R6880 “Improved methods of peri-urban natural resource information collection, storage, access and management developed and tested”

Appendix 1: Literature reviews on various aspects of the project

1. A review of some of the RRA/PRA literature pertaining to the research project

This review draws together a number of recent papers which describe GIS applications which are of some relevance to the Kumasi peri-urban project. These papers are relevant either by virtue of their field of application (*e.g.* rural development planning, monitoring land use change in the urban/rural fringe) or by their findings and conclusions on such issues as adopting GIS in developing Countries.

The papers are discussed under three main headings: Former Communist States and the Middle East, newly industrialising economies, and other developing Countries.

Russia, the Former Communist States and the Middle East
A number of reports have appeared recently of GISs being set-up in former Soviet/Communist Block states and Middle Eastern countries, some of which have relevance to the situation in many developing Countries as conditions are in some respects similar. Four of the most relevant reports are summarised below.

Albania
Evans (1996) describes the development of Albania’s first GIS. The fundamental information required for this GIS is cadastral *i.e.* land parcel definitions, ownership information, classification of usage *etc.* One of the main obstacles to the development of this system has been the lack of suitable maps for digitising - the existing 1:5,000 maps had to be redrawn by hand to scale 1:2,500 (inevitably reducing accuracy of the data) prior to digitising in order to accommodate the smaller land parcels. Another day-to-day problem, which is not considered insurmountable, is the unreliable electricity supply.

The author notes that Albania is learning from other countries’ mistakes in introducing GIS - particularly from the Swiss. Albania’s cadastre is based on a parcel-based system, unlike Switzerland which at great expense had to change from an owner-based system to a parcel-based system (on the basis that owners can move, parcels do not).

The issues of who is going to use the GIS, who is going to provide the system and who is going to maintain it, do not appear to have been resolved in Albania.

Latvia
In post-independence Latvia it is now legal to own land - and there is great pressure not only to update the existing cadastral database- Dataflex - but also to incorporate it into a simple GIS (Fry, 1996). Although Dataflex is a purely textual database it is

designed to link to a spatial database. This work is being undertaken with advice from the UK's national mapping organisation, the Ordnance Survey.

Lebanon

Fry (1997) describes how war-torn Lebanon is gradually introducing GIS. Initial steps were taken in 1990 when a GIS division was established and orientation seminars were conducted to increase the general awareness of GIS. The initial focus was on universities with the aim of forming a new generation of graduates with GIS know-how. The first organisation to recognise the potential of the technology was the national electricity company (EDL), staff of which worked on two prototypes and only after this success did they move forward to a first phase on implementation. The first implementation phase (mapping overhead lines) revealed that many necessary maps were missing - entailing tape measure surveys to reference points such as building corners to locate the electricity poles. Although this was considered accurate enough at the time, the next phase will be greatly improved through the use of global positioning system (GPS) receivers giving sub-metre accuracy.

The developers of the GIS in the Lebanon admit the system delivered is not 100% complete and accurate. It will, however, be refined to bring it up to an acceptable level of accuracy by newly trained staff. There is concern over the accuracy and maintenance of the inter-related land-based data since the electricity company is not responsible for up-dating this data (parcel data is the responsibility of the Dept. of Cadastre; building data is the responsibility of the Ministry of Public Works or Planning or the Municipalities).

The author states that the apparent absence of a central body responsible for gathering and maintaining data is likely to hinder advances of GIS in Lebanon. Furthermore, the absence of a postal address system (which is a common situation in peri-urban areas worldwide) limits the scope of the system. Efforts are being made to create base maps with roads/buildings (often using GPS) and to allocate addresses; this will form the foundations for a cadastral information system , vital for urban planning and infrastructure development.

Russia

Kondratyev et al (1996) describe an urban-based GIS which might improve the environmental threats from metallurgical processes, thermal power plants, mines and pulp mills around Russia's second largest city, St Petersburg. The system processes and analyses environmental information at two levels; one to collect, manage and analyse large volumes of spatially referenced data; the other deals with more generalