

# Future Applications of GIS: Depth vs Breadth- The case of the Land Use Profiler

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Presented at AURISA 2000 – The 28<sup>th</sup> Annual Conference of AURISA  
Hyatt Coolum Resort, Coolum QLD, 20-24 November 2000

## ABSTRACT

As society becomes increasingly spatially enabled, Geographical Information Systems (GIS) will evolve, and geographical information will be embedded in most information applications and services that society uses. This trend presents many opportunities and challenges. It means GIS technologies will facilitate ‘more’ by becoming ‘less’. As the general use of GIS increases, the visible appearance of GIS decreases, as it becomes an integrated part of organisational and societal information systems. The trend is for GIS to move from a multi-use tool for project and departmental systems, to specific product systems for multiple users, multiple applications and multiple purposes. These new systems are not all technically GIS, but are systems with embedded geographic knowledge, and the data and tools to capitalise upon the capabilities and to facilitate distribution.

The Land Use Profiler (LUP) system is an easy to use spatial analysis tool developed by the Department of Infrastructure in Victoria. It constitutes an illustration of these trends in GIS. Developed to locate areas of land best suited to particular land-use purposes, the LUP is a tool being piloted to facilitate preliminary investment decisions. The LUP adopts user-friendly interfaces, easy-to-assemble query structures and GIS embedding to facilitate broad-spectrum inquiries across a number of datasets using a ‘what-if-analysis’. The use and implementation of such a tool raises interesting issues about the transparency of spatial information processing. It reinforces the developmental trends of GIS and provides an indication where these trends may lead.

## KEYWORDS

Geographical Information Systems (GIS), GIS trends, Spatial Information,  
Integrated Information Systems, Land Use Profiler (LUP)

## 1. INTRODUCTION

Even though society is increasingly flooded by the benefits of new technologies for earth observation and the ensuing unprecedented amounts of data, our ability to extract meaning and make useful decisions from this data has not kept pace (UCGIS 2000a). Faster and cheaper computing, the shift from mainframe to desktop, the development of the Internet and many other breakthroughs have made it easier to process and store geographic information in digital form. The development of Geographical Information Systems (GIS) have

taken users of geographical information a tremendous step forward in their ability to analyse, map and model the spatial world. However, existing systems are still frequently constrained in being able to respond to new technologies for data collection or processing, a problem that is further complicated by variable levels of users' technical abilities and training across the disciplines (NCGIA 2000).

The GIS available today are still evolving and the changes in the last few years in data handling and in products are altering the way GIS are used and by whom (Burrough and Mc Donnell 1998). The previously mentioned trends in data availability, as well as current technologies and societal trends, are producing great increases in the availability of and demand for GIS and related services by all sectors of society (NCGIA 2000). Until recently, most GIS were limited in their scope in terms of both the spatial and the study field covered. The systems tended to be used by a number of specialists, who were familiar with the software, were responsible for the technology and the database, and who generally transferred analysis results in hardcopy for the use by a much wider group of workers. However, GIS is being increasingly seen as the key to implementing methods of spatial analysis, making such tools more accessible to a broader range of users, and hopefully more widely used in effective decision making (Goodchild and Longley 1991).

Trends in GIS technology developments have proceeded towards a series of specialist sub-products. This evolution of the GIS market in tandem with the increased provision of digital data, have resulted in significant change in the users. Whilst some areas of GIS use continue to be a specialist activity, developments of more specialised modules offering querying and mapping capabilities, support new sets of users who do not necessarily have GIS technical know-how. The newer easy-to-use interfaces allow users, who have a good understanding of the data, to interact with the system directly, much as they would a spreadsheet. This means that they do not have to communicate their analytical needs to a second person. Internet facilities also offer organisations an efficient way of providing geographical data and system capabilities to a wide-range of people in a user-friendly way. For many users of the current internet/intranet technology, GIS are essentially digital atlases or gazetteers (Burrough and Mc Donnell 1998). The users tend not to collect data and many do not make maps; they are essentially a new type of user – the spatial browser (Burrough and Mc Donnell 1998).

These are just some of the ways the use of GIS is increasing while the appearance of visible GIS decreases and becomes an integrated part of organisational and societal information systems. GIS is increasingly becoming both a background technology, “more akin to word processing than spatial interaction modelling” (Goodchild and Longley 1991, p570) and a technology that can be subdivided and repackaged as niche products (Goodchild and Longley 1991). GIS technologies are undergoing a transition from multi-use tools for project and departmental systems, to specific product systems for multiple users, multiple applications and multiple purposes. The many GIS packages offer a wide range of combinations of analysis functions, housekeeping support, different ways of presenting the same phenomena, variable levels of sophistication in visual display and performance (Goodchild and Longley 1991). These are not all technically GIS, but are systems with embedded geographic knowledge, and the data and tools to capitalise upon the spatial data capabilities and to facilitate distribution. There will be tools for documenting datasets, describing their properties (accuracy and history), and others that support data sharing in the form of format converters or Internet interfaces. Society is increasingly becoming spatially enabled with the result that geographical information will be everywhere - embedded in most information applications and services that society uses.

Changes in GIS in the next few years will be governed by developments in information technology, by various international and industrial standardisation agreements, and by the expansion of data availability and the provision of associated infrastructures (Burrough and Mc Donnell 1998, Gore 1998). However, many of the predicted changes for GIS are only now becoming evident. Software and hardware developments, economic factors, institutional awareness and leadership have all influenced the introduction of GIS into a variety of applications that were previously unthinkable.

Within the context of these developments, this paper presents an overview of some of the key trends observed in GIS and explores them in relation to a prototype initiative of the Department of Infrastructure (Victoria) – the Land Use Profiler (LUP). The LUP is application software developed to facilitate preliminary investment decisions in the NorthEast Region of Victoria. LUP will be used to explore the realisation of some of the predictions of GIS evolution.

## **2. THE EVOLUTION OF GIS**

The evolution of GIS has been a process of over-coming impediments such as expense, accessibility, usability, lack of data, adaptability and fostering a more user-driven environment. Developments have

included modular/component architectural developments; industry alliance developments leading to technical standards, interoperability, data exchange formats becoming group concerns and thence initiatives; increased usability through adoption of user-friendly geographical user interfaces and transparency of GIS processing; increased adaptability due to incorporation of multi-media features; increased adaptability to new data-sources and new data-types resulting from new harvesting technologies. Thus, GIS have been characterised in recent years by rapid technological and scientific developments.

## **2.1 Overview**

GIS have evolved significantly since the mid-1960s when they were developed as an inventory tool for natural resources management in Canada. The GIS framework has developed to include both the geo-referenced data and the tools for data manipulation (UCGIS 2000a). It is only since the 1960s with the availability of the digital computer that both the conceptual methods for spatial analysis and the actual potential for quantitative thematic mapping and spatial analysis have been able to develop (Burrough and Mc Donnell 1998, Goodchild and Longley 1991). By using GIS, highly visual methods of spatial analysis, that were prohibitively expensive and computationally intense, have become accessible at reasonable costs. Though many aspects of current commercial systems are still based on innovations developed in the public or academic sectors in the 1960s or 1970s (Goodchild and Longley 1991, NCGIA 2000), packages used by scientists over the last decade are different in fundamental respects from the 1960s' programs. Contemporary packages enable data analysis through a large numbers of statistical methods, and also provide support for the maintenance of data and the creation of information (Goodchild and 1991).

The history of using computers for mapping and spatial analyses shows that there have been parallel developments in automated data capture, data analysis, and presentation (Burrough and Mc Donnell 1998, Goodchild 1998). The multiplicity of effort in several initially separate, but closely related fields has resulted in the emergence of general-purpose GIS (Burrough and Mc Donnell 1998, Goodchild 1998).

During the 1990s there were several important technological and organisational developments that greatly assisted the wide application and appreciation of GIS. These were increasing awareness, advances in computing technology (including lower costs) and availability of data sets.

