leave some out or include additional questions based on his/her perception of what seems appropriate in the context of the conservation.

Questionnaires and interviews have a number of advantages and disadvantages associated with them. Nachmias and Nachmias (1981) stress that the advantages to be gained by employing self-completed questionnaires as opposed to interviews include lower costs if the sample is dispersed, a reduction in biasing error, greater anonymity, considered answers and accessability. Questionnaires are however limited in terms of the complexity of the questions that can be asked, and unlike interviews there is no opportunity to pursue interesting points raised. In addition to these limitations, unless delivering the questionnaire personally or through an intermediatory and waiting until it is filled in, there is no guarantee that the target person(s) will complete the questionnaire. Often the greatest problem with questionnaires sent through the post are the low response rates.

There are various methods of overcoming the low response rates associated with questionnaires. Robson (1993) lists a number of methods to ensure a good return rate, such as improving design and layout, ensuring the covering letter is tailored towards the audience or contains altruistic appeals and sending follow-up letters. A number of these methods were tried with both questionnaires with mixed results.

What constitutes a good response rate differs widely in available literature. Behr (1988) contends that anything under 70% lacks validity, while Babble (1979) feels that a response rate of at least 50% is adequate for analysis and reporting. Behr (1988) warns of a serious bias if no notice is taken of non-replies. Behr urges researchers to recognise non-respondents by means of a statistical check on how respondents differ from non-respondents. This should be taken into account when assessing conclusions reached.

The decision to use a questionnaire study to obtain information from selected rural organisations was based on logistics. The organisations making up the sample population were spatially distributed throughout South Africa making the preferred method of collecting information, the semi-structured interview, expensive and time consuming to undertake. However, semi-structured interviews were conducted with personnel of two of the selected organisations due to their accessability.

## 4.2 - Sampling procedure

A number of government departments, parastatals, research institutions and non-government organisations (NGO's) are involved in rural development in South Africa. Organisations differ from each other in size, scope of operation, focus, involvement and approach to rural development. Due to these differences it was decided to limit the questionnaire survey to those organisations who are actively involved in rural development and who displayed characteristics similar to the organisations involved in the Shixini Development Project (refer to Chapter Five for more details on the Shixini Project).

Selected organisations needed to display the following characteristics:
- primarily involved in rural development (as defined in Chapter One).
- research orientated or involved in implementing or facilitating rural development projects,
- follow a bottom up or community based approach.

A list of organisations involved in development in Southern Africa was obtained from the Prodders Development Directory of 1992/93. The directory contains as comprehensive a list of Southern African development organisations as was available in South Africa during that period; it includes a brief summary of the approach to development of each organisations, as well as their activities and geographical areas of operation. A survey of the organisations listed by Prodders yielded a sampling population of twenty six organisations. These organisations were divided into three broad categories 1) research institutes or organisations operating from universities, 2) parastatals and 3) non-government organisations (NGOs).

There are no absolute rules that dictate sample size. Chadwick *et al* (1984, p.69) asserts that sample size is generally based on the nature of the population, the purpose of the study, and the resources available. Due to the small size of the population (twenty six) a 100 per cent sample was taken.

## 4.3 - The preliminary questionnaire

In order to achieve the objective of the questionnaire study, two questionnaires were designed. A preliminary questionnaire was designed to ascertain broadly the awareness of the selected organisation to GIS and the depth of this involvement. The questionnaire also acted as a screening mechanism for a more detailed follow up questionnaire. The second questionnaire was sent to those organisations who answered positively to questions three, four or five of the initial questionnaire (see Table 4.1). The second questionnaire was designed to ascertain the organisation's general attitudes towards, and problems with, GIS, based on their experiences within the South African operating environment.

The preliminary questionnaire was kept simple, comprising a covering letter which explained the purpose of the questionnaire (Appendix One) and the questionnaire itself. The questionnaire consisted of a single closed question with five situations, as illustrated in Table 4.1. The respondent was required to tick the situation(s) most appropriate to that organisation.

Table 4.1 : An example of the structure of the preliminary questionnaire

| | | |
|---|---|---|
| 1. | Have never heard of the term, geographical information systems (GIS): | ☐ |
| 2. | Have heard of GIS but have never considered using the technology: | ☐ |
| 3. | Have considered using GIS: | ☐ |
| 4. | Have used or acquired a GIS: | ☐ |
| 5. | Have contracted an external agency/person to do GIS work: | ☐ |

Of the 26 initial questionnaires sent, 22 (84.6%) were returned. Only one questionnaire returned contained more than a single answer, a NGO who answered in the affirmative to both situation four and five of the questionnaire. This double answer is reflected in the NGO row of the "answers received column" of Table 4.2. Table 4.2 illustrates the number of questionnaires sent, and the spread of answers received, according to the three categories.

Table 4.2: An indication of the breakdown and number of answers, according to category and situation.

| Organisation type | Questionnaires sent | Q1 | Q2 | Q3 | Q4 | Q5 | Questionnaires returned |
|---|---|---|---|---|---|---|---|
| Parastatal | 5 | | 2 | 2 | | | 4 |
| NGO's | 13 | 3 | 4 | 3 | 1 | 1 | 12 |
| Research Institutes | 8 | | 2 | 3 | 2 | | 7 |
| Total | 26 | 3 | 8 | 8 | 3 | 1 | 22 |

**4.4 - The second questionnaire**

A second questionnaire was sent to nine of the eleven organisations who responded positively to question 3, 4 or 5 in Table 4.1. The remaining two organisations were visited due to their accessible location, and a semi-structured interview based on the second questionnaire was conducted with a member of their staff. A 60% return from the questionnaires was recorded and 100% for the interviews giving an overall "return" rate of 66 per cent.

The questionnaire consisted of one closed and four essay type open ended questions, together with a covering letter explaining the purpose of the questionnaire (see Figure 4.3 ), and a self addressed, stamped return envelope. The closed question asked if the respondent considered GIS an appropriate tool for rural development/planning in South Africa. Respondents had the choice of a negative, a positive or an "in between" answer. The open ended questions probed the reasons for the choice by asking questions which reflected on the problem areas of the research. Problems which might be encountered when using open ended questions were discussed earlier in this chapter.

Figure 4.3: Structure of the "second questionnaire"

**GEOGRAPHICAL INFORMATION SYSTEMS: AN AID TO RURAL DEVELOPMENT?**

Accurate, timeous information plays an important role in reducing risk in decision making. Geographical information systems (GIS) provides a method and set of techniques to analyze, manipulate, model and store spatial data and its attributes in order to supply such information. GIS is a valuable tool for any number of applications involving geographical data. Like other information technology GIS are not without problems. Common problems include the cost of the technology, technical institutional and data related problems.

This questionnaire forms part of a study examining the appropriateness of using GIS for rural planning/development purposes in South Africa. Based on your knowledge / experience of the subject please answer all the questions as fully as possible.

1. Do you think that GIS are appropriate technologies to assist in rural development/planning? Please indicate your choice by ticking the appropriate square.

   YES ☐

   NO ☐

   IN CERTAIN CIRCUMSTANCES ☐

   OTHER ☐

2. Please substantiate your choice of answer made in question 1:

3. Do you think the situation will change in the future? Please substantiate your answer:

4: What do you see as the main problems inhibiting successful GIS incorporation in rural projects?

5: The bottom up or grassroots planning method of planning is the prevalent method of planning in South Africa rural projects at the present time. Do you think that GIS is compatible with this method of planning?. If you think there is a place for GIS, where do you think (or where does) GIS fit in the organisational structure?

Thank you for your time.

The use of open ended questions is justified in this context, as the questionnaire was designed to reflect the respondents views of GIS based on their experiences. It was also considered that the use of closed questions would not have provided suitable results as not enough was known about the organisation's situation to write suitable response categories associated with closed questionnaires.

Semi-Structured interviews proved to be a useful information gathering tool. Interviews followed the same core questions as the second questionnaire, but proved to be more flexible. This allowed respondents to express and expand their views at length, and allowed the interviewer to deviate from the core topics in order to pursue 'spin off' topics. The result was greater insight of these organisations operating methods and relationship with GIS, topics that were not adequately covered in the questionnaires. The advantage of this additional information was to a large extent impeded by the more general nature of the information available from the questionnaires. Care was taken not to place to much emphasis on this "extra" information in the 'discussion' section of this chapter.

**4.5 - Limitations and problems with the questionnaire survey**

Although the questionnaire revealed a number of important limitations of the use of GIS in the rural sphere and therefore ostensively achieved its objective, in retrospect the questionnaire study was poorly conceived and designed in terms of acquiring information. The questionnaire study was limited by the researcher's lack of knowledge at the time (1992/1993). Had it been designed after the completion of the pilot study more pertinent questions could have been asked. The most critical of these questions was establishing the exact relationship between GIS and the individual organisation, and an idea of the application role of GIS, actual or perceived, in the development process. Answers to the these questions were touched on in the essay type answers, but did not emerge strongly. In retrospect these questions and others, concerning the background of the organisation and the role of the respondent in the organisation should have been included as closed questions in the second questionnaire.

Problems were experienced in the first questionnaire with regards to who would fill it in. Questionnaires were addressed to the contact person provided by Prodders but it is possible that some of these people were no longer in the employ of the organisations concerned. The contact people were asked to pass the questionnaire along to an "appropriate" person and therefore there was no control over who would fill it in.

This problem was largely repeated in the second questionnaire as a number of the initial questionnaires returned did not, as requested, contain the name of a contact person.

It is possible that either or both questionnaires may have been completed by someone without extensive knowledge of either GIS or its full relationship with the organisation. The questionnaires might also reflect an individual's particular knowledge and attitude to GIS. The questionnaires in both cases therefore reflect the sum of the individual's knowledge of the topic or lack of it. This is not always perceived as a problem as an organisation is composed of individuals; what is important in this context is that the individual is aware of the organisations activities. Wrong situational answers may occur if the respondent is not aware of relevant information. If the respondent occupied a suitable position in the organisation they would be aware if either situations three, four and five had occurred in the organisation, however if the respondent identified either situation one and two, it may reflect their personal knowledge of the topic and not be a true reflection of the organisation as a whole. Therefore answers to situation one and two may not apply to the organisation as a whole, whereas answers to situations three, four and five are seen to be true.

### 4.6 - Survey results: the preliminary questionnaire

Twenty two organisations out of twenty six sampled responded to the preliminary questionnaire. Of those organisations that responded, 12 had used or considered using the technology, and a further 7 had heard of the technology. This implies that 73 percent of the total sample population had heard of, considered using or had used GIS. This would appear to indicate a fairly high awareness of the term GIS within the sample population. The depth of this knowledge in terms of the different aspects which make up GIS could not be ascertained from the questionnaires. It is therefore possible that many of those who indicated that they had heard of GIS may have a relatively superficial knowledge of the technology. Likewise those organisations which indicated that they had considered using the technology might be put into different categories, ranging from a passing interest in the technology to those organisations that had seriously looked at the advantages and disadvantages that GIS has to offer them. The depth of an organisations (individual) knowledge are to a certain extent exposed in the second questionnaire, where the advantageous and disadvantageous of GIS in rural development planning are discussed. This may, however, be negated by the fact that individual respondents might put as much or as little effort into answering the questionnaire as they wish, and the answers may not be a true reflection of their knowledge on the subject.

Despite the fact that more than half of the responding organisations had considered using GIS, only three had actually used the technology in one form or other. It is significant that of these organisations two are attached to universities and the other is actively involved in rural resource surveys (physical). The significance of this must be seen in the context of Chapter Two where this was observed as a trend in Third World countries. This aspect will be discussed in the conclusion to this chapter. Thus although there appears to be a high awareness rate of GIS technology within the sample population this has not been converted into a high user rate. The second questionnaire provided some of the reasons for this trend.

### 4.7 - Survey results: the second questionnaire and semi-structured interviews

All respondents expressed a belief that GIS could have a role to play in rural development in certain circumstances, two organisations could not substantiate their choice.

Most organisations viewed GIS as a rapid response tool capable of providing timely information and answering what if type questions. This capability was considered important to grassroots planning as the process was seen to rapidly accumulate large amounts of often conflicting data, objectives and needs. The role of a GIS in this scenario was as a tool capable of ordering and assessing these needs and being able to supply some idea of their consequences.

GIS was also seen as a mapping tool capable of displaying spatial data in an innovative way for areas which were not normally well mapped. In the case of resource mapping the base data held by GIS was seen as the framework on which diverse data collected during the duration of the project could be laid.

A single organisation indicated that information supplied by GIS had a positive impact on the community development process in that the information supplied provided a good feedback system for grassroots people to decide on the course of action they should take, with a full understanding of all the implications.

The ability of an organisation to respond to changing situations was considered critical by all organisations when implementing rural projects. The perception that GIS could supply information in a reasonably short time frame was seen as important in helping ensure the momentum of the project.

Little direct information was obtained from the questionnaire as to what stage(s) of the project cycle the use of GIS and information produced by the GIS information would be useful. Two phases which were identified was the use of GIS for strategic and tactical decision making and the implied use already touched on where GIS could be used during the implementation stage to provide information to the grassroots.

A number of problems were seen by the organisations as limiting the technology's effective application to rural planning. Problems were both case specific, effecting individual organisations and more general in nature affecting a number of the organisations involved.

Specific problems related to the organisation's situation in terms of staff and resources at their disposal. The magnitude of each of these problems was affected by the particular focus of the organisation which reflected the broad grouping of the organisations (ie: NGOs, research, or parastatal).

Non Government Organisations and parastatals cited a shortage of trained staff as a limiting factor to the incorporation of GIS, although it appeared that the parastatals had more access to the required expertise than the NGOs. The exception was a NGO who contracted out its services to other organisations. This organisation, whose primary focus was resource surveys for the procurement of physical data for planning and project work, stressed that they possessed adequately qualified staff to maintain a GIS. The research institutes were in a similar position and did not feel that they had a problem with obtaining sufficiently qualified people.

In general all organisations found money a limiting factor, the technology was seen as expensive with a tacit acknowledgement that the entry cost of different hardware and software varied substantially. Most organisations indicated that they possessed some of the hardware necessary to support GIS such as personal computers. One organisation also indicated that although they did not presently have GIS capabilities they did use CAD and that the upgrade to full GIS functionality would not be difficult. Lack of money was seen as a constraint by the NGOs in attracting suitably trained staff. A lack of an adequate and constant source of funds was seen as a major factor in limiting the effectiveness of the research capabilities and potential of existing GIS installations at the research institutes. Some of the parastatals and NGOs expressed the limited financial resources available for alternative technology in terms of the development process. They also stressed the necessity of spending money to improve the quality and effectiveness of field workers rather than on alternative information systems.

Repeated references were made to field staff, a reflection perhaps of their importance in the community development process. In community development the organisation is represented by the field operative. The field operative plays a critical role in stimulating and guiding the process of implementation and development. In real terms the success or failure of the field operative is instrumental in the success or failure of a project. The general feeling amongst the NGOs and parastatals was that money would be better spent on training the field operative in order to ensure that at least a crude plan could be reasonably well implemented.
The emphasis of these organisations on field staff possibly reflects the perception of some of the organisations, that the role GIS would fulfil in the development process was as a backup and management tool, one which could provide interesting information, but which did not form a vital part of the implementation process. This view was clearly expressed by one member of staff interviewed who said that it was far more beneficial to have a hands on official in the field working actively on community problems and needs than someone at head office conducting theoretical planning. This attitude I was told by a member of a research institute was frustrating as they had found that other organisations were prepared to use GIS as a tool for solving ad hoc problems but would not integrate GIS fully in the planning process.

A problem encountered by all the organisations was the lack of suitable data. Organisations reported that when data was available it was often inaccurate or incomplete. A general disparity was also noted between the availability of data concerning the physical environment and socio-economic data with more data being available on the former.

The expense of procuring data through primary means was seen by the NGOs as exorbitant as this information, if necessary, might have to be collected through an outside source. Other organisations such as the parastatals and institutes who were able to command the necessary expertise found this less of a problem.

A strong message received from the NGOs was that compromise was necessary with regards to the collection of data and that the experience of the organisational "team" often compensated for a lack of quantitative data. The implicit implication is that GIS might only be used in cases where sufficient data is available to warrant its use or that the high level of geographical information that could be supplied by a GIS might not always be used. It was also felt that obtaining data for strategic planning purposes would be too expensive to capture and maintain in a GIS and that this problem might better be solved by either regional or national authorities.

Dissatisfaction was expressed by a number of organisations over the Directorate of Surveys and Mapping's policy of high pricing for digital data. The feeling was expressed that buying base maps would increase project costs significantly. This resulted in organisations obtaining the data from other sources or digitising the information themselves. A parallel complaint was the lack of funding and interest by the government in supporting information generating initiatives.

Certain problems associated with GIS at the organisation level could be seen as originating in a broader context. The lack of suitably trained personnel might be seen as the inability of this particular sector to provide suitable incentives to attract skilled people. Alternatively it could also be viewed as a result of an uncoordinated education program where tertiary institutions appear to have little idea of what is expected from the commercial sector in terms of skills. There also appears to be little interest in training different types of GIS users for the planning field (although this is changing). Some of these problems may be traced back to the debate on whether GIS is a subject in its own right or destined to be taught as a small course in a number of facilities.
Although the paucity of certain types of data are a world wide phenomenon (as discussed in Chapter Two), this can be exacerbated by particular conditions within countries. In South Africa data shortages could to a certain extent be blamed on government apathy regarding the funding of information technology. Although there are suitable structures for the transfer of information, these are generally not observed (see Chapter Three) resulting in duplication and a waste of valuable resources. One of the reasons for this is the unresolved nature of the cost of information in South Africa. The dissatisfaction expressed with the cost of digital information from the geological survey is a case in point, and it is clear that an explicit policy regarding the provision of information is needed by the government.

**4.8 - The future of GIS in South African rural development**

The response to the possible future use of GIS in the rural planning sphere was mixed. Some organisations said that the present problems were unlikely to change in the near future. Others felt that an increase in the amount and quality of digital data in the future would reduce costs and see an increase in the number of GIS in use. It was felt that the democratization of South Africa would increase the pressure from first world academics, agriculturalists and aid agencies to pursue the option of GIS, as the technology had been used extensively in the first world and "its something they feel comfortable with" (Anon, pers comm. 1993).

Optimism was expressed by some organisations who felt that the technology would play an increased role in rural areas, although at a regional planning level. Tasks identified included the identification of suitable land for redistribution, and the siting of infrastructure and services. These tasks have taken on added importance with the availability of funds for this purpose from the Reconstruction and Development Program and the introduction of a land claims court.

### 4.9 - Conclusion

GIS was generally seen as an ideal tool for strategic and scenario planning in rural development, as well as for storing data and mapping purposes. Although its use during the implementation stage as a tool for project feedback was mentioned, its usefulness during this stage was later questioned. This attitude was clearly stated by the NGOs who felt that the technology was limited to management. This has resulted in the attitude that the technology could only be used as a theoretical planning tool and, as such, was considered a useful but non-critical support technology. Although less sceptical, the institutes acknowledged that institutionalising the GIS in a project was a problem, due mainly to the attitudes of some NGOs.

Limited financial resources have seen the majority of organisations involved in rural development maintain their focus on their primary objective which is to help facilitate the development of the rural people, a task which many consider best served by well trained field operatives.

Of the three organisations who actually operated a GIS two were research institutes attached to universities. This is not surprising as the focus of these institutes was to foster research development in the rural areas of South Africa. The institutes usually have a number of advantages over the NGOs with regards to testing new technologies. The university environment provides easy access to skilled personnel and labour such as post-graduate students. These institutes are also often the recipients of donations of hardware and software and are able to take advantage of the specialised equipment offered by the University such as plotters. Research institutes, however, tend to lack operating capital with a result that the GIS projects undertaken are generally small, short term experimental projects which are disbanded as soon as funding stops, limiting the scope and effectiveness of the research.

The availability of data has a huge impact on the viability of GIS in any given situation. The primary collection of data is expensive, which forces some organisations, especially NGOs, to make concessions with regards to the amount of data to be collected. The emphasis of those organisations using GIS is on physical resource planning, which is perhaps a result of data availability (Chapter Three) and of the data needed in the development process (Chapter Five).

The advantages offered by GIS were seen to be offset by the disadvantages apparent in the South African operating environment. Advantages such as data sharing to avoid data duplication and to allow for a more efficient data flow have not yet become a reality. The perceived and real problems experienced by organisations are interesting in that they have not pointed out problems with the technology itself, but rather at the factors needed to support the technology such as data availability, financial constraints and live-ware problems, aspects that were discussed in Chapter Two. The probable future of the technology in the rural planning sphere centred around the improvement or continuation of these factors.

A number of questions have been raised at this point. Is GIS an expensive toy or is it, as the literature research would suggest a technology capable of saving money and enhancing a small expertise base? Does the information which the technology is capable of producing have a place in the planning process or is such information superfluous? If there is a place for the information, in what stage(s) of the projects life is it likely to have an impact? The next section will, through a case study, attempt to answer some of these questions.

# CHAPTER FIVE

## RURAL DEVELOPMENT IN THE TRANSKEI, COMMUNITY DEVELOPMENT AND THE SHIXINI DEVELOPMENT PROJECT

### 5.0 - Introduction

The facilitation of the Shixini Rural Development Project, by the Institute of Social and Economic Research (ISER) and the Transkei's Appropriate Technologies Unit (TATU) enabled these organisations to examine the possibility of applying a new technology (GIS) to rural planning. The Shixini Administrative Area is an ideal study site as it is situated in one of the least developed areas of South Africa.

Rural poverty and rural development in the Transkei can be better understood within the context of Bantustans policies and apartheid. The Transkei was essentially a political construction created through the "balkanization" of South Africa into a number of self governing and independent states. The ideal behind the formation of these states (Bantustans, homelands) has varied since their conception.

From the early 20th century it was generally accepted by historians that the restriction of African land rights would ensure a cheap constant supply of labour for the mines and would simultaneously protect the emerging class of commercial white farmers from the successful black peasant farmers of the period (Natrass & Natrass 1990, p.518). In addition the Bantustans served a number of economic purposes for the export of labour by providing a support base for the migrant and a subsistence base for unproductive labour. The subsistence base role of the Bantustans contributed to the reproduction and maintenance costs of the migrant and helped justify the low wages paid to migrants by employers. The importance of labour export from the Bantustans has increased since the early 20th century. As the viability of subsistence agriculture in these areas has eroded, it has resulted in an increased reliance on cash wages and migrant remittances.

The need for the successive South African political elite to maintain a relative status quo through changing economic and political periods resulted in the overt politicisation of development initiatives, with development often being used as a means to maintain this precarious balance and justify separate development and Apartheid policy. In the rural areas one of the principal ways of achieving this was through betterment planning.

### 5.1 - Betterment planning practices

Betterment was widely implemented in the Transkei and other "homeland" areas from the 1930s onwards in order to improve farming methods and conserve the quickly deteriorating agricultural base of the "Bantustans". Betterment initially entailed the spatial division of land into residential, arable and grazing areas, theoretically other measures such as fencing, provision of boreholes, infrastructure, soil conservation practices and the provision of agricultural extension officers for an area were also included. However, in the Transkei lack of finances often limited these practices to the division of land (McAllister 1989).

Betterment represents a top-down, "technocratic approach" to planning, the process relying extensively upon imposed physical measures to achieve the desired aims. The social and economic consequences of betterment planning have been extensively covered in the Transkei and Ciskei areas *inter alia* McAllister (1989), (1989a), (1991), (1991a), DeWet (1985), (1987), (1991), Talbot (1988). These authors have noted the destructive effects that the breakup of existing communities has had on the social structure and ultimately on the economic viability of the effected communities.

### 5.2 - Betterment planning in Shixini Ward

Betterment planning was approved in Shixini in 1980. The approval was in response to an application by the chief of Shixini and his sub-headmen to the Department of Agriculture and Forestry (DA&F) for betterment to be applied to the area. In principle the application for betterment planning can only take place after consultation with the people of the affected area. In Shixini this took place in the form of a series of meetings in 1979. McAllister (1989a) casts doubt on the representativeness of this process due to the small number of people in Shixini who attended these meetings and to the fact that the sub-headmen were assumed to represent the view of their particular sub-ward. McAllister (1989a) points out that this issue was not discussed at sub-ward level and that the sub-headmen are appointed by the chief and may not have been willing to oppose him in this matter.

The betterment plan was drawn up over two days in August 1980 by representatives of the Department of Agriculture and Forestry and the Shixini Development Committee which consisted of the Chief and his sub-headmen. The betterment plan followed general betterment procedures in that it divided the area up into residential, arable and grazing land. The only immediate effect of the plan was the planting of a eucalyptus and wattle plantation in the central portion of Shixini which resulted in the relocation of the people living in the demarcated area. By 1988 the betterment plan was still in its initial stages. McAllister (1989) observed that the implementation of the betterment plan had been limited to the marking out of new residential areas and that the relocation of a few people to these sites had taken place He attributed the slow progress of the scheme to the lack of adequate funds for fencing and the provision of facilities. McAllister (1989) emphasized that there was a certain amount of hostility towards the scheme due to uncertainty over issues such as reimbursement for moving, land and social issues.

The betterment scheme in Shixini was criticised as early as 1983 by De Wet and McAllister

(1983) who found the scheme to be poorly conceived and based on a superficial knowledge of the area. Later research by Talbot (1988) on land use practices and the betterment plan and Burchmore (1988) on vegetation and soils in Shixini concluded that the scheme failed to recognise the importance of the present land use pattern, and would therefore not induce sustainable development in the area. The ultimate failure of the scheme however was its lack of support by the people it was meant to help.

**5.3 - The concept of community development**

Community development, unlike betterment planning, operates at the grassroots or community level. The process is a direct attempt to involve the people of the area in a project or projects which are beneficial to themselves. Community development is not primarily a physical process, but rather an attempt to address abstract needs through the use of concrete proposals, such as a need expressed by the community. Through the community development project it is hoped that people, and in turn the community, will become more self sufficient by learning skills with which to better control their environment (Swanepoel 1989).

The role of government, parastatals, NGOs or other interested parties in this process is a facilitating one, achieved by creating a climate in which development can occur. Representation of interested organisations in the development process is usually achieved through the use of fieldworkers. Fieldworkers often live with or are a trusted members of the community in which they work. The community worker/fieldworkers role in the development process varies. Swanepoel (1989) notes that a fieldworker may perform one or more of the following roles in a project: expert, guide, enabler, advocate and catalyst. The field worker also forms a crucial link between the community and the organisation which he represents.

Community development projects are aimed at the grassroots level, for this reason the process recognises the need for community involvement at all stages of the development process. Community participation occurs through meetings and personal contacts. Communities are sometimes large which would make the process difficult to manage. In cases such as these community representatives in the form of an action group or committee need to be elected to help manage the project.

Projects should address a need expressed by the community. These needs require a clear objective in order to obtain community support. Projects, planned and formulated with the direct involvement of the community, are usually small and unsophisticated allowing the participants to develop skills within a realistic framework.

According to Swanepoel (1989) information plays an important role in the community development process. He identifies a need for information through formal research to be conducted on the study area at the start of a project in order to bring about the following results:

- the identification of the community needs and the context within which they occur. "This includes the interrelatedness of, and the causality between needs and the variables which may influence needs." (Swanepoel 1989, p.37).
- to establish what resources are available to address expressed needs as it is crucial to know who and how many will benefit from the needs expressed by the community. The resource survey should include physical, legal, cultural and socio-economic impediments to the use of the identified resources.
- a simple planning cycle. Planning is of necessity incremental and short term in community development projects as community development does not always follow a predictable path, making long term planning impractical. The planning cycle should therefore be simple and direct, dealing with actions and not concepts.
- systematic record keeping is necessary throughout the project to provide a written record of decisions and happenings, for evaluation purposes and as an academic exercise to improve future methods. Information is also necessary to establish a benchmark against which changes arising from the project can be measured (Cobbett, 1987).

Swanepoel (1989) recognises four kinds of resources which are important in this context. These are:

1) human resources including skills, norms and traditions and their possible impediments to development such as resistance to change or sometimes elitism;

2) natural resources which are made use of by people or a community, obvious natural resources include soil, fuel, water and a favourable climate;

3) manufactured resources such as telecommunications, electricity and roads;

4) organisational resources within which any kind of development or resource utilisation is made possible.

A community development resource survey is not necessarily exhaustive, information needs must however be relevant and necessary for the progress of the project and should not become an isolated exercise. Swanepoel (1989) stresses the need for a survey to have both discipline and structure as well as the need for both information gathering and storage to be structured in order for it to be effectively utilised.

Both the community and the community worker play an important part in this process; the community worker serves both as a collector of data and as a liaison between the community and the development organisation, while the communities are both a source of data and recipients of information.

### 5.4 - Background to the Shixini Development Project

Based on criticism of betterment and the expressed needs of the Shixini people a study was initiated by the Development Studies Unit of the Institute of Social and Economic Research (ISER), Rhodes University in January 1988, in order to develop an alternative development strategy to that provided by the betterment plan for Shixini Ward. This initiative was made possible by the increasing failure of betterment to achieve development in the rural areas, a fact recognised officially by the Transkei government in the 1991 Transkei Agricultural Development Study (McAllister, 1991a).

The Shixini Development Project (SDP) consisted of two distinct phases. The initial phase of the project involved an interdisciplinary research effort by the ISER and other departments of Rhodes University which culminated in the Shixini Development Proposal in July 1989. Besides outlining a number of the problems associated with Betterment Planning and the dangers of implementing it in Shixini, the proposal offered an alternative plan, listed its objectives and provided an insight into the plan's component parts. Based on thirteen development principles, the plan was accepted by both the Transkei authorities and the Shixini people. The principles are as follows ((McAllister 1989, pp.7-8):

1. "The plan must be acceptable to all parties involved including the Department of Agriculture and Forestry, the rural Development Division of the Office of the Military Council, the Willowvale and Shixini Authorities and the ordinary people of Shixini.
2. It must be accommodated within the framework of Transkei rural development policy and must not be seen in isolation from development in Transkei and South Africa as a whole.
3. It must be based on adequate information - social, demographic, economic, ecological, geographical and political.
4. It must be flexible, allowing for changes if and when necessary, for the incorporation of new elements, and for a degree of experimentation. This means that it will require constant monitoring and evaluation.
5. It must be holistic or multifaceted, addressing as many aspects of rural development as possible, in an integrated and coordinated way.
6. It must be sustainable in the long term.
7. It must be a plan based on peoples real, expressed needs, which will be implemented by the people themselves, in accordance with their own priorities. Government and semi - government agencies, NGOs and outsiders such as researchers can play no more than a facilitating and assisting role.
8. It must foster economic self sufficiency on the part of all the people in the community. This implies an emphasis on food self-sufficiency as a high priority goal in the first phases of the project.
9. It must not disrupt local social organisation, but instead respect established community values and lifestyles.
10. It must use local organisational structures as far as possible to implement development

action.

11. It must be a low cost appropriate technology scheme rather than an expensive, high technology one.
12. It must be environmentally appropriate, aiming to halt and reverse environmental deterioration.
13. It must recognise the important role played by women, who shoulder something like 70% of the agricultural work as well as many other duties. Women must be explicitly drawn into any development projects if they are to succeed; they must be involved in the decision making process as well as in the implementation phases."

An implementation stage formed the second phase of the development process. The services of the Transkei Appropriate Technologies Unit (TATU), a parastatal organisation, were obtained to facilitate this phase of the project. Collaboration between the ISER and TATU was approved by TATU in February 1992.

During the implementation phase of the project the ISER contributed their research experience of the area, coupled with their research and technical capability, as part of a university. In addition the ISER undertook to document the development process. The Transkei Appropriate Technologies Unit were responsible for the day to day implementation of the project.

The implementation phase was prioritised according to the stated needs of the Shixini people. Four areas of concern were initially targeted, these were:

1) the provision of water and the protection of existing water resources,
2) income generating opportunities,
3) the provision of agricultural supplies through co-ops,
4) an investigation into livestock diseases.

Work on these projects started in March 1992. Water committees were established in each sub-ward and the Department of Agriculture and Forestry undertook a ground water survey. Progress on these projects was slow and by the end of 1992 there was little concrete evidence of development in terms of achieving any of these objectives. In November 1992 an indefinite lock out of TATU management by TATU personnel and increasing political instability and violence in the Transkei effectively ended the ISER involvement in the Shixini project. The implications of these events on this study were documented in Chapter One.

### 5.5 - The Shixini Project administrative structure

The Shixini project administrative structure plays an important role in identifying possible users of geographical information in the project as well as the possible flow of information.

The administrative structure proposed in the Shixini Development Proposal (after McAllister

1989, p.46) is illustrated in Figure 5.1. A project manager assisted by the two field officers were seen as the main interaction point between the Shixini people and the participating development organisations. The Shixini people, through elected sub-ward development committees, would be responsible for development in their particular sub-wards. Certain members of each sub-ward committee would in turn represent the sub-ward at a central committee level whose purpose would be to oversee the development process in the ward (administrative area) as a whole. The central committee would also deal with matters of common interest to the ward and liaise with the local Tribal Authorities (TA). Although the Tribal Authorities were considered inappropriate by the ISER as a body through which to channel development because they were considered unrepresentative of the people and were associated with betterment planning, the TA did represent an important part of local government and as such its network capabilities with other government departments were considered important. (McAllister 1989 pp.43-46).

The proposed administrative structure was never fully realised during the implementation phase. A structure which was considered more representative of the administrative process during the implementation stage is illustrated in Figure 6.2 of Chapter Six.

In relation to the proposed administrative structure only the sub-ward development committees for the water project(s) were realised. The employment of a project manager and assistants never materialised and this pivotal role was performed by the TATU fieldworker stationed in Shixini. He was assisted by an ISER research assistant who made periodic visits to the Shixini area to attend meetings and document the progress of the project. The TATU fieldworker reported directly to the TATU management of the Shixini project and indirectly to the ISER through a steering committee composed of both ISER and TATU personnel. The purpose of the committees was to review the project's progress, provide a forum for discussion on problems encountered and suggest ways forward. The committee convened irregularly during 1992 and eventually ceased functioning the same year.

### 5.6 - GIS and the Shixini Development Project

The development principles of the Shixini Project allowed for a degree of experimentation. GIS would appear to fit into this category with money being made available in January 1992 to examine the feasibility of incorporating the technology as a tool in the latter stages of the project. The GIS study had top management support being approved by both the director of the ISER and that of TATU. The impetus for the possible inclusion of a GIS stems from a visit by a member of the ISER to the Institute of Natural Resources (INR) in Pietermaritzburg (McAllister, Pers Comm. 1992) who at the time were heavily involved with GIS in rural areas.

Personnel at the ISER viewed the GIS project as experimental in nature in that its potential for rural community development projects was largely untested. If the study proved successful it was perceived as a possible trendsetter, not only for the Shixini project but for future rural development projects in the Transkei (McAllister, No Date p.4).

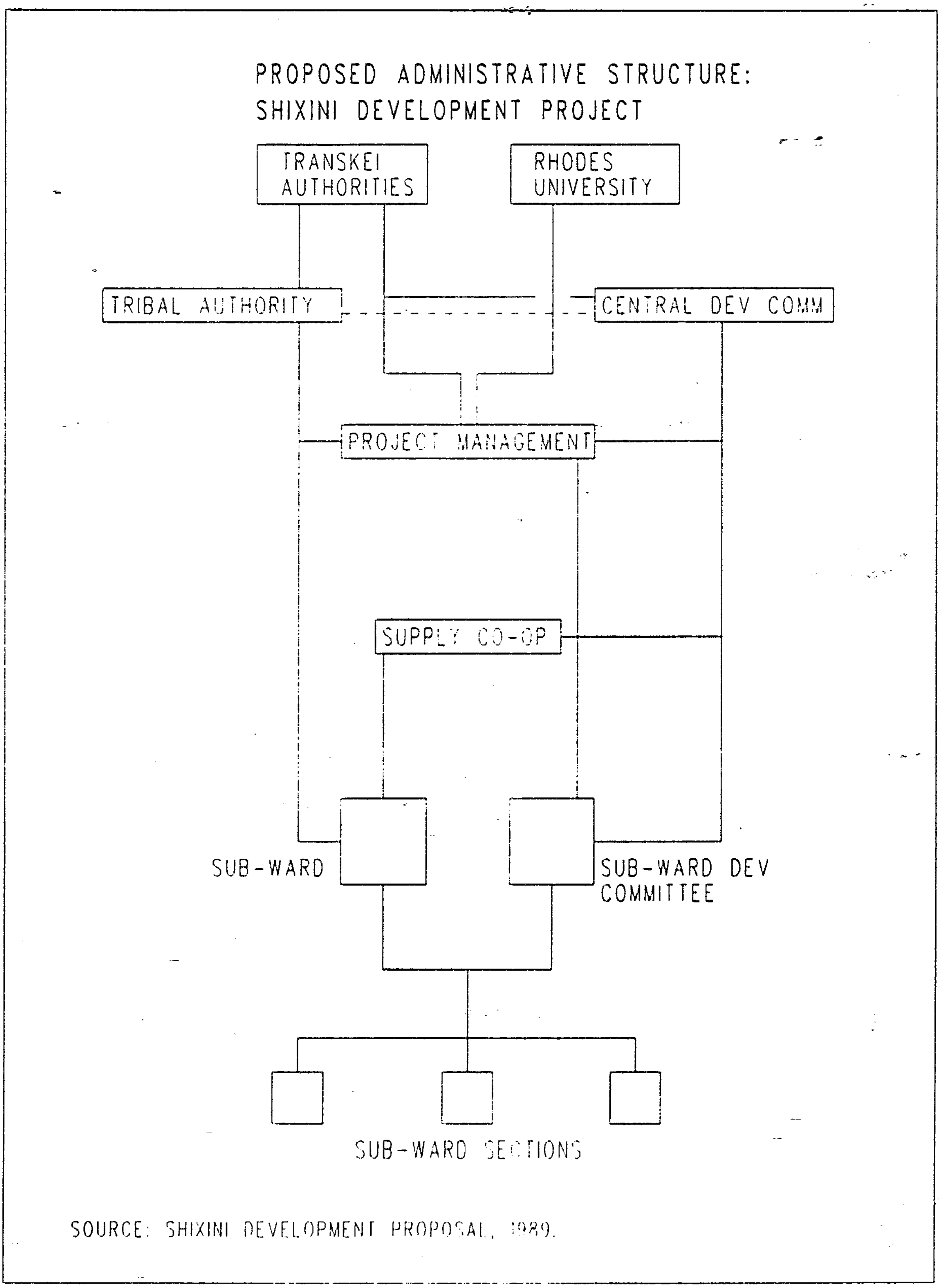



Figure 5.1 Proposed Shixini administrative structure

Despite mention being made of the possible use of GIS as a land-use tool if considered useful, it was made clear by Professor McAllister of the ISER that the feasibility study would define the possible role of GIS in the development process.