GIS has already adapted to several changes in computing architectures: early mainframe system extension to remote sites using phone lines and terminals; late 1970s microcomputers were replaced by workstations and personal computers, increasingly networked for the exchange of data; and client/server architectures were adopted in the late 1980s in a first step towards distributed software, hence electronic network connections facilitated sharing of expensive data and software (USGIS 1996). Today such architectures are being generalised to full distribution, while the user may be presented with an integrated view of the system bearing little relationship to its actual structure (USGIS 1996). By 1995 computer technology had provided huge amounts of processing power and data storage capacity on modestly priced personal computers enabling GIS to be used by individuals and organisations with limited budgets (Burrough and Mc Donnell 1998). Standardisation between interfaces of data base and other computer programs made it easier to provide the functionality for handling large amounts of data effectively, to the point where basic spatial data handling functionality achieved wide acceptance through a level of commercial system uniformity (Burrough and Mc Donnell 1998), to an extent this has precipitated the wider-context effect that spatial tools are no longer recognised as the domain of purely spatial industries.

Diffusion of GIS throughout the 1980s-2000 also attests to the increasing domain of GIS users and the evolution of the applications and varying levels of sophistication of GIS technologies and products. Over this period GIS has been incorporated into most university educational and research programs and has even made an impact on secondary school geography and computing education. Private sector has embraced and developed the technology over this period, whilst governments have invested resources in furthering the relationship between data, custodian and technological initiatives. The change in thinking, abilities and applications of users of GIS, in combination with other technological advancements have interdependently shaped the role and profile of GIS and related technologies today.

## **2.2 Trends of GIS Development**

Advances in awareness, computing technology, affordability and data set availability, have been significant drivers in the development process of GIS. In particular, fostering a more user-driven environment has placed significant emphasis on factors such as usability, expansion to specific product-based GIS, and dispersed cooperation and decision-making, facilitated often by the role of institutional leadership. These

specific trends are investigated and parallels drawn in the development of spatially-enabled systems like the Land Use Profiler.

### **Usability**

Over the last decade there has been an increase in the functionality of GIS, and a contemporary user has greater control over the computer environment than ever before (Golledge 1998). Unfortunately the increased sophistication of GIS has not always been accompanied by an improvement in usability, because GIS make considerable demands on users (Medyckyj-Scott and Hernshaw 1993). GIS can be complex to understand, the number of functions may be daunting, and interactions may be formulated in a non-intuitive way. Where GIS are not user-friendly this has the effect that users have to spend time and effort learning how to work a specific system before they are able to produce any effective output (Golledge 1998). The consequence of this is that GIS are often only used for a small number of well-known tasks and consequently the potential benefits of the technology are not fully exploited (Golledge 1998, Gore 1998, Medyckyj-Scott and Blades 1990).

GIS designers have realised the requirements of users to retrieve and transform data are unlimited. Today's trends in GIS are to provide a larger range of user friendly interfaces in order to save the extensive training required in the past for users. The aim is to make GIS interfaces more intuitive, so users are able to interact with them in ways that reflect their natural thought processes (Golledge 1998, Gore 1998). The simplest are menu-driven commands that can be selected by the simple point-and-click of a mouse. This is an efficient way of providing complex functionality to an ordinary user, to make geographic information (GI) technologies more accessible to inexperienced and disadvantaged users, and also to increase their power and effectiveness in the hands of experienced users (UCGIS 1996, Burrough and Mc Donnell 1998, Golledge 1998).

Another technique used to facilitate easier use of spatially enabled technology has involved development of task-specific functionality that can be incorporated with different information technology systems. As GIS evolves, geographical information becomes more embedded in the information applications and services that society uses, becoming an integrated part of organisational and societal information systems. As mentioned these are not technically all GIS, but are systems with embedded geographic knowledge, and the data and tools to capitalise upon the capabilities and to facilitate distribution. Examples include Car Navigation Systems which combine GIS and GPS (Geographic Positioning Systems) technologies with hierarchically based way-finding models (Car 1997), thus providing one of the most sophisticated GIS functions - optimal routing using network analysis - without need for any user-knowledge of GIS (French and Krakowsky, 1995). The proliferation of interactive atlas and map browsers on the World Wide Web (WWW) is another example of the embedding of GIS functionality into systems that promote usability and access for the inexperienced user. The GI CONNECTION initiative established by the Victorian Government (Land Victoria 2000) is an example of such developments.

In the Australian context, a good example of spatially-enabled products transcending the usability issues impeding wide-spread, integrated use of GIS applications is *HealthWIZ* (Prometheus, 2000). The HealthWIZ project was undertaken by Prometheus Information for the Australian Commonwealth Department of Health and Aged Care. HealthWIZ was designed for broad public use, aiming to increase public access to statistical information by providing a wide range of health data from many sources across Australia, that would be an easily usable information resource, incorporating advanced software design. Data for HealthWIZ is stored in a single database and comprises reliable, current and historical, health, welfare and population data. The latest version of the HealthWIZ desktop database was officially launched in Canberra in April 2000. Analytical capabilities and new features which have been integrated into Version 5, include maps, graphs and frequency charts, which can be displayed at the click of a button, to visually assist in analysis of the vast store of data supplied in this new version.

Limitations to the advantages of improving levels of usability include opening the way for misuse of GIS. Lack of an appreciation of the complexities involved in working with spatial data, in conjunction with the increase in ease of use, has led to users collecting the wrong data, using data (locational and attribute) at the wrong scale and/or resolution, and performing invalid analytical operations, with the result that erroneous conclusions are drawn (Golledge 1998). It has been argued that avoidance of such errors and misunderstandings require the education of the user in GIS concepts, data structures, and operator algorithms, and that GIS should only be used by spatially aware experts (Golledge 1998). Used in this way, however, GIS would become the domain of the well-trained and professional user, and would limit the

potential of the system because access to technology would be restricted (Golledge 1998). The challenge for GIS software developers is to solve this problem.

### **Divergence**

The proprietary GIS that once dominated the industry attempted to provide a full range of GIS services in one homogenous environment. Data were stored in proprietary formats, often commercial in confidence, making it difficult for others to expand the capabilities of the system by programming extra modules (Goodchild and Longley 1991). The evolution of GIS, in conjunction with 'Open GIS' initiatives (<http://www.ogis.org>), have shown a gradual transition from *convergence* on spatially-enabled specialist information technologies, such as a general GIS environment, to the current trends being witnessed in *divergence* - application-oriented GIS, with a niche environment, a broad-spectrum use and focussing on the opportunities to share data across systems, between organisations and in distributed environments.

The versatility of GIS is ultimately determined by the set of data models it enables – the most powerful GIS will be the one that implements the largest subset of the geographic data models, assuming of course that the associated functionality is also provided (Goodchild 1998). The significance of a data model lies in its role in defining the ability of a system developer to add functions, by providing the structures needed to store the essential data. When these structures are highly specialised to a given application, the user is provided with a well-defined environment adapted to his or her particular needs. When the structures are general, the onus is on the user to adapt the framework to the needs of the application. Seen from this perspective the data models supported by GIS are extensive, but in general much more highly specialised than those underlying spreadsheets, the statistical packages, or relational database management systems (Goodchild 1998).

Data transformations in GIS can operate on the spatial, topological and the non-spatial aspects of the data, either separately or in combination. Many of these transformations, such as those associated with changing scales, fitting data to new projections, logical retrieval of data, and calculations of areas and perimeters, are of such a general nature that they should be found in every kind of GIS in one form or another (Burrough and Mc Donnell 1998). Other kinds of manipulation may be extremely application specific and their incorporation into any particular GIS may only be to satisfy the particular users of that system (Burrough and Mc Donnell 1998).

Although GIS has generally been presented as a comprehensive computing environment for handling geographic information, several significant niches have emerged within its broad umbrella. This may indicate that in time a distinct class of software environment will emerge with data models designed to be of greatest value to a specific application. This will depend, of course, on the potential of the size of the niche, and its homogeneity.

At the other end of the scale, contemporary software environments make it increasingly possible to process one previously alien data type entirely within the environment of another. In the future we are likely to see much greater interoperability between software environments, which will be much less driven by data and model distinctions (Goodchild 1998).

### **Institutional leadership**

One of the major forces driving the development of spatial information is a growing need for governments and businesses to improve their decision-making and increase their efficiency with the help of proper spatial analyses (Gore 1998). Information about the character and location of natural and cultural resources and their relationship to human and economic activities is essential to effective decision-making (Gore 1998). In response to this need, GIS and associated technologies have proliferated rapidly in recent years among all levels of government, academia and industry (USGIS 2000b).