Two points must be made at this stage concerning the scope of the feasibility study: 1) the study is a feasibility study and no mention was made of either the ISER or TATU acquiring a GIS, 2) GIS facilities were available at Rhodes University and it was through these facilities that the possibility of incorporating GIS was to be examined.

### 5.7 - Discussion

The Shixini development project has been classified as a community development project because of the similarity between the Shixini projects development aim and principles to this kind of development. In any kind of development process it can be expected that the type of planning practised and development principles followed will profoundly affect the possible role of a GIS.

Theoretically the planning process in community development is seen as "bottom up", however this term negates to a certain extent the role played by the facilitating organisation(s) in the development process. Facilitating organisation(s) have a large role to play in determining the direction of the development process, this was evident in the case of Shixini. Here the people of Shixini indicated their needs at meetings but the plans drawn up to meet these needs were achieved without local assistance by the facilitating agency. Similarly the fieldworkers who play a critical role in the development process are far from passive facilitators. The fieldworker may have a number of roles in the development process and it is not implausible to assume that the fieldworker might direct development projects according to either his/her own perceptions or through him/her, the facilitating agencies perceptions on how to achieve certain objectives. This influence may be subtle such as the weight of 'expertise', or readily apparent as in controlling the project's purse strings and therefore the options open. It is therefore suggested that this process is not strictly a 'bottom up' approach to development planning, but more accurately a combination of 'bottom up' and 'top down', with different organisations adopting different combinations in different situations. The idea that the facilitating organisation(s) guides the development process necessitates that this involvement is based on a more formal information supply than if the process was only undertaken by the community affected. This point is important for the formal incorporation of geo-referenced information in the planning process.

The succinct points that would therefore seem to characterise the community planning process are; it is based on information, it involves the grassroots in the planning process, a guiding or facilitating role is played by the development organisation(s) and short and medium term as opposed to long term planning is prevalent.

The following points would therefore be expected to result from this type of planning process: 1) the pace of the development process would be dictated by the people of the target area, 2) the development process would not proceed at a constant pace 3), the period of time needed to complete the project would therefore be undeterminable, 4) although the long term direction of the project may be plotted, detailed long term planning is superfluous due to the uncertain nature of the development process and 5) data collected for the project would most likely reside with the facilitating organisation.

### 5.8 - Conclusion

The approach adopted to development affects the flow of information, the type of information collected and the use made of the information. It is therefore critical to link GIS to the development principles underlying a project as these factors are likely to affect the possible incorporation, scope and application areas of GIS. These factors will be discussed in a structured framework in Chapter Six.

# CHAPTER SIX

## THE SHIXINI GIS: A CASE STUDY

The case study is divided into two chapters, Chapters Six and Seven. Chapter Six introduces Clark's model of GIS acquisition, the methodology used to address the case study. Chapter Seven is a pilot project.

### 6.0 - Introduction

The feasibility of using GIS as a tool in the Shixini Development Project could be approached at two levels. The first level is a practical approach to the problem where a pilot study is set up to demonstrate the usefulness of the technology. Although this method is an important indicator of the ability of GIS to perform a task, no distinction is made as to whether the organisation's current system is any more or less suitable than a digital GIS. A second level can therefore be discerned, one where an objective comparison is needed to distinguish between competing systems; this may be achieved by comparing selected criteria such as functionality and cost, thus providing an objective basis for systems selection.

A number of models attempt to provide this objectivity (see Calkins and Marble 1987, pp.105-119; Goodchild and Rizzo 1987, pp.67-76; Hine 1989 , pp.1-14; Dickson and Calkins 1988, pp.307-327; Clark 1991, pp.477-488; De Man 1990). Of these authors Clark (1991) provides the most clearly defined and comprehensive model. Clarke (1991) provides a general model for GIS specification, evaluation and implementation, combining both levels mentioned above into a single model. The general nature of Clarke's model reflects the change in GIS development, where the advances made in commercial systems ensure that the majority of GIS bought since the mid 1980s are off the shelf, rather than developed in-house. It is this model which will used to establish the feasibility of incorporating a GIS in the Shixini Development Project. The four stages making up the model are illustrated in Table 6.1. Each of the stages consists of a number of steps. Each step follows a logical progression to the model's ultimate aim, that of GIS acquisition.

In order to achieve the aim and objectives of the study (discussed in Chapter One) only the first stage of Clarke's mode 'Analysis of requirements' needed to be addressed. This stage incorporates the following aspects necessary to achieve the aims of the study: 1) a structured approach establishing organisational needs and matching them with a preliminary GIS design based on this information; 2) establishing possible staff and organisational impacts; 3) the establishment of the business case based on a cost benefit analysis and 4) the practical application of a GIS through its application to a user defined problem (pilot project).

The primary objective of Clark's model is to establish the case for GIS implementation by examining both the functionality and the business argument for the technology. Clarke's model is intimately concerned with hardware and software due to their obvious impact on costs when establishing the business case for GIS through the cost-benefit analysis as well as differences in GIS functionality and specifications. The Shixini GIS Project differs in this regard in that the objective is not to isolate a particular GIS with a view to implementation, but rather to examine the feasibility of using GIS technology as a tool for rural development planning in Shixini. Clarke (1991) stresses the need for a market survey to be conducted during stage one to ensure that

Table 6.1: An overview of Clark's four stage acquisition model. After Clark (1991, p.478)

**Stage 1: Analysis of requirements**
1. Definition of objectives
2. User requirements analysis
3. Preliminary design
4. Cost benefit analysis
5. Pilot Study

**Stage 2: Specification of requirements**
6. Final design
7. Request for proposals

**Stage 3: Evaluation of alternatives**
8. Shortlisting
9. Benchmark testing
10. Cost effectiveness evaluation

**Stage 4: Implementation of system**
11. Implementation of plan
12. Contract
13. Acceptance testing
14. Implementation

present GIS can meet the required specifications; specific hardware and software are not usually required until the pilot study however this is not the case in this study (see following paragraph). For this purpose and to keep costs to the minimum only GIS available at Rhodes University were considered for the pilot project.

In order to accommodate the development of a digital GIS database for the Shixini Project there have been a number of slight alterations to the original order of Clarke's model. Most of these alterations occur in Step 2. The following differences occur: the "preparation of data" has been

Table 6.2: An overview of Chapter Six's structure

**Stage One of Clark's model: Analysis of requirements**

**6.1 - Step 1. Definition of objectives**
6.1.1 - Agency objectives
6.1.2 - Scope and GIS project objectives
**6.2 - Step 2. User Requirements Analysis**
6.2.1 - An assessment of existing information, information flows, data and data characteristics.
6.2.2 - Identification of potential users
6.2.3 - Definition of information needs
6.2.4 - Analyses of data requirements, preliminary database specifications and data preparation
6.2.5 - Data requirements of the Shixini database
6.2.6 - Update method and frequency
6.2.7 - The use of a data directory
6.2.8 - Estimation of workloads and hardware performance
**6.3 - Step 3: Preliminary design**
6.3.1 - Preliminary functional specifications
6.3.2 - Preliminary system models
6.3.3 - Market survey for potential systems:
**6.4 - Step 4: Cost benefit analysis**
6.4.1 - Estimation of costs
6.4.2 - Identification of benefits
6.4.3 - Assessment of impacts
6.4.4 - Analyses of results
**6.5 - Step 5: Hardware, software and the Shixini GIS database**
6.5.1 - Selection of a pilot system
6.5.2 - Input of base datasets
6.5.3 - Database volume, preparation and digitising times and the cost of the database
**6.8 - Discussion and Conclusion**

**7.0 - Step 6: Pilot project**

added to the step while "preliminary database specifications" which usually falls under Step 3 of Clark's model was also included as a part of Step 2, this was done in order to cut down on repetition, in this case the projects data requirements. An extra step has been added to Clarke's model between Step 4 and the pilot project. This step, Step 5, accommodates the input of the data into a GIS, a step which normally only occurs during the pilot project. This was done to ensure the continuity of Chapter Six as well as fulfill one of the objects of the study, namely the creation of a working database for Shixini. Table 6.2 provides an overview of the steps and major components of Clarke's model which were followed in this case study. More specific information is provided at the beginning of each step.

**Stage One of Clark's model: Analysis of requirements**

### 6.1 - Step 1: Definition of objectives:

This step determines the possible scope and objectives of the GIS within the Shixini Rural Development Project, this was achieved through the use of existing project literature and an interview with the project director.

#### 6.1.1 - Agency objectives

The objective of the GIS feasibility study was to examine the possible benefits and disadvantages of using GIS as a tool in the Shixini Rural Development Project. The results of the study were expected to influence the further use of the technology in both the Shixini Development Project and in future rural projects in which the ISER were involved.

The role the ISER played in the Shixini project was as a facilitator between the Shixini people and the implementing agency, TATU. The ISER played an active role in the initial research conducted in the Shixini area; this research culminated in the Shixini Project Proposal, a document outlining alternative development initiatives to those offered by Betterment Planning in the area. This document was accepted and approved by both the people of Shixini and the relevant authorities in the Transkei. The ISER's role in the implementation stage of the project was to assist in guiding the development process through their expertise and knowledge of local conditions in the area. In addition the ISER would monitor and record the development process.

#### 6.1.2 - Scope of the GIS and project objectives

Careful consideration of the possible objectives of GIS in the Shixini project was required due to its impact on system selection, functional requirements, manpower requirements, cost and the need for supporting organisational procedures. The objectives of a GIS in the project were influenced by the approach to development planning employed by the ISER and TATU in the project and the proposed use of the GIS (as discussed in Chapter Five).

The approach adopted in the Shixini Project would have direct implications on information needs and flows which could possible affect the scope and objectives of a GIS used in the project (as discussed in Chapter Five), the conclusions reached in this chapter were thought to have the following impact on the possible scope of the GIS:

1) the length of time that a GIS would remain operable could not be determined due to the

uncertain lifespan of the project;

2) the need for geo-referenced information would be periodic, depending on the development phase;

3) the limited funds available to the project placed constraints on the range of options open to the study;

4) the GIS feasibility study looked at the information needs of the project as a whole, but focused on the ISER as the host agency due to its role of providing information from research conducted in the area.

The aim of the GIS in the Shixini development Project was developed from three principal sources, 1) the SDP proposal aims and objectives, 2) Shixini development project documentation addressing the possible use of GIS and 3), personal communication with the director of the ISER and other members of the Shixini Coordinating Committee.

The role of a GIS in the Shixini Project was not clearly defined from the outset of the Shixini GIS feasibility study. The possible objectives of a GIS in the Shixini Development Project were not clearly stated by project management despite a meeting between the author and the ISER Director to discuss these issues. The reason for this is that the ISER regarded the GIS feasibility study as the primary step in the process towards the possible incorporation of GIS in the project; it was believed that this process would define the role played by GIS in the project (McAllister pers. comm.). There is also a possibility that the capabilities of the technology were not fully understood by the Shixini project management before the onset of the feasibility study. If this is the case the inexperience of the author, in not holding a workshop explaining GIS concepts and possible application areas with the project personnel, may have contributed to the lack of information.

Reference to the use of GIS in the project was made in a SDP document (McAllister No Date, p.4). The document stated that a digital database of the Shixini area existed and that the database could be readily updated with more recent geographical data available to the ISER. It was envisaged that the updated geographical database could provide a valuable resource for later phases of the development process such as land use planning, erosion control, determining the location of paths and roads, the demarcation of arable land, the location of residential sites and any aspect of development that required land use planning and an appreciation of the variety of factors that have to be taken into account when such planning is conducted (McAllister No Date, p.4). Many of these GIS applications relate directly to the objectives expressed in the Shixini Proposal (McAllister 1989).

From this limited background a broad aim for the Shixini GIS was articulated by the author as follows. The aim of the Shixini GIS was to provide a flexible resource and land use management tool capable of providing a range of timely geo-referenced information in a variety of formats to assist in the process of land management and development planning in the Shixini Administrative area.

Additional short term goals of the Shixini GIS were to:

- consolidate existing geo-referenced data available at the ISER,
- convert this data into a suitable digital format,
- identify data gaps, and possible future data needs,
- demonstrate the utility of the GIS database by solving a user set problem,
- identify possible areas of application beyond those identified in the initial aim.

### 6.2 - Step 2: User requirements analysis

This step determines user requirements which form the foundation of GIS implementation. It is on the basis of this information that the GIS will be designed and evaluated. This was achieved through the use of existing project literature and informal discussions with project personnel. This step can be broken down into the following five component parts: an assessment of existing geographical information, processes and data; the identification of potential users; a definition of information needs; an analyses of data requirements; preliminary database specifications and the estimation of workloads and hardware performance.

#### 6.2.1 - An assessment of existing information, information flows, data and data characteristics

This component required an understanding of what geo-referenced information was being used, who was using it, and how the source data, both graphic and attribute, were being collected, processed stored and maintained. This information formed the basis of the geo-referenced information system operating in the Shixini Development Project and it is against this system that GIS was evaluated. The primary methods used to ascertain this information was through the use of informal discussions with project personnel, appropriate literature and existing documentation of the project.

**Information used in the project**

Geo-referenced information collected by the ISER and TATU has concentrated on land use characteristics of the area and the relationship between the Shixini people and the natural environment. Topics have included a basic resource assessment, land use practices, agricultural practices and settlement and demographic characteristics. Social and economic data collection has focused on local government, social and economic networks of the area and, in some cases, individuals. The bulk of this information is available in the form of written literature such as theses, journal articles and project documentation. These sources are displayed in Table 6.3. This table also includes an indication of which features have been mapped. Table 6.4 indicates the sources, scales and characteristics of available digital coverages and paper maps.

**Table 6.3 Literature and map coverage of the Shixini Project area.**

| Feature | Literature available | Map coverage and reference no. | Digital Coverage and reference no. | Literature Reference no. |
|---|---|---|---|---|
| Water resources | Water problems in the Shixini area are well documented. An initial research report on underground water potential of the area is also available. Any subsequent reports on this topic were unavailable. | Yes (3, 6, 7) | Yes (3, 4) | (1, 2, 4, 7, 8, 9, 12, 13, 14, 15) |
| Geology | Geological references to the Transkei region, were too coarse to isolate the specific surficial and bedrock structures occurring in the Shixini area. These features were referred to by Burchmore (1988) and the DF&A groundwater report in descriptive terms only. | No | No | (2, 4) |
| Vegetation | A broad indication of plant communities occurring along the Transkei coastal strip including the Shixini area can be obtained from Acocks (1975). A detailed classification of the plant communities and species occurring in Shixini area is available in Burchmore (1988). Broader vegetation classifications of the same area are found in Andrews (1992) and Heldstrum (1989). All three classifications differ considerably with regards to the identified plant communities and the spatial extent of each community in the Shixini area. | Yes (1, 2, 3, 4) | Yes (3, 4) | (1, 2, 7) |
| Agriculture | Extensively covered in different contexts, including the mode of production, crops grown, agricultural change, relationship to kinship and social structures and soil characteristics. | Yes (1, 2, 3, 4 ,8 ,9) | Yes (3, 4) | (1, 2, 3, 5, 7, 9, 10, 11, 16) |
| Development Initiatives | Widely documented. Majority of literature stems from the ISER's association with the Shixini area and its people. Aspects covered include the proposed betterment plan and its possible impact on social structures, economic life and ecology of the area. A number of references cover the aims, objectives and progress of the Shixini Rural Development Project. | Yes (1, 9, 10) | | (1, 2, 3, 4, 7, 9, 8, 10, 11, 12, 13, 14, 15, 16) |
| Infrastructure | Reference is made to different infrastructure and services in a number of references, but none of these sources is complete or detailed. | Yes (2, 5, 8, 9) | | (1, 3, 7) |
| Erosion | Comparison of the rate of erosion between Shixini and Ntlahlana a neighbouring Ward, quantitative figures provided of the rate and composition of erosion in Shixini but only for the central portion of Shixini. A brief mention of erosion in the area is made in a couple of other references. | Yes (4, 9) | Yes (4) | (1, 2, 15) |
| Soil | A soil survey and analysis of the Shixini area was conducted by Burchmore (1988). | Yes (1) | | (2) |
| Demographics | Reference to demographic pattern and population numbers are made in a socio-economic survey of Shixini. Various references are made to different sub-wards of the area. | Yes (2, 5, 9) | | (6, 1, 7) |
| Social and Cultural | The social and cultural traits of the Shixini people are referred to in a number of anthropological studies These studies also provide an idea of the social and cultural impediments to development. | | | (1, 3, 5, 9, 10, 11) |
| Politics | Literature deals with the political structure in Shixini. The political structure of the Transkei in 1991 can be found in the Development Bank of South Africa's Transkei Development Information, 1987. | | | (3, 5, 9, 10, 11) |

| | | | | |
|---|---|---|---|---|
| Economic | Literature dealing with the economic system in Shixini, as well as its relationship with the surrounding areas, and the rest of South Africa. | | | (1, 5, 7) |
| Organisational resources | Literature covering local organisational resources in the area. | | | (1, 4, 5, 9, 10, 11) |
| GIS | Literature includes the possible role of GIS in the Shixini Development Project as well as work completed using the technology in the area. | | | (1, 8, 16) |

* References referred to in Table 6.3 are provided below. The map reference numbers referred to in the table can be found in Table 6.4

**References**


1 - Andrew, M. (1992) A Geographical Study of Agricultural Change since the 1930s in Shixini Location, Gatyana District, Transkei. (unpublished Master of Arts Thesis, Rhodes University).

2 - Burchmore, A. (1988) The soils and vegetation of the Shixini Administrative Area, Transkei (unpublished Bachelor of Science Honours degree, Rhodes University).

3 - Deliwe, D. (1992) Responses to Western Education among the conservitive people of the Transkei. Unpublished M.A, Rhodes.

4 - SPDoc (1992) Report on Underground Water Supply Investigation at Shixini - Willowvale (Hydrological sub-division, Engineering Branch, Department of Agriculture and Forestry, Transkei) (6 pages).

5 - Heron, G. (1990) Household, production and the organisation of cooperative Labour in Shixini, Transkei.' Unpublished M.A thesis, Rhodes University.

6 - ISER Survey (1988) ISER household survey.

7 - Talbot, M. (1988) Land Use Practices and Betterment Planning in Shixini Location, Transkei (unpublished Honours Thesis, Rhodes University).

8 - McAllister, P. (1989) Proposal for a development Plan for the Shixini Administrative Area, Willowvale District. (Document submitted to the Transkeian Department of Agriculture & Forestry, July 1989).

9 - McAllister (No Date) The Shixini Development Project ( A project update), (6 pages).

10 - McAllister, P. (1989a) Resistance to Betterment in the Transkei: a case study from Willowvale district Journal of Southern African Studies, Vol. 15 No 2.

11 - McAllister, P. (1988) The Impact of Relocation in A Transkei "Betterment" Area (in Cross & Hains, Towards Freehold, Juta and Co).

12 - SPDoc June 1992 Report on meeting held in Shixini in June 1992 for the Shixini Rural Development Project (10 pages).

13 - SPDoc June 1992 Shixini community development Programme: Proposed work Schedule for June 1992 to December 1992 (2 pages).

14 - SPDoc June 1992 Minutes of the Shixini Development Committee meeting held at Umtata in June, 23, 1992.

15 - Whisken (1991) An assessment of the effectiveness of betterment planning in combatting soil erosion. Unpublished Hons. Thesis, Rhodes University.

## Table 6.4: Paper map, digital and remote sensed data sources of the Shixini Development Project

| Primary sources | Year | Scale | Information |
|---|---|---|---|
| Aerial Photographs | 1942 | 1:29000 | Job number 5 of 42) |
| | 1962 | 1:30000 | Job number 468 |
| | 1982 | 1:30000 | Job number 101/E |
| | 1989 | 1:10000 | Job No 481 |
| Orthophoto maps | 1982 | 1:10000 | Numbers 3228 BC 8, 9 13, 14, 15, 19 and 20. |
| **Secondary Sources and their reference number** | | | |
| 1 - Burchmore (1988) | 1988 | 1:16666 | A complete vegetation and land use map of the Shixini AA. The map also contains approximate sites from which soil samples were collected. The map has no coordinates, and no projection is indicated. |
| 2 - Heldstrûm | 1989 | 1:10000 | Funded by the ISER these maps are derived from the 1989 aerial photographs. The series consists of four separate themes these are 1) vegetation, arable fields and gardens, 2) hut distribution, 3) roads and the administrative boundary and 4) contours. The individual themes lack common visible tick points, a common boundary and coordinates. |
| 3 - Andrew (1991) | 1991 | scaleless | Complete area coverage of the following themes were completed using ARC/INFO: landuse, huts, kraals and roads for the years 1942, 1962 and 1982. In addition a later indicating perennial and non-perennial streams. Andrews used the 1982 orthophoto maps as a base map for the extraction of relevant data from the 1942, 1962 and 1982 aerial photographs. Information concerning the class or category of point, line and polygon features was not supplied with these coverage's. These features were matched with the help of a hardcopy map produced by Andrews (1991) for her thesis. |
| 4 - Whisken (1991) | 1991 | scaleless | Incomplete digital erosion map coverage of the Shixini area for the years 1942, 1962 and 1982. Sub-wards covered include Kwitshi, Mugwevu and Ngqungqumbe. Coverage's indicate the distribution and intensity of erosion features of these sub-wards using a modified SARRCCUS (1981) classification. |
| 5 - Deliwe (1992) | 1992 | - | Three rough field maps of Kwitshi sub-ward. The maps provide an indication of the used, unused and fallow fields in the sub-ward. They also indicate the geographical position of the chiefs house and other important public buildings such as Jingqi clinic, Dumisile school and the Tribal Authority buildings. A significant feature of these maps is that they provide a clear indication of the Kwitshi sub-ward boundary, which is the only available reference to this feature. |
| 6 - Andrews | 1982 | - | A hardcopy map plotted by Andrews in 1991 of the perennial and non-perennial streams of Shixini Administrative area. Used by the fieldworker resident in the Shixini area to plot the position of likely spots for earthen dams. |
| 7 - Dept. A&F | 1992 | - | Rough position of test boreholes sunk in the area by the DA&F. |
| 8 - Heron | 1990 | - | Rough field map showing the position of a sub-ward. |
| 9 - Talbot | 1988 | - | Indication of infrastructure present in Shixini, sequence of maps showing the land under agriculture for the years 1942, 1962 and 1982 and a sequence showing settlement patterns for the same years as the previous sequence. |

Geographical information available to the project was used by the project management to backup criticism of betterment planning as well as to help define and support development initiatives and tactical and project planning. During the implementation process information was used to support individual viewpoints with regards to alternative paths to specific project goals as well as to orientate individuals and provide quantitative information.

**Data sources and collection methods**

The collection of specific source data to fulfill information requirements for the project had, with the exception of land use and vegetation data, had been one off events. Both primary and secondary source data were used to fulfill required information needs.

Two distinct data collection periods can be identified. The first was conducted by the ISER between January 1988 to December 1991. The period was characterised by a vigorous initial data collection period by a multidisciplinary team of researchers who built on the anthropological research done by McAllister since 1976.

The ISER has taken full advantage of its position as part of a University, using the skills of post-graduate students in the disciplines of anthropology, geography and botany to undertake research in the area. Much of the research was undertaken as post-graduate studies with the final report being presented as a thesis (Talbot 1988; Burchmore 1988; Heron 1990; Andrew 1992 and Deliwe 1992). An exception is Heldstrüm (1989) who was contracted to map land use features from the 1988 aerial photographs of the area. In addition a number of journal articles published during this period or earlier articulated the possible negative social, economic and environmental consequences of implementing betterment in the area (McAllister 1988, 1989b; McAllister and DeWet, 1983; Heron, 1991).

Project implementation forms the second period of data collection. This period extended from March 1992 to December of the same year. During this phase project specific data was gathered mainly through primary data collection methods by the fieldworker(s) stationed in the Shixini area and consultants, primarily the Department of Agriculture and Forestry's Hydrological Division. The geographical data collected during this phase dealt principally with factors relating to the provision of an adequate water supply to the upper Shixini area.

Data collected during these two periods occurs at different levels of completeness, currency and accuracy.

**Data and information flows**

The flow of information and data prevalent during the implementation phase of the Shixini development project is indicated in Figure 6.1 An important distinction is made in the diagram between the flow of physical data and that of social and economic data. Data related to the physical environment was collected mainly by post-graduate student researchers, while the ISER had been responsible for the collection of the majority of social and economic data. In addition fieldworkers from both TATU and the ISER have collected both types of data on an add hoc basis.

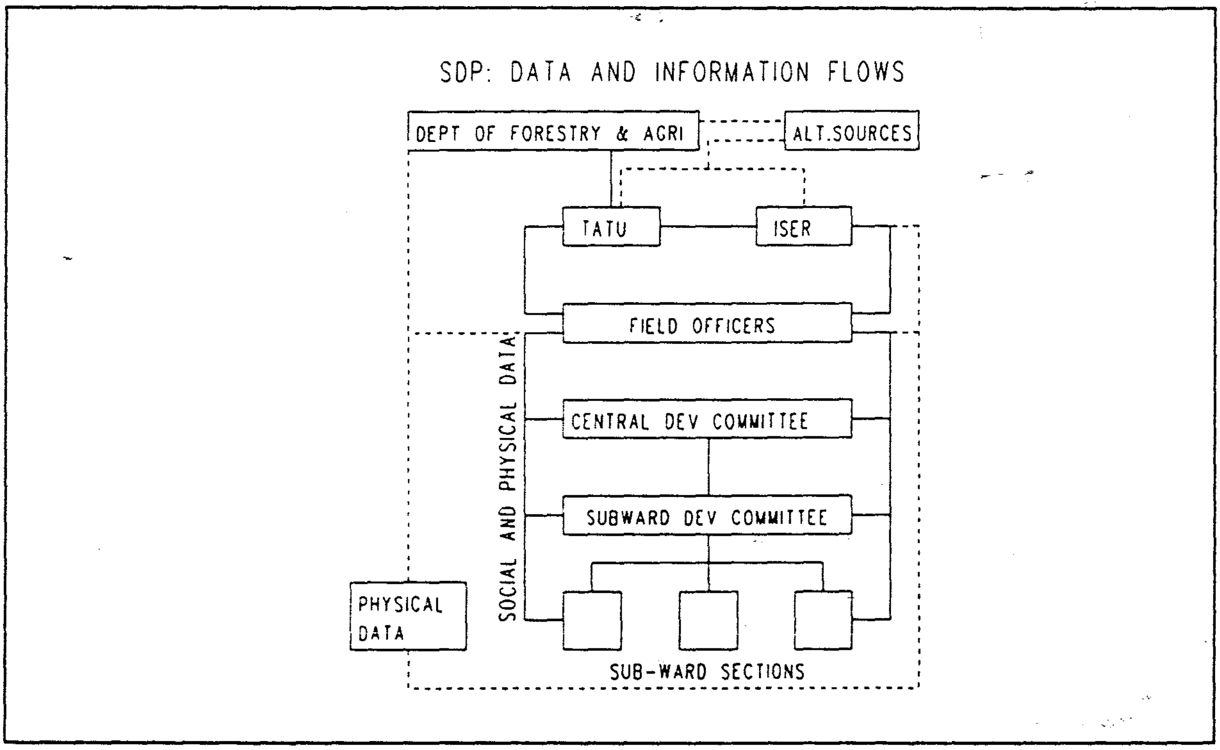



Figure 6.1 Data and information flows of the Shixini Development Project.

Figure 6.1 shows that data is collected by fieldworkers, other organisations or contract workers. This data usually found its way to either the ISER or TATU depending on who it was being collected for. Information flowed between the development organisations and the contract workers and vice versa and from the development organisations to their fieldworkers either directly through personal contact or indirectly through the Shixini Steering Committee. The fieldworkers in turn formed the interface between the ISER/TATU and the respective sub-ward development committees in Shixini.

Potentially the weakest link in the flow of information illustrated in Figure 6.1 was between the ISER and TATU. Separated physically by a considerable distance, the information flow between the two organisations relied on post, telecommunications (facsimile) and meetings to keep in contact. Organisational requirements and other commitments by members of both organisations coupled by the distance between them restricted the exchange of information over the active implementation period.

**Data and information storage at the ISER**

The ISER premises act as a store for project data collected during both the research and implementation stages of the project. Documents, theses, primary data, and maps were shelved in the ISER Director's office while personnel documentation, financial records and communiqués between the ISER and TATU are filed. Certain published papers and project reports were available in digital format as were Andrew's (1992) ARC/INFO coverages which were available from the Geography Department at Rhodes.

**Information and data problems associated with the Shixini Project**

The large number of contributors which form the basis of the existing geographical information of the Shixini area has resulted in a number of general problems:

- The use of post graduate students for project work supplies students with excellent experience as well as financial support for post-graduate studies. However the resultant information obtained by the ISER in the form of theses reflects the students need to obtain a degree rather than serving the direct data needs of the project. For example there are three vegetation classifications of the area, these being Burchmore (1988), Heldstrüm (1989) and Andrew (1992), none of which coincide spatially. The lack of an integrated data collection policy combined with the separate flow of physical and socio-economic data has resulted both in the loss and duplication of information

- The synthesised geographical products are often the only information returned to the ISER. The aggregation of field data results in the loss of important information for future users.

- Researchers, often fail to mention the source of a map or any pertinent details of the information it contains with regards to its currentness or completeness (eg Burchmore 1988).

- Maps completed for theses have been produced at different scales. This makes it difficult to compare information between them.

- The maps are often not comparable as no reference points such as latitude and longitude are provided. This is especially apparent in the maps compiled by Heldstrüm and Burchmore (Table 6.4). Correction of these problems are time consuming and the results are often inaccurate.

- Classifications of entities differ according to author and purpose of the information. Classification systems are often not explained or not adequately explained and the definition of entities is often not mentioned, making updates difficult to attempt.

- There is limited attribute data for existing analogue maps beyond that conveyed by their spatial location and relationships. It has already been noted in this chapter that the procurement of landuse and environmental spatially referenced data have followed different processes to that of social and economic data. This has resulted in a relatively well mapped land use and settlement pattern with little or no linkage to the social and economic data, diminishing what is potentially useful spatial information for a rural community development project.

### 6.2.2 - Identification of potential users

This component identified all users and potential users of geo-referenced information as these people were important in defining information requirements.

The identification of potential users of the Shixini GIS was achieved with the help of a revised schematic representation of the Shixini administrative structure displayed in Figure 6.2, ( the original project structure is illustrated in Figure 5.1). The revised figure is based on project documentation, communication with project personnel and the observation of project activities.

Table 6.5 Potential users and their information needs

| Potential Users of geographical information | Possible information needs |
|---|---|
| ISER and TATU (monitoring, trends and documentation) | All geographical, political, social and economic information in both graphic and tabular formats. |
| Shixini Steering Committee (decision makers) | Basic thematic maps, the ability to answer questions such "as 'what is available (how much)", "what if" and "where is" type questions. |
| Fieldworkers (decision makers and data collectors) | Require current project relevant information capable of supporting day to day project management and decision making. |
| Shixini people (steering committee's) (decision makers) | Need an understanding of what the problems are affecting them as well as an understanding of the different options open to them to address these problems as well as the possible consequences. |
| External contractors (application specialists and data collectors) | Base geographical information in a variety of formats on which it project specific or specialised data can be integrated. |
| GIS personnel (data processes and application specialists) | Require a variety of data to support other users needs. Data should conform to set standards and format to allow for the easy input of such data. |

2) individual members of the Shixini steering committee (decision makers); 3) the fieldworkers (users of information and collectors of geographical data); 4) the people of Shixini and 5)

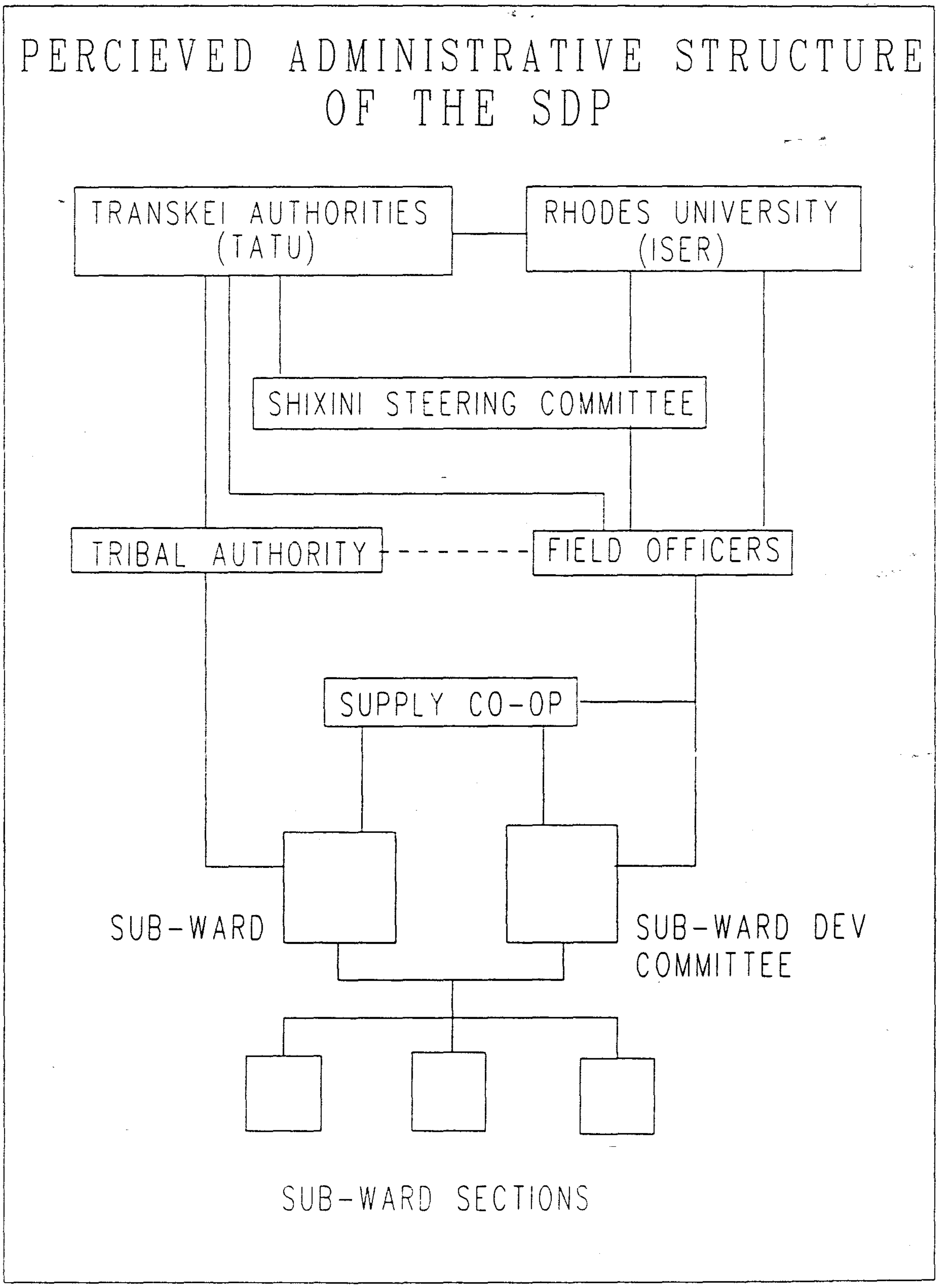



Figure 6.2 Percieved administrative structure of the SDP

Six potential levels of GIS users requiring geographical information can be discerned, five of these from the schematic diagram in Figure 6.2. They are: 1) The ISER and TATU (research and decision making purposes; contractors, including user application specialists and data processors and 6) those people that process data to obtain information, included in this level would be the people directly involved with the GIS.

Each of the identified groups require a mix of information in order to support their objectives and activities in the planning process. A summary of the potential users and their information needs is provided in Table 6.5

1) Both TATU and the ISER had a interest in learning from the process which they were undertaking in Shixini. It has already been mentioned earlier in the chapter that the ISER's role in the implementation stage of the project would include a research and recording component. To fulfill this role different types of information need to be gathered, including current and historical geographical information.

Of special importance in this process from a development perspective is the ability to monitor certain trends and distributions such as changes in land use or settlement pattern or social and economic distributions. Information and data needs to support this research would cover all aspects of geographical information gathered for the project and should be available in either tabular or graphic format.

2) The activities and composition of the steering committee were referred to in Chapter Five. Although a number of individuals who sat on the steering committee had visited Shixini, their individual knowledge of the area varied. Geographical information had an important role to play in orientating members to current developments and in illustrating future development initiatives. The presentation of geographical information was achieved with the aid of the 1:50000 topographical map of the area. Geographically related queries which could not be answered immediately were postponed to the following meeting. The limited use of geographical information at this level was, in the authors opinion, not indicative of a lack of geographical data, but rather the means of presenting it. Geographical information at this level varied according to the project initiative under discussion and the person presenting it. The source of information at this level differed substantially with fieldworkers drawing on their firsthand knowledge of the area, while some other members of the committee relied on specialist application knowledge and existing information of conditions in the area.

At this level there was a need for two kinds of information. The first was a factual quantitative information source e.g. where is the closest source of water to a certain area, do the people of the area use it for drinking, if so how many people use it? These questions require access to a number of data sets or require the fieldworker to ascertain the facts. The second kind of information need relates to the recognition and understanding of trends, a task requiring access to historical data. A question which is often asked at this level of planning is what if? and where is? e.g. What would happen if a certain policy was implemented, would land degradation occur, where is the nearest access road?

3) The importance of fieldworkers (community workers) in the community development process was indicated in Chapters Four and Five. The ISER and TATU fieldworkers (one from each organisation) who were active in the Shixini area were both black South Africans. Both were formally educated, the ISER fieldworker having read for a Master of Arts Degree in anthropology. The fieldworkers operated on two levels of the Shixini Project, acting as operational managers in the field and as active participants of the steering committee. Their role in the project called on them to act as both collectors of data and disseminators of information. The information needs of the fieldworker are at one level similar to other members of the steering committee, however as they are also involved in the day to day running of the project. One of their tasks was to provide information to other members of the steering committee of developments and problems in the field. As these problems were invariably related to the community or individuals a topographical map was often the only source of information necessary to assist in explaining the problem(s). A different approach is required when disseminating information in the project area as the target audience is often illiterate and frequently cannot visualise the information supplied by traditional maps. In this context spatial information is imparted verbally to the target audience through reference to known landmarks such as a person's residence, a large tree or local place names. It is the fieldworkers knowledge of the local geography which is important in this context and the use of GIS was not expected to form a major component of this aspect.

Fieldworkers require a simple means of collecting data and recording/monitoring the development process. A map of surface water sources generated by a GIS was used successfully by the TATU fieldworker to record the possible location of dams in Shixini. However the use of orthophoto maps of the area would probably impart finer detail to a fieldworker than a basic thematic map. As the orthopho maps are out of date, the combination of orthophoto and GIS generated maps would be ideal for the task. The use of GIS generated maps also ensures that lengthy data preparation times are avoided and safeguards the continuity of the data.

4) The people of Shixini form a potential user group. The needs of the Shixini people formed the basis of the Shixini Development Proposal drawn up by the ISER. The Shixini people also had to approve the project and therefore required information of the different project initiatives that would be undertaken. The involvement of the people in the project through steering committees required that they understand the different alternatives open to them and the possible effects of the alternatives so that they could make decisions based on adequate information. Chapter Three highlighted the use of an information system to bridge the gap between the planner and the community enabling the community to effectively partake in the planning process (MacKay No Date). In practice this technology will prove difficult to use as only a couple of people in the country have the expertise capable of supporting it. Other solutions do exist. There are many

case studies that show that illiterate communities can think spatially if they are allowed to draw their own maps. GIS may provide a possible solution to these problems by being able to combine different mediums to create new map compositions and styles. Ideas include multimedia video clips and 3-D models and photography combined with recognisable icons representing identifiable features (the development of alternative ways of displaying information are beyond the scope of this study and are not addressed).

5) The fourth level identified is that of the contractor. The facilitating organisations involved in the Shixini project often hire external contractors to perform or guide concrete projects which are specialised in nature, an example of this is the drilling of boreholes. Information requirements for contractors will therefore differ according to the particular aspect of the project in which they are involved. The information provided to the contractor in this context would in all probability be basic environmental and social data of the area, to help provide a base upon which the contractor could work and prevent unnecessary duplication of data. Information transfer to the contractor can, using GIS, be achieved in a number of ways such as by means of hardcopy or digital transfer. Whatever the medium used to transfer information it is important that contractors follow certain procedures in order to preserve the integrity of the GIS database. Procedures followed should also ensure that data generated by the contractor is in a suitable format to allow for easy input into a GIS.

6) GIS personnel (data processes and domain specialists) require a variety of data and information to support different user needs. It is important that data received from the various sources, especially the fieldworkers and contractors, conform to a set standard to ensure that the data can be used for a variety of purposes. Domain specialists could potentially be anyone involved with the project, including external contractors.

### 6.2.3 - Definition of information needs

This component attempts to provide a clear and unambiguous view of the information required, as well as its format, media and content needed for the project. This information is based on the data collected in the first two component parts of the step. A starting point in this process is the examination of existing geographical products. It must, however, be taken into account that users may require other geo-referenced products and these needs must be facilitated within the definition process.

Possible information products were derived from the aim and objectives of the Shixini GIS in the project, old information products, defined project objectives and the information needs of potential users.

Information products gathered before the implementation stage of the project were defined in Table's 6.3 and 6.4. This information forms an important part of the information available to the project both in terms of fulfilling current information needs and for discerning trends in the Shixini area. This information also constitutes an important part of the recording and research component of the project.

Future information needs included information needed to support decision making in the project implementation process. Not all of the aspects covered in the Shixini Proposal could be tackled simultaneously during the implementation phase; this resulted in the prioritization of peoples needs into different project areas (as discussed in Chapter Five). Phase one of project implementation concentrated on six areas: the establishment of social structures in the Shixini area capable of supporting the development process, the provision of an improved water supply; an investigation of livestock diseases; the establishment of a farmers depots; income generating activities; the training of people with regards to these goals; the monitoring and documentation of the development process. The information needed to support these projects are dealt with separately below.

The establishment of social structures: information required includes a list of social structures in Shixini as well as their area of influence. Attribute information could include names of influential people within social structures as well as their place of residence.

Improved water supply: ideally the following geographic information is required; topography, settlement patterns and resource based information especially surface and sub-surface water resources. Attribute information required includes identifying which sources of water are used by the community, when it is used, what is it used for, why is it used, how often it is used, how reliable is the water source and what is the water quality and rejuvenation (recharge) times of identified water sources. Other information needed includes the communities preferences with regards to water sources as well as possible delivery systems. The format required for these products includes maps and tabular data. To answer unasked questions, an information source which can be interactively used is required.

Investigation of livestock diseases: Requirements include information on natural resources such as water, vegetation and soils. Information related to agricultural matters including animal distributions and grazing patterns in the area. Attribute information required includes information on vector habitat and life cycle. Other information requirements include information on animal diseases and vectors occurring in the Shixini area. It is possible that the siting of dips would be needed in the future to help combat livestock diseases in this case manufactured resources as well as land use data may also be helpful.

Farmers depot: requirements include information on present agricultural infrastructure (dips, depots, supply points), land use and settlement patterns as well as agricultural related organisations (such as ploughing companies) and their area of influence. Other information includes manufactured resources such as information on the location and type of agricultural supplies sold in the Shixini area. Polygon attribute information would include the name of the agricultural organisation; useful information needs might include the names and location of important farmers in the ploughing companies.

Income generating activities: required information includes physical resource and land use, manufactured resources and their location as well as settlement related information. Attribute data might include community related information such as available skills and meeting places

Training: Training was to be used to provide sufficient skills for the community to manage those initiatives whose information needs have already been discussed. Information needs therefore vary according to the particular project being considered.

It is apparent that information needed to address the different projects within the SDP are often similar, the most common information required included land use and natural resource data, manufactured resources and community related information, these needs will be referred to as core needs.

Project specific information differs according to the project area. The following broad information needs are needed to support the different project initiatives.

Base information (core data needs)
Land Use and natural resource information
Agricultural information
Information on settlement
Topographic information
Socio-economic information
Manufactured resources (infrastructure)
Organisational resources
Demographic, community and individual related information

The media required to support the various users of the information would primarily be in the form of graphic representations (maps) or tabular outputs. It is also possible that information would be displayed on an computer screen or when necessary passed on in a digital format. The data required to fulfill the identified information needs are addressed in the following section.

#### 6.2.4 - Analyses of data requirements, preliminary database specifications and data preparation

This analysis of data requirements determines data requirements from the breakdown of product or information requirements. Data requirements need to be fully stated and their characteristics noted. Clark (1991) stresses that data analysis should identify the following characteristics for each data type: classifications, accuracy, and update frequency. In addition to these characteristics the source(s), volumes and structure of each data source should be catalogued. This component includes the preparation of data into a format suitable for digitizing. The preliminary database specifications component usually falls under Step Three of Clark's mode in this case it was included as a part of Step Two in order to avoid repeating the project's data requirements. The decision on entity representation in the database according to the world view is also decided through matching information requirements to the preferred functionality offered by either a raster or vector representation model or possibly a mixture of the two (as discussed in Chapter Two). Once product and data requirements have been determined it should be possible, based on that information, to make a preliminary assessment of the required GIS workload and performance characteristics.

**Data requirement analysis, preliminary database specifications and data preparation**
This component differs from Clark's methodology in that preliminary database specifications usually fall under Step 3 of Clark's methodology and data preparation in Step Five. Joining these components together enables one of the objectives of the Shixini GIS to be fulfilled (the development of a database for the project). The figure numbers located next to the heading of each theme refers to the map displaying that particular theme at the end of this chapter.

The following data characteristics will be addressed for each data type: resolution, accuracy, classifications, and update frequency. In addition to these characteristics the source(s), possible volumes and structure are provided for both spatial and attribute data, this data is provided in Table 6.6. Consideration also needs to be given to the choice of a spatial data model due to its affect on data structure, GIS price, functionality, space and processing time of the GIS as discussed in Chapter Two.

**Spatial data models**
The spatial data models open to the project include both raster and vector. Vector representation was chosen for the following reasons:

- The software selected was familiar and did not require basic orientation ie Arc/Info.
- The small size of the project and limited volume required for the database make any advantages offered by data representation in terms of calculations and storage efficiency negligible.
- Price was not an issue as software and hardware were available at the university. Lower end raster and vector GIS are similar in price although vector tends to be a little more expensive.
- The functionality required of the GIS is relatively simple with basic overlay capabilities needed. There was, however, an emphasis on quantitative areal data which are theoretically more accurate on vector systems (the accuracy of the database and the uncertainty of some entity classifications such as vegetation negate this advantage to a certain extent).
- Vector is less abstract than raster. Vector data representation deals with lines points and areas as opposed the a typical raster representation which represents all entities as a series of cells. Abstraction makes it difficult for many people to relate to what they are seeing on a map, the increased abstraction of the raster model increases this difficulty.
- The availability of digital data in a vector format made vector data representation a logical choice for the Shixini project, the cost of converting the digital data available to the

project would have increased the cost substantially.

- The GIS would be used for archiving phenonomenologically structured physical data such as vegetation and land units, a task normally undertaken by vector (Burroughs 1986)
- The representation of housing structures which would form the basic unit for socio-economic data in Shixini would require a raster resolution of at least 7.5 x 7.5 meters to represent them in raster format would be a monumental task when inputting from a keyboard.

**Data resolution**

There are three basic entities used to represent the real world in a vector data structure, polygons (area), lines and points. Selection of layer type for entity representation should be governed by the use of the data but is often constrained by more practical problems such as the scale and resolution of the source data. Most environmental and land use data for the Shixini development project occurred at a scale of 1:10000 which according to Robinette (1991) is the upper extreme at which data can be used at an operational level. Data digitised at this scale could therefore be considered suitable for all planning levels. It was therefore decided that the resolution provided by the existing source documents was sufficient to meet the stated aim of the Shixini GIS and that the collection of data for the entire area at a larger scale did not warrant the extra cost. This decision was influenced by two factors: 1) that the majority of hardcopy maps produced for documentation and project purposes would be produced at a scale of approximately 1:40000 the approximate size of an A4 size piece of paper, and 2) it was envisaged that hardcopy maps produced for fieldwork and project implementation would be produced at a scale of 1:10000 so that they could be used in conjunction with the available orthophoto maps of the Shixini area.

The collection of data at a larger scale for task specific objectives is a possibility that can be catered for by the data collection strategy outlined later in Section 2 of this chapter, it must be borne in mind however that the accuracy of the database is constrained by the least accurate or complete layer. This would mean that base maps of the Shixini area would have to be recaptured at a higher resolution. Cowen and Shirley (1991) indicate that to capture data at a scale larger than 1:10000 would cost approximately three times as much.

**Accuracy**

At a scale of 1:10000 a positional accuracy of 3 to 15 metres is sufficient for certain functions such as location analysis. Depending on the source of the data the majority of the land use data of the Shixini database falls within this range. Where possible the positional accuracy of digitised data should where possible be checked against the source document or a higher source of accuracy. When checking primary remote sensed data (aerial photographs) this represents a problem as features obtained from this source need to be manually transferred to a base map. Although this method is reasonably accurate there is a considerable margin for error, as the positional accuracy depends on the experience and eye of the individual doing the work. The accuracy of original data bases are sometimes hard to check as touched upon earlier in Step 2

**Table 6.6: Characteristics and estimated values of data used in the Shixini GIS database**

| DATA TYPE | SOURCE | RESOLUTION | ACCUR-ACY | CLASSIFICATION | STRUCTURE GRAPHIC | ATTRIBUTES | ESTIMATED VOLUMES | UPDATE FREQUENCY |
|---|---|---|---|---|---|---|---|---|
| Administrative boundary (1988) | Andrew (1992) | 1: 10 000 | 0 - 10m | - | area<br>line | name<br>names | 0.06 Mbytes (actual) | Only if there are official boundary changes |
| Sub-ward boundaries (1992) | Heron (1991), Deliwe (1992) and orthophoto maps (1982) | 1: 10 000 | unknown | - | area<br>line | name<br>feature names | 0.05 Mbytes | Only if a new source of information is found |
| Roads and tracks (1989) | Andrew (1992), aerial photographs (1989) | 1: 10 000 | 0 - 5m | Secondary roads<br>Tracks | line | name | 0.1 Mbytes | Not necessary unless new roads are built |
| Roads and Tracks (1982, 1962, 1942) | Andrew (1992), aerial photographs (1942, 62 and 82), orthophoto maps (1982). | 1: 10 000 | 0 - 5m | Secondary roads<br>Tracks | line | name | 0.036 Mbytes (actual) | |
| Delimitation of orthophoto boundaries (1982) | Orthophoto maps (1982) | 1: 10 000 | 0m | - | area | reference number | 0.04 Mbytes | - |
| Contour (1982) | Orthophoto maps (1982) | 1: 10 000 | 0 - 2m | - | line | contour height | 0.8 Mbytes | - |
| Vegetation (1988) | Heldstrûm (1989), orthophoto maps (1982), aerial photographs (1989) | 1: 10 000 | 0 - 50m | Heldstrûm (1989) | area | class name | 0.6 Mbytes | 2 - 5 years |
| Vegetation (1982, 1962 and 1942) | Andrew (1992), aerial photographs (1942, 62 and 82), orthophoto maps (1982) | 1: 10 000 | 0 - 50m | Andrew (1992) | area | class name | 1.64 Mbytes combined (actual) including agricultural features | - |

| DATA TYPE | SOURCE | RESOLUTION | ACCURACY | CLASSIFICATION | STRUCTURE GRAPHIC | ATTRIBUTES | ESTIMATED VOLUMES | UPDATE FREQUENCY |
|---|---|---|---|---|---|---|---|---|
| Agricultural land (1989) | Heldstrûm (1989), Andrew (1992), Orthophoto maps (1982) and aerial photographs(1989) | 1: 10 000 | 0 - 15m | fields<br>gardens | area | class names | 0.3 Mbytes | annually<br>bi-annually |
| Agricultural land (1982, 1962 and 1942) | Andrew (1992), Orthophoto maps (1982) and aerial photographs (1982, 62, 42) | 1: 10 000 | 0 - 15m | fields<br>gardens | area | class name | 0.85 Mbytes (actual) | - |
| Erosion features (1989) | orthophoto maps (1982), aerial photographs (1989) | 1: 10 000 | 0 - 5m | Ntsaba (1989) | area<br>line | class name | 0.4 Mbytes | 5 - 10 years |
| Perennial and non-perennial streams (1982) | Andrew (1992), orthophoto maps (1982) | 1: 10 000 | 0 - 5m | perennial<br>non-perennial | line | class<br>feature name | 0.42 Mbytes (actual) | - |
| Natural depressions (1989) | Aerial photographs (1989, 1982, 1962, 1942), orthophoto maps (1982) | 1: 10 000 | 0 - 5m | - | area<br>point | - | 0.03 Mbytes | As soon as relevant data is found |
| Boreholes (1992) | Department of Agriculture and Forestry | 1: 50 000 | - | | | | 0.005 Mbytes | As soon as relevant data is found |
| Spot heights (1982) | orthophoto maps (1982) | 1: 10 000 | 0 - 2m | - | point | height in metres | 0.03 Kbytes | - |

Table 6.6: continued

| DATA TYPE | SOURCE | RESOLUTION | ACCURACY | CLASSIFICATION | STRUCTURE GRAPHIC | ATTRIBUTES | ESTIMATED VOLUMES | UPDATE FREQUENCY |
|---|---|---|---|---|---|---|---|---|
| Slope (1982) | orthophoto maps (1982) | 10: 000 | 20m resolution- | Schwabe and Johnson | area | class names | 0.34 Mbytes | - |
| Settlement (1989) | Andrew (1992), aerial photographs (1989), orthophoto maps (1982) | 1: 10 000 | 0 - 15m | - | point | - | 0.25 Mbytes | annually bi-annually |
| Settlement (1982, 1962 and 1942) | Andrew (1992), aerial photographs (1982, 62, 42) | 1: 10 000 | 0 - 15m | Andrew (1992) | point | Cattle kraal class | 0.52 Mbytes (actual) | - |
| Manufactured resources (1988) | | | | | | | | |
| Educational Commercial Administrative Health related | Talbot (1988), orthophoto maps (1982), fieldworkers | 1: 10 000 | 0 - 5m | names | point | feature names | 0.02 Mbytes | annually bi-annually |
| Post and telecommunicati on-cations (1994) | Transkeian Telephone Directory (1994), orthophoto maps | 1: 10 000 | 0 - 5m | point | point | building names telephone numbers | 0.002 Mbytes | annually |

Table 6.6: continued

of this chapter where it was stated that the source of some data sets were not recorded. Those that were recorded could be checked against the original source. Primary data collection from the field is also hard to check and this type of data would normally need to be ground truthed. Attribute data (data associated with a feature) were also checked, where possible against alternative sources of information.

**Groundtruthing**

Groundtruthing forms an important part of checking spatial data and their attributes. Although the study area was visited during 1992 these visits occurred before the completion of the digital coverage's. Problems were experienced in Groundtruthing data, the reasons for this are discussed in Chapter One.

**Preparation of data into a format suitable for input into a GIS**

The types of geographic data found in GIS were discussed in Chapter Two. With a few exceptions the preparation of geographic data and its attribute information into a format suitable for input into a GIS followed a similar path. The 1982 Orthophoto maps were used as a base onto which data from others sources were transferred. The orthophoto maps were secured to a light table with sticky tape. Care was taken to ensure that there were no folds in the orthophota maps and that the maps were lying flush on the surface of the light table. Tracing paper was secured in a similar manner over the orthophoto maps. Each piece of tracing paper was given a minimum of four reference points. A reference or tic point is a point of known location. Common tic points can be used to accurately align separate pieces of tracing paper or when digitising enable a GIS to accurately place the area on the surface of the earth according to the coordinates of the tic points. Geographic data extracted from a primary data source such as an aerial photograph are then mapped onto the tracing paper covering the Shixini orthophoto maps. A number of the secondary sources were also transferred in this manner. Suitably geo-referenced maps such as the South African 1:50000 topographic map could be digitised directly although due to a different coordinate and projection system this map would have to be changed to geographical coordinates in order to fit the data to that of the orthophota maps. Another method of achieving this objective is to use recognisable points common to both the topographic and orthophoto maps. This method could be used for a number of the maps without coordinate systems identified earlier in this chapter. In addition to the methods of data preparation mentioned above, geographical data if supplied in LO coordinates could also be entered directly into the GIS via the keyboard or be inputted via a digital source such as a string of coordinates in ASCII format.

An important component of preparing data for digitising includes providing the feature with an ID so that feature can be recognised. Lines, areas and points are meaningless without a pointer identifying what feature they represent e.g. a line could represent a number of things such as rivers, roads, railway lines, pipes and many more, a unique ID can differentiate lines into recognisable features. Features may in turn have a number of categories requiring identification e.g. roads may be differentiated into national roads, main roads, secondary roads and dirt roads.

The identification scheme chosen for a particular data types depends on the ultimate use of the data. It also has important connotations for the attachment of attribute data, for example if all the residences in Shixini are given an ID of 1 it would be extremely hard to identify the Chiefs residence both in the database and the graphic representation. If however the chiefs residence was given an unique ID of 10 then displaying the location of the residence or adding attribute information in the database would be simple.

Attribute data is usually attached to a unique ID or IDs in a database. Preparation of such data can be achieved by directly inputting the data into the GIS's database or by importing it via another product such as a spreadsheet. The structure of the attribute data depends on its type and the number of characters. GIS database structures usually allow for the input of attribute data as binary, characters or numerals. The different choices have different maximum lengths (usually imposed by the software) and allow different operations to be carried out on the data.

### 6.2.5 - Data requirements of the Shixini database

The following data needs were discerned from the information requirements.

**Data requirements for a base map of the Shixini area**

Although not specified directly as an information need the purpose of a base-map is to provide a template to which other geographic covers can be aligned. Base map features include the following data: administrative and sub-ward boundaries, roads and paths, contours orthophoto map boundaries.

- **Shixini Administrative Boundary (Figure 6.3)**

The Shixini boundary was obtained in a digital format from Andrew (1992). The cover contained 14 tic points based on LO coordinates of the area. A further four tic points were added by keyboard to increase their number in certain areas. The extra tic points were common points included to make use of Heldstrüm's (1989) vegetation data. The features making up three of Shixini's boundaries could not be absolutely fixed. These features are the coastline and the Shixini and Jujura rivers. In the case of river boundaries the bank of the river rather than its middle were taken to indicate the boundary line and the coastline was demarcated by the beginning of the rocks forming the sea barrier.

Attribute data includes the name of the ward as well as the names of the features making up the boundaries.

- **Sub-ward boundaries (Figure 6.3)**

These features were derived from Deliwe (1992) and Heron (1990) who described Kwitshi and Nompha sub-wards respectively. The boundary lines were traced from features present on the orthophota maps. The remaining sub-ward boundaries were derived using the known boundary lines as starting points. The final product was approved by the ISER's Director (pers comm). The sub-wards are critical features as the base unit of the development process (McAllister No

Date, p.3). Sub-wards also form areal units within which resource and socio-economic data can be compared and displayed. The sub-ward boundaries accuracy could not be verified as no other definitive source of the information could be found. Although every effort was made to ensure that these features were correct it is possible that faults do occur. Attributes include the sub-wards names and name (if possible) the features defining the boundaries.

- **Roads and tracks (Figure 6.3)**

Roads and Paths of the Shixini area were available in a digital format for the year 1982 from Andrew (1992). This coverage was plotted at a scale of 1:10000 and overlaid on the orthophota maps. The overlay was updated with data extracted from the 1988 aerial photographs. Roads were differentiated into secondary roads ( gravel roads which are graded) and tracks (not graded and usually impassable by a car in the rainy season). Attribute data differentiated the two types of roads.

- **Orthophoto map boundaries (Figure 6.4)**

The orthophoto map boundaries and their reference numbers were included for easy reference to the orthophoto maps. LO coordinates were read off the orthophoto maps and entered into the package as strings of comma delimited numbers.

Attribute information included consisted of the orthophoto reference numbers.

- **Contours (Figure 6.5)**

Contours were extracted directly from the orthophoto maps at a contour interval of 20 metres. This was considered to provide enough resolution should the data be needed for a digital elevation model (DEM). The Transkei Surveyor General was unable to supply orthophoto map numbers 3228BC3 and 3228BC4 which made up 2.02 per cent of the surface area of Shixini (see Figure 6.4). Contours were instead digitised at a 20 metre interval from the 1:50000 topographical map for this portion. For display purposes a contour interval of 60m was used. Attribute data included identified the contour heights.

**Land use and physical resource data**

The majority of the land use data were acquired from the 1988 aerial photographs. The photographs were examined under a stereoscope and the relevant geographic data comprising the following types extracted: vegetation, settlement, agricultural land, plantations, erosion features, springs and natural water features. Surface water features, boreholes, dams and slope data were obtained from other sources such as the orthophota maps, the Department of Agriculture and Forestry and maps compiled by the TATU fieldworker.

- **Vegetation cover (Figure 6.6)**

Vegetation data for the area was broken down into a broad and simple classification similar to that used by Heldstrüm (1989). The following vegetation communities were distinguished:

grassveld, acacia savannah, valley bushveld, coastal forest, passerina rigida (coastal scrub). Exotic plantations and agricultural land, which was divided into fields and gardens, were also delineated.

The exotic plantation is clearly visible from the aerial photographs as it forms a distinct continuous fenced area. According to Burchmore (1988, p. 67) the vegetation consists of Acacia meansii, an alien to the area, which is used by the local inhabitants for roofing and the walls of houses.

Fields and gardens were reselected from the 1982 digital land-use coverage made available by Andrew (1992). These features, together with the tic points, were plotted onto tracing paper at a scale of 1:0000. These plots were overlaid on the 1982 orthophotas. The 1988 aerial photographs were then used to update these features. Gardens were easily identifiable on the aerial photographs as small fenced cultivated areas located to the front or side of the homesteads. Demarcated fields were also easily identified, however a problem occurred when trying to distinguish between cultivated, fallow and recently abandoned fields. Andrew (1992) noted that fallow fields tended to have a less regular vegetation pattern than did recently cultivated fields. Abandoned fields tend to have a similar pattern to that of the fallow fields although vegetation growth may be more prolific than on fallow fields depending on how long it has been abandoned. This data was not gathered but would be considered very useful. Project implementation began in 1992, making the source data four years old at the time. In terms of land patterns in a rural area this is a relatively long time and this was evident when examining more recent field sketches completed by Deliwe (1992). Sketches revealed that one area that was classed as arable land in 1988 was in fact residential land in 1992. It is therefore possible that there is a large margin for error with regards to land use due to the data not being up to date. Attribute data included identified the vegetation class.

Historical data available from Andrew (1992) includes land use data for 1942, 1962 and 1982. The vegetation communities used by Heldstrüm (1989) are not the same as those used by Andrew (1992). Andrew's vegetation classes would have been used to allow for continuity, however, it was indicated by the project management that of the sources available Heldstrüm's would be preferred. Other features included arable fields and gardens.

- **Erosion Features (Figure 6.7)**

Erosion data were identified from the 1988 aerial photographs. The erosion classification system used for the study is a simplified version of the Southern African Regional Commission for the Conservation and Utilisation of soil (SARCCUS)(1981) which was chosen for its applicability to the southern African region. The simplified classification is one originally used by Ntsaba (1989, 59) for mapping erosion features of the Maqualika dam catchment, Masuru.

The SARCCUS system indicates both the type and intensity of erosion features, identification of the former is often straightforward but the latter is problematic due to the large number of categories in the SARCCUS system and the difficulty of distinguishing these intensities from aerial photos. As a result of this problem Ntsaba (1989) reduced the SARCCUS classification system from 15 classes to six broad erosion categories (see Table 6.7) which maximise visible differences between erosion features. Erosion features delineated in the database should be seen as areal units.

The three main types of erosion mapped, sheet, rill and gully erosion, are described in SARCCUS (1981, p.2). The original SARCCUS classification system allows for both wind and water erosion; Ntsaba's (1989) simplification does not distinguish between the eroding agents. Attribute information included identified the erosion class.

| EROSION CLASS | DESCRIPTION | SARCCUS CLASS |
|---|---|---|
| 1 | No erosion | S1 |
| 2 | Slight sheet erosion without rilling | S2 |
| 3 | Severe sheet erosion with slight rill erosion | S2R2, S3R2 |
| 4 | Severe sheet and rill erosion without gullying. | S3R3, S4R3, S4R4 |
| 5 | Sheet and rill erosion with low density first order gullying | S2R2G2, S3R2G2, S3R3G2, S4R4G2, S4R2G2, S4R3G2, S4R4G2 |
| 6 | Sheet and rill erosion with high density second order (and above) gullying | S3R2G2, S3R3G3, S4R2G3, S4R3G3, S4R4G3, S4R3G4, S4R4G4 |

Table 6.7: Simplification of SARCCUS after Ntsaba (1989).

• **Soils data**

Considering the importance of agriculture in the Shixini area soils form an important information need. Data collected by Burchmore (1988) remains the only source of this information. Although Burchmore did a complete soil analysis on a number of soil samples taken from various points around Shixini, her extrapolation of this data to cover the whole of the Shixini area is vague. Burchmore based this extrapolation on her vegetation classes, however the results of the chemical analysis was so widely spread between samples taken from the same vegetation group that little reliable extrapolation could take place. This is despite trying to rework the data using other factors such as slope and historical land use. Data on soils remains an important requirement and should form part of a GIS database.

Attribute information should include the soil name, the number of horizons, the bedrock type and its depth. A chemical breakdown of the soil would also be useful as well as clay, sand and silt content.

- **Water resources (Figure 6.8)**

Perennial and non-perennial rivers were available in digital format, these being one of the digital coverages completed by Andrew (1992). The data was mapped from the orthophoto maps.

Line attribute data distinguished perennial rivers from non-perennial rivers and identified the feature by name, if available. Attribute data should include all the main tributaries by name as they are useful features for orientation purposes.

A number of natural depressions which were filled with water and probably used for domestic purposes were identified from the 1988 aerial photographs, in conjunction with the orthophoto maps and aerial photographs for the years 1942, 1962 and 1982. Each of these sources was used to ascertain the consistency with which these features contained water. That the features contained water were evident on all the sources consulted. The list of water features is not complete. Data on spring locations and their attributes such as recharge values collected by the TATU fieldworker were not available.

Attribute data that could be linked to the water features include identifying sources used by Shixini residents, the number of people/animals who use these sources, the purpose of its use, the amount of water used and the sources reliability. Other data could include a basic analysis of the water quality an estimate of water quantity, and where possible recharge values. Information concerning boreholes in the area was supplied by the department of agriculture and forestry on a rough 1:50000 map. The data supplied indicates the approximate location of test holes sunk by the department. No attribute data concerning the boreholes was available. Useful data would include estimates of water reserves, water quality and recharge values.

**Topographic data**

Certain topographic data namely contours have already been discussed.

- **Spot heights**

These features were mapped from the orthophoto maps. Point attribute data consisted of the spot height in metres.

- **Slope (Figure 6.9)**

Slope gradient was estimated by the absolute height method in which the maximum slope is determined by the distance apart of contours. This method was applied directly to the contours on the 1982 orthophoto maps of the Shixini area. Although contour intervals on the orthophota maps varied between 5 and 10 metres the slope was determined at a 20 metre interval. This resolution was considered sufficient to address most project related problems that might occur.

The intervals used in the slope classification are displayed in Table 6.8. This classification was used by Schwabe and Johnson (1990) in the rural and informal areas of Natal in order to determine slope limitations on agricultural and urban development. A slight modification was made to the original classification system which grouped "valley bottoms and crests", these were separated due to the need to try and derive a soils map from existing information ie the application of the catena concept, and to isolate suitable residential land (Chapter Seven).

| Slope Classes | | |
|---|---|---|
| Class | Gradient | Topographical feature |
| 1) > 1:3 | (33 - 100%) | Scarps |
| 2) 1:5 to 1:3 | (20 - 33%) | Midslopes |
| 3) 1:20 to 1:5 | (5 - 20%) | Footslopes |
| 4) < 1:20 | (< 5%) | Crests |
| 5) < 1:20 | (< 5%) | Valley bottoms |

Table 6.8 Slope classification - after Schwabe & Johnson (1990, 23)

The limitations of these classes on agriculture and peri-urban development are taken from Schwabe and Johnson (1990, p.23)

1) Slopes greater than 1:3 are suitable for natural vegetation or afforestation but not urban development.
2) Slopes from 1:5 to 1:3 are suitable for some ley crops and permanent pastures with some residential development being viable.
3) Slopes from 1:20 to 1:5 are suitable for occasional ley crops and residential development with some commercial development, including schools being possible.
4) Slopes less than 1:20 suitable for growth of lay and annual crops with most forms of development being possible.

Attribute data included identifies the slope class of the polygons and the gradient.

**Settlement data (Figure 6.10)**

Settlement data encompassed houses (huts), trading stores, local administrative buildings, schools and clinics of the area. Settlement data was available in a digital format for the year 1982. This data was plotted at a scale of 1: 10 000 and overlayed on the orthophota maps. In conjunction with the 1988 aerial photographs new building structures were added to the overlay and those that no longer existed or were abandoned, deleted. No distinction was made between the morphology of the building structures in the area which were either the 'traditional' round shape or a more modern rectangular or square shape. This may have been important as Deliwe (1992) observed that the round shape is characteristic of the 'reds' or more conservative people in the area while the rectangular shape is mainly built by the 'progressive' people (see Chapter Seven for the possible significance of this information).

No attribute information was included, however a number of attributes could be linked to the settlement data including demographic data, community and organisational data as well as data concerning individuals.

Digital data of the area for the years 1942, 1962 and 1982 was available from work done by Andrew (1992). Included as attribute data is a classification of kraal types as developed by Andrew.

**Manufactured Services (Figure 6.11)**

Certain manufactured resource data such as roads have been dealt with already.

**Educational, Commercial and Administrative buildings**

Education facilities, shops, the chiefs residence and the Jinqui Tribal Authority buildings were mapped directly from the orthophoto maps and updated with information obtained from Deliwe (1992) and the fieldworkers in the area. The need to check the original source became apparent when it was found that Dumilise school had moved premises since 1982.

Point attribute information identifies the name and purpose of the building(s)

**Post and telecommunications (Figure 6.11)**

The location of postal drops in Shixini was acquired from Talbot (1988). The data was collected by Talbot while doing fieldwork in the area. Locating the postal drops on the orthophoto maps was easily achieved as they were all located in well frequented buildings such as the trading stores.

Point attribute information included identifies the location of the postal drop.

Telephone services and their locations were acquired directly from the 1994 Transkeian telephone directory. At the time there were only three telephones listed for Shixini, all of which were situated in known locations.

Attribute information includes the name of the subscriber or building as well as the telephone number.

**Roads and paths**

Roads and tracks have already been dealt with under base data. Road and track data is also available in digital format for the years 1942, 1962 and 1982. This data was mapped by Andrew (1992) using the aerial photographs for the corresponding years. Attribute data included distinguishes between the two categories ie, roads and paths.

**6.2.6 - Update method and frequency**

It is evident that some of the source data for certain geographical entities were already dated by the start of the implementation period in 1992 to the extent that it could not be used with certainty. This reference is aimed specifically at agricultural land and settlement covers. Updating forms a critical (and expensive) component of maintaining a relevant database and cannot be neglected, consequently backup procedures need to be present to ensure that the data available is as current as possible. Updating of data available to the project have already been performed in that the 1982 land use coverages completed by Andrew (1992) were updated. However primary data acquisition using remote sensed data sources such as aerial surveys and satellite imagery for rural areas is expensive and could not be used for simple updates. The only realistic alternative is to utilise existing structures such as the Tribal Authorities (TA) or local steering committees set up for the project in conjunction with the fieldworker stationed in the area. McAllister (1989a, p.351) noted that field boundaries were fixed whereas gardens can be enlarged with permission from the nearest neighbours, fields become available only if new arable areas are demarcated by the TA. Although the application for a residential area starts at section level, a final approval is given at TA level in the form of the chief who registers the application (McAllister 1991, p.5). From the above information it is evident that the TA in the form of the chief acts as a repository for certain land use data and as such should be used as a source of data for the project. The chief's cooperation is needed to allow the fieldworker easy access to this information. The fieldworker in turn is needed either to record the new residential and garden sites onto the orthophoto maps or to fix the location of the site with a Global Positioning System (GPS) and do a field sketch of the site. The update frequency of this data would ideally be every four months or biannually. Other data such as roads, water features, slope and contours are less likely to change in the short term unless development initiatives include projects such as road construction. Other features such as natural vegetation may change in the course of a year, however small changes in the area occupied by a vegetation class are hard to update as the features are not absolutely located in the database. Unless changes are substantial updating these features would not be necessary.

Socio-economic data should forms an important part of a GIS aimed primarily at land use planning. Despite the lack of socio-economic data in the Shixini GIS database at the present time, this component should not be ignored and an accurate updated settlement cover could be used as a framework to which socio-economic data can be attached. Socio economic data changes rapidly and an annual survey, preferably at the end of the agricultural season would not be considered excessive. In the rural areas these surveys are hampered by the lack of literacy prevalent in the rural areas, which means that labour intensive collection methods are necessary to collect this data. Fieldworkers would be required to fulfill this function. A consistent spatial collection method is required which the use of a GPS in conjunction with orthophoto and GIS maps could provide.

### 6.2.7 - The use of a data directory

In any system the human factor is a variable component. This point is pertinent in the case of the ISER where the post-graduate students they have made use of are available only for a limited tenure. It was indicated earlier in this chapter that certain information collected during the course of the Shixini project, although potentially useful, could not be used due to various shortfalls. To help ensure that a continuum exists between one person and the next a detailed data directory is necessary to accompany the database. A data dictionary defines geographic items providing attribute values and their identities. The need for such procedures may appear basic, however experience at a university level indicates that these procedures are rarely carried out. In terms of a GIS database it is critical for the ISER to insist on such procedures to ensure a data flow between personnel. Reference should also be made to the lineage of the data and its classification in order to ensure a certain data standard (or at least provide an idea of how the data and its attribute values were determined). A data dictionary helps ensure that such a continuum exists. The concept of writing down key factors about a coverage is a simple one, the concept was used for the Shixini GIS and served quite adequately (the structure of the data dictionary forms Appendix Two).

### 6.2.8 - Estimation of workloads and hardware performance

This component is based on product definition and information requirements and forms an important part of hardware and software specification. Aspects addressed here include the number of simultaneous users, data volumes, response times and required production rates.