Despite large investments in Geographic Data development by governments and the private sector, there is often a lack of knowledge of issues arising from the community-wide creation, compilation, exchange and archiving of large spatial datasets. The government sector plays an important role in developing and coordinating the fundamental spatial data infrastructure because of its activities in the systematic collection, maintenance, and dissemination of geographic data (Gore 1998, USGIS 2000b). These resources have significant uses beyond their governmental purposes; a dataset can be simultaneously the output of one person's science and the input to another's. For example, subsequent use of geographic information by organisations can stimulate the growth and diversity of the information services market (Gore 1998, USGIS 1996, 2000b). At the same time, public access to government information remains essential to ensuring government accountability and democratic decision-making.

New government information technologies can make it easier for the public to obtain access to government information and to become involved as stakeholders in land-related decisions (USGIS 2000b). Presenting the technical and institutional means to support creation and contribution of local knowledge, in particular, presents a novel challenge to technologists and decision-makers alike (USGIS 1996, 2000b).

Because government institutions are the single largest producers of spatial information, they can serve as model developers of a Spatial Data Infrastructure (SDI) that promotes community-wide sharing and use of spatial data and technology (USGIS 2000b). The social and economic benefits of sharing these resources with private, public and other government sectors have yet to be realised. The advance of electronic networks (the Internet, Intranet and WWW for example) have made it practical to share data among many organisations at all levels and over great distances, enhancing the potential value of collaborative decision-making for spatial decision-support (NCGIA 2000).

The problems and applications that GIS addresses seem particularly suited to take advantage of distributed computing. Geographic decisions supported by GIS must often be made by stakeholders distributed both geographically and socially, in different tiers of the administrative hierarchy (Rajabifard *et al.* 2000); data custodians may also be distributed, as may be power to process geographic data in sophisticated software and hardware (USGIS 1996, Philips 1998). Digital technology is moving rapidly to distributed computing. It is now possible for parts of a database to be stored and maintained at different locations; for users to take advantage of economical or specialised processing at remote sites; for decision makers to collaborate across computer networks to make decisions; or for large archives to offer access to their data to anyone connected to the Internet (USGIS 1996). These and a host of other opportunities are offered by recent developments in hardware, software and large bandwidth communications technologies.

### **3 THE CASE OF THE LAND USE PROFILER**

#### **3.1 Background**

The Land Use Profiler (LUP) is a regional development initiative sponsored by the State of Victoria's Department of State Development (DSD) in 1999 to facilitate preliminary investment queries in the North East Region of Victoria. The LUP is a product-based spatial information management tool, integrating web-based technologies and spatial functionality, to undertake site selection analysis using map-based data (DOI 2000b). The system was developed by the Department of Infrastructure (DOI, Corporate Information Technology), and project design proceeded in conjunction with the North-East Regional Forum in Victoria and the Department of Natural Resources and the Environment (DNRE).

The LUP has been designed for use by the broad community, the public and the private sectors, where the user and skill base require no background and minimal training in the spatial technology operation. Potential users include regional development officers, regional planners, those involved in economic development facilitating inquiries by potential investors, developers, agriculturists and conservation organisations (DOI 2000a,b,c). State and local government agencies and regional bodies are institutional targets for the LUP.

The LUP produces a profile, which is a set of characteristics describing a particular land use and established upon three components: geographic extent, lists of data required, and data class conditions. The LUP creates layers from sets of topographic, socio-economic, cadastral, utility, natural resource, industry, infrastructure and administrative data in a GIS-type environment, enabling classified-data selection, polygon selection and attribute masking, to identify land suited to particular uses. One hundred datasets were assembled for prototype development with data providers including State government, water and energy utilities and the Australian Bureau of Statistics (DOI 2000a, 2000b). The responsibility for maintaining the accuracy and currency of the datasets remains with custodians of the data – the data providers.