If a GIS were incorporated in the Shixini project there would have been little need to cater for simultaneous users due to the distances between the ISER, TATU and the Shixini Administrative Area. Ideally GIS facilities should be made available at both the university and TATU buildings with the Internet could then form the data highway between the two organisations.

Data volume in vector GIS differ according to the represented theme, its complexity, and the amount of attribute data associated with it. The estimated volume of the core and historical data coverages in a vector data structure is approximately 5.054 Mbytes (Table 6.6). The actual volumes are indicated in Table 6.10.

If a GIS were incorporated into the SDP the workload of the GIS as indicated in Step One of this Chapter would probably be irregular and would depend on the phase of the project being covered. Response times may be critical during certain periods of the project a point emphasised in both Chapters Four and Five. However the drawn out nature of the project would allow for data preparation, data input, editing, processing, data analysis and plotting to be completed without bottlenecks occurring. If the GIS belonged to the university problems may be experienced during the implementation period, especially when information requirements for the SDP coincide with GIS courses at the university, or other critical periods such as when post-graduate theses have to be completed. During these periods there is increased utilisation of the equipment and bottlenecks may occur.

Production rates do not necessarily apply to a project of this nature where no consistent product is required.

### 6.3 - Step 3: Preliminary design

This step is software and hardware independent. Preliminary design usually combines the various user requirements into an integrated database design this was however completed in Step 2. The step examines the preliminary functional specifications and system models necessary to support and produce the products defined during Step 2. These specifications are then taken to the market place to see if these needs can be fulfilled. This involves combining individual needs and perceptions identified in Step 2 and merging them into a single project related design. This step forms the basis of all future implementation and maintenance operations. Clark (1991) identifies the following procedures in preliminary design.

Preliminary design normally consists of the following components, preliminary database specifications, preliminary functional requirements, preliminary systems model and a market survey for potential systems. The first of these components 'preliminary database specifications ' was included in Step Two.

**6.3.1 - Preliminary functional specifications**

This component defines the desired functions and systems necessary to develop the database and provide the products discussed in Step 2.

The information products required for the SDP in Step 2 determine the preliminary functional specifications required of the GIS. Due to the nature of project work specific products were difficult to define for the SDP, however general information products were identified, these include:

- strong mapping facilities (Land use, topographic and thematic maps);
- the ability to input data in a number of ways;
- the ability to query both spatial and attribute data in order to answer 'where is' type questions;
- the ability to generate quantitative numerical reports; and
- the ability to combine spatial data in a number of ways in order to answer 'what if' type questions.

From these information requirements the following basic tools are needed by the GIS. A number of basic spatial tools which are capable of combining a number of different themes are needed in order to derive new data. Spatial tools are also necessary to display existing geographical relationships. These tools need to be coupled with a database with basic statistical functionality capable of performing selection and query operations on attribute data. Query capabilities need to extend to the graphics component so that the question 'what is' and 'where is' can be answered interactively with the user and displayed on the screen. The ability to measure distance on the screen would also be an advantage. Other capabilities should allow for the input of data from a number of sources including a digitising table, keyboard, interactively (using a mouse or trackball) and other digital sources. The package should also be able to import and export digital data in a number of formats in order to be able to take advantage of other digital sources.

A strong cartographic package capable of manipulating spatial data into different formats for output is essential; the package should also allow selective data retrieval and display.

The package should include a powerful and detailed HELP facility capable of explaining any problem that a user would encounter, or should come with a full set of manuals. A hotline to solve difficult problems as well as product based training would also be advantageous.

It would also be beneficial if the user interface system used by the package were able to satisfy expert and novice alike by incorporating a menu system coupled with a command driven system and a basic programming language to customise menus.

Although the initial tools required for the SDP are basic it would be advantageous if the basic functionality of the package could be upgraded or linked to other packages if increased functionality was required. Additional features might include routing functions and the ability to be linked with a raster based package capable of manipulating remote sensed data and producing DEMs.

### 6.3.2 - Preliminary system models

This purpose of this component is to describe the logical and physical design of the proposed system (Clark 1991, p.480). Aspects covered include hardware, software, people and organisational arrangements. Calkins and Marble (1987) note that the primary objective here is to match the conceptual model with the more restrictive commercial models available on the market.

The response time required of the GIS in the Shixini Development Project was seen as critical (Step 2, workloads and hardware performance), however the limited data volume of the core database and the modest estimated volumes of individual covers indicated in Table 6.6 would seem to indicate that demands on processing time would not be excessive on even low powered PCS. This would suggest that, depending on software requirements, the minimum hardware requirements would be a personal computer operating on either DOS or windows. The use of a laptop computer would however provide a more versatile hardware platform for this type of project as it is portable and is capable of being used in the field. Ideally this could be linked to an A1 size digitizing table and output device such as an inkjet printer or plotter capable of producing A1 plots.

### Personnel Requirements

Personnel (liveware) are an important component of a GIS (as discussed in Chapter Two) which can affect both the cost and the organisational structure of a project or organisation. Nine personnel functions can be identified they include: manager, GIS analyst, database manager, senior processor, cartographer, digitizer operator, system administrator, programmer and the end user (Hine 1989). The number of personnel required and their skill level differ according to the needs of the organisation.

A number of options are available to fill these positions. Hine (1989) notes that these positions may be filled individually or they could be filled by a single person. In the case of the Shixini GIS the subject of personnel would be very much determined by the policy adopted regarding the inclusion of the GIS as well as the long term aim (if any) of the ISER.

In terms of the GIS project the following options are available: a) the employment of a full time project member with GIS skills, b) training of an existing staff member and, c) the use of an external agency or person. Each of these options will be discussed in turn.

a) The employment of a person capable of operating a GIS would imply a certain commitment to the technology by the ISER or project management (even if the position is a fixed term). A full time employee might suggest a longer association with GIS. The advantage of employing someone at the ISER for a particular project are:

- it offers centrality and the employee is answerable to other members at the ISER,
- it was indicated in Chapter Two that in order to be used in an effective manner the GIS must form part of the decision support system. The person/persons using the Shixini GIS would therefore need to be involved in most phases of project work, such as data gathering, meetings and implementation projects. This can only be achieved by someone who's job description caters for such demands.

b) Another option is the training of an existing staff member(s) to fulfill the task. An advantage available to both the SDP and the ISER is that hardware and software is already available at Rhodes University and could be used. In addition student labour could be employed to digitise the identified data needs for a fraction of the price that an employee of the ISER could. An important advantage of training ISER staff to operate the GIS is that the decision maker, with his expert knowledge of development planning and the situation in the Shixini area, would have a better idea of what information he requires and what data is needed to obtain this information. He is also not dependent on others to answer simple data queries. A disadvantage is that a learning period is required during which the GIS would be unproductive.

c) The third option open to organisations is to employ a contractor or external organisation with the necessary expertise and equipment to fulfill the GIS requirements. The advantages offered by this is a ready system and the expertise to handle it. GIS data can also be kept and used in the future if the organisation finds that it is viable to purchase their own system (a problem with project related data is that it is usually only used for a short period and is then discarded ie, it may not benefit the organisation in the future). There are however a number of disadvantages associated with contracting out. These are:

- there is less control over the information process
- the benefit of having a database capable of answering basic spatial queries and of dynamically displaying data would be lost as there is no way for the organisation to display this data.

**The need for data processes and training.**

The flow of data and information in development organisations where limited diversification of skills occur will rarely follow a regular path. The reason for this is that external organisations/people with the necessary expertise are usually contracted to fill these gaps. This implies that the organisation facilitating the project needs to specify data standards (in the absence of a national standard) to make sure that data and information produced outside of the organisation can be used in the future. This point also applies to data collected within the project. Due to the importance of the fieldworker in the data collection process a certain amount of training is required to make the person aware of data collection procedures and the value of observing these procedures in terms of increasing data value and decreasing the future work load. Basic courses in practical GIS as well as spatial data collection and recording techniques and map reading skills could be offered. Additional courses in the handling of a GPS would also be an advantage (as discussed in Chapter Three).

**6.3.3 - Market survey for potential systems:**

Specifications obtained from Step 2 and Step 3 were combined in a brief which was sent to a number of the major GIS vendors in South Africa (Appendix Three). The vendors were required to list which specifications they could fill, the hardware limitations of their software, backup services, training courses offered and the approximate prices of these products.

The market survey examined certain characteristics of four commercially available GIS, these packages were Arc/Info, ReGIS (which are known as full or upper end GIS), MapInfo and Atlas (desktop mapping systems). Generally upper end GIS are more expensive and have more functionality than desktop mapping systems. Characteristics examined included the package's ability to satisfy the preliminary functional requirements of the Shixini GIS. The survey also established the cost of the package, the type of operating platform, the minimum hardware requirements, the user interface, export and import capabilities as well as backup services offered by the vendor.,

The different systems all offer the functionality required by the Shixini Development Project. Both upper end GISs have sophisticated analysis tools capable of analysing most spatial problems. The functionality required by the SDP fall well within the functionality offered by both packages. Both packages have sophisticated display and mapping facilities capable of producing intelligent maps. Both ReGIS and Arc/Info offer a pull-down menu system, in addition Arc/Info can be command driven. Despite these features Arc\Info and ReGIS are large packages and difficult to learn. ESRI the supplier of Arc/Info does offer a separate spatial display and mapping package called Arcview. Arcview One is now freeware while Arcview Two retails at about R 5 400. The package is however heavy on memory and needs at least a 486 with 16 Mbytes of RAM.

The two desktop mapping systems MapInfo and Arc/Info are not normally used for the input of data from a source such as a digitizer, but do have the functionality to do so. The systems are mainly used to display and map spatial data, at the same time they both incorporate spatial analysis tools such as overlay and buffer features. This capability is coupled with strong database capabilities. Due to their primary role as a means for displaying data they also have strong data exchange facilities. These packages incorporate easy to use pull-down and icon driven interfaces.

All the packages can be customised using either the specific programming language provided with the packages or, in the case of Atlas, a number of readily available programming languages.

All but one of the main distributors (vendors) of the products offer a hotline (sometimes dependent on a maintenance contract) and training courses the exception being Atlas for which this information could not be ascertained. Most of these courses are limited to the main centres (Johannesburg, Cape Town and Durban). Arc/Info has a single distributer in South Africa who is located in the Johannesburg area, courses are only available at this centre. The vendors do offer to travel if it is viable for them to do so.

**6.4 - Step 4: Cost benefit analysis**

This step establishes the economic sense of acquiring a GIS against the alternative of maintaining the original system(s) or other competing information systems. Cost benefit activities include: An estimation of all costs, an identification of benefits, an assessment of impacts and an analysis of the results.

**6.4.1 - Estimation of costs**

An estimation of quantifiable costs include: possible costs of the acquisition, running and maintenance of hardware and software, data capture and its subsequent update and maintenance, staff and training costs, site preparation and user support and overheads including re-occurring costs.

Cost plays a critical role in determining the feasibility of incorporating any technology into a project. In this analysis of costs involved and options open to the ISER and SDP real figures based on late 1994 early 1995 prices have been used. There is a danger that this section will read as a consultancy report, however the critical nature of costs as an indicator of technology suitability make this part of Clarke's model important as an indicator of the technologies appropriateness in a particular situation.

A cost benefit analysis should also determine or provide an idea of the usefulness of the technology. A number of factors affect the cost of incorporating a technology into a project/organisation these include the cost of the technology and its component parts, possible changes in organisational structures and systems and additional staff or staff training.

In Chapter Two it was mentioned that data costs are typically 80% of total system costs. This is not necessarily true with regards to small project related GIS where the relatively limited duration of the project and data make the hardware and software proportion of the total cost substantially higher, especially where no financial arrangements are made for future funding.

In the case of an organisation wanting to make use of a GIS there are a number of options open, each of which has a number of advantages and disadvantages. These include 1) the outright purchase of hardware and software, 2) the contracting out of data requirements and, 3) a mixture of the two. Each of these are discussed below.

1) When looking at the outright purchase of hardware and software there are a number of options available as well as substantial differences in costs. Hardware costs as mentioned in Chapter Two have been substantially reduced over the years while at the same time have increased in power. A common PC configuration available on the market is the 486 2/DX, with a 520 Mbyte hard disk and 4 Mbytes of RAM can retail at anything from four thousand rand upwards. With

this configuration however more RAM is required which can be expensive ranging from between R 100 and R 200. An option open to organisations who already have hardware is to avoid the cost of buying new equipment and simply upgrading if necessary. Software prices differ substantially as can be observed in Table 6.9. Prices range from between R 2 800 and R 26 300 for the basic product, a number of other costs such as software maintenance can push this price up substantially.

Table 6.9: Results of the GIS market survey (Conducted 16-20 October, 1995)

| Features | PC Arc/Info | ReGIS | MapInfo | Atlas |
|---|---|---|---|---|
| Operating system | DOS<br>Windows | Windows<br>Windows NT | Windows | DOS<br>Windows |
| Programming language | SML (simple macro language) | SEGAL | MapBASIC | Industry Standard<br>Visual Basic<br>Visual C<br>C++ |
| Minimum hardware requirements | 386 with 8 Mbytes of RAM | 486 with 8 Mbytes of RAM | 386 with 8 Mbytes of RAM | 386 with 8 Mbytes of RAM |
| Hotline | Yes | Yes | Yes | Not established |
| Training and cost | Offers three day course in Johannesburg, price unknown | Vendors offer a three day course in either Johannesburg, Pretoria or Cape Town. The price of the courses is unknown. | A number of two and five day courses offered throughout the year in Pretoria at approximately R 550 a day. | Not established |
| Cost of the basic package | Basic cost for the entire package R 18 700, maintenance cost (optional) is an extra R 2000. | Basic cost of the package is R 26 300, software maintenance R 4 208 annually. Educational institutions can get special deals. | Basic cost, R 6 500. Educational institutions get the package half-price | R 2 800 (educational institutions)<br>Normal R 3 800 (three licences). |

The purchase of peripherals such as a basic digitising table and plotter are expensive depending on the needs of the organisation. The minimum cost of a new monochrome plotter capable of plotting A1 size paper is approximately R 13 500, while a colour inkjet plotter starts at around

R 30 000. Printers including laserjet and inkjet are available from R 2 600 upwards. An A0 digitising table will vary in cost from R 15 000 to R 60 000 depending on the design features and accuracy required, the A1 starts from a little less. Digitizing tablets sizes A4 and A3 can start from R 1 500.

Added to these costs are maintenance, media supplies and possibly a suitable system environment such as humidifiers and air conditioning.

Taking these factors into consideration the cost of basic hardware could range from as little as R 11 300 for a system consisting of a new computer and a desktop mapping system such as Atlas coupled to a A3 digitising tablet and an inkjet printer up to tens of thousands of rands. Coupled to these costs are the costs associated either with the hiring of an additional staff member or the training of staff within the organisation. If the latter is used there will probably be a relatively steep learning curve until the GIS becomes fully operational.

2) A second option is to use a GIS through a contractor or organisation who maintains the necessary equipment and possible expertise. The information requirements and data are produced for the organisation. In this way the majority of the equipment and maintenance costs are borne by that organisation. This is similar to work done on GIS for the ISER where the facilities used were those of the Geography Department, Rhodes University. The costs of hardware and software maintenance as well as software licensing was borne by this department. The advantages of using this equipment included access to a number of PCS as well as a digitizer, colour plotter, laser and colour inkjet printers and a number of GIS software.

Possible costs involved in project work for the SDP would encompass labour costs or a fixed sum which would normally cover a portion of the contractors overheads.

3) A third option involves a combination of the preceding two options. In this option an organisation maintains some hardware and software but contracts portions of the work such as the digitizing and plotting to external organisation with these facilities. In this case costs are limited to the hardware and software and possibly a peripheral such as laser printer. In this case the expensive peripheral equipment is not needed, useful output can be maintained, costs are minimised and the actual spatial manipulation can be carried out by someone in the organisation. The minimum hardware and software cost for an organisation would be R 9 400 which includes a cheap printer. In the case of the SDP where the ISER has both the necessary hardware this would be limited to the purchase of the software starting at R 2 800. Added to this amount would be the data costs of converting existing data in to a suitable digital format, these costs are estimated at about R 2 500 in a university environment (a rate between R 10 and R 15 and hour). This amount includes the data preparation, data input into a GIS, the cleaning of the digital data and providing it with some intelligence through correct labelling. In the large centres such as Johannesburg digitising costs worked out at R 50 an hour (as of October 1995).

**Data base costs**

An estimate has been made of data base costs in the preceding paragraph. The actual cost and time involved in achieving this objective is provided in Table 6.10. Excluded from these figures are the covers digitised by Andrew (1992) which if included would have increased the costs substantially. It is assumed that the actual costs of data collection would be present no matter which system was used and are therefore not included.

**6.4.2 - Identification of benefits**

This component identifies all benefits of incorporating GIS, both tangible and intangible. Three kinds of benefits can be identified, two are tangible and the third intangible. Tangible benefits identified by Calkins (1991) include efficiency and effectiveness. Efficiency in this case refers to savings that could be made through time and cost, while effectiveness relates to improvements in the information process resulting in better informed decision making through more timely or new information products. Intangible benefits could include a more modern image ie: prestige (Calhoun *et al.* 1987). Although the possible benefits of a cost analysis as a general indicator are widely used, the limits of this method are sounded by Arnoff (1989) who stressed that it was rare that solid cost benefit expenditure could be made for computer systems, due to the difficulties in quantifying often intangible benefits. Arnoff (1989) stresses that "cost benefit justification tend to include some quantification of benefits, but are still more or less a leap of faith" (Arnoff 1987 p.252). This view echoes that of Calkins (1983) who observed that although it is possible to quantify or give a monetary value to efficiency, the value of "effectiveness" and the intangible benefits are hard to quantify. In view of these misgivings it is felt that, rather than quantifying the benefits offered by GIS for the Shixini development project, it would be more useful to follow a course of action suggested by Chorley (1988), that is to indicate the quantifiable costs and list the possible benefits and allow them to be assessed and analysed by those who make strategic decisions.

Possible benefits offered by GIS fall in to a number of categories these are quantifiable benefits, expanded benefits and intangible benefits. A number of these types of benefits are ambiguous in nature and may fall in more than one category.

**Quantifiable efficiencies**

These benefits are quantifiable in that they would accomplish certain tasks in less time and possibly more accurately than the manual methods that would otherwise be used.

If data has been suitably automated, map production is a routine function which can be completed in a fraction of the time of manual methods. Information derived from the GIS can also be displayed or presented in a number of formats.

Map update is relatively painless and using the old data as a template makes it unnecessary to duplicate that data which remains the same.

The automation of base features and the GIS functionality has created an opportunity to generate multiple specialised products which without GIS would probably not be attempted. The problem addressed in Chapter Seven is an example of such a product.

The generation of new information such as potential erosion from existing factors was achieved using the GIS basic functionality. This information could be obtained using manual methods but this would be both a difficult and time consuming process.

Assuming a well set up and accurate database the GIS could decrease, but not exclude the number of visits by management to the development site.

In general the benefits of GIS are hard to quantify in that no clearly defined products were produced at regular times during the life of the SDP. The changes to and subsequent production of a map, which manually would be time consuming, might or might not be required in a project situation. Clearly the number of times that a time saving action is performed will effect the financial benefits of using the technology.

**Expanded benefits**

A number of expanded benefits have been mentioned already. These benefits are those tasks which are useful but are not undertaken due to the manpower element required to derive a suitable answer. In these instances GIS acts as "extra staff".
In the case of the SDP these include the following tasks:

- the production of maps and tables for use during steering committee meetings;
  the manipulation of existing data sets in order to produce new information and decreasing the time spent in the field,
- spatial analysis of problems which are routine in GIS, but difficult to achieve using manual processes such as calculating the average size of gardens in the Shixini area or counting the number of homesteads associated with gardens,
- the backing up of "experience" with tables, maps and graphs obtained in a clear and retraceable way.

**Intangible benefits**

Intangible benefits include 'improved decision making'. A number of the above 'benefits' to the Shixini Development Project have an intangible quality. The provision of accurate quantifiable data which can be used to assist in decision making and to provide timely information as well as possible options and impacts would be of the greatest benefit to the development process. The volatile nature of the development process and the need for the facilitating organisation(s) to be seen as achieving concrete goals might prompt the facilitating organisation to proceed without adequate information of the possible consequences of a particular action. The benefits of presenting information in a number of different mediums may improve the decision makers perception of a problem.

The data available to the project via a GIS might be useful in providing information to other organisations involved in the area such as school feeding schemes and other RDP related organisations leading to increased cooperation with other organisations. The ability of presenting maps of development in the area as well as probable areas might also improve the chances of getting increased funding in rural areas such as Shixini, especially from foreign donors who are familiar with the use of GIS for projects.

One of the benefits of using GIS is that in order to utilise the technology effectively a structured approach to data needs has to be adopted. This will improve the focus and quality of data. Data collected in this manner will also include all the relevant aspects needed for other sectors of the project, decreasing the need to collect the data again.

**6.4.3 - Assessment of impacts**

This component assesses the impacts of GIS on the organisation and staff. GIS affects the organisation and its staff in a number of ways, some of them economic: new organisational procedures and structures, new staff and/or the education of present staff, changes in data collection procedures and its possible political and legal implications.

**Personnel requirements**

The costs associated with personnel are not given as they vary with skills and according to the organisation's own salary structure. In the case of outright purchase personnel would be needed to install, customise and run the GIS. Installation may be performed by the staff, vendors or other university staff. The installation of a PC based GIS would point to either a member of staff being trained or being employed/contracted (as discussed in Step Two). Hiring a new staff member with the relevant skills is costly and implies a long term commitment to the technology. A much cheaper option is to hire students to do the job as the institute does not have to pay fringe benefits as it would with a full time employee and it provides the student(s) with much needed experience.

Contracting external staff and resources to process and produce the required information, would reduce the overheads and capital expenditure required for the project. A defined cost for the project work to be undertaken or an hourly rate is paid for the information.

The third option might best be served by the training of the end users to operate the GIS so as to get the best results. It will also be necessary to find an organisation/person capable of converting existing data as well as future data needs into a suitable digital format. This is possibly the best of the options as the capital cost of acquiring the GIS is not exorbitant and the benefits of using a GIS within the organisation can be realised.

If official GIS product training is required the cost to an organisation is high, especially when that organisation is located in the rural areas or in a small town. Official courses are offered only in the major metropolitan centres, however, vendors are willing to make the trip to a specific location provided that there is sufficient inducement to warrant such a trip. To send a single staff member for training on a typical five day course in Johannesburg would cost the ISER approximately:

| | |
|---|---|
| Course costs | : R 2 500 |
| Travel | : R 900 (motor Vehicle) R 1 800 (air travel) |
| Accommodation | : R 1 250 (@ R 250 a day) |
| Subsistence | : R 300 (@ R 50 a day) |
| Total | : R 5 850 |

Other costs include the opportunity cost of that persons absence from his place of work.

**6.4.4 - Analyses of results**

The costs, benefits and risks need to be analysed, and presented in some way ie see Dickeson and Calkins (1988). Calkins (1991) stresses that the minimum requirement is to represent the basic economics of the proposal together with the factors not quantified in this case intangible benefits and effectiveness. Actual costs have been provided during Step 4, as an indication of the expenses involved in GIS acquisition. These expenses should be weighed against the benefits of the GIS discussed in Step 4.

Various options have been discussed for actually acquiring the technology or using the technology in the Shixini project. Although the technology is not cheap the various options discussed earlier in the step indicate that costs might be tailored to fit the pocket, however the maxim holds that the less the system costs the less the functionality of the GIS. Hardware and software costs are just part of the costs involved when acquiring a GIS. Acquisition requires a concomitant of staff and resources to maintain the GIS as well as the cost of inputting and maintaining data. At the outset is would have to be said that the acquisition of a GIS solely for the Shixini Project would be uneconomical due to the small size of the project and its limited budget. The only economically viable option open for project work of this kind is the use of external equipment and staff, a policy currently pursued by the ISER. The disadvantages with this policy were discussed earlier in this step. Possible solutions to these problems would be the long term training of an existing staff member or staff members involved in project work at the institute who could then use the equipment available at the university. The Acquisition of a GIS for project work would only be feasible with a long term commitment to the technology by the ISER. Relying on inputs for its continued use from project related work would mean that a high turnover of projects would be necessary due to the irregular nature of community development (as discussed in Step 1 of this chapter) when the GIS might not be used for long periods of time.

**6.5 - Step Five: Hardware, Software and the Shixini GIS database.**

This step, although not part of Clark's acquisition model, fulfils one of the objectives of the Shixini GIS which was the establishment of a digital database. The Step essentially carries on from Step Two where the base data requirements for the Shixini GIS were defined. Step Five describes the hardware and software used for the project, the digitising process, preparation times, database volumes and costs involved in setting up the database.

### 6.5.1 - Selection of a pilot system

The pilot system chosen was the PC version of Arc/Info. A product of ESRI, Arc/Info is one of the oldest and most successful commercial tumkey GIS systems on the market today. Important factors leading to its selection as the pilot system include:

- the system is vector based
- it was available for use at Rhodes University
- the author was familiar with the product
- the digital data made available from other sources was available in the systems internal format.
- it represented a system with the full functionality required by the Shixini GIS.

Arc/Info consists of two primary components, Arc which stores coordinate data and performs operations on that type of data and Info which is a relational database management system (DBMS) (Dangermond and Smith 1988, pp.301 - 306; Understanding GIS, the ARC/INFO Method 1993, pp.3-13; Green & Wiggins 1985, pp.295 - 301). ARC/INFO is a modular, vector based GIS capable of importing and exporting data in a number of digital formats. ARC/INFO is comprised of a number of modules of which the following were used in the project: ARCEDIT, ARCPLOT, PC STARTERKIT, TABLES and OVERLAY.

The following software packages were used in conjunction with Arc/Info. Quatro Pro was used as a spreadsheet for the analysis of attribute data exported from the DBMS and for the input of attribute data into the DBMS, it was also used to increase the range of the data for presentation purposes. WordPerfect was used in conjunction with ARCPLOT for lengthy documents and for ancillary map information such as map keys which requires input in ASCII, and lastly the DOS editor which was used to write Simple Macro Language programmes (SML) in order to customise repetitive Arc/Info functions.

The hardware platform used for the project consisted of a PC 486 DX/2 66 linked to a flatbed digitiser capable of accommodating A0 sheets of paper and a Hewlett Packard DraftMaster SX pen plotter capable of plotting maps of a similar size. Other hardware included a Hewlett Packard laser printer and an inkjet printer.

### 6.5.2 - Input of base datasets

The base data which was identified and prepared for digitizing in Step 2 formed the basis of the Shixini GIS database. Each of the covers identified in this step were digitised using a flatbed digitizing table, the exception were the orthophota boundaries which were keyed in via the keyboard. Information concerning each cover (theme) digitized was noted in the directory developed for this purpose (see Chapter 6, Step 2). The completed forms are found in Appendix

Two. The times taken to transform the initial data into a format suitable for digitising, digitising itself, and cleaning/editing are recorded in Table 6.10 as are the volumes of each cover.

Digitising is a labourious and time consuming process which forms the basis of the database. The input of data is a mundane but critical process which if not done properly can lead to a number of spatial and attribute errors which will ultimately affect the quality of information obtained from the system. The following steps were used during the digitisation process. The themes which were traced onto tracing paper during Step 2 were placed flat on the digitising table and secured. Using the digitising tablet the tic points were digitised. This process lets the program know where the lines and points are in relation to a defined point. Lines and are then digitised by tracing the feature. Arc/Info allows the operator to give the lines, points and polygons unique identifiers while digitising, emphasizing the importance of preparing the data before digitising.

Once digitised the cover is edited. Digitising is subject to human error, often operators overshoot an intersection (the line extends past the point of origin) or undershoot the line in either case the polygon is not properly closed. In order to rectify these errors the operator may clean the data automatically (the software closes the polygons) or each error must be moved. Failure to clean the data results in various errors occurring while performing spatial operations and queries. The software used has built in algorithms which can detect and correct a number of these errors. Attribute data was checked by plotting out the relevant themes and checking against the source. Each of the covers digitised was plotted for this purpose, the following plots can be found at the end of this chapter:

| | |
|---|---|
| Shixini administrative boundary | (Figure 6.3) |
| Sub-ward boundaries | (Figure 6.3) |
| Roads and Tracks | (Figure 6.3) |
| Orthophoto map boundaries | (Figure 6.4) |
| Contours | (Figure 6.5) |
| Vegetation data | (Figure 6.6) |
| Erosion Features | (Figure 6.7) |
| Water Resources | (Figure 6.8) |
| Slope | (Figure 6.9) |
| Settlement data | (Figure 6.10) |
| Manufactured services | (Figure 6.11) |

**6.5.3 - Database volume, preparation and digitising times and the cost of the database**
The volume of the Shixini database is small by most project standards with a volume of 5.7 megabytes. This does not include the volume of the plot files. The volume of a raster based GIS such as IDRISI with a resolution of 7.5m X 7.5m and a grid of 800 X 1356 cells would occupy approximately 21.7 Mbytes.

**Table 6.10: Indicating approximate cost and time taken to complete individual base coverages**

| Cover(s) | Currency of Data | Representation | Volume in Bytes | Preparation Time Hours | Digitising Time Hours | Editing Time Hours | Total Hours | Total Cost @ R 10 /h |
|---|---|---|---|---|---|---|---|---|
| Landuse | 1988 | Polygon | 944.454 | 38 | 15 | 11 | 64 | 640 |
| | 1982 | Polygon | 801.597 | | | | | |
| | 1962 | Polygon | 405.845 | | | | | |
| | 1942 | Polygon | 434.366 | | | | | |
| Slope | - | Polygon | 334.391 | 22 | 11 | 6 | 39 | 390 |
| Contours | - | Line | 683.694 | 2 | 12 | 1 | 15 | 150 |
| Erosion | 1988 | Polygon\line | 210.480 | 11 | 3 | 4 | 18 | 180 |
| Rivers | - | Line | 415.763 | | | | | |
| Dams | 1988 | Polygons | 15.369 | 1 | 0.5 | 0.5 | 2 | 20 |
| Boreholes | 1992 | Points | 6.732 | 0.4 | 0.25 | - | 0.65 | 6.50 |
| Roads | 1988 | Line | 48.895 | 4 | 0.5 | 0.25 | 4.75 | 47.50 |
| | 1982 | Line | 36.628 | | | | | |
| Settlement | 1988 | Point | 301.030 | 15 | 4 | 4 | 23 | 230 |
| | 1982 | Point | 206.666 | | | | | |
| | 1962 | Point | 170.450 | | | | | |
| | 1942 | Point | 140.329 | | | | | |
| Boundary | - | Polygon\Line | 65.307 | | | | | |
| Sub-Ward boundaries | 1988 | Polygon\Line | 34.441 | 8 | 1 | 0.5 | 9.5 | 95 |
| Ortho- Boundaries | 1982 | Line | 45.445 | 0.5 | 0.5 | 0.5 | 1.5 | 15 |
| Total | | | 5738.042 | 101.9 | 47.75 | 27.75 | 177.40 | 1774.00 |

(*) = Coverage's digitised by Andrew (1992) (-) = Step unnecessary

The time taken to create the various covers (themes) making up the Shixini database are given in Table 6.10. The total amount of time taken, 177.4 hours, includes preparation time, digitising time (including attributes) and editing time. The time provided in Table 6.10 does not include that of Andrew (1992). Based on the work completed for this study a broad estimation of the time taken by Andrew (1992) would be two to three months. The majority of this time (101.9 hours), was spent preparing the data for digitising, this process was explained in Step 2 of this chapter. Digitising times depended on the complexity of the themes being digitised, the more complex the cover, the longer it takes to digitise. Complex covers such as landuse and slope where a number of small polygons needed to be digitised were also more prone to errors such as overshoots and undershoots and therefore required more editing time.

The cost of the database was worked out at ten to fifteen rand an hour, typical student rates in 1994. The cost of preparing the database therefore works out at between R 1774.00 and R 2 661 which is very close to the estimate made in Step 4 of this chapter. If digitised outside the university environment the database would, at 1994 prices (@ R 50.00 an hour) cost approximately R 8 870 .

### 6.6 - Conclusion

In terms of the short term objectives of the Shixini GIS the following was achieved in this chapter: geo-referenced data relating to the Shixini project was consolidated and a number of data gaps as well as future data needs were identified. Data that could be used from that data collected was converted into a digital database.

Chapter Seven will be used to demonstrate the capability of the database by addressing a user set problem. Possible application areas of the GIS in the development process will also be identified.