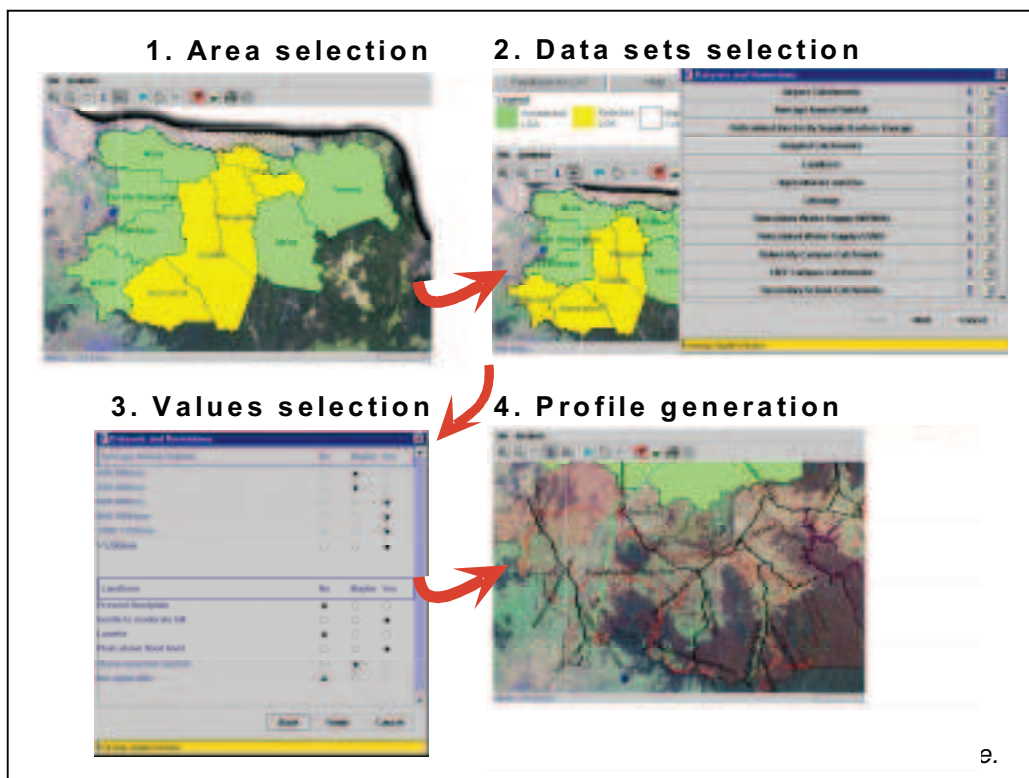
The LUP has been designed to address a range of query processes in regard to varied land-use activities. These query processes have been investigated by informal meetings with staff in DOI-Corporate IT, by LUP system assessment, and through access to Land Use Profiler Help Files (DOI 2000c).

The LUP profile-building requires three steps to delineate the answer - set areas displayed on a map – (1) nomination of an area of interest; (2) nomination of datasets relevant to the land use, from a range of available data; and (3) nomination of data classification. Figure 1 illustrates these steps and the profile generation. The resulting profile generates a map, and the user may generate a report of the profile description and map. The map generated may be varied by size in accordance to the resolution of the screen,

which can be altered to enable use of smaller or larger maps. The generated map shows the area of land for which all the profile conditions exist. Unsuitable areas are cross-hatched in red, potential areas are hatched (where some but not all of the condition sets are true), and suitable areas meeting all the selection criteria are not hatched at all. Contextual information may be added to the map by adding data layers with the names of towns, roads, rivers, lakes *etc.* in order to be displayed, but are not part of the profile. Not all layers are visible at all zoom widths, but will appear as the zoom width decreases to optimise map readability as well as the re-draw speed. Navigating around the map is by means of zoom and pan functions.

The LUP demonstrates many of the trends predicted and starting to be observed in the evolution of GIS technologies toward product-based embedding of spatial technology functionality, and to facilitate straight-forward application by users of differing levels of experience and training. LUP provides an un-intimidating GIS-type environment adopting an easy-to-use interface format with standard icon, menu and help-tool operators; a collection of spatial tools for display of thematic and spatial search queries; a selection of Boolean logic query operators for data ranges; ready-to-use spatial data with pre-established data classification; a ‘wizard’ style tool used to select datasets and specify data ranges; and dataset overlay facilities.

The following sections explore the functionality behind LUP’s usability, its divergence from a full GIS, as well as exploring issues such ‘diffusion’ to the general user raises in terms of transparency, data availability and quality. The institutional role of government, namely DOI, DSD, DNRE and the North-East Regional Forum, in developing such products as the LUP to facilitate community and regional commercial and resource initiatives, and develop local and regional knowledge domains is very important. The institutional role of the LUP not only raises the spatial awareness of users coming into contact with the product and with genuine needs met by the product, but goes a long way toward fostering cooperation to develop such innovations and encouraging further technical developments by establishing such ‘proof of concepts’.