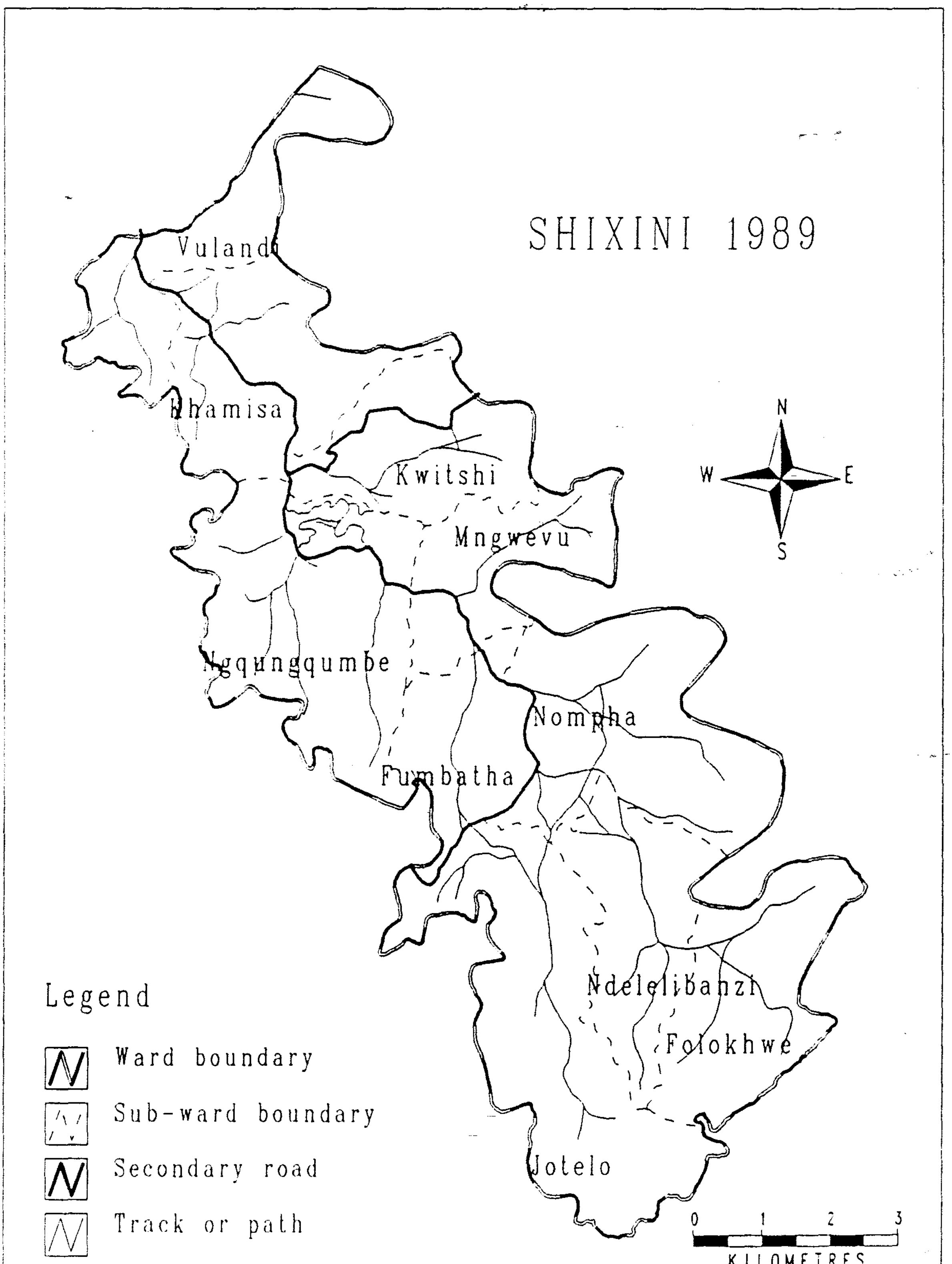



Figure 6.3 Administrative boundaries, roads and tracks

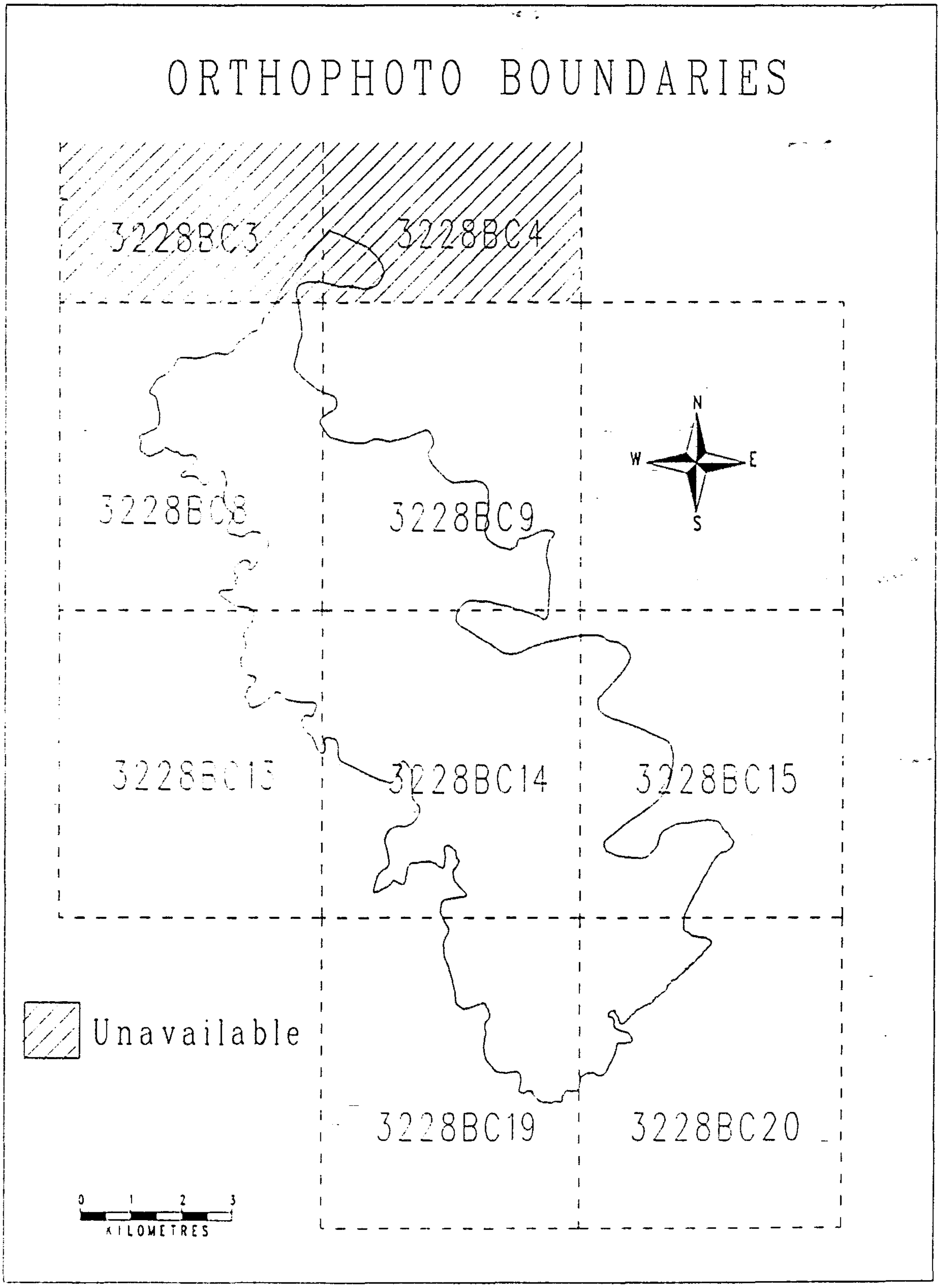



Figure 6.4 Orthophoto map boundaries

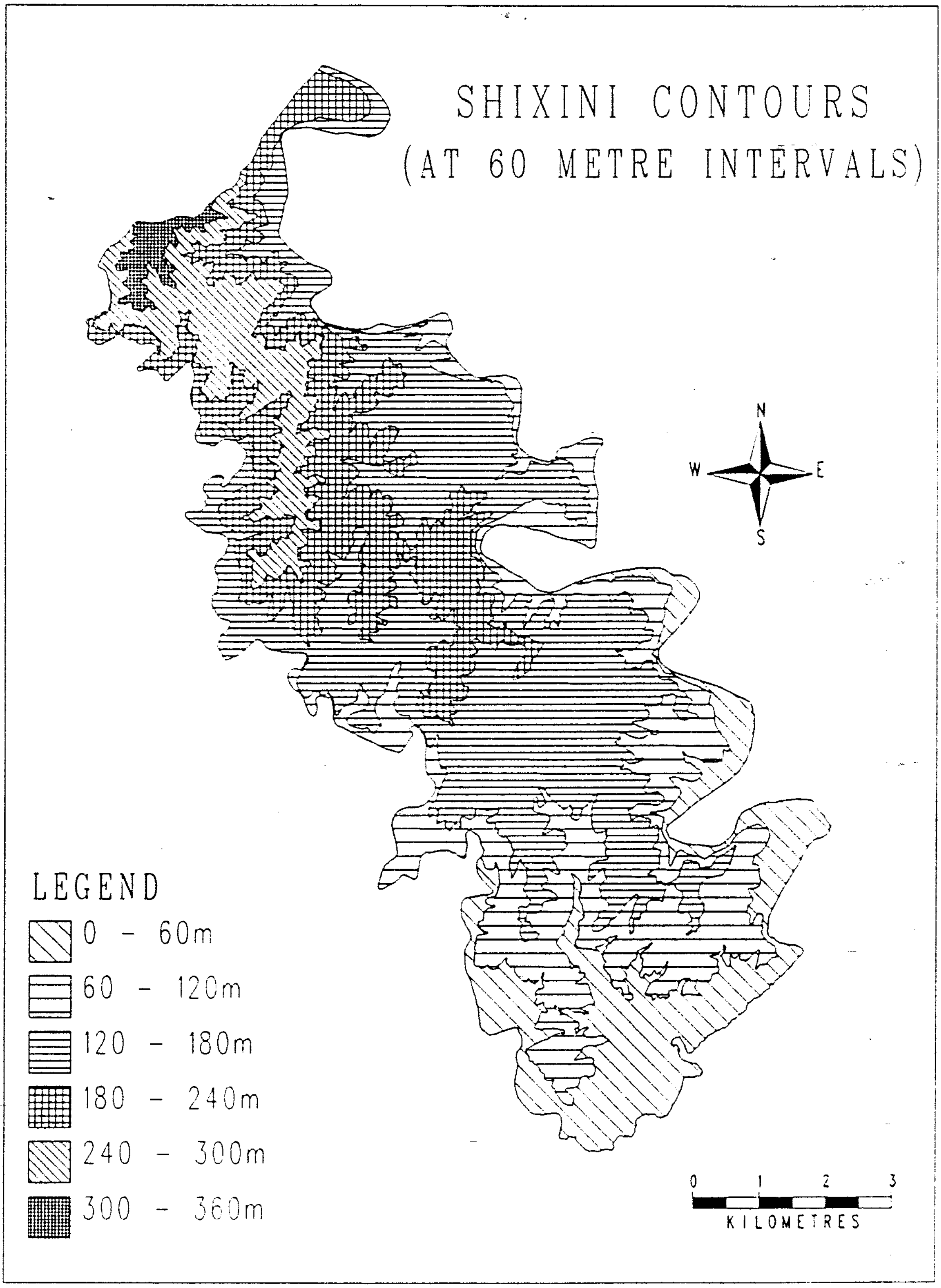



Figure 6.5 Shixini contours

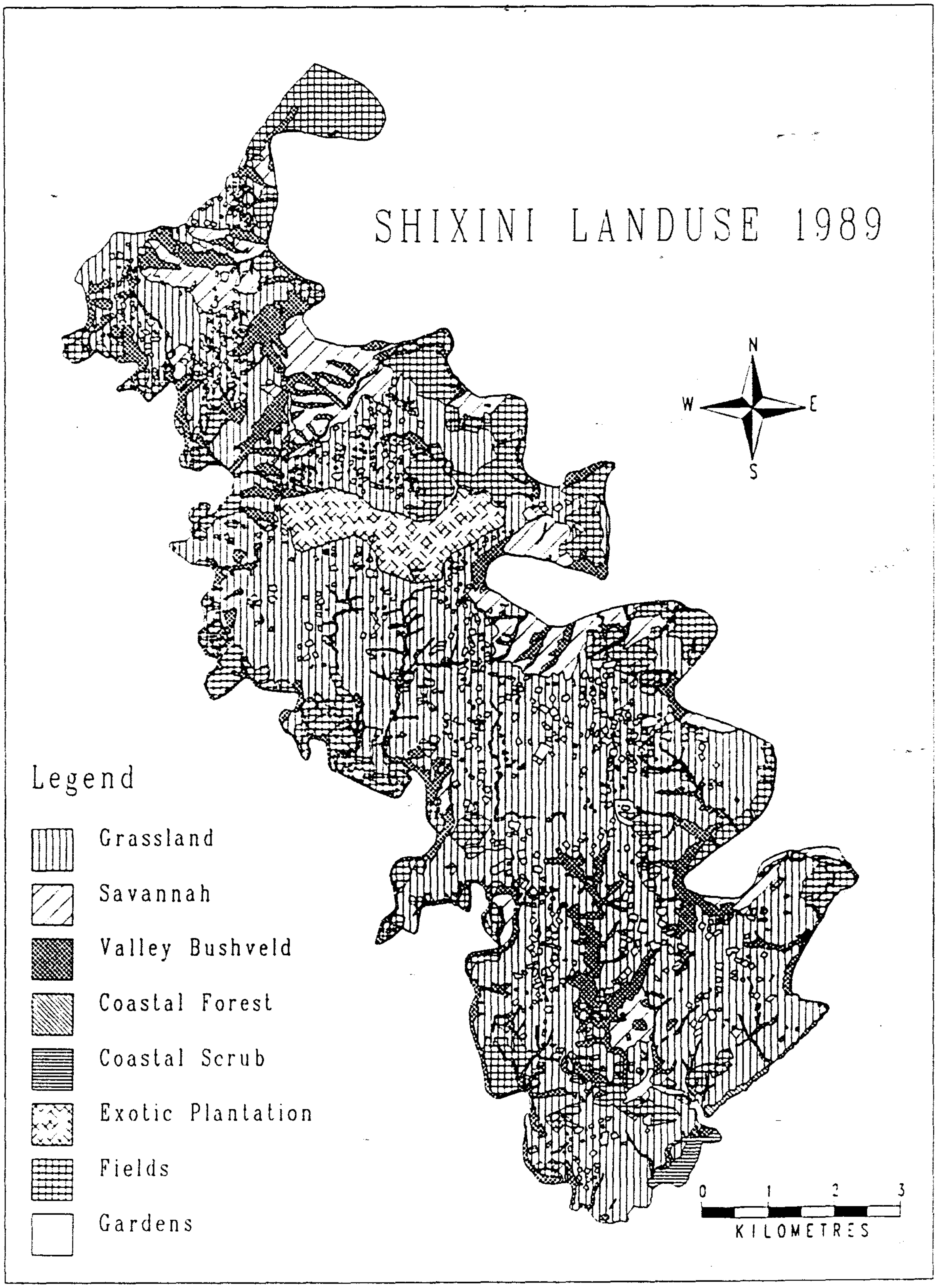



Figure 6.6 Shixini landuse 1989

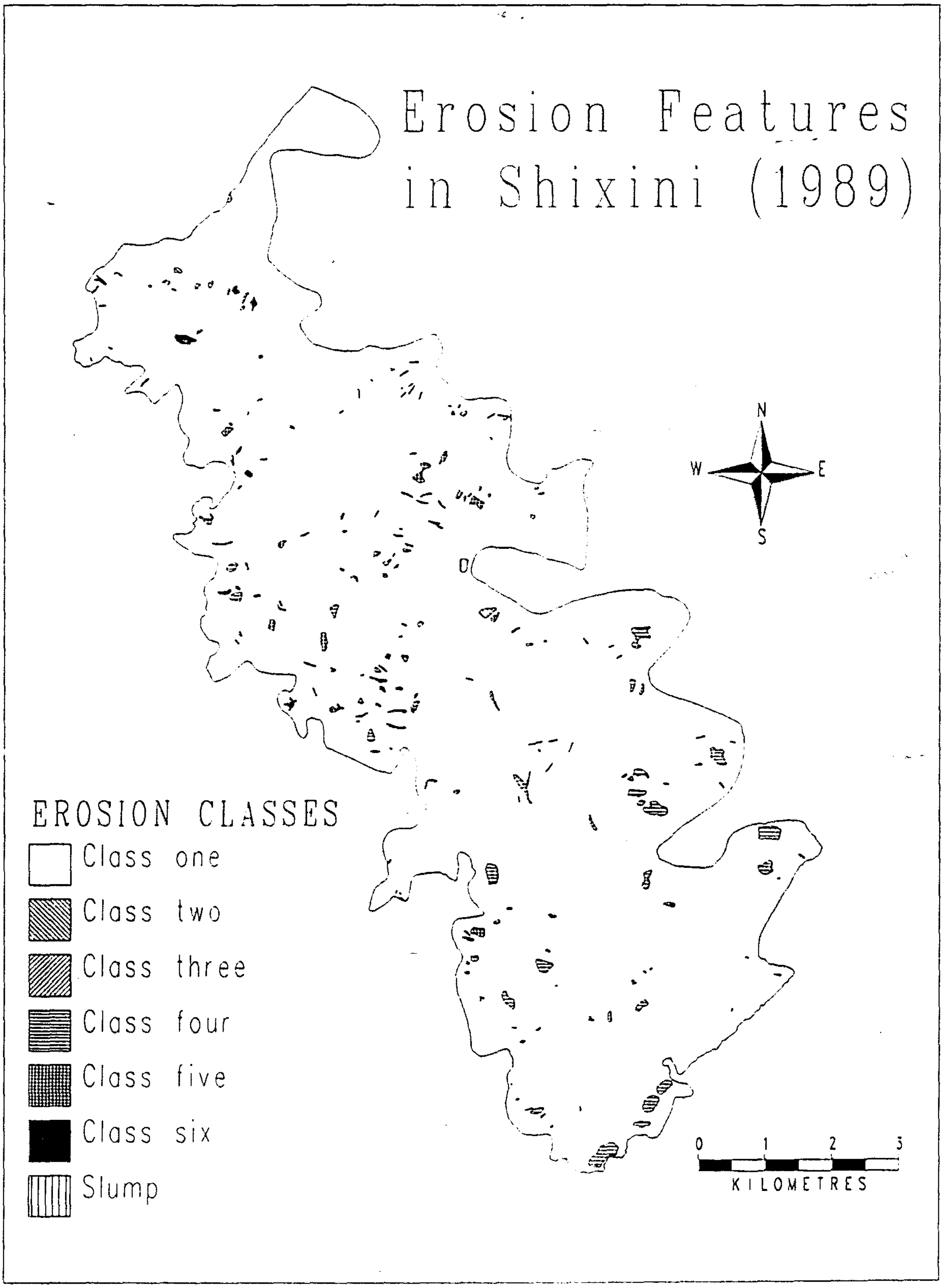



Figure 6.7 Erosion features, Shixini (1989)


Figure 6.8 Shixini water resources

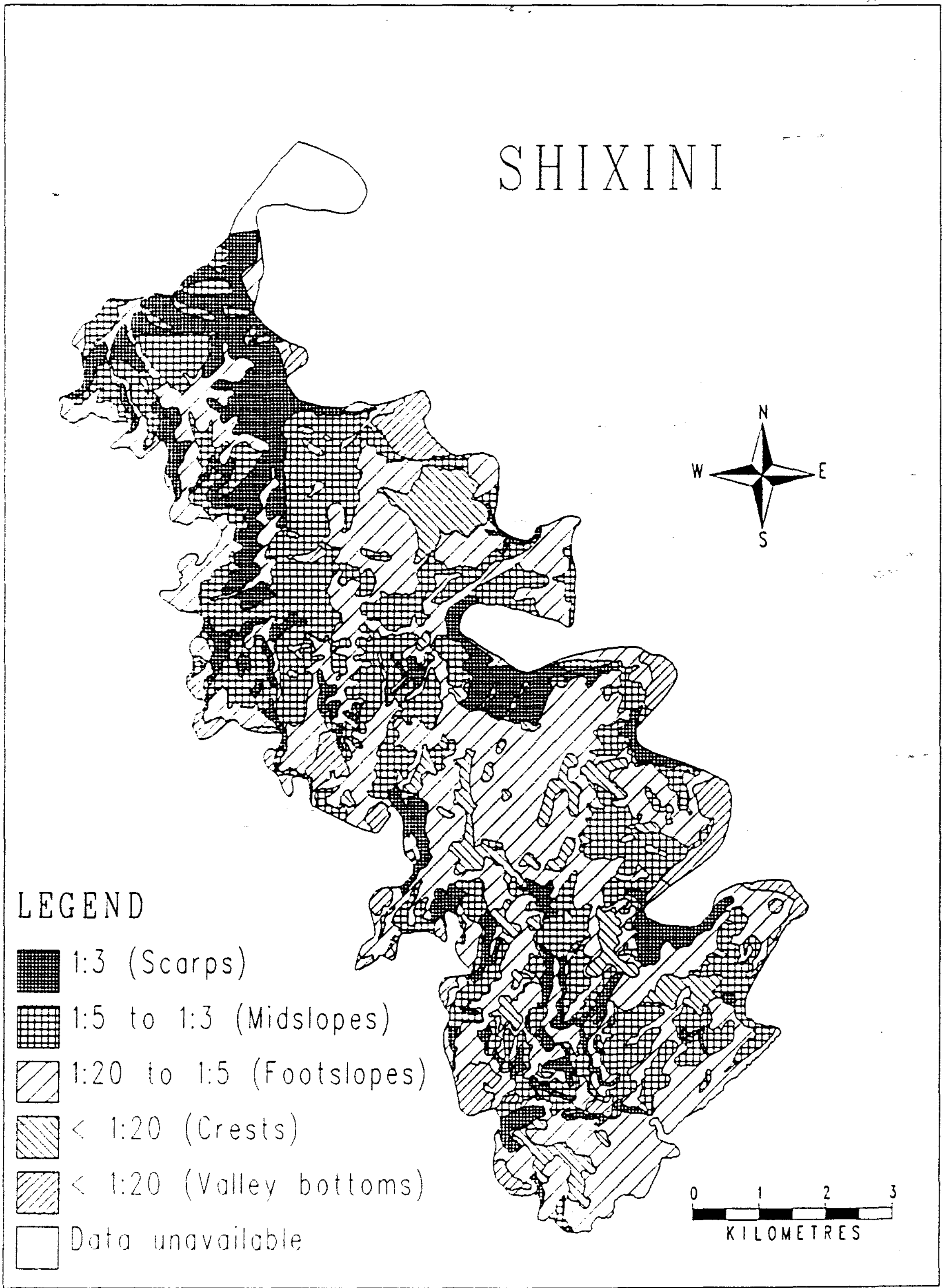



Figure 6.9 A slope classification of the Shixini area

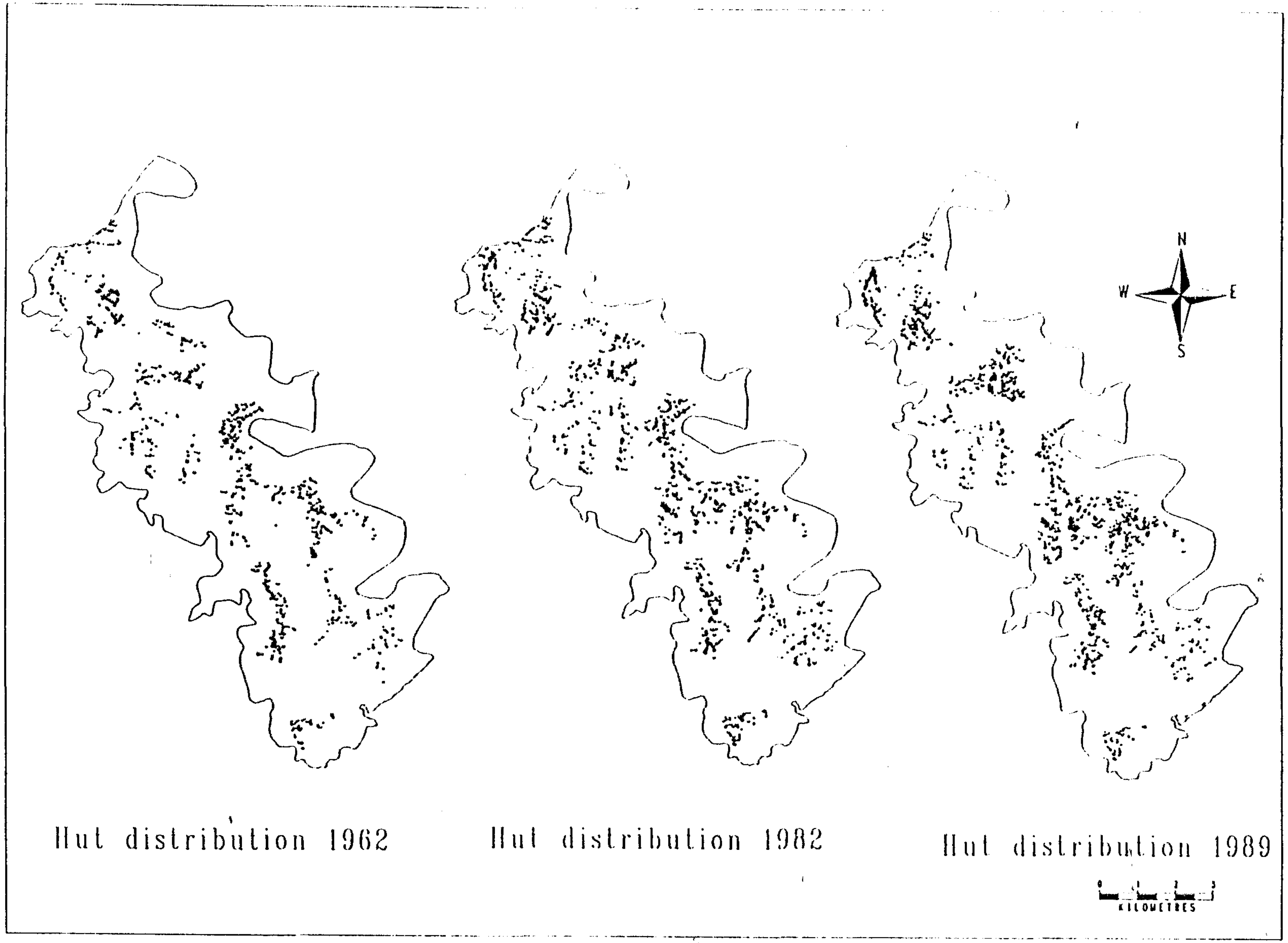



Figure 6.10 Illustration of settlement patterns 1962 - 1989

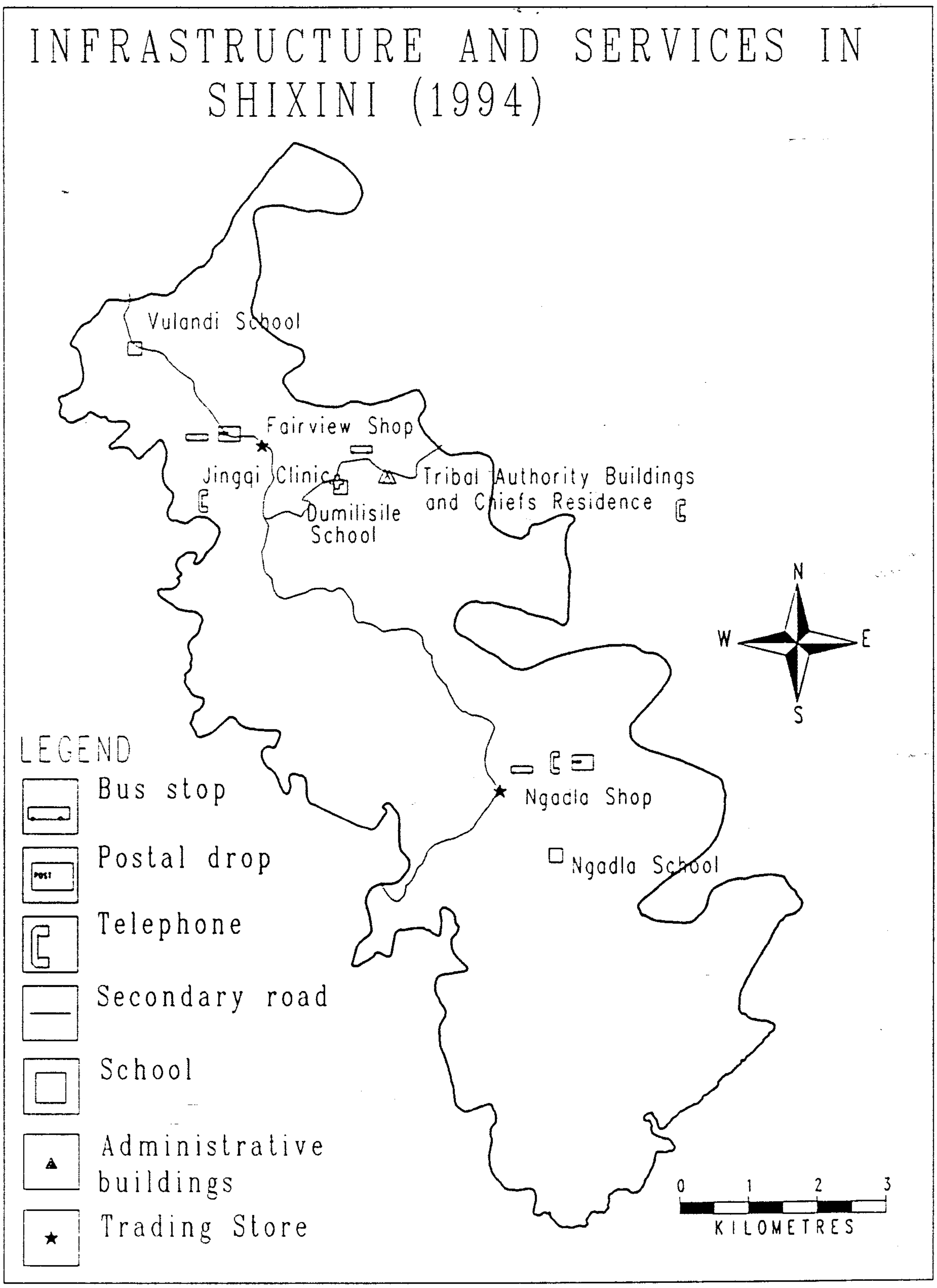



Figure 6.11 Shixini: Infrastructure and services

# CHAPTER SEVEN

## STEP 6: THE SHIXINI GIS PILOT PROJECT

### 7.0 - Introduction

A pilot study was seen by Clark (1991) as the primary means for an organisation to test the preliminary GIS design before committing major resources to acquiring a GIS. The objective of a pilot study is to apply the GIS to a problem or task which addresses the representative needs of the organisation as discussed in Chapter Six.

A pilot project serves a number of purposes. It provides valuable experience to the users; it is also a good indicator of data suitability as well as information flow, bottlenecks and other potential problems. It can also verify the estimated costs and benefits identified in Chapter Six. As such the pilot study forms an integral part of determining the GIS system's overall suitability. It therefore needs to be thoroughly documented as the results of the study can be used to build or refine the first four steps of the model. This documentation should include:

- a definition of objectives and tasks
- selection of a pilot system
- a definition of the pilot area and database contents
- a specification of the tests and evaluation criteria. This evaluation criteria can include a number of simple tasks such as converting and digitising data and other forms of data entry, simple applications, data retrieval, map production and analysis functions.

The primary objective of the pilot project was to test the preliminary GIS design and the relevancy of the database through its application to a user specified problem. Although fielded as a theoretical problem the pilot study was approached in as realistic a manner as possible, which was not always possible ( as discussed in section 7.2 of this chapter).

Chapter Seven consists of the following sections:( 7.1) is a general introductory section to the pilot project addressing general issues such as pilot design, selection of a pilot system, hardware and software, a definition of the pilot area, pilot data, pilot products and evaluation criteria. The problem brief which forms the focus of the pilot project consists of the following sections: (7.2) an introduction to, and examination of, the problem brief; (7.3) an introduction to the problem and a discussion of criteria likely to influence the siting; (7.4) a synopsis of the site selection process followed; (7.5) results of the site selection process; (7.6) additional expertise required; (7.7) processing times, covers and data volumes generated during the pilot project and (7.8) conclusions reached.

## 7.1 - A general introduction to the pilot project

### Design of the pilot study

The general objectives of the pilot study have been stated in the introduction. The objective of the pilot project is to test the preliminary GIS design by addressing a user specified problem. The user defined problem serves another purpose in that it tests the usefulness of the database defined in Step 2, of Chapter 6.

### Selection of a pilot system

The pilot system PC Arc/Info was chosen in Step Five of Chapter Six.

### Definition of the pilot area

The pilot area covered the whole of the Shixini Administrative Area. The location of the administrative area and other background information was discussed in Chapter One.

### Acquisition of pilot data

The base data which was identified and prepared for digitizing in Step 2 of Chapter Six and digitised in Step 5 formed the pilot project database.

### Products of the pilot project

The pilot project examines the functionality of the GIS and its ability to address 'what if?' and 'where is?' type questions. Information products produced by this process will be in the form of maps and tables which were identified during Chapter Six as products required by the SDP. The main products identified during this process consisted of graphic and tabular land use data.

### Evaluation criteria

The evaluation criteria adopted for the pilot study is simply the production of the required products , the testing of spatial tools such as overlay and buffering facilities and the confirmation of workloads and hardware specifications.

## 7.2 - An introduction to the problem brief

The problem brief and its validity as a representative problem in the context of the Shixini development process:

The director of the ISER (in his capacity as originator of the Shixini Rural Development Project) was asked, together with Dr Rowntree of the Rhodes University Geography Department, to field a problem capable of meeting the objective of the pilot project. The resultant brief is displayed in Table 7.1.

**SHIXINI PROBLEM BRIEF**

"Let us assume that there is a need and a policy to create rural 'service centres' in the Transkei. These would be centres outside of the established towns and could serve as administrative service and commercial centres for current administrative Areas or Tribal Authorities (which may consist of more than one Administrative area). The centres would provide focal points bringing services closer to rural people and, in the course of time, could evolve into small towns or villages."

- "Given the information currently available on the GIS, select the most suitable site for such development (rural service centre) in Shixini District and give any alternative sites.
- Explain clearly to your client (an appropriate development agency) the reasons for your choice.
- Using the GIS database, undertake an assessment of the impacts on the local environment if the service centre is located at the site selected above.
- Make recommendations as to what other GIS compatible data, if any, need to be collected with respect to this problem and outline how much data should be collected. Give an indication of the time and expense that is likely to be incurred in this data collection and prioritise.
- Make recommendations as to what other (non GIS) information or expert advise, if any, is required to assist the decision making process."

Table 7.1: The Shixini Problem Brief. After (McAllister & Rowntree, 1994)

The problem defined by the brief was fielded as a theoretical planning problem, as the ISER had by this stage distanced itself from the Shixini Development Project. Despite this fact, the problem may be seen as appropriate to the original objectives of the Shixini Proposal, which advocated, amongst others, the demarcation of a 'village centre' in Shixini (McAllister 1989, p.21). Another factor which may have influenced the decision to develop a service centre was the understanding that the Shixini project had to operate within the framework provided by rural development policy in the Transkei at the time (McAllister 1989, p.7). The 1991 Transkeian Government White Paper on rural development continued to identify the establishment of villages in the Transkei region as a priority requirement for development. Standard reasons are given for this stance which include: security of tenure through freehold title for non-farmers and easy access to services and facilities. The proposed establishment of a village centre (service centre) in Shixini (as proposed in the SDP proposal) differed from past government proposals in that the demarcation of a village was seen as a long term project, with people being drawn to the area through incentives such as improved facilities, rather than through coercion as happened during betterment.

## 7.3 An introduction to the problem and criteria likely to influence siting

### The Shixini Problem Brief

The problem brief essentially deals with two levels or scales of planning. The first level is primarily a regional planning problem as it deals with the "Transkeian national policy" of creating service centres over a large geographic area. Data requirements at this level are derived from aggregated local data with as little noise as possible, allowing planners to identify the relationship between demographic and service characteristics of the region and to expose apparent limitations within this relationship. This information would place regional planners in a position to plan a regular hierarchy of service centres, which, once implemented, would make goods and services available at different scales in rural areas. The second level identified is presumably the result of the regional planning exercise, where a particular area, in this case Shixini, has been identified by the regional planners as an ideal location for a service centre. Data requirements at this level are site or area specific.

The brief mentions the possibility of the proposed service centre providing services to more than one area. Shixini is one of two locations administered by the Jinqui Tribal Authority. The buildings housing this authority are located in Shixini. The other administrative area, Ntlahana, borders Shixini in the east and is connected to Shixini by a single secondary road through Kwitshi sub-ward. If the service centre was intended to serve both administrative areas then it may have been better to site the centre according to a more encompassing view of both administrative areas. The database however is specific to Shixini. As a consequence the siting of the proposed service centre in Shixini only took cognisance of the influence of Ntlahana AA in terms of accessibility to the chosen site along the secondary road connecting the areas.

The problem was perceived as a fairly representative test of the applicability of the Shixini GIS database to rural planning, as it required the incorporation of a wide variety of data sets in order to reach a possible solution. It also leaves the siting criteria open to interpretation by not specifying site parameters. If normal community development guidelines were followed, it would have been customary to involve all interested and affected parties in this process, in order to establish the necessary criteria within which the problem could be addressed. Due to problems with the Shixini project mentioned in the opening paragraph of this section, this course of action could not be pursued. Possible parameters which may have influenced the siting of the centre were consequently obtained from available literature, expert opinion, existing project documentation and literature covering the Shixini Area, in order to make the exercise as realistic as possible.

### 7.3.1 - The application objective

Based on relevant site criteria to select an area within Shixini Administrative Area suitable for the establishment of a service centre and long term development of a village around this point.

### 7.3.2 - The approach adopted to the problem

The approach taken to the problem could be broadly described as descriptive modeling. In describing the suitability of a location for a site a distinction is usually made between what is called site criteria and situation criteria. Tomlin & Johnston (1990) define site criteria as those relationships between a proposed land use and the characteristics of the existing study area. Situation criteria on the other hand are those that involve relationships between a proposed land use and other proposed land uses. The process followed in the pilot study concentrates principally on site criteria with situation criteria being relegated to the possible impacts of the site on the surrounding area.

### 7.3.3 - Siting criteria

Criteria considered relevant in siting the proposed development were obtained from existing literature and personnel communication with an urban expert.

De Wet (1991, p.10) notes that the "physical terrain, patterns of land use, access to resources and social relationships are all important factors at the local level constraining and influencing the way in which a villagisation plan takes effect in a particular area", while Fox (pers comm, 1994) suggests that density (accessibility) and present infrastructure are important siting criteria.

In keeping with the principles of community development planning, siting of a service centre must take into account both human and physical factors. While the siting of a centre in terms of the relevant physical factors was relatively easy, incorporating social factors such as local politics and public opinion could not be dealt with in the context of this problem due to the circumstances described in Chapter One. The possible use of GIS in the project was seen by the author as a support to decision making. In order to provide planners with alternative options three possible areas together with their associated advantages and disadvantages were identified.

The location of possible service centre sites was based on the following principles: 1) the site must take into consideration the preferences shown by the Shixini people with regards to residential location, 2) the siting must be based on sound environmental principles to limit possible degradation, 3) resources in the Transkei are limited, the site must therefore take advantage of the infrastructure and services presently offered in Shixini and 4) the site must be as accessible as possible to the people of Shixini.

The factors considered relevant to the problem were placed into five categories; 7.3.4) area required for proposed development, 7.3.5) land-use and physical factors promoting or constraining the land available for the development, 7.3.6) the location of available infrastructure and services in the ward and their relative importance in terms of the development, 7.3.7) population distribution in Shixini and 7.3.8) social factors which were not included as an active component of the problem but are discussed as a possible limiting factor concerning the growth of the proposed development.

#### 7.3.4 - Amount of land required for the proposed development

The number and type of services that would be offered by the service centre were unspecified, therefore any special area requirements needed to accommodate these functions were unclear.

The amount of land required for the service centre was taken to be a product of erf size multiplied by the number of erven needed. Additional space for amenities and infrastructure would also need to be included. In the Shixini proposal, McAllister (1989) proposed a site size of 70 X 70 meters (0.49 Hectares). This area needed to be sufficient for a garden, a cattle kraal and the homestead. Using the GIS database facilities an analysis of the 1989 land-use coverage of Shixini revealed an average garden size of 0.35 of a hectare with a standard deviation of 0.3 of a hectare. If the average size of 0.35 is accepted as an adequate area for the establishment of a garden, a site size of 0.49 hectares would allow for a normal sized garden with 0.14 of a hectare (10 X 14 meters) remaining for the homestead and a cattle kraal.

The commercial sites (trading stores) present in Shixini during the project period were both in excess of 3.5 hectares. It is doubtful whether such large areas would be set aside for a single service within a designated service centre unless the service actually required that area. For want of a suitable size, commercial and administrative functions were taken to occupy a standard sized erf (0.49 ha).

**Number of erven required**

The initial number of sites required was considered problematic for the following reason. McAllister (1989, p.7) suggested that 600 sites of 0.49 ha each should initially be allowed for (an area of 294 hectares). This area would be sufficient to settle 60 per cent of the Shixini population (1989). Difficulties were however experienced trying to isolate areas of a suitable size in the administrative area. Based on land availability it is suggested that the minimum land required for the development is 80.8 hectares, the area needed for 150 residential sites, and 15 commercial/administrative sites. This area was sufficient for the settlement of 15.1% of Shixini's population (1989). The development of 165 new sites would probably exceed this area as space is needed for walkways and roads, however 80.8 hectares was the smallest area considered for the centre.

#### 7.3.5 - Land-use and physical factors promoting and constraining the land available for development.

**Physical terrain (slope)**

The physical terrain acts as a constraint on development initiatives which can be implemented in any particular area. Shixini is steeply incised in its upper regions such that 44.26 % of its land surface was considered unsuitable for residential development. The slope classes displayed in Table 6.9 and illustrated in Figure 6.9 were used to identify land unsuitable for residential and commercial development and conversely to identify preferential residential areas which are identified in the subsequent paragraph.

**The prevalent land use pattern in Shixini**

The settlement pattern in Shixini was described by Andrew (1992) as traditional. Homesteads are dispersed throughout the ward although they are generally situated in a linear pattern along the ridges and spurs of the area. This pattern was especially noticeable in the higher areas adjacent to the Jujura river and its tributaries and only the extensive gently sloping areas near Ngadla shop and Kwitshi sub-ward showed any deviation from this pattern. Established homesteads consisted of a number of huts/houses placed in a semicircle facing the family kraal/garden. Fields were situated on the foot slopes and valley bottoms often a considerable distance from the homestead. Land not used for residential or agricultural purposes was used for grazing.

Indigenous vegetation such as valley bushveld (Figure 6.6) was limited to the steeper slopes of the valleys and along drainage lines. The majority of the ward was covered by grassland interspersed in certain areas by acacia savannah.

It can be inferred from the brief description of land-use patterns that certain topographical features such as crests may be generally associated with certain land-uses such as residential land-use. Therefore although the settlement pattern in Shixini has been described as dispersed, a relative concentration of homesteads should occur along certain preferred natural features. This point is illustrated in Table 7.2. This table indicates that topographic features identified as crests have a housing density of almost 1:1. This figure is almost twice as high as foot slopes which have a density of 0.55:1. However the table also reveals that 63% of all houses in Shixini are built on what has been classified as foot slopes. Both crests and foot slopes were seen as preferential features when defining site criteria.

**Erosion**

The consequences of increased population pressure on an area could be an escalation in some types of land degradation such as erosion. De Wet (1991) and Silberfein (1989) stress that this is due to factors such as the denudation of resources in the immediate vicinity of the residential area due to activities such as the collection of fuel, increased vehicular and foot traffic on paths and roads and the possible increased concentration of cattle.

Shixini does not appear to have a serious erosion problem. The GIS database indicated that 2.1 percent of Shixini was visibly eroded in 1989. This figure may be considered relatively low for the Transkei. A study conducted by Whisken (1991) of the erosion rate of a neighboring ward which had undergone betterment planning and villagisation, failed to reveal an increase in the erosion rate of that area 20 years after its introduction. Whether this was due to the prevalent soil properties of the area, or special steps taken to avoid degradation occurring is not known. A number of steps can be taken to avoid an increase in erosion in Shixini such as limiting cattle numbers, establishing cattle camps and woodlot's, laying paths and limiting development in close proximity to existing erosion and water features. Despite the limited erosion in the area it was recognised that erosion may be regarded as both a limiting factor in terms of land suitability and a possible consequence of the development of a village. Cognisance was therefore taken of the possible threat that could be posed by erosion .

**Water availability**

Water availability and the location of water features such as river and drainage networks were viewed as both an attracting force in terms of settlement (water is a basic need) and as a negative land use.

The people of Shixini had expressed their concern over both the quality and quantity of water available in the Shixini area during both the 1988 needs assessment and in the series of meetings conducted in the AA in 1992 & 1993 (McAllister 1989, No Date).

Water resources are unevenly spread in the Administrative Area, affecting the upper Shixini sub-wards to a greater extent than those situated closer to the coast. Water collected in the ward came from a variety of sources including springs, the two perennial rivers draining the area, and pools left over from the rains (Figure 6.8). Other sources included rainwater tanks and transporting water from Willowvale. Deliwe (1992) asserts that there is unequal access to water in the ward both as a result of its unequal spatial distribution and to socio-economic factors which enable some segments of the population to afford rainwater tanks and/or cart water.

The main source of water in upper Shixini appeared to be the Shixini and Jujura rivers. The topography of the area and the practice of siting homesteads on the ridges and spurs of the area make it necessary for residents to walk long distances on steep slopes to reach this source. The water quality from both rivers and other sources is often poor as the water is used for a number of purposes apart from human consumption, including domestic cleaning purposes and watering livestock. The importance of the water issue was reflected in the Shixini project where it formed one of the development foci areas. These needs were to be catered for ostensively through the development of new water sources in the ward such as boreholes and small dams. Although the project was prematurely curtailed a number of test boreholes were sunk in upper Shixini (Figure 6.8) and possible dam sites were identified in upper and middle Shixini.

Seasonal, unprotected seepage springs are the main source of water in lower Shixini. These springs produce both an unsuitable quantity and quality of water. Measurement of a seepage flow in Vulandi Ward in lower Shixini by a field worker revealed a flow rate of a litre a minute (SDP Minutes, 23 June 1992). There were no existing means of storing excess flow from the springs when not in use.

It is apparent that access to adequate water resources was already a problem in Shixini and that an increase in population pressure in certain areas would probably serve to increase this pressure. The siting of a centre close to a viable source of water should therefore form a critical aspect of any potential site. Unfortunately although the location of visible water features such as streams and rivers, as well as the approximate location of boreholes had been mapped in the area (Figure 6.8), other features such as the location of springs were not available. In addition the existing geo-referenced information was considerably weakened by a lack of attribute data for the water features including the test reports of the yields and water quality of boreholes. A further limiting factor was the lack of documentation concerning the nearest source(s) of water available to residents in the various parts of Shixini (these information needs were identified in Chapter Six, Step 2).

As such the inclusion of water sources as a limiting or attracting factor in the siting process was not included. This decision was not only based on the lack of suitable information but on the fact that a great deal of Shixini had not yet been surveyed for sources of underground water, and it was felt that to limit the sites to available information would disadvantage potential sites. It is felt however that present water sources in Shixini would be inadequate so serve a future village site and that new sources such as dams and underground water would have to be found. A brief synopsis of any information concerning the chosen sites present access to water was added to the description and analysis of the three possible sites chosen later in the chapter.

The area occupied by surface water features such as rivers and streams was perceived as an undesirable land use in terms of siting the service centre. Cognisance was therefore taken of the possible degenerative effects of development on these features in terms of increased erosion and water pollution.

**7.3.6 - Infrastructure and services in Shixini**

Infrastructure in Shixini was limited to roads and a telecommunication network. Services available in the area included administrative services (the Tribal Authorities and the Chief of Shixini), commercial (trading stores and local drinking houses where liquor is sold (shebeens)), education and health facilities, dipping tanks and an agricultural depot (formerly run by the ISER). Infrastructure and services were unevenly spread throughout the ward as seen in Figure 6.11. The map clearly indicates that a concentration of administrative and medical functions occurs in a particular part of the ward, to be more precise, in Kwitshi sub-ward. This sub-ward also contained the only junior/secondary school in the ward.

The clinic did not have a doctor in residence, the nearest being located in Willowvale, but was staffed by two to three nurses at a time (Talbot 1988). Because of this the clinic caters to different segments of the population each day of the week and has been referred to as a one day clinic by Talbot (1988) because of this.

A single trading store is located in each of Nompha and Ngqungqumbe sub-wards. Trading stores appear to play a substantial role in Shixini serving as a post office and bus stop site in addition to providing normal services (Talbot 1988). A questionnaire survey of 50 households conducted by Andrew (1992) in Shixini revealed that all those sampled, purchased foodstuffs such as maize, mealie meal, samp and small groceries one or more times every two months. Whether these purchases were from local traders or shops in Willowvale was unclear. Other goods purchased by Shixini people include agricultural inputs such as seed, fencing wire, tools and fertiliser. A number of these items were also available from the trading stores in Shixini. In addition to selling produce, traders buy goods such as livestock, crafts, tobacco, skins and wool from local inhabitants, although according to Andrew the percentage of the goods sold to traders is small compared to trade between residents. From this brief synopsis it appears that trading stores play an important role in the general economy of the ward. Shebeens are spread throughout the ward operating from houses, these features have not been mapped and their location, number and impact are unclear.

Educational facilities in Shixini consisted of three schools, 2 primary schools, one each in Ndelibanzi and Khamisa sub-wards and a junior/secondary school in Kwitshi sub-ward. The junior/secondary school caters for children up to and including standard seven.

According to Deliwe (1992) educational services are recognised as important in the ward. A population pyramid constructed by Andrew (1992) indicated that Shixini exhibits a typical Third World population structure where a high proportion of the population is of a school-going age and younger. Deliwe (1992) notes that school attendance is affected by the agricultural cycle and household needs.

It can be assumed from the location of the schools in relation to the residences in the ward that in the absence of alternative transport some of the pupils have to walk long distances to reach these facilities. It is therefore important that the siting should attempt to minimise the distance to these facilities.

Alternative services to those offered in Shixini are available in Willowvale which is the closest town to Shixini and the only town in Gatyana district. The centre is approximately 20 to 36 kilometers away from Shixini depending on the residents location in the ward. Services offered in Willowvale included banking and shopping facilities, churches, bottle stores, schools, a petrol station and government offices. It was from this centre that pensions were distributed, it is likely that this centre serves a number of the present needs of the Shixini people.

The range of each of the services offered in Shixini and Willowvale was not researched, it was therefore assumed that the closest service available to an area would be utilised. Therefore services with a single location such as those offered by administrative and medical facilities and access to the secondary school were taken to serve the ward as a whole as there were no closer alternatives.

**Telecommunications**

According to the 1994 Transkei telephone directory there are three telephones operating in the ward. These are situated at the Chief's residence, Jingqi clinic and at Ngadla shop (Figure 6.11).

The telephone lines bringing these services to the area were not discernable from the aerial photographs (the service might not have been available in 1989). The location of the telephones therefore had to serve as an indication of their likely path. Although telecommunications might not be considered critical to the majority of Shixini residents new services to the area might find them necessary.

**Roads and Tracks**

The roads in Shixini were classified by Andrew (1992) as secondary dirt roads (Figure 6.3). These features were in a bad condition when fieldwork was undertaken in the area in 1992. These features play an important role in connecting Shixini to its neighboring administrative areas and to the centres of Willowvale and Idutywa. Tracks and paths make up the majority of access ways in Shixini, these features serve as roads linking the outlying homesteads to the secondary road. Generally speaking these features are in a worse condition than the secondary roads, as erosion and natural hazards such as stream beds decrease their functionality. Roads and tracks form an important part of the transport network in Shixini, their presence often indicates the only way for a vehicle to cross natural barriers. Their use extends to pedestrians as the roads take advantage of the gentler slopes of the area and often require less effort than some of the shorter but more rugged footpaths which exist.

**Accessibility to Services in Shixini**

Short (1984) states that the ease with which a household can overcome the distance between their different centres of activity can be termed a measure of accessibility. Accessibility is an important factor in any consideration of the quality of life as it has value in the real income of households. Relative accessibility differs between people and groups of people, in terms of their location to the different centres and access to alternative means of transport other than by foot, such as cars.

In cities there is a close relationship between urban morphology and forms of transport (Knox 1982; Short 1984 and Yeats 1990). In cities the ascendency of the automobile as the dominant means of personal transport has resulted in employers, retailers and planners tending to make their location decisions on the assumption of perfect personal mobility (Knox 1982). This relationship cannot be assumed to hold in Shixini where the most common form of transport is by foot. There does however appear to be a relationship between the settlement pattern and forms of transport as the dispersed settlement pattern allows easier access to unevenly distributed resources, such as fuel, land and water. This pattern places households closer to their resources, effectively lessening daily traveling time and making daily essentials more accessible. If a village is to develop organically around a service centre easier access to these essentials is required.

Relative accessibility, or what Hägerstrand (1970) refers to as effective accessibility to any given site, is measured in terms of people's time budgets as well as the proximity of locations and the effort needed to reach the destination. Hägerstrand (1970) contends that an individual's ability to move between one location and another is effected by three types of constraints; 1) capability constraints such as the transport available, 2) authority constraints including laws, rules and customs and 3) coupling constraints such as the hours that the service is open or the amount of time a facility is available. In Shixini the amount of time available in a normal day to go shopping is probably limited as daily chores such as fetching water or fire wood or agricultural activities take up a large proportion of the day, although this will vary between households. In the case of extended families the division of labour may give some individuals more free time than others. The proximity of a service such as a shop, to people without means of transport other than by foot is important. People living in close proximity to the shop are more likely to visit the shop when a good is required than those people that have to walk further. The latter may plan such trips carefully in order to reduce the time spent traveling or will wait until more suitable transport is available. The access of Shixini people to other forms of transport, and the distance people are prepared to walk, before they will consider alternative forms of transport, is not known. However such information could be potentially useful in the siting as the majority of people could have a higher mobility than is being assumed, which would allow greater freedom in the placing of the site.

Relative accessibility in the context of Shixini is affected by the mode of transport, the infrastructure present and its condition, and the physical relief of the area; if the site offers a service then the amount of time that the service operates may also be a factor. The importance of roads and paths as a measure of accessibility to services in different areas of Shixini was recognised in terms of a numerical suitability score, see Table 7.3. In terms of this method the location of the proposed site would be influenced by the infrastructure and services already present in the ward as discussed earlier in the chapter. Access to existing facilities/services in Shixini from a proposed site must be balanced by access to the service centre itself. The awkward shape of Shixini and the distribution of people in the ward ensure that some areas in the ward would always be relatively disadvantaged in terms of access by proximity. With this fact in mind, and the assumption that the dominant mode of transport in Shixini is by foot, it would be most logical for the site to be located in such a way that it serves as many people of the ward as possible within the shortest possible distance.

**7.3.7 - Demographic factors**

The population of Shixini is widely scattered in the ward, however a number of population concentrations can be identified from Figure 6.11. The possible reasons for these concentrations have been discussed earlier in this chapter. A household survey (1988) conducted by the ISER revealed that each household in Shixini consisted on average of 2.23 huts and each hut had on average 2.3 persons occupying it. If these figures hold true for 1989 then the ward was made up of some 984 households with a combined population of 5050 people. Although the average population density of Shixini is 36 per km$^2$ some topographic features such as crests average 229 per km$^2$. Population density in an area could be an important factor with regards to the subsequent growth of a village centre after the establishment of a service centre. Certainly the service centre should be as close as possible to the majority of the people in Shixini Ward in order to be useful.

### 7.3.8 - Social factors

Social factors are likely to be the greatest determinant of a service centre and village's success or failure. The brief has two parts to it in terms of the social impact on the area, firstly the establishment of a rural service centre in the area which would serve as a administrative, service and commercial centre, and secondly the organic development of a village around the chosen site. The provision of services to the area, such as pension payments are likely be welcomed in the area. However, in terms of social impact the possible demarcation of land for the development of a village is likely to have far wider social ramifications than the service centre. The reasons given are straight forward: the demarcation of a centre and village is likely to compete directly with other land uses; it was mentioned in Chapter Five that the ward was divided into ten sub-wards each of which administers its own resources such as grazing as well as allocating more land for gardens. If the proposed development is situated in a single sub-ward it would mean gaining access to certain services for the loss of 7 or 8 hectares of land. More controversial would be the siting of the village which would attract mostly landless people to the area to settle on 74 hectares or more, of possibly prime land.

Research completed in the area by anthropologists such as McAllister (1988, 1989a) and Deliwe (1992) have indicated that a degree of conflict exists within the ward and sub-wards between 'red' and 'educated' people (as discussed in Chapter 6, Step 2) as well as a result of resettlement caused by the implementation of betterment planning. This conflict which exists stems from the different approaches by the people of the area to western institutions. Deliwe (1992) suggests that for want of a more suitable term 'Red people' (Reds) may generally refer to people who are traditional, illiterate and conservative; 'educated people' on the other hand have embraced westernism, and are regarded as progressive.

The differing ideologies identified above have resulted in differential access to resources and political power. Deliwe (1992) argues that as part of their ideology 'educated people' have been able to assume political control in Shixini, he asserted that this was evidenced by the membership of the local Tribal Authority, where every member of the authority was regarded as 'educated'. Deliwe (1992) stresses that 'red' ideology may be seen a form of resistance to white domination, he asserts that this ideology has evolved to include resistance against the educated.

Conflict has occurred over perceived differences between the two groups, as well as over certain issues such as the introduction of betterment planning by the 'educated people' who were seen to approve the decision to proceed with betterment against the wishes of the reds. The distinction between red and educated people, however is not as strongly polarised as has been made out. According to Deliwe (1992) there is a continuum rather than sharply defined class differences.

As a result of betterment planning a number of people were relocated into different sub-wards and sub-ward sections. It was mentioned earlier that one of the objections of the people of Shixini to betterment was the forced relocation of their homesteads to new areas with consequent economic and social disruptions. The Shixini Proposal (McAllister 1989) lists a number of reasons for these objections: the most important in the present context is "conflict with new neighbours" who are seen, especially by the young landless people of the 'invaded area', as competition for scarce resources such as land. McAllister (1989a) has observed three instances where movement between sub-wards and within the subsections (sub-ward sections) has resulted in conflict.

It is not known how the conflict between the red and educated people who make up Shixini would affect the siting of the service centre and village. Certain areas of lower Shixini would however appear to be dominated by red people, as reservations concerning the implementation of the Shixini Development Project were expressed in this area. There does however appear to be a parallel between the residential areas proposed by betterment and the proposed service centre

and organic development of a village, in that although people would not be forced to relocate to the area, those living in the area would not appear to have any choice over the 'invasion' of their land.

### 7.3.9 - Additional GIS compatible data required

Certain data needs may have already been touched on. Additional data considered necessary for a final site allocation are principally related to the Shixini people's perceptions as well as data on the physical environment, these include:

- Information on the Shixini people's perceptions of a service site and the criteria that it should conform to. This data would be required before the initial site selection and could be gathered by the fieldworker by means of a number of small meetings which he would facilitate. Information might include answers to the following questions: would you like a service centre in your ward?; where do you think the centre should be located and why?; what services would you like to see in a service centre?; would you make use of the services?; how often would you make use of the services?; would you consider moving to the area?

- An indication of the location of all potable water sources, their reliability and water quality as well as an idea of the closest water source(s) utilised by the different areas in the ward. This data would ideally form part of the siting criteria as discussed earlier. The information could again be collected by a fieldworker and the Shixini people as it requires interaction with the designated water committees of the sub-wards.

- An indication of soil and sub-surface soil conditions, and its suitability for building/agricultural purposes. This data forms an important characteristic of a site as the garden would remain an important source of nutrition for the people drawn to the area. The data would ideally be collected by somebody with expertise in this area. Experts could be contracted from either one of the government departments or one of the soil institutes. The whole of Shixini need not be surveyed as a large area of Shixini is not suitable for development.

- An indication of burial sites (which are usually located in the household kraal) and any other religious or historically treasured land which should not be considered for development. This data would again be collected by the fieldworker through interaction with the Shixini people.

Except for the first articulated data need, the other data could be collected after possible service sites had been identified, but it would be better to collect it prior to the siting exercise. The collection of the data need not be expensive, the chief cost is the time of the fieldworker. The soil related data need not be expensive either as the soil institutes and the government often provide these services free of charge or at a nominal fee.

Data collection might take a week or a month depending on the time taken by the fieldworker to set up the meetings and collect the other data required.

### 7.4 - Site identification

#### 7.4.1 - Introduction

In order to address the siting problem a number of composite maps were derived from the database established in Chapter 6. Each composite map addressed one of the factors discussed above. Some of the composite maps were obtained passively be simply overlaying and plotting existing covers, others, such as ascertaining the different areas access to infrastructure were established by means of a numerical suitability score.

The task of specifying site criteria and determining suitability scores would in the context of a rural community development project be determined by a number of interest groups and selected professionals (as discussed later in the chapter).

Scores given to individual factors reflect a personal assessment of that factors relative importance. This assessment was based on the frequency that the service/infrastructure was used and its ability to attract development. Five composite maps were used to indicate possible locations for the siting of the service centre and village. The first composite map, Step One: identified available land suitable for development. The second composite map, Step Two: indicated numerical accessibility scores to infrastructure and services in the Ward. The composite maps composed in step one and step two were overlaid in Step Three; resulting in a land suitability map with service and infrastructure access scores. These scores differentiated the suitable land into different categories based on their access to infrastructure and services.

Areas with the highest amenities scores and which contained land suitable for the development were then isolated to provide three potential sites. This process was repeated in Step Four where new minimum access scores were set with the objective of isolating a primary area (service centre) for each of the areas identified in Step Three. The primary areas corresponded to the proposed service centre and the secondary areas to the residential areas. Step Five examined the access to each of the demarcated service areas by the Shixini population, by means of population distribution covers, and Step Six indicates the perceived advantages and limitations of each of the areas in terms of situational factors.

**7.4.2 - Step One: Identification of land suitable for development**

The first suitability map recognised that only certain slope classes and current land uses were suitable for the development of a residential area. The map restricts the land available for the proposed development in Shixini using the criteria discussed below. No attempt was made to place the selected land into different classes, as other factors such as access to infrastructure and services and access to the area by the Shixini people would differentiate these areas.

**Slope and land-use Factors Considered**

Residential use competes with garden, agricultural and grazing land for space as well as the steep slopes which characterise certain parts of the Shixini area. The present pattern of land-use in Shixini and the limitations on slope classes (discussed in Chapter Six, Step 2) restricted site selection to two slope classes, crests and foot slopes, (Table 6.8). These features correspond to the preferential residential areas indicated by this existing pattern. Table 7.2 confirms this point. The table reveals that 82.2% of all residences in Shixini are sited on either of these classes, which combined represent 50% of the surface area of Shixini. A fair percentage of the residences are located on slopes classified as class 2. These slopes were considered marginal for certain types of development and were not included.

A number of plant communities and land-uses were not considered suitable for development, these included some communities of indigenous vegetation such as coastal forest, coastal scrub and valley bushveld, developed land such as the exotic plantation and residential "erven" (represented by gardens) were also excluded. Land-use and vegetation considered suitable for development consisted of grasslands, savannah and fields, the majority of fields are excluded as they are situated along the valley bottoms. Present residential areas were also included as potential sites although the area making up the homestead was excluded.

Other features excluded from possible site locations were erosion features greater or equal to class five of Table 6.8. These features were buffered by 20 meters. This was done to prevent increased erosion of these areas. It also acknowledges the difficulty of rehabilitating severely eroded areas.

| Slope Class | Topographic Description (area in hectares) | Number of Residences | % of Residences | No of residences per ha |
|---|---|---|---|---|
| Class 1 | Scarps (926 ha) | 65 | 3.0 | 0.07 |
| Class 2 | Midslopes (1775 ha) | 324 | 14.8 | 0.18 |
| Class 3 | Foot slopes (2548 ha) | 1401 | 63.7 | 0.55 |
| Class 4 | Crests (407 ha) | 406 | 18.5 | 0.99 |
| Class 5 | Valley Bottoms (320 ha) | 0 | 0 | 0 |
| Unclassified | (123 ha) | 0 | 0 | 0 |
| Total | (6102 ha) | 2196 | 100 | |

Table 7.2: The relationship between slope and residential areas.

Perennial and non-perennial water features (non-perennial streams) were buffered by 50 meters and 20 meters respectively. This was done in order to exclude the rivers flood plain as a possible location for development. The buffer was also necessary to prevent development on the non-perennial water courses which tends to increase water pollution. It also served to stop development where flooding might occur. The buffer distances used were sufficient to raise the potential development areas at least five meters above the present level of the water courses.

The land suitability composite map consisted of the following covers: slope, erosion, rivers and the 1989 land-use cover, each of these covers was described in Chapter Six, Step 2. A number of these covers were modified either by being buffered or by being given unique identifiers before being overlaid into the initial composite cover which is displayed in Figure 7.1.

Areas which adhered to the criteria specified above were then reselected from the initial composite cover to provide a composite map of land areas suitable for the proposed development. This composite map is displayed in Figure 7.2.

**7.4.3 - Step 2: Access scores to infrastructure and services in Shixini**

Each area in Shixini has a differing access to infrastructure and services, based on their location/distance, available infrastructure and transport. These factors were used to give each area in Shixini an access score to the facilities. The access score of each area was based on the areas access to the following services or structures; education, administrative, medical and commercial. Infrastructure considered consisted of roads and tracks. The access scores used to determine the area's accessibility to services are displayed in Table 7.3. The scoring system reflected the perceived importance of the services offered to the Shixini people, based on the frequency that these services were needed as well as their perceived ability to act as nuclei for development. The majority of services were given a score out of 10, areas within a certain distance of the service given a score based on this distance, the greater the distance between the service offered and the area the lower the access score. In addition the access scores were weighted. The weight given to each service is reflected in the size of the decrease per distance;

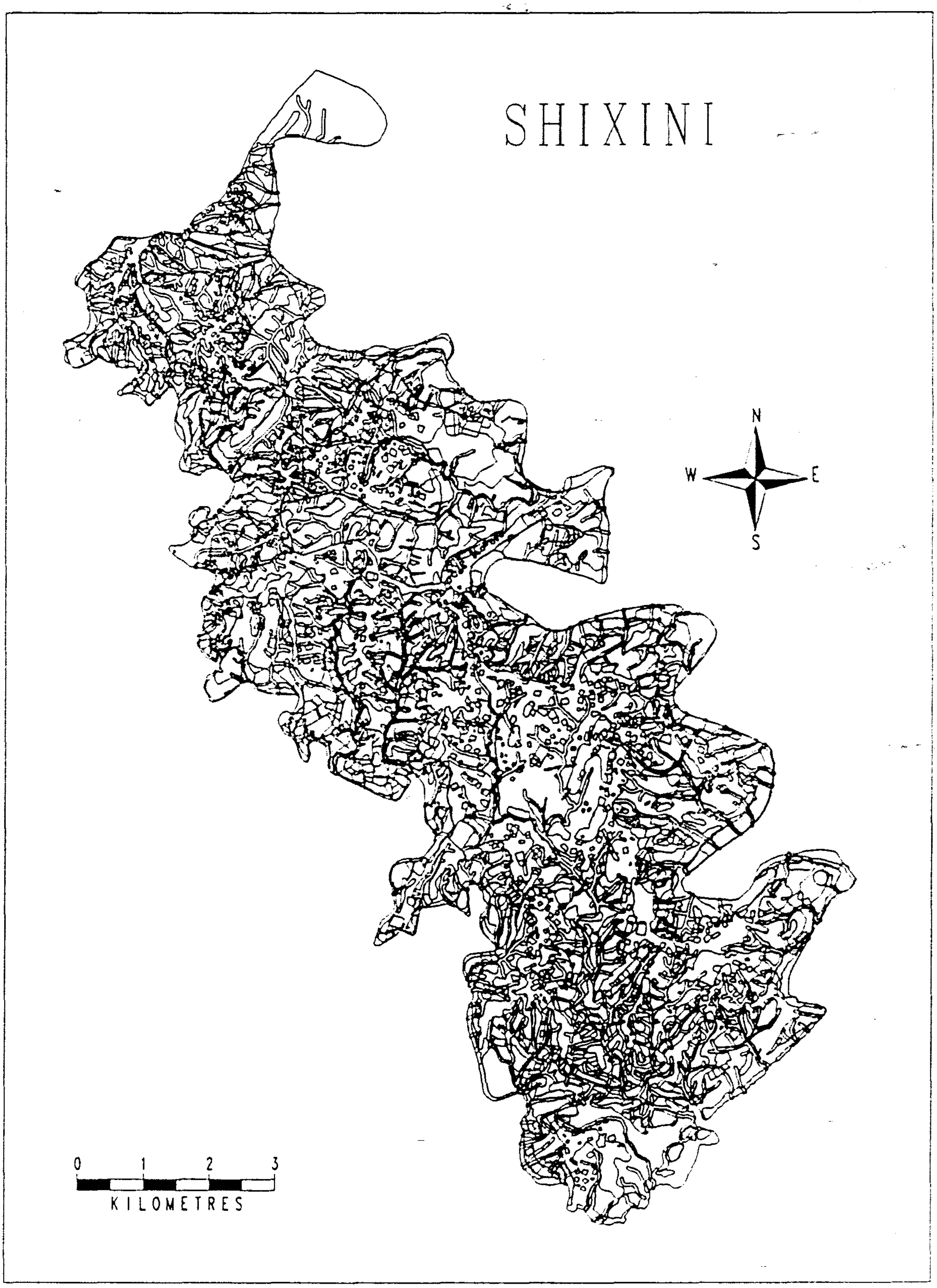



Figure 7.1 Composite map of land suitability factors

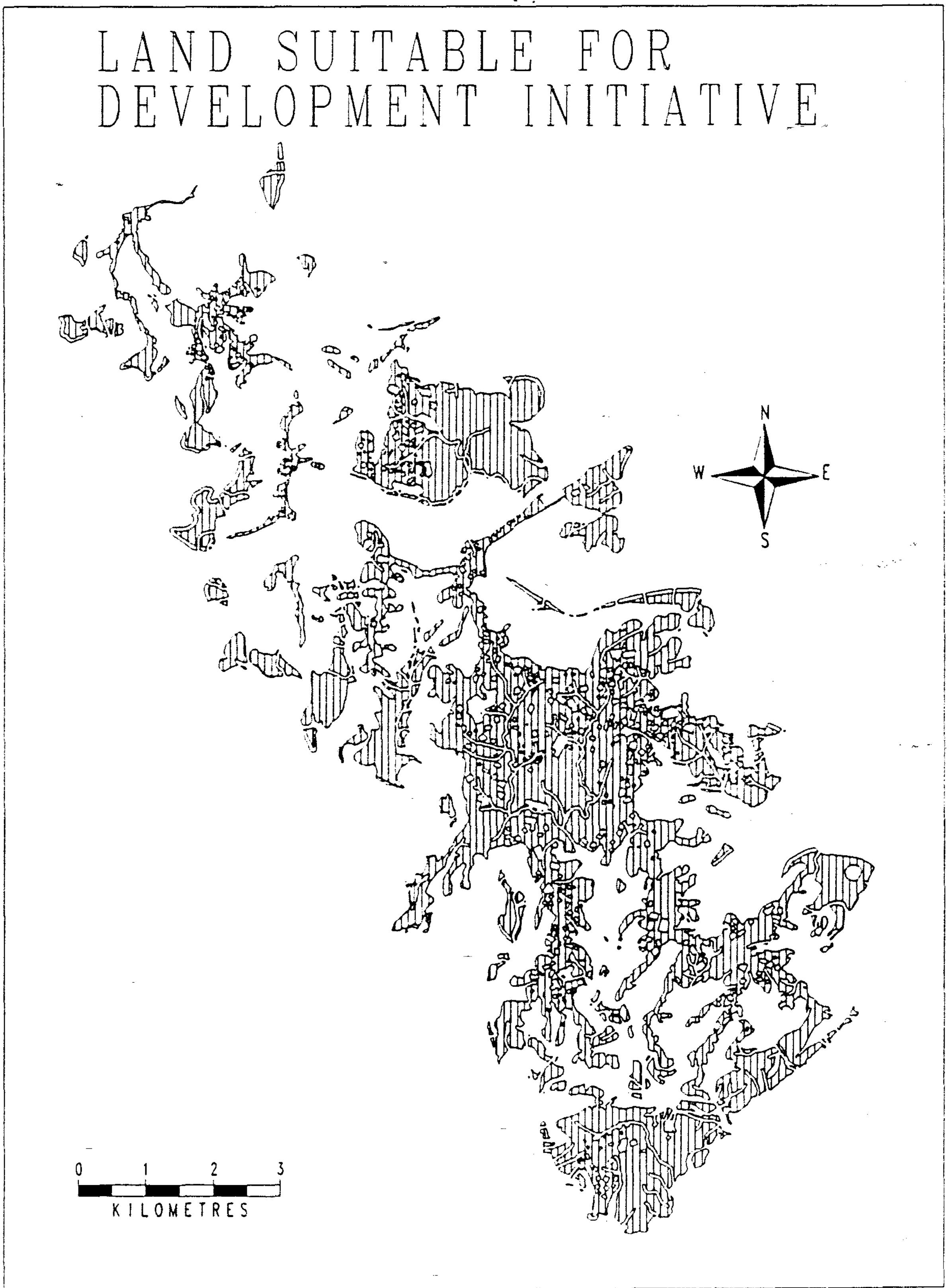



Figure 7.2 Land suitable for devlopment

those services which were not considered as important access scores decrease less over a certain distance than those considered important. For example an area 3 kilometers away from the trading store which is considered important would receive an access score of 6 but at the same distance from administrative services (which are not as important) would receive 8 points. In this way the importance of the service is reflected. The scores given to each service were based on the following information.

**Roads and Paths**

Roads and paths would increase the accessibility of people to the service centre site both from within the Shixini area and from Ntlahlane Administrative area. Roads and tracks have been sited to take advantage of the gentle slopes of the area making traffic flow less strenuous than on many of the footpaths which make less use of the topography of the area and which often traverse the valleys which are covered in thick valley bushveld. Tracks connect the dispersed residential areas in Shixini with the secondary roads of the area.

| Distance | Tracks | Secondary Roads | Junior Schools | Secondary School | Clinic | Trading Store | Administ-rative |
|---|---|---|---|---|---|---|---|
| 100m | 10 | * | * | * | * | * | * |
| 200m | 8 | * | * | * | * | * | * |
| 250m | * | 20 | * | * | * | * | * |
| 300m | 6 | * | * | * | * | * | * |
| 400m | 4 | * | * | * | * | * | * |
| 500m | 2 | 16 | * | * | * | * | * |
| 1000m | 0 | 12 | 10 | 10 | 10 | 10 | 10 |
| 2000m | 0 | 8 | 8 | 9 | 9 | 8 | 9 |
| 3000m | 0 | 4 | 6 | 8 | 8 | 6 | 8 |
| 4000m | 0 | 0 | 4 | 7 | 7 | 4 | 7 |
| 5000m | 0 | 0 | 2 | 6 | 6 | 2 | 6 |
| 6000m | 0 | 0 | 0 | 5 | 5 | 0 | 5 |
| 7000m | 0 | 0 | 0 | 4 | 4 | 0 | 4 |
| 8000m | 0 | 0 | 0 | 3 | 3 | 0 | 3 |
| 9000m | 0 | 0 | 0 | 2 | 2 | 0 | 2 |
| 10000m | 0 | 0 | 0 | 1 | 1 | 0 | 1 |

* Indicates that the lower score applies to these distances

Table 7.3: Access scores and their corresponding distances for available services and infrastructure in Shixini

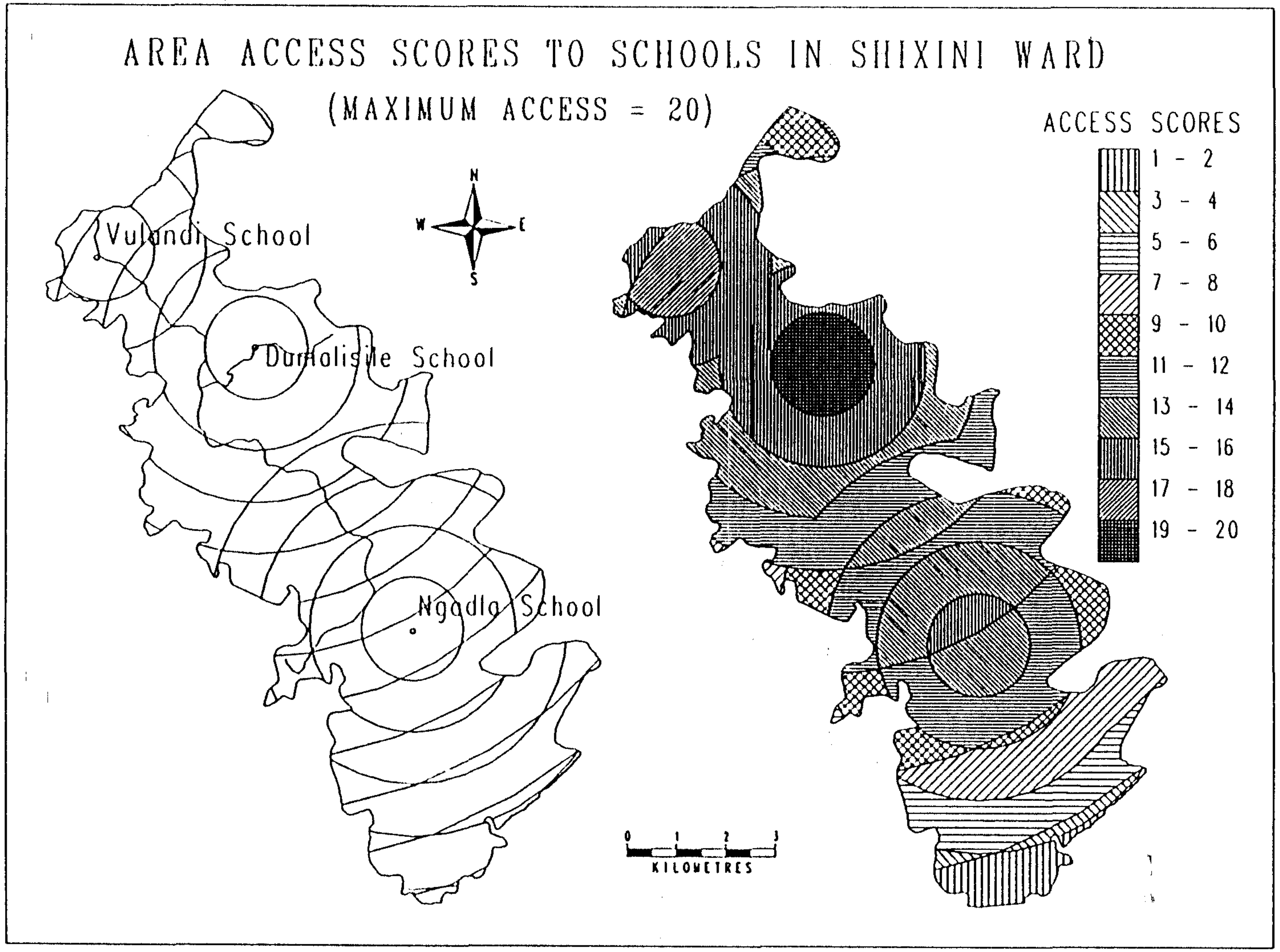



Figure 7.3 Area access score's to schools in Shixini Ward

Access to a secondary road was considered critical and a total score of 20 points, for adjacency to a secondary road, was awarded. Secondary roads were also heavily weighted, decreasing rapidly with distance to ensure that these features played a major role in defining the potential site area.

Tracks were considered important, but provided reduced accessibility to a location, and were correspondingly given a lower total score (maximum of 10). They were not considered relevant siting criteria in defining the service centre. Distance from the secondary road or track was considered here, the further away the area was from one of these features the lower the score.

**Education Facilities**

Education facilities were given a high priority due to the frequency of the service offered. The importance of education as a critical aspect of development and the fact that pupils often have to walk long distances to reach these facilities, often to the detriment of their education. There are two primary schools in the area and a single junior/secondary school which caters for pupils up to standard seven. So as not to complicate the scoring system by having to provide a combined access score for primary schools it was assumed that pupils of a school going age. would attend the junior school including the junior/secondary school located closest to their area Junior schools were given an access score of 10 and a weight of 2. The secondary school component was also given an access score of 10, but unlike the primary schools, had a weight of 1, limiting its overall affect on the total access scores of areas. This is due to the narrow range of this service, in this case standards six and seven.