### 3.2 Functionality and making a profile

The LUP has a Lotus front-end and a MapXtreme applet. The system utilises basic GIS principles such as polygon selection (Local Government Areas - LGAs), incorporates classified datasets (pre-established at fixed intervals) and emulates buffering (though not around all elements) and dataset intersection by application of visual masks (patches) following the standard Boolean operations yes, no, maybe (or). Metadata is recorded for each dataset according to ANZLIC Metadata Standards (page 0 and 1) and is

augmented by LUP metadata categories (scale minimum and maximum, licence expiry date and expiry, comments, LGAs included in the dataset). Metadata for each dataset is accessible to the user by selection of a metadata icon at the dataset selection stage of profile building. Movement around the map screens is by pan and zoom operations and selection of the desired 'map size' at the beginning of a profile query establishes the resolution at which results are viewed.

The LUP is accessed via the Internet using the tool URL. Profile development commences with area selections and are refined progressively by dataset and data range nominations.

Satellite imagery is used as the map underlay and available Local Government Area (LGA) polygons are layered over the top. The datasets available to a query depend on the LGA polygon selected for the query area (Figure 1, Area Selection). At this stage, other LGAs may also be selected to participate in the profile, so users are not limited by doing an LGA by LGA search for appropriate investment areas to their selected criteria. One feature that deserves some emphasis is that some data sets are not complete across the state and may not have representative information for every LGA. This can be overlooked when reviewing profile results which instead of advising of the lack of data availability, may instead indicate that an area has no potential development opportunities with regard to the proposed criteria.

Datasets include a variety of spatial and contextual information, ranging from topography, lithology, airports, agricultural land use, roads, water and electricity facilities, to name a few (Figure 1, Data Sets Selection). Access to metadata and marketing information about each dataset is through icons located beside each dataset. Dataset queries are fundamentally metadata queries and are a real incentive for metadata generation of datasets if products such as the LUP are to be developed on a continuing basis in the future.

Data class selection (Figure 1, Values Selection) enables further refinement of the dataset query when determining the profile, and is aided by a selection 'wizard'. Average Annual rainfall, for example, may be classified into 200mm classes, whereas land location in road catchments may be classified in accordance with distance from roads in kilometres. Classes are pre-established at fixed intervals. Decision priorities may be established by use of Boolean logical operators that establish yes, no or maybe scenarios, each generating a visual mask conditioning the visual answer-set based on satisfying all masking criteria. Buffers are pre-established at fixed intervals and not around all possible elements (*eg.* buffering is possible around roads and utilities such as water and electricity, schools, but not necessarily around a rainfall 'district'). Each classified data set has been created as an independent layer.

A template of a profile may be prepared in order to retain the profile results for future consultation, general use by others, or to advance the profile by supplementing further queries. Progressive templates can be altered or supplemented, incorporated and/or saved as a new profile or template. Template development is one feature enabling incorporation of expert-knowledge or experience and enabling profile saving and availability for general use. The template function is useful for building up corporate knowledge within an organisation, or within a local area or region, and may enable identification of knowledge-gaps in data set availability or quality.

The report generated for each profile provides documentation of the data used (and not used) and the assumptions and decisions made. It documents all aspects of the profile as well as an 'audit trail'. The report consists of both the generated map (at the current zoom width), written details of the profile, the person who generated the profile at the given time and date, and is saved as the same name as the profile, with a unique report id number for audit purposes. The report details are comprised of the LGAs selected, the data sets, the data classes included and excluded, the layers included and excluded and the satellite imagery underlay. Importantly, the report also has a disclaimer which protects the system developers from liability should the user misuse or misinterpret the profile.

### **3.3 LUP – Issues of Transition in the Evolution of GIS Technologies**

Though LUP does not have the full analytical complement of GIS functionality to explore process interactions in spatial phenomena or any form of temporal phenomena, the function of the embedded spatial technology still enhances what were previously manual processes. Another feature of the embedded GIS technologies that take LUP beyond the constraints of operating with map-form spatial data is that once data has been stored in the LUP database, it can be retrieved and transformed to produce the required profile and be used over and over again without deteriorating in quality (Burrough and Mc Donnell 1998).