An illustrative composite buffer of the location of these schools and the access of different areas in the ward to these facilities is displayed in Figure 7.3. What is immediately noticeable in this figure is that the buffers are round, reflecting the shortest distance between points, in consequence they do not directly take cognisance of the accessibility provided by the infrastructure (roads and tracks) of the area, this applies to other services as well. The reason for this is that the score and weighting of the roads and tracks of the area was considered sufficient to provide an idea of the services accessibility to the population, as all of the services offered with the notable exception of Ngadla school are located adjacent to the secondary roads of the area.

**Administrative Functions**

Administrative services included access to the Chief of Shixini and the Tribal Authorities whose buildings are located adjacent to each other in Kwitshi sub-ward. The administrative services provided from this location were assigned a combined score of 10. The functions of the chief and the tribal authority, are referred to in Chapter Five. Despite the services offered McAllister (1989a) observed that many people did not attend meetings and other functions due to the distance of the chief and Tribal Authorities from lower Shixini, in addition people were often represented by the sub-headman of the sub-ward in which they lived, and therefore found it

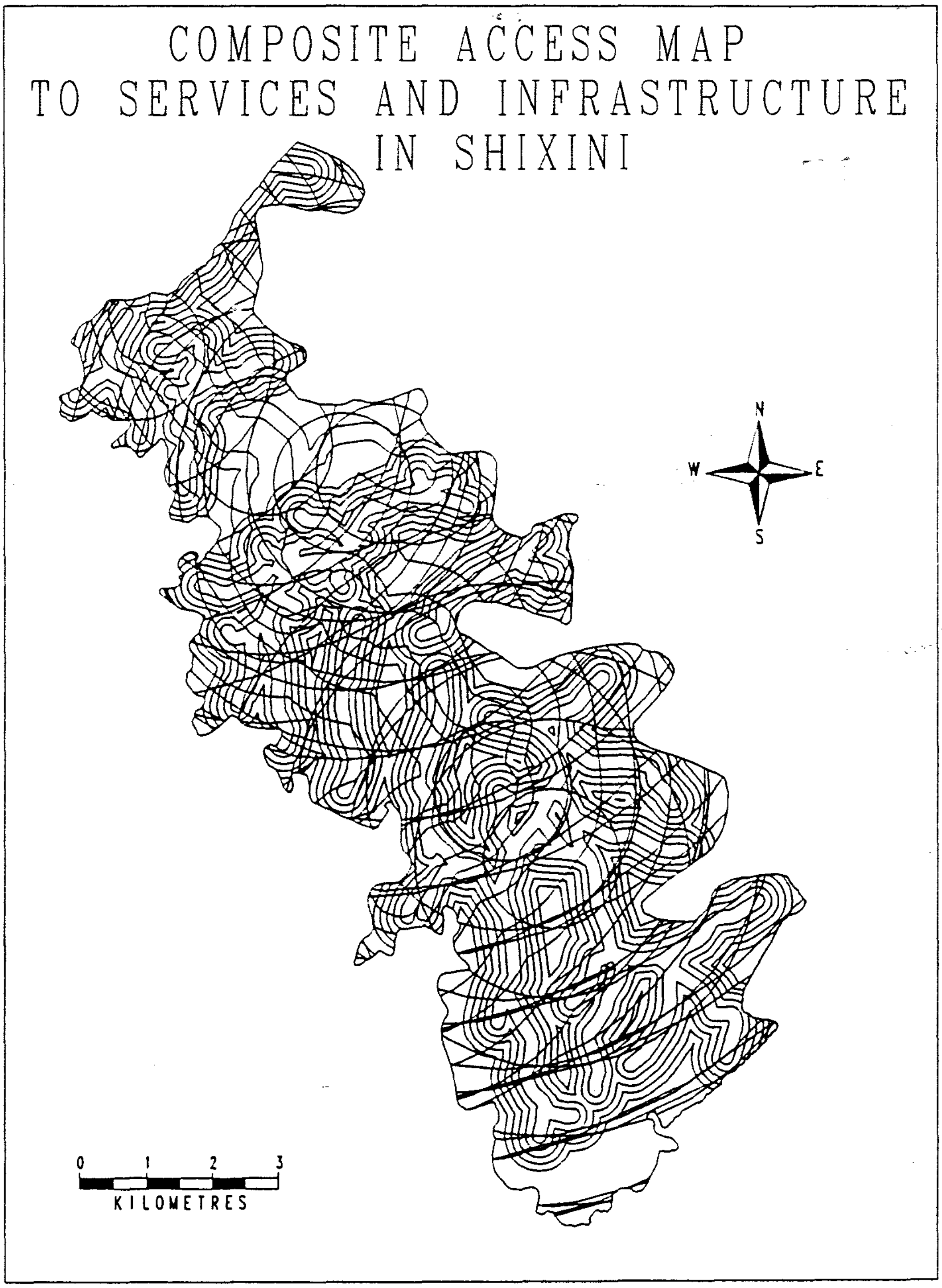



Figure 7.4 Buffer map of services and infrastucture

unnecessary to travel there themselves. It was therefore concluded that visits by the majority of people were at best infrequent. The Administrative services offered were therefore regarded as necessary, but not vital for everyday living, and were therefore given a weighting of 1, as displayed in Table 7.3.

**Medical Services**

Access to medical facilities is important to any community. The clinic was given an access score of ten but the fact that it operates as a "one day clinic" decreases its impact and accessibility to certain segments of the population during the week. The clinic was therefore given the same weight as that given to administrative functions i.e a total score of 10 and a weight of 1.

**Commercial Services**

Commercial services considered were limited to the two trading stores operating in the area. Trading stores appeared to be important focal points in Shixini and were considered necessary services which are likely to be frequented quite often. Trading stores were also used as sites for postal drops as well as taxi disembarkation and collection points. They are considered important as focal points for the possible development of ancillary activities and were given a score of 10 and a weight of 2 (see Table 7.3).

**An initial composite map of infrastructure and services.**

A composite map of the entire location area displaying buffered infrastructure and services is displayed in Figure 7.4. The polygon attribute table (PAT) of this coverage (see Figure 7.6 for an example of a PAT) was exported to a spreadsheet where the composite scores of each individual location were calculated out of a possible maximum numerical access score of 80. A number of items were added to the PAT in the spreadsheet, including the total composite score of services and infrastructure for each area, as well as a number of course and fine scales to make the ranking of these total scores more manageable in Step 3 (as displayed in the PAT of Figure 7.6). The spreadsheet was then imported back into Arc/Info. Figure 7.5 indicates at a very coarse scale the relative access scores of the areas making up the ward. What can be seen immediately from this map is that lower Shixini is relatively disadvantaged in terms of access to services and infrastructure, in contrast upper Shixini and the areas running down the centre of Shixini have better access to these features, the strong showing of these central areas reflects the location of the secondary road in the ward.

### 7.4.4 - Step 3: An initial composite of land suitability and service accessability

The land suitability map created in Step One was overlaid with the composite access map created in Step Two, with only areas common to both coverage's being retained (Figure 7.6).

Area's with attributes considered desirable for the establishment of both a service centre and village were then isolated. The first factor considered was access to infrastructure, only areas with a road and track score equal to or greater than 20 were considered. The second criteria was a service score of equal to or greater than 60 points and the third criteria was an area equal

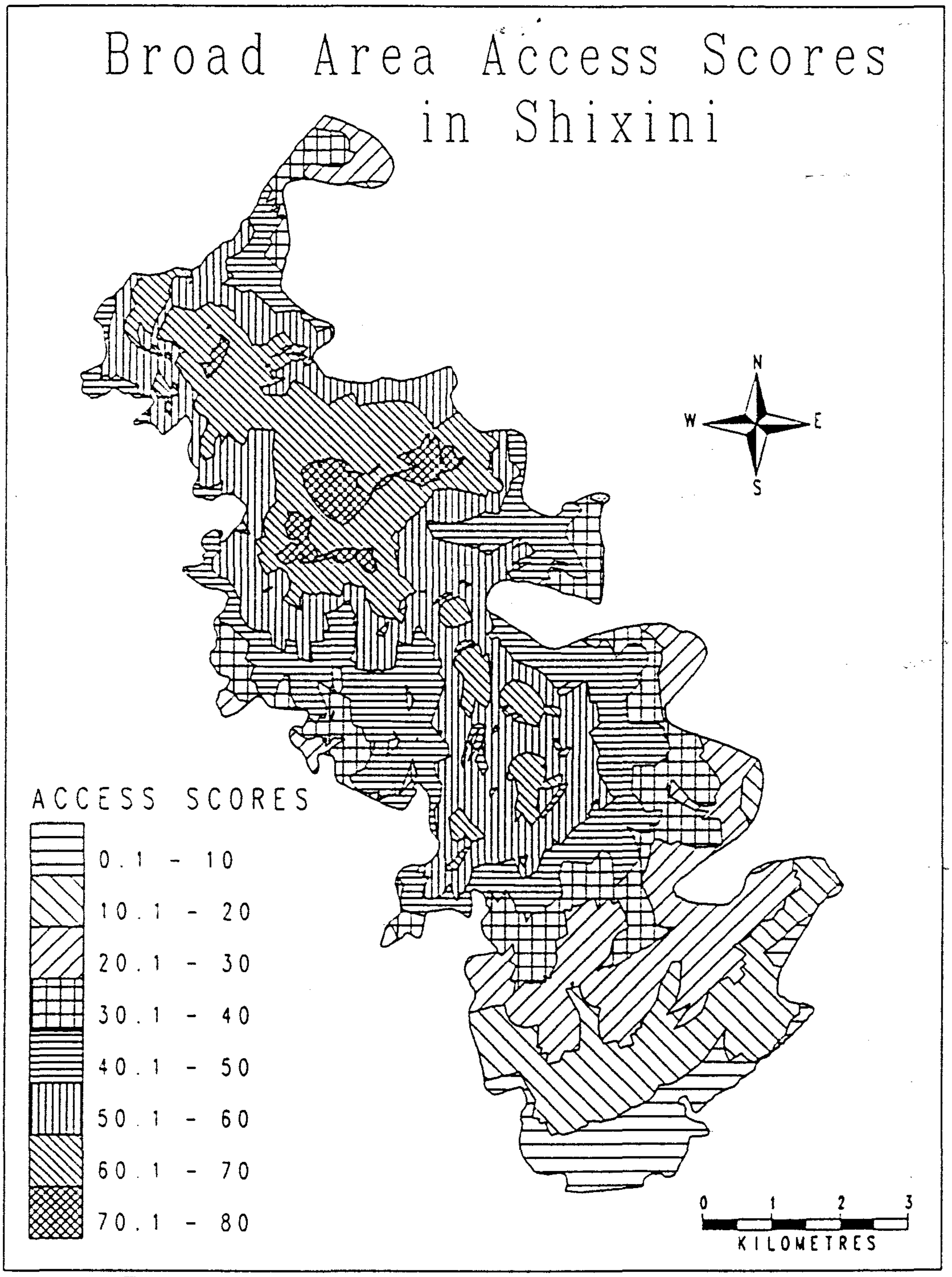



Figure 7.5 Broad access scores to infrastructure and services in Shixini Ward

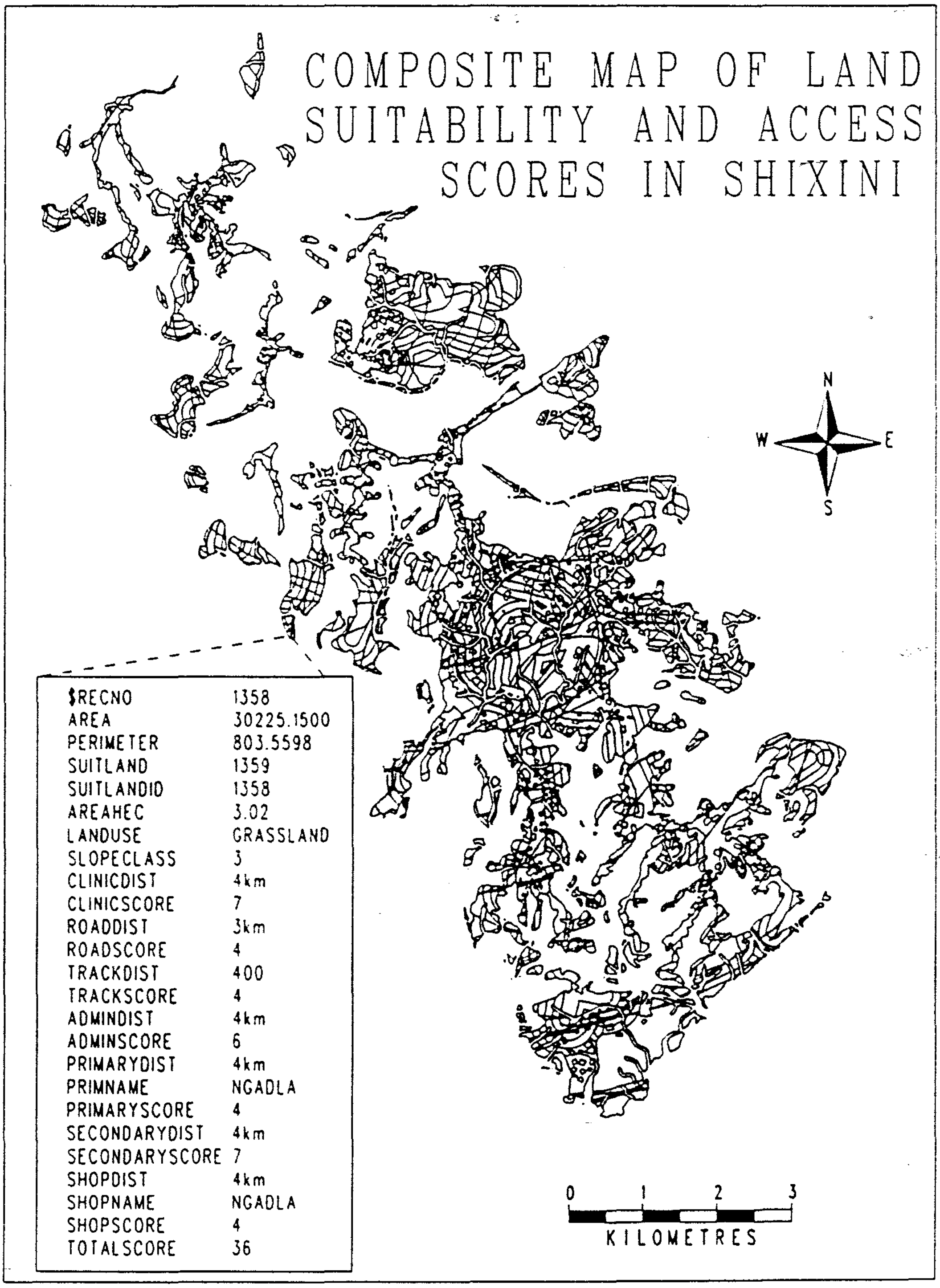



Figure 7.6 Composite land suitability and infrastructure access scores

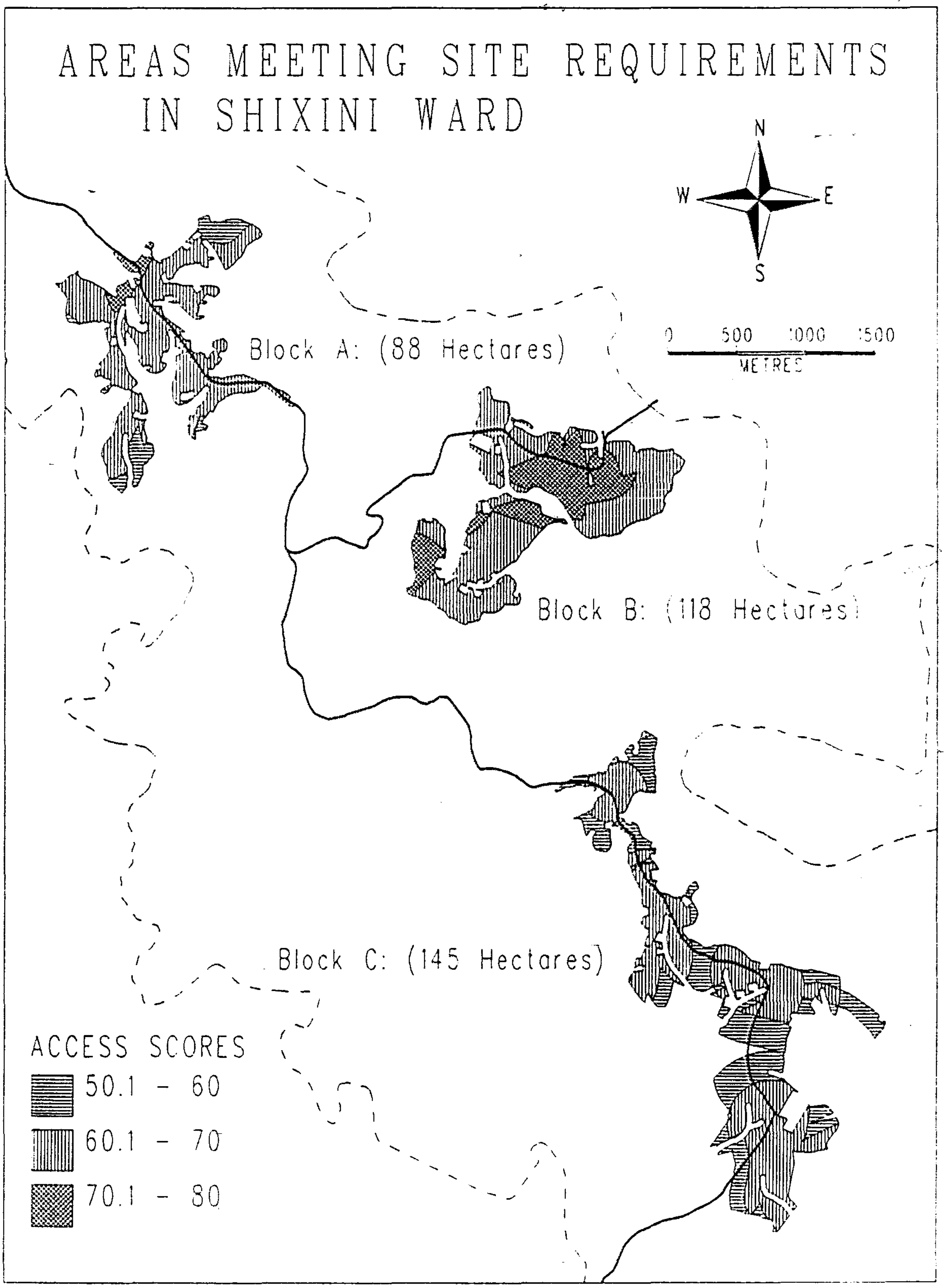



Figure 7.7 Areas meeting specified site requirements

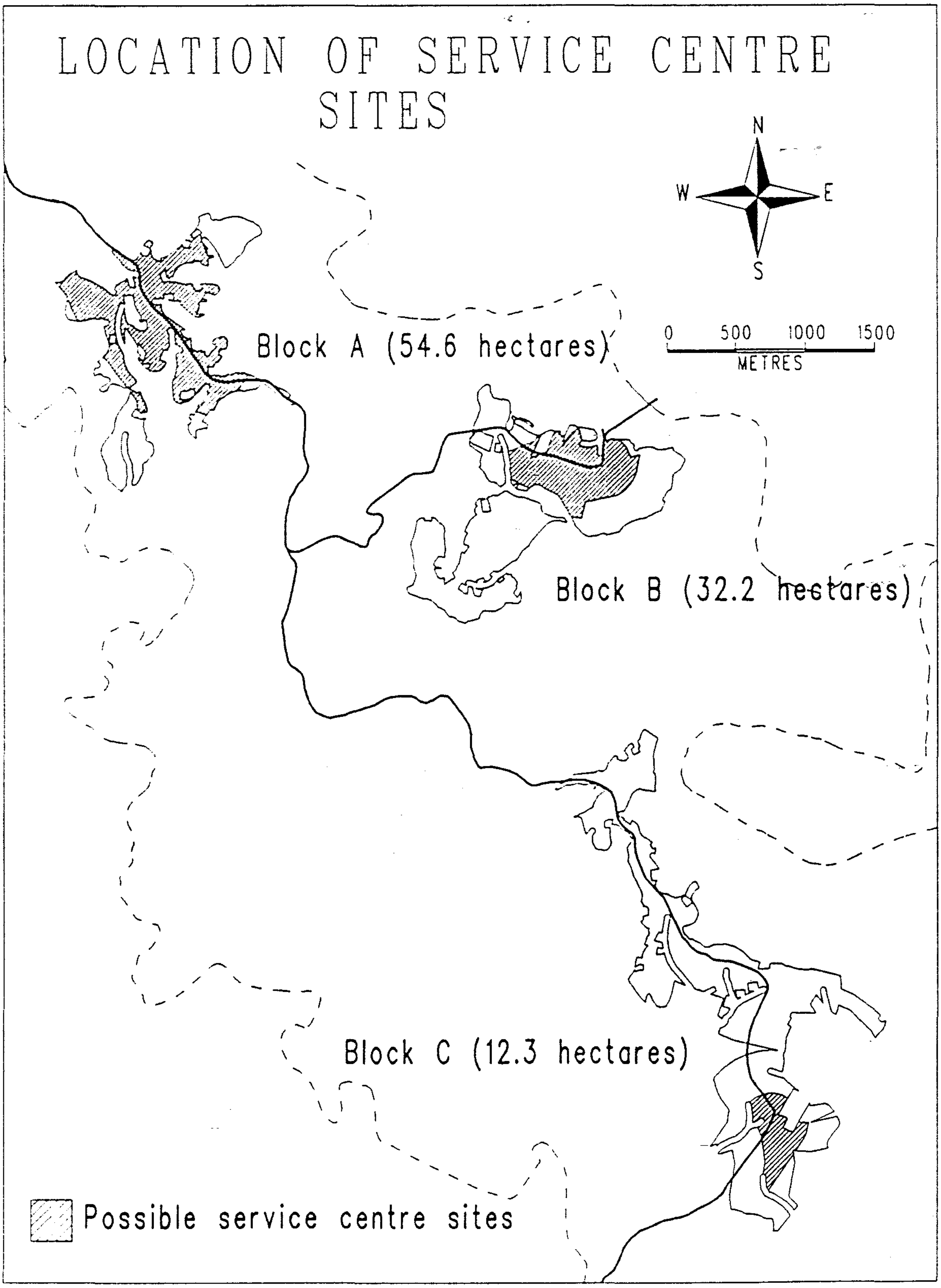



Figure 7.8 Possible service centre sites within each block

to or greater than 80.8 hectares, the proposed area of land needed for the development.

What was immediately apparent was that only a single area fitted this criteria, this area, located in Kwitshi sub-ward was called Block B in this study (as displayed in Figure 7.7). As three areas were required and access scores only formed a component of the final area chosen, additional areas were required to provide alternatives. This was achieved by lowering the required access scores, areas with lower scores being merged with the higher scoring areas (as displayed in Figure 7.7). This process was repeated until an additional two locations were identified. These areas were for convenience designated as Block A and C.

### 7.4.5 - Step 4: Selection of a core area for each of the selected blocks

It was noted briefly in Step 3 of this chapter that access scores differed between areas and within individual blocks. It was therefore necessary to find a primary area within each block suitable for the siting of the proposed service centre.

Table 7.4: Primary block attributes and access scores.

| BLOCK CHARACTERISTICS | BLOCK A | BLOCK B | BLOCK C |
|---|---|---|---|
| Total Area of block | 88.4 ha | 118.3 ha | 145.0 ha |
| Primary Area | 54.6 ha | 32.2 ha | 12.3 ha |
| Clinic | Le 3 km | Le 1 km | Le 6 km |
| Primary\Schools | Le 2 km | Le 1 km | Le 2 km |
| Secondary School | Le 3 km | Le 1 km | Le 6 km |
| Trading Store | Le 2 km | Le 3 km | Le 1 km |
| Administrative | Le 3 km | Le 1 km | Le 5 km |
| Secondary Road | Le 250m | Le 250m | le 250m |
| Total Access score of primary areas (maximum of 70 as it excludes tracks). | 60 | 66 | 54 |
| Combined distance to present service's in Shixini. | 13 km | 7 km | 19 km |
| Average distance to the services from the primary site. | 2.6 | 1.4 | 3.8 |
| Distance along the secondary road from Ntlahana to the proposed service centre | 4.79 km | 0.63 km | 9.87 km |

A process similar to Step 3, was followed. The service centre required an area of at least 7 hectares in order to accommodate the fifteen erven. The area also needed to be adjacent to a secondary road in order to take advantage of existing services and infrastructure as well as to be accessible to other areas. The service centre also required the highest access scores to services possible within the constraints of the first two factors. The primary area's derived from these site factors are displayed in Figure 7.8 while each area's attributes are displayed in Table 7.4.

The last factor 'distance from Ntlahana to the proposed service centre' was included as an indication of the distance to that administrative area's border (the problem brief mentioned the possibility that the service centre might serve this administrative area as well as Shixini).

### 7.4.6 - Step 5: Accessibility of the primary sites to the people of Shixini

As it was assumed that the bulk of the population was without access to vehicles, the location of the service centre in terms of the population distribution in the ward was of critical importance. The service centre would have to serve as many people as possible in as short a distance as possible. A process similar to that used to determine access scores was followed. The primary areas of each block were individually buffered a number of times with each buffer spaced a kilometer apart. The composite buffers were then overlaid with the 1989 settlement pattern which consisted of the residences present in Shixini at that time. The number of residences within each zone were calculated and converted to a percentage of the total population in a spreadsheet. The results of this exercise are presented in the form of a graph (Figure 7.9).

## 7.5 - Results of the site identification

**Land Suitability**

All three blocks were similar in terms of their suitability for residential and commercial development. Block B however was the most consolidated block in terms of the area to perimeter ratio at 86\1, followed by Block C 66\1 and Block A 44\1. This may or may not play a role in the cost of future amenities such as water but a consolidated block would probably be easier to administer than say block C which stretches over four kilometers in length.

**Access to present infrastructure and services in Shixini.**

There was very little initially to choose from between the three blocks of land in terms of their access scores. Block B as expected returned the highest access score to services followed by block A and block C. The block scores are however relatively close, this is due to the weighting's given to the individual services. The numerical scoring system and the weights given to services, may have placed too little or in some cases too much emphasis on some services and may have distorted the 'real' picture in Shixini. However, these distortions if they do exist, could not be addressed without access to the relevant parties.

**Location in terms of serving both administrative areas in the Jinqui Tribal Authority**

Block B occupies the most favourable location to serve both Shixini and its neighboring administrative area, Ntlahana. Access to the site was measured in terms of distance from the boundary of the two administrative areas along the secondary road. Block B is located just 637m from the bridge connecting the two administrative areas, Block A is 4.8 km away while a distance of 9.8 kilometers separates block C to the bridge. The distance between the bridge and block C highlights the difference between the shortest distance between two points (ie: a straight line) and the distance between the same points along existing infrastructure. For example the shortest distance between the Primary area of block C and the clinic is less than 3km while along the secondary road they are 8.63 kilometers apart. The shortest route according to mapped tracks is 6.2 kilometers although there may be a more direct footpath.

**Access to the primary sites of each Block**

Block C proved to be the most accessible and centrally located of the three sites in terms of the population distribution in the Ward. Figure 7.9 displays the percentage of the wards population that would be served by each service area within specified distances (ie: within a 5 kilometer radius Block C would serve 78% of the wards population, Block B 72% and Block A 49%). The centrality of the primary area in Block C in relation to the other blocks is demonstrated by its ability to encompass the entire wards population within 9 kilometers.

**Access to resources**

Access to resources such as water, fuel and land differ according to their current availability at each site. Both Block A and B are located within a single sub-ward area while Block C stretches over 3 sub-wards. If resources such as land and grazing are used and maintained solely by the sub-ward concerned, then both Block A and B will be at a relative disadvantage to block C where the pressure on resources caused by an increase in the population can be spread between a number of sub-wards, obviously the idea of occupying a village erf guarantees the resident to a garden but not necessarily to a field. Access to fuel and building material will offer similar disadvantages. Although the central woodlot is relatively close to all the blocks, (it borders parts of block B and C and is located 1.2 km from Block A), access to this source differs according to the location within each block. Burchmore (1988) stressed that although wood from the plantation was used as building material, it was not often used as a source of fuel. This she attributed to the large trees growing in the area which made it difficult for the women or children who collected firewood to obtain wood from this source. Therefore smaller trees or trees of a different species to those planted in the plantation are used as firewood. As mentioned before this may cause the area around the proposed village area to be denuded of this resource, making it necessary for women to walk further and further for fuel. An alternative is the establishment of an alternative source of fuel or woodpile in the village area.

The quantity, quality and access of each block to water in the ward was unclear, however it is likely that each of the identified areas suffer from periodic water shortages. This statement is based on information discussed earlier in this chapter. Boreholes were sunk in close proximity

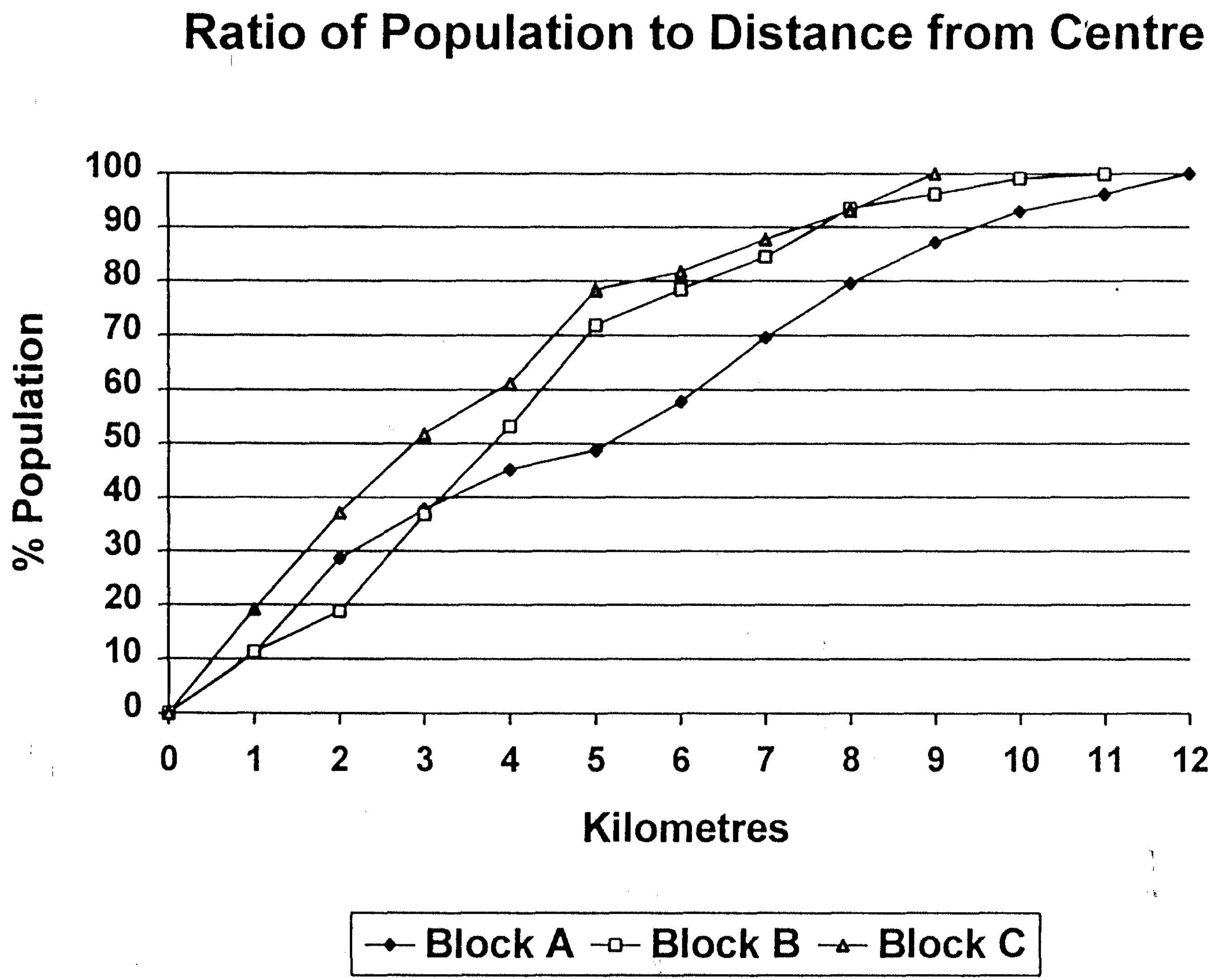



Figure 7.9: Ratio of population to distance from centre

and within the demarcated areas of Block A and B, and possible dam locations were identified in close proximity to Block C indicating that these areas lack either a suitable quantity or quality of water or both. Access to water probably represents the greatest obstacle to concentrated development in these areas at the present time. The fact that there is groundwater and potential dam sites at these locations is promising. However the present location of these water sources are often at a lower altitude than the potential sites diminishing the possibility of a natural reticulation supply (gravitational).

**The identification of a primary site.**

Based on the preceding factors the most suitable area available for the establishment of a service centre and village is Block B. The area offered the greatest access to infrastructure and services available while still being relatively accessible to the majority of the Shixini people. The area has the added advantage of being ideally situated to serve the people of Ntlahana. It is interesting to note that all three of the possible areas selected for the development of the service centre and residential area were all demarcated as residential areas in the betterment plan. In addition Kwitshi sub-ward was indicated as the preferred site for a village centre in the Shixini Proposal (McAllister, 1989).

The choice of Block B as the service site would disadvantage the people resident in the lower sub-wards of Shixini, however block C, the most centrally situated of the blocks does not offer that much more advantage in terms of access. It was shown in Figure 6.11 that those people living in lower Shixini are already relatively disadvantaged in terms of access to infrastructure and services in the area. A second disadvantage of the primary area in Block B is the absence of a shop/trading store, the nearest of which is 3 kilometers away. The trading stores may arguably be the strongest attractors in the ward in terms of present services offered, therefore the possibility of establishing a shop in Block B would have to be investigated, a step which may adversely affect existing commercial enterprises in the area. A study examining the minimum threshold population needed to support this and other ventures would have to be conducted.

**The possible environmental impact of the development of Block B in Kwitshi**

The Kwitshi area has a low erosion potential. This assessment is based on the prevalent farming practices in the area which is limited to the gentler slopes of the area . In addition gentle slopes and thick grass-swards presently cover 44.8 % of the area. The steeper slopes are vegetated by valley bushveld, but there is also some habitation of these areas which could lead to erosion. Soil samples analyzed by Burchmore (1988) revealed that the entire ward was characterised by a low organic and chemical content probably as a result of leaching. The low organic content of the soil coupled with the high intensity rainstorms which occur in the area, indicate that there may be an increased risk of erosion if the protective vegetative cover is thinned or removed.

There is a danger of increased erosion if the natural valley bushveld is cleared. This vegetation occurs along the steeper slopes of the ward and bordering the drainage lines of the area;

removal of this vegetation would possible result not only in an escalation of erosion in the area but in an increase in the sediment load of streams and consequently a further deterioration in water quality. Proactive planning will decrease this danger by not allowing development to occur within 20 meters of a water course, however the vegetation community would remain vulnerable to people collecting fuel and would therefore need to be protected.

The settlement pattern in Kwitshi appears partly to follow the general residential pattern in Shixini in that 66% of the structures are situated on slope class 3 (as indicated in Table 7.5).

Table 7.5 Percentage area covered by different slope classes in Kwitshi sub-ward as well as the location of residences in these areas.

| Slope Class | Area of Kwitshi Covered | | Residences | |
|---|---|---|---|---|
| | Area in (ha.) | % of total Area | Number | % of Total |
| Class 1 | 11.1 | 2.3 | 8 | 2.6 |
| Class 2 | 128.6 | 26.3 | 94 | 31.1 |
| Class 3 | 193.9 | 39.7 | 200 | 66.2 |
| Class 4 | 50.6 | 10.4 | 0 | 0 |
| Class 5 | 104.5 | 21.4 | 0 | 0 |
| Total | 488.7 | 100.1 | 302 | 99.9 |

Table 7.6 Slope and landuse composition of Kwitshi Sub-Ward

| SC | Grassland | | Bushveld | | Savannah | | Woodlot | | Fields | | Gardens | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % |
| 1 | 4.0 | 1.8 | 3.4 | 12.7 | 1.5 | 5.8 | 0 | 0 | 1.7 | 0.9 | 0.5 | 1.8 |
| 2 | 69.5 | 31.7 | 8.8 | 33.1 | 19.1 | 73.7 | 2.1 | 56.8 | 18.4 | 10.0 | 10.6 | 37.4 |
| 3 | 96.3 | 44.0 | 3.3 | 12.3 | 5.3 | 20.5 | 1.6 | 43.2 | 70.2 | 38.0 | 17.2 | 60.8 |
| 4 | 3.4 | 1.5 | 5.3 | 20.1 | 0 | 0 | 0 | 0 | 41.9 | 22.7 | 0 | 0 |
| 5 | 46.2 | 21.0 | 5.8 | 21.8 | 0 | 0 | 0 | 0 | 52.5 | 28.4 | 0 | 0 |
| Tot | 219.4 | 100 | 26.6 | 100 | 25.9 | 100 | 3.7 | 100 | 184.7 | 100 | 28.3 | 100 |
| % of total area | 44.9 | | 5.4 | | 5.3 | | 0.8 | | 37.9 | | 5.8 | |

SC = Slope Class
Area in hectares

The remaining 34% are situated either on slope class 1 or 2, a high percentage considering the average for the ward was 18%. Despite the overall preference of Shixini residences to be situated on crests in the ward this has not occurred in Kwitshi sub-ward. Approximately 50 hectares is classified as crests in the sub-ward , Table 7.6 indicates that 42 hectares (83%) of this area is used for field agriculture and the rest for grazing.

The demarcated village area would effectively reduce the area open to grazing in Kwitshi by 82 hectares in the long term, resulting in an increase in pressure on grazing land. Burchmore (1988) cited overstocking as a probable cause of erosion in Shixini and suggested limiting the number of cattle allowed. A questionnaire distributed by Andrew (1992) indicated that the majority of livestock owners (78%) were happy with their access to and quality of grazing, although Andrew does indicate that this satisfaction may be seasonal, with good grazing in summer and bad in winter. Andrew's study also indicated that 78% of the household heads questioned were not satisfied with the size of their herds, and would like to expand them. This is an indication of the importance of these herds as a form of wealth (cattle are used for ploughing, ritual sacrifices and for payment of lobola). It may also indicate that the pressure on grazing will increase as a result of the reduction of available grazing land and as more residents become economically active and start their own households. Increased pressure for grazing land would also lead to general environmental degradation through the removal of bushveld to increase the grazing area, this was already cited as a problem by Burchmore in (1988). The possible problems of overstocking if and/or when it exists is a complex issue which needs to be discussed with the community.

### 7.6 - Additional expertise required

The siting of a service centre is a complex problem, requiring the involvement of a multi disciplinary team. It is unlikely that a single person would have sufficient expertise to address all of the different aspects which characterise it. Each of the aspects addressed during the siting problem such as the provision of water, possible environmental consequences, soil suitability for agriculture and waste removal options requires input from a number of domain experts. The access scores and weightings derived for the study also requires a multi-participatory approach, including various domain experts, community leaders, possible investors in the service centre, local and central government and any other individual or organisational role players.

### 7.7 - Processing time, covers and data volumes of the Shixini pilot project

The covers used in the pilot project, procedures and functions followed, as well as the volumes of intermediate and final covers and their processing times are provided in Table 7.7

The initial Shixini database created in Chapter Six, used 5.3 Mbytes (Table 6.10) of disk space. What can be seen from Table 7.7 is that project work rapidly takes up space. The main covers produced in the pilot project take up a further 13.4 Mbytes. This figure excludes various covers created and discarded leading up to their production, as well as the plot files (map compositions) made to display the data. The largest cover produced during the pilot project was the composite

Table (7.7) Processing times, covers, operations and data volumes of the Shixini pilot study

| Step Number | Cover | Volume Kbytes | Operation and Time (min) | Operation and Time (min) | Cover | Volume Kbytes | Operation and time (min) | Cover | Volume Kbytes |
|---|---|---|---|---|---|---|---|---|---|
| Step one | | | | | | | | | |
| | Landuse | 0.94 | • | • | • | • | • | • | • |
| | Slope | 0.33 | • | Overlay (26.56) | Composite Landuse | 5.0 | Reselect (4.41) | Suitable Land | 0.36 |
| | Rivers | 0.42 | Buffer (6.48) | • | • | • | • | • | • |
| | Erosion | 0.21 | Buffer (4.43) | • | • | • | • | • | • |
| | Roads | 0.36 | Buffer (28.08) | • | • | • | • | • | • |
| Step Two | | | | | | | | | |
| | Education | 0.92 | Buffer (24.37) | • | • | • | • | • | • |
| | Administration | 0.48 | Buffer (20.16) | Overlay (22.30) | Access to Infrastructure | 1.2 | • | • | • |
| | Clinic | 0.46 | Buffer (21.04) | • | • | • | • | • | • |
| | Schools | 0.55 | Buffer (23.15) | • | • | • | • | • | • |
| Step three | | | | | | | | | |
| | Suitable land | • | Overlay (11.16) | • | Composite 2 | 2.0 | Reselect (3.40) | Area's suitable for development | 0.18 |
| | Access to Infrastructure | • | | • | • | • | • | • | • |
| Step Four | | | | | | | | | |
| | Composite two | • | Reselect (2.02) | • | Area's suitable for a service centre | • | • | • | • |
| Sub-tot | | 4.67 | 2:36:16 | 0:49:43 | | 8.20 | 0:8:35 | | 0.54 |

Total processing time in hours, minutes and seconds: 3:41:24
Total volume of covers generated: 13.41 Mbytes

land-use cover with a volume of 4.95 Mbytes. The larger the files involved the longer the processing time required for functions performed on that data. In addition more disk space is required in order for the data to be processed.

The pilot project confirmed that hardware specification identified in Chapter Six, Step 3 was adequate to handle the processes and volumes required for the pilot project.

The time taken to isolate the three potential service centre and the village centres is indicated in Table 7.7.

### 7.8 - Conclusion

The pilot project was successful in that it managed to provide information capable of supporting a user defined question. User defined products in both a graphic and tabular format were produced in a timely, transparent, clearly repeatable and flexible process. However, the process by which the answer was derived was unrepresentative in that it was not guided by a steering group of professionals and or interested parties. This may have ensured the relative simplicity of the process. In a similar vein there was no way to ensure that the solution generated was either acceptable or adequate for the people of Shixini.

The transparency of the process (in terms of maps which indicate graphically what was done) is important to show the different levels of potential users (as defined in Chapter Six, Step 2) how an the possible alternatives were derived. It is however unlikely that the technique would be understood by the Shixini people in its present form, however this process would help provide information and options at the organisational and committee level. This information would then be transferred in a different format to the Shixini people by the fieldworkers.

From a planning level a number of advantages of using a GIS as opposed to the more manual methods used are apparent. The information and possible options supplied by the GIS were derived in a relatively short time period (Table 7.7). If this problem was undertaken using manual processes it would have taken considerably more time, and some of the tabular data produced by the GIS such as calculating the average garden size in Shixini would probably not have been attempted. A manual process could also not compete with the flexibility demonstrated by the GIS, any changes in the parameters would necessitate lengthy delays as the work was done over again.

At the outset it must be said that the areas identified by the GIS are the same as those identified during betterment planning and the primary area chosen was the same as that identified in the Shixini proposal, however, the processes undergone in reaching these conclusions are different. Both betterment planning and earlier planning relied heavily on individual knowledge of the area. The factors used in this process are unclear as well as the representation in the process. These decisions were also made with a less than clear insight of the possible consequences of the actions or the possible alternatives. The use of the GIS on the other hand followed a number of transparent steps based (depending on the age of the data) on what is actually there and not on an individuals or groups perception of what exists. The GIS therefore provide a degree of impartiality in that the data produced is based on the available data and not on sentiment or political considerations. The information produced is not however completely free from bias as the process and factors chosen to derive the information will often influence the results.

The GIS managed to dynamically integrate a number of different themes to produce new information/data in this case siting criteria to support the problem brief.

The process was flexible, new factors or existing factor weights could be quickly altered, reincorporated or excluded from the process, the system could therefore easily incorporate different or conflicting viewpoints and provide compromises or alternatives.

The speed with which the GIS can produce useful spatial related information was established by the fact that once the procedure had been set up and the steps documented, the actual time taken to obtain the three possible areas was just over five hours.

The GIS has a number of advantages over a static data source such as a document or paper map, including the ability to query the database and establish relationships between different types of entities, backing up suppositions with quantitative facts. When establishing site criteria a supposition was made based on an observation by Andrew (1992) that crests were a preferred residential area. To check this assumption using conventional methods would have proved time consuming and would probably not be worth the effort. With the help of a GIS however, a five minute deviation established that the observation was partially correct in that crests had a far higher density of residential buildings per hectare than any other topographic feature but that the majority of houses in the ward occurred on foot slopes.

The database proved to be adequate for the set problem, with the tacit acknowledgment that the answer to the problem was structured, around the information in the database. The problem may have been addressed differently had the database been structured around the problem.

An aspect of the problem which was not answered satisfactory was the possible environmental affects of the development on the site area. This was partly due to the lack of soil and water related attribute data and partly due to the limitations of the operator concerning that area of expertise. This point emphasises the fact that the GIS is simply a tool in the planning process and that the value of the information derived from it depends partly on the quality and extent of data in the system and partly on the knowledge of the person/people guiding the process. In a developmental context where a wide variety of topics are covered, this support may of necessity be multi disciplinary.

Some of the attribute data and covers making up the Shixini database were criticised by Dr Mike

Stocking who questioned the appropriateness of the values assigned to the data in terms of the area it was supposed to represent (Stocking, pers. com. 1994). This criticism appears to be valid and on reflection the Shixini database may certainly be guilty of being "Eurocentric" in design, as the attribute data reflects values important to academics rather than reflecting the resources or areas which the Shixini people attach importance to in their everyday lives. An example of this is apparent in the vegetation classification which does not reflect the value of the vegetation community to the Shixini people. The different vegetation communities play an important role in Shixini life; certain preferred trees are used for the building of huts, kraals and fencing poles and certain woods are preferred sources of fuel. Different grasses are important in the area not only for grazing but for thatching as well. A classification based on these factors would probably provide a better idea of environmental conditions in the area. The local names for the different features in the area could also be used to make the database more representative of the area it covers, as well as help the fieldworkers pass on information to the grass roots. The source of the majority of data in the database (having been collected mostly by post-graduate students) and the data itself is at present a reflection of its purpose, which was initially to secure an academic degree for the person concerned and secondly to add to the information which formed, together with McAllister's research, the basis of the Shixini Project. As such the data proved sufficient for these purposes. This criticism is however important if GIS were to be extended to the grassroots level of the Shixini project.

# CHAPTER EIGHT

## CONCLUSION AND RECOMMENDATIONS

The Aim of this study was to examine whether GIS is an appropriate technology when applied to rural community development planning in South Africa.

The Shixini GIS feasibility study has shown that the use of GIS could be beneficial to the Shixini Development Project for a number of reasons, these include the ability to respond quickly to changing scenarios; an increase in the utility of collected data by combining different data sets, the ability to aid holistic planning, the provision of new products, which were previously impossible to produce, either through the improved functionality offered by the technology or by decreasing the time needed to produce a product and finally the technology can be used to aid communication through the production of geo-information products within the project.

This study has also shown that the process of acquiring or of using a GIS in any given situation involves a lot more than the simple acquisition of the hardware and software. GIS consists of a complex set of components which need to be integrated to make up a functioning system. Those components that were identified in Chapter Two as hardware, software, data and liveware which operate together in an institutional context also need to be present. Without these factors present a GIS will either not operate effectively, or will not operate at all. These factors therefore provide constraints on the use of the technology in any given situation.

In some aspects the Shixini GIS can not be compared to other community development projects in that most organisations do not have access to either the equipment or skills that were available to the Shixini Development Project. Four of the above mentioned factors, hardware, software, data and liveware were available to the Shixini project. Liveware skills existed throughout the staff compliment, including the ISER fieldworker who held a Masters Degree in Anthropology. Other organisations facilitating development in rural areas often do not have the same advantages either in terms of access to equipment or liveware. It is a common practice in community development to use community workers from the area in which the development is taking place. The reasons for this include, a working knowledge of the area and the trust of the local community. These community workers differ in terms of their experience and formal training, and organisations might have to provide extensive training for their fieldworkers in order for them to play the same role as the fieldworkers active during the SDP.

The feasibility study indicated that GIS can offer a number of advantages to the planning level of those organisation(s) facilitating the development process, down to the level of the fieldworker. This view was only partly shared by those organisations responding to the questionnaire survey who viewed the technology primarily as a useful but non-essential management tool.

The direct relationship of GIS to the community is not clear from the study. The Shixini feasibility study did not examine in any depth the relationship between the proposed GIS and the community, concentrating instead on the role of GIS in the facilitating organisations, from the level of project management down to the level of the fieldworkers/community workers. The study identified the fieldworkers/community workers as the conduit between any GIS and the community, due to their pivotal role in the development process. Their inclusion in the process was therefore seen to be vital.

It is evident from the literature survey that the technology can be used at community level. Chapter Three indicated that GIS and related technologies can help bridge the gap between planners and the community. The benefit of the technique developed in this example is, however, offset by the expertise needed to sustain the technology developed for this purpose, which limits its widespread application. This study does indicate however that communities with a low level of formal education are able to grasp spatial concepts relatively easily if presented in a suitable way.

One of the greatest obstacles to incorporating GIS in project planning is the nature of the planning process itself. There appears to be a disparity between the literature regarding the need for data in the planning process and the hard reality of the situation where funds are often limited. The facilitating organisation has to choose between competing needs, invariably the need to provide training and concrete benefits which ensure that the grass roots remain receptive to development possibilities will take priority over the collection of data or incorporating GIS. In this case the organisation will rely on what data there is as well as the expertise and experience of their 'development team'.

Monetary considerations are without doubt one of the most important considerations facing organisations today. To make resources available to purchase and maintain a GIS requires the assurance that the technology is going to provide sufficient returns to the organisation to make the purchase viable as the technology has to compete against other needs. The nature of community development projects (usually small to middle sized projects with limited costs) works against the purchase of a GIS for short term work. Data and training costs would, depending on the size of the project, make it uneconomical to purchase a GIS for a project as it only becomes cost effective in the medium to long term. Community planning is a democratic process relying on the interaction of different interest groups in order to reach consensus on development objectives and the method of achieving them. This process might take months or years. GIS can be used effectively to help achieve consensus by modelling alternative scenarios and their possible impacts. Financial viability is a problem which might be encountered in a scenario where the GIS might be active in some phases of the project and not in others, as the GIS and its liveware component might be inactive for long periods of time (depending on the activities of the organisation involved). The costs of GIS hardware and software were shown to differ considerably in Chapter Six. It was also shown that other costs (which did not include hardware and software maintenance) could increase the price substantially. Without the concomitant by an organisation to provide suitable skills and facilities to keep a GIS running the technology would be underutilised or worse still, unused.

This makes the ownership of the GIS and the factors supporting it vitally important. Cost is a major consideration in any project. The perception of what is expensive in a project differs in relation to the amount of money available to a project. It was shown in Chapter Six that a number of options are open to the potential user of a GIS, each of which has expenses, advantages and disadvantages associated with it. The purchase of GIS is therefore not usually viable just for a short term project unless the expertise and equipment is supplied by someone other than the facilitating organisation. This factor may suit organisations which normally contract external organisations to collect data.

It was interesting to note in Chapter Four that, of those organisations responding to the questionnaire survey, only those with a strong mandate to collect data related to the physical environment actually used GIS, this trend was also discussed in Chapter Two. This is probably due to the relative ease with which this type of data can be obtained as opposed to socio-economic data. This point is reinforced by the Shixini GIS where most of the data collected for the database are either from aerial photographs or orthophoto maps. Although obtaining data in these formats is expensive, the primary cost of collection is often borne by the Surveyor General. Primary mapping of environmental data in Shixini would be expensive and time consuming, as would the collection of socio-economic data.

The Shixini area of the Transkei was a study area for a number of years and although certain classes of attribute data were missing or insufficient for certain purposes, the coverage of the area could be considered good. Work done in the pilot project exposed the weaknesses in the data and highlighted a number of points. Firstly that the quality of information received from a GIS depends on the quality and type of data present in the system and secondly the information obtained from a GIS is dependent on the data in the system, the way the data is manipulated and the functions performed on the data. A clear idea of how to derive information from data or a set of data is needed, this means that domain and other experts are still required when addressing problems using a GIS.

Data availability in a digital format can improve the information available to a project as well as reduce the costs of a GIS significantly. In South Africa the rural areas are often neglected in terms of the spread and quality of data available to other regions. This situation is however changing rapidly as the democratically elected government through the Reconstruction and Development Program (RDP) and together with provincial governments have started investing large sums of money on collecting and updating data bases in previously disadvantaged areas of the country.

The following steps are recommended if GIS is considered as a tool for rural community development planning.

- Obtain a clear view of what the technology is to be used for and the perceived benefits resulting from this action.
- Examine the short and long term viability of using a GIS within the organisation.
- Carefully consider each of the factors needed to support GIS and whether each factor and their associated costs can be catered for within the framework of the project.
- Canvas the support of the management and the personnel working in the field.
- Adopt a structured approach to possible acquisition and implementation with special emphases on the:
  - aims and role of GIS in the project
  - institutional arrangements to ensure that this role is achieved
  - ensuring that personnel actively involved with the project are the 'owners' of the GIS.
- Investigate the possibilities of incorporating GIS in the organisation before the project has begun or at the very least structure data collection in such a way that it is 'GIS friendly' should a GIS be incorporated later in the process.

In conclusion it can be seen from this study that GIS bears a dual relationship to appropriate technology. On the one hand the technology is relatively expensive and requires a knowledgable skills base to operate effectively which is contrary to general AT principles, on the other hand the technology can be used to augment the effectiveness and capabilities of the limited skills base within the country. The benefits of using a GIS in any given situation however, is dependent on the availability of the factors needed to support the technology.

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## APPENDIX ONE: QUESTIONNAIRE COVERING LETTER

Dear Sir/Madam

LETTER OF INTRODUCTION

I am currently a Masters Student at Rhodes University, Grahamstown. I am researching the applicability of Geographical Information Systems (GIS) to rural development planning.

At present I am trying to ascertain which organisations involved in rural development have used, are presently using or are thinking of using GIS.

Enclosed with this letter of introduction is a slip which has five situational scenarios printed on it. Please tick the answer which you feel pertains to your organisation and post it in the self addressed envelope provided for this purpose. If you have not heard of GIS or are not sure what it means please indicate this on the return slip, I would like to hear from you too.

It must be emphasized that your answers are for research purposes only and will not be supplied to any GIS vendor.

Thank you for you time.

Yours sincerely

J. Whisken

## APPENDIX TWO: DATA DIRECTORY: SHIXINI RURAL DEVELOPMENT PROJECT

**Project Name:** Shixini Rural Development Project

**Geographic Area:** 32°17', 32°25' South and 28°38', 28°45' East.

**Description:** The Shixini Administrative area, lies between the Jujura and Shixini rivers, in the Gatyana District of the former Transkei (now the Eastern Cape Province), South Africa. The area is covered by Sheet 3228BC of the South African 1:50 000 topographic map series.

**Start Date:** 24/05/92 **Finish date:** 23/10/94

**Status:** Completed

**GIS Contact Person:** Mr J. Whisken
**Phone:** 0461-311320

**GIS Package Used:** PC Arc/Info 3.4D

| | |
|---|---|
| **Storage Medium** | Hard-disk: Personal Computer |
| | Directory: Shixini.COV |
| | Stiffy: Series Shix.Proj, Numbers 1-10 |

The TIC points below apply to all of the coverages in the Shixini database.

**PROJECTION:**

Projection: Gauss

Units: Lo

Parameters:

CENTRAL MERIDIAN

29° EAST

**TICS**

| TIC Number | X | Y |
|---|---|---|
| Tic 2 | -29.000 | -3589.000 |
| Tic 5 | -32.000 | -3587.000 |
| Tic 6 | -30.000 | -3587.000 |
| Tic 7 | -27. → | -3585.000 |
| Tic 10 | -32.000 | -3583.000 |
| Tic 12 | -28.000 | -3587.000 |
| Tic 15 | -30.000 | -3583.000 |
| Tic 18 | -34.000 | -3581.000 |
| Tic 20 | -29.000 | -3582.000 |
| Tic 23 | 35.000 | -3579.000 |
| Tic 26 | 30.000 | -3580.000 |
| Tic 35 | 36.000 | -3576.000 |
| Tic 36 | 33.000 | -3576.000 |
| Tic 37 | -28.000 | -3588.000 |
| Tic 40 | -31.000 | -3585.000 |
| Tic 41 | -30.000 | -3588.000 |

## GEOGRAPHIC DATA SET DOCUMENTATION: COVERAGE

Coverage Name: LANDUSE

Description: Landuse cover of Shixini, integrated features

Feature: Various - concentrations on Vegetation

Map Units: meters miles feet other:

Data Type: poly line point annotation image grid

Annotation levels:

Related Info files:

Data Volume: 944.454

Storage and location: Strategy Shix. Proj. No. 1

**Source Data Information**

Source: Material held at ISER, Rhodes University, including Orthophoto maps, Aerial photos 1989, Fieldwork 1989

Owner: ISER

Projection: - Various

Publishing medium:

Original: Ground Survey Photograph Orthophota GPS

Scale: 1:10 000

**Capture data information**

Method: Digitise Scan Keyboard Other:

Operator: J. WHISKEN

Software package used: ARC\INFO 3.4D. (PC)

Comments/limitations ± 15. accuracy level 1

**ATTRIBUTE CODING**

File name: landuse.pat

| Item Name: | Item Description: |
|---|---|
| Veg-type - 1 - grassland | See Aklocks 1988 for a |
| 2 - Savanah | description of each |
| 3 - Valley Bush | community |
| 4 - Coastal Forest | |
| 5 - Plantation | |
| 6 - garden | |
| 7 - Fields | - No distinction between |
| 8 - Coastal ~~Forest~~ Scrub | cultivated and fallow |
| ~~9 - Coastal Scrub~~ | fields |
| | |
| Landuse.AAT - landuse-ID | features were digitized |
| | with an ID of 5 except |

for the boundary which retained its own ID.

| Item Name: | Width: | Output: | Type: | No of Dec.: |
|---|---|---|---|---|
| Veg-type | 15 | 15 | C | — |
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GEOGRAPHIC DATA SET DOCUMENTATION: COVERAGE

Coverage Name: Slope

Description: Map of slope values for the ward except for a portion of the NW.

Feature: Slope

Map Units: meters miles feet other:

Data Type: poly line point annotation image grid

Annotation levels: —

—

Related Info files: —

Data Volume: 334.391 Bytes

Storage and location: Stirling Swx. proj. No. 2

**Source Data Information**

Source: Derived from the orthophoto map series of the area see (Winsler) 3228 BC 8, 9, 13, 14, 15, 19, 20

Owner: Winsler

Projection: Gauss

Publishing medium: paper

Original: Ground Survey Photograph Orthophoto GPS

Scale: 1:10 000

Capture data information

Method: Digitise Scan Keyboard Other:

Operator: Winsler

Software package used: Arc/Info 3.4D

Comments/limitations: Coverage is missing NW portion approx 2.02% of Stirling land area.

**ATTRIBUTE CODING**

File name: Slope . Pat

| Item Name: | Item Description: |
|---|---|
| Topo_Name - Scarps | 1:3 6-Topo_No |
| - Midslopes | 1:5 to 1:3 7- |
| - Footslopes | 1:20 to 1:5 8- |
| - Crests | <1:20 9- |
| - Valley_B | < 1:20 10- |
| | |
| | Classification after Schwarz |
| | and Johnson 1990 an INR |
| | report |
| / | |
| Slope.AAT - Slope-ID = | 4 - All featured digitized |
| | were given a line ID of 4 |

| Item Name: | Width: | Output: | Type: | No of Dec.: |
|---|---|---|---|---|
| Topo_Name | 15 | 15 | ~~A~~ C | - |
| Topo_Num | 3 | 3 | N | 0 |
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## GEOGRAPHIC DATA SET DOCUMENTATION: COVERAGE

Coverage Name: Roads

Description: Roads and paths / tracks

Feature: Roads & paths / tracks

Map Units: meters miles feet other:

Data Type: poly line point annotation image grid

Annotation levels: —

—

Related Info files: —

Data Volume: 48.895 Bytes

Storage and location: Stiffy Swx.proj No. 3

### Source Data Information

Source: Orthophoto maps (3228BC 8, 9, 13, 14, 15, 19, 20). Aerial photographs (Job No 481)-ISER

Owner: —

Projection: Gauss,

Publishing medium: photo, paper

Original: Ground Survey Photograph Orthophota GPS

Scale: 1:10000

### Capture data information

Method: Digitise Scan Keyboard Other:

Operator: Wessels

Software package used: Arc/Info 3.4D

Comments/limitations

**ATTRIBUTE CODING**

File name: Roads.aat

| Item Name: | Item Description: |
|---|---|
| Roads_id — S<br>— 2 | — secondary Rds<br>— tracks/paths (main) |
| Rd_type — Sec | name of feature |
| — Path | |
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| Item Name: | Width: | Output: | Type: | No of Dec.: |
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| Roads_id | 3 | 3 | N | |
| Rd_type | 15 | 15 | C | |
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GEOGRAPHIC DATA SET DOCUMENTATION: COVERAGE

Coverage Name: Contours

Description: Contour map, at Contours at 20m intervals

Feature: Contours

Map Units: meters miles feet other:

Data Type: poly line point annotation image grid

Annotation levels: —

—

Related Info files: —

Data Volume: 683·694 Bytes

Storage and location: Stuffy Shx. proj - No. 3

**Source Data Information**

Source: Orthophoto Maps (3228BC, 8, 9, 13, 14, 15, 19, 20)

1:50 000 Topographic No. 3228BC (Mazeppa Bay)

Owner: —

Projection: Gauss

Publishing medium: Paper

Original: Ground Survey Photograph Orthophota GPS

Scale: 1:10000 ; 1:50.000

**Capture data information**

Method: Digitise Scan Keyboard Other:

Operator: Wanda

Software package used: Arc/Info 3.4D

Comments/limitations

**ATTRIBUTE CODING**

File name: Contours.AAT

| Item Name: | Item Description: |
|---|---|
| Contours_ID | User defined ID - from |
| | 0 metres to 360 metres. User |
| | ID started at 100 - for 0 metres |
| | increasing by 2 each 20 m i.e. |
| | 102 = 20 ; 104 = 40 etc. |
| Metres | The contours height above |
| | sea level; in metres. |
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| Item Name: | Width: | Output: | Type: | No of Dec.: |
|---|---|---|---|---|
| Contours_ID | 7 | 7 | N | — |
| Metres | 7 | 7 | ~~B~~ C | |
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GEOGRAPHIC DATA SET DOCUMENTATION: COVERAGE

Coverage Name: $Huts ( Settlement )
Description: Settlement (structures in Shix)
Feature: Huts/Buildings
Map Units: meters miles feet other:
Data Type: poly line point annotation image grid
Annotation levels: —
—
Related Info files: —
Data Volume: 301.030 Bytes
Storage and location: Stuffy Shix.proj No. 4

**Source Data Information**

Source: Aerial photographs (1989) Job No 481 (Held at ISER) in conjunction with orthophoto
Owner: ISER
Projection: —
Publishing medium: Photo
Original: Ground Survey Photograph Orthophota GPS
Scale: 1:10000

**Capture data information**

Method: Digitise Scan Keyboard Other:
Operator: Winston
Software package used: Arc/Info 3.4D
Comments/limitations

**ATTRIBUTE CODING**

File name: Huts.pat

| Item Name: | Item Description: |
|---|---|
| Huts_id - 21 | School buildings |
| 22 | Administrative buildings |
| 23 | Clinic |
| 24 | Trading Stores |
| 25 | Huts (residence) |
| | |
| ~~Build~~ Build_na | Name of the building / Structure |
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| Item Name: | Width: | Output: | Type: | No of Dec.: |
|---|---|---|---|---|
| Huts_id | 3 | 3 | N | |
| Build_na | 30 | 30 | C | |
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## GEOGRAPHIC DATA SET DOCUMENTATION: COVERAGE

Coverage Name: EROSION

Description: EROSION FEATURES OF THE Shixini area

Feature: EROSION

Map Units: meters miles feet other:

Data Type: poly line point annotation image grid

Annotation levels: –

–

Related Info files: –

Data Volume: 210.480 Bytes

Storage and location: Stuff, Shix. proj No. 4

**Source Data Information**

Source: Orthophoto maps, Numbers (3228 BC 8, 9, 13, 14, 15, 19, 20)
Aerial photographs, Job No. 481

Owner: –

Projection: Gauss, –

Publishing medium: paper

Original: Ground Survey Photograph Orthophota GPS

Scale: 1:10 000

Capture data information

Method: Digitise Scan Keyboard Other:

Operator: Whisker

Software package used: Arc/Info 3.4D

Comments/limitations: Units are ~~not~~ defined, rather than to exact boundaries of the erosion feature.

## ATTRIBUTE CODING

File name: EROSION.PAT

| Item Name: | Item Description: |
|---|---|
| EROS_CLASS (EROSION CLASS) | This item has six classes |
| | which are a simplification of |
| The IDs given to the | the SARCCUS soil classification |
| individual features range | model. The original simplification |
| from 1-7. The first 6 | can be found in Ntsaba (1989) |
| coincide with the classification | |
| on the right hand side. | |
| The seventh is a feature | |
| identified as a 'slump' | |
| (see SARCCUS, 1981) | |
| | |
| | |

| Item Name: | Width: | Output: | Type: | No of Dec.: |
|---|---|---|---|---|
| EROS CLASS | 3 | 3 | N | – |
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## GEOGRAPHIC DATA SET DOCUMENTATION: COVERAGE

Coverage Name: Ortho

Description: Orthophoto maps extents

Feature: Boundaries Ortho

Map Units: meters miles feet other:

Data Type: poly line point annotation image grid

Annotation levels:

Related Info files: Ortho.txt

Data Volume: 45.445 Bytes

Storage and location: Stuffy Shx proj. No 5

**Source Data Information**

Source: Orthophoto maps

Owner: —

Projection: Gauss

Publishing medium: paper

Original: Ground Survey Photograph Orthophoto GPS

Scale: 1:10 000

**Capture data information**

Method: Digitise Scan Keyboard Other:

Operator: Wunster

Software package used: Word Perfect, ARC/INFO 3.4D

Comments/limitations Coordinates entered via keyboard, it included on Stuffy Shx. proj. No5 (Ortho.txt).

**ATTRIBUTE CODING**

File name: Ortho.pat

| Item Name: | Item Description: |
|---|---|
| Ortho_id -60-66 | - unique IDs |
| Ref_no | - Orthophoto reference number |
| | |
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| Item Name: | Width: | Output: | Type: | No of Dec.: |
|---|---|---|---|---|
| Ortho_id | 3 | 3 | N | |
| Ref_no | 9 | 9 | C | |
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## GEOGRAPHIC DATA SET DOCUMENTATION: COVERAGE

Coverage Name: Boundary & S-Ward

Description: Ward boundary & sub-ward boundaries

Feature: A/

Map Units: meters miles feet other:

Data Type: poly line point annotation image grid

Annotation levels:

Related Info files:

Data Volume: 65.307 Bytes S. Ward 34.441 Bytes.

Storage and location: Stirling Shx. proj No. 5

### Source Data Information

Source: Boundary (Anaew 1992) and orthophoto maps)
Sub-ward (Deline 1992, Heron 1990, Orthophoto maps)

Owner: —

Projection: —

Publishing medium: paper

Original: Ground Survey Photograph Orthophota GPS

Scale: 1:10000

### Capture data information

Method: Digitise Scan Keyboard Other:

Operator: Whistler

Software package used: Arc/Info 3.4D

Comments/limitations — Sources are thought to be fine however other sub-wards were derived and are possibly wrong.

ATTRIBUTE CODING

File name: Boundary.PAT, AAT, Subward PAT, AAT

| AAT Item Name: | | Item Description: |
|---|---|---|
| Boundary-id - | 1 | coastline |
| | 16 | Shimmi & Jajura rivers |
| | 77 | Northern boundary |
| PAT | | |
| Ward_id | 1 | |
| Ward_na | | Name |
| AAT | | |
| S-ward_id | 1, 16, 77 | Same as boundary |
| | 15 | Boundary Ian |
| S-Bound | | Name of feature, boundary follow- |
| PAT S. ward_na | | Subwards name |
| | | |

| Item Name: | Width: | Output: | Type: | No of Dec.: |
|---|---|---|---|---|
| Boundary-id | 3 | 3 | N | |
| Ward-id | 3 | 3 | N | |
| Ward-na | 15 | 15 | C | |
| | | | | |
| S-Ward-id | 3 | 3 | N | |
| S-Bound | 30 | 30 | C | |
| S-Ward-na | 30 | 30 | C | |
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## GEOGRAPHIC DATA SET DOCUMENTATION: COVERAGE

Coverage Name: RIVERS, BOREHOLES, DAMS &

Description: Water related features of Shurugwi

Feature: Rivers, boreholes, standing water features

Map Units: meters miles feet other:

Data Type: poly (DAMS) line (RIVERS) point (Borehole) annotation image grid

Annotation levels: —

Related Info files: —

Data Volume: Rivers 415.763 Boreholes 6.732 & DAMS 15.369

Storage and location: Stiffy Shur Proj No 6

### Source Data Information

Source: Rivers (Arcview 1992) Boreholes (Dept. A&F, Travsler) Standing features (Orthophoto maps, aerial photos 1942, 62, 82 & 89)

Owner: As above

Projection: —

Publishing medium: Various

Original: Ground Survey Photograph Orthophota GPS

Scale: Rivers (1:10000) Boreholes (1:50000) Standing (various) (1:10000)

### Capture data information

Method: Digitise Scan Keyboard Other:

Operator: Wunsler

Software package used: ArcInfo 3.4D

Comments/limitations

**ATTRIBUTE COCODING**

File name: Rivers.aat ; Borehole.pat & Dams.pat

| Item Name: | Item Description: |
|---|---|
| Rivers_ID - 16 = perennial | Identifies perennial & non- |
| 4 = non-perennial | perennial rivers. |
| Loc_name | Name of the river/stream |
| | |
| Borehole_ID = 93 | Point feature 93 is the symbol |
| | for windmill in Arc/Info |
| | |
| Water features | |
| Dams_id = 10 | Standing feature linked to drainage network. |
| 11 | Natural depression & springs |
| | |
| | |

| Item Name: | Width: | Output: | Type: | No of Dec.: |
|---|---|---|---|---|
| Rivers_ID | 3 | 3 | N | — |
| Loc_name | 30 | 30 | C | |
| Borehole_ID | 3 | 3 | N | |
| Dams_id | 3 | 3 | N | |
| | | | | |
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## APPENDIX THREE: STRUCTURE OF THE QUESTIONNAIRE USED IN THE GIS SURVEY

Dear Sir/Mam

**PRODUCT FUNCTIONALITY**

The Shixini Rural Development Project, is a rural betterment project run under the auspices of the Institute of Social and Economic Research, Rhodes University. The ISER has instituted a study on the feasibility of incorporating GIS as a management and resource planning tool for the project. We are starting to look at the GIS market for a suitable GIS to fulfil user defined requirements. As a starting point we are interested in the functionality of your product. Please fill in and return the following questionnaire at your earliest convenience. Please note that functionality is related only to product features presently available. As a starting point we are only looking for a GIS package capable of being supported on a PC and using either DOS or Windows as an operating system.

**DATA STRUCTURE (please indicate the name of the product structure next to the appropriate type )**

Tessellation:
regular (type):________________ irregular (type)(TIN)___________________

Vector:
unstructured (type):_______________ topologically structured(type)________________
Hybrid:
(type):__________________________________

**ATTRIBUTE DATA STRUCTURING (please tick appropriate data structure)**

Flat file:______ Inverted list:______ Hierarchical:______ Network:______
Relational:______ Other(please specify):________________________

**DATA CAPTURE (please tick the relevant features)**

Remote sensing scanner:_____ radars:_____ cameras:_____ GPS:_____
field surveying:_____ Scanners:_____ Keyboard:_____ Table digitizers:_____
Stereoplotters:_____ Attribute Data loggers:_____

**DATA TRANSFER (please indicate type)**

Geographical Data

System dependent format(type)______________________________

System independent (type)______________________________

Attribute Data

System dependent:______________________________

System independent______________________________

**GEOMETRIC ANALYSIS PROCEDURES (Please tick either Yes or No)**

Overlay facilities:______________________________

Restructuring

Vector to Cell_____ Cell to Vector_____ Polygon dissolve:_____ Point in polygon:_____

Buffering (corridoring):_____ Windowing:_____ Coordinate filtering:_____

Line length calculation:_____ Area perimeter calculation:_____

Contingency analysis (adjacency relationships) ________

**CARTOGRAPHIC DATA NETWORK ANALYSIS PROCEDURES** (able to perform)

Flow simulation:_____ Time/distance districting:_____

**CARTOGRAPHIC DATA DIGITAL TERRAIN MODELLING PROCEDURES** (able to perform)

Contouring:______

Slope aspect (capability of calculating topographic slope for each aspect of a given area) ____

Viewsheds:_____ Watershed analysis:_____

**CARTOGRAPHIC DATA QUERY PROCEDURES (able to query)**

Spatial query?_____

Attribute query?________

## CARTOGRAPHIC DATA DISPLAY/COMPOSITION PROCEDURES

Scale (any user defined):________

Cosmetic enhancement (text and cartographic symbology):_____

## CARTOGRAPHIC DATA DISPLAY/PRESENTATION PROCEDURES

Polygon mapping:_____

Point Mapping:_____

Line mapping:_____

Surface mapping (2D or 3D):_____

Annotation and text:_____

Type of user software interface (ie pulldown menu, command driven etc)

______________________________________________

______________________________________________

______________________________________________

## TRAINING

Do you offer training courses of the use of your product?

If affirmative Where are these courses held____________________

Duration of course____________________________

How often are they held________________________

Cost of course(s)____________________________

Comments:______________________________________

______________________________________________

______________________________________________

______________________________________________

Does your product have a fully operational and comprehensive Help facility______________

Is your product supplied with fully comprehensive setup and reference manuals___________

Please indicate where the nearest centre capable of supplying backup support is situated in relation to Grahamstown.

______________________________________________

______________________________________________

**COST**

What is the cost of the entire product package? ____________________

If the product is available in discrete modular form please break down the cost into the component parts: ____________________

**MINIMUM HARDWARE SPECIFICATIONS**

Please indicate or supply the minimum PC platform requirements necessary to support your product ie RAM, hardrive size etc.

Please recommend peripheral hardware commonly used with your product.
Plotter (capable of plotting on a A2 sheet of paper including approximate cost and agent).

Digitiser (capable of supporting an A2 sheet of paper, approximate cost and agent in).

If there are any queries or suggestions please phone me at (0461 - 318/319/320) or by E-mail G87w4978@Giraffe.ru.ac.za or attach them to the questionnaire.