The spatial functionality of the LUP providing overlay and cartographic modelling of different forms of spatial data have scope beyond database and mapping functions, without the processing time or complexity



of full-functionality vector-based GIS. This has both advantages and disadvantages. For many of these early examples of spatially-enabled products, the lack of transparency prevents the user from seeing data calculations, the operations behind functionality, and where the limitations of data, technology, user-scope and project scope begin and end. Whilst the illusion of more complex functionality is presented in the LUP by prompts to 'buffer' data, create overlay intersections, zoom features that retain the query profile initially created rather than reprocessing the profile at a different visual resolution, at times technological processing speed or data availability and/or quality, not to mention query structuring (and other variables) restrain product development in order to keep the product within the realms of common usability.

The danger of embedded restricted GIS technologies, such as those developed in the LUP, is that misuse can result from the user having expectations that are greater than the scope of the product, which is search-based rather than analytical. The assembly of datasets in a product-based tool like LUP is subject to the difficulties inherent in a data world where the creators and users of data may share little in the way of common disciplinary background, or very different objectives, which leaves the datasets when combined, vulnerable to misunderstanding and misinterpretation. The objectives of the database formation are spelled out clearly for the LUP in the HELP FILES and the training manual provided to pilot users. Again, the disclaimer on the report of each profile clarifies the role and intended use of the product and liability conditions.

LUP was designed as a preliminary inquiry into potential investment sites, which then needs to be followed by in-depth research as to the availability and potential of sites. If the profile is taken as a definitive result, problems can occur, such as the limitations of data appearance when the data set layers incorporated into the product are incomplete across the State. Absence of information in the selected LGA polygon, results in the area being rejected as if it were not suitable, whilst it possibly could be. Again, the results of the queries represent a snapshot in time, when the database was assembled. The sheer nature of an investment proposition, in the case of the LUP, may change available facilities, like extension of power and water facilities in order to sustain a winery development; an eventuality the LUP can in no way cater for as a preliminary search tool, but vital for the user to understand in order to obtain optimum functionality from the tool. In response to computing power, custodianship and commercial liability issues, a distributed network of databases was not assembled for the pilot study of LUP, though the advances in technology and the appreciation of the value of partnership initiatives will eventually make distributed computing an ideal medium for such regional cooperation toward land management and decision-making.

#### **4. CONCLUSION**

Widespread adoption of GIS has value beyond simple efficiency, profitability or even communication. It has value in increasing the awareness and spatial literacy of society and thus facilitating more effective decision-making.

The institutional role in this process is fundamental to developing the information infrastructures that will encourage efficient and effective use of spatial data resources and the development of technologies appropriate to the skill-levels of requisite users.

LUP is an example of the role institutional support can play in the development of GIS-related technologies and products as part of such an information infrastructure. As GIS technologies are making this transition, from generic specialist systems toward a range of user-oriented specialised sub-products, products such as the LUP are emerging, with varying data models and functionality integrated to a greater or lesser extent. Developments like the LUP will enable more data to be accessible to a wider audience, promoting more use of geographical information in problem solving. LUP demonstrates many of the predicted trends in the evolution of GIS technologies have been accurate, especially since it constitutes a non-GIS product with restricted spatial functionality that is usable by a broad number of users with no need for GIS background.

LUP, however, most particularly demonstrates the ongoing need to promote awareness and understanding about GIS related issues such as data quality, data usability and data integration of differently scaled data bases, to avoid misuse and the predicted risks of GIS popularisation – over expectation.

#### **Acknowledgements**

The authors wish to gratefully acknowledge the support of the Department of Infrastructure, Corporate IT (DOI-CIT) and the members of the spatial data infrastructure and cadastral research group at the Department of Geomatics, the University of Melbourne ([http://www.geom.unimelb.edu.au/research/SDI\\_research/](http://www.geom.unimelb.edu.au/research/SDI_research/)) in the preparation of this paper and the associated research. The support of Land Victoria (LV) of the Victorian Government, and the Australian Research

Council (ARC) are also greatly appreciated. However, the views expressed in the paper are those of the authors and do not necessarily reflect the views of DOI-CIT, LV or ARC.

Special thanks are due to Ms Geraldine Ambrose and Mr Duncan Brooks for their time and demonstration material, which supported the writing of this paper.

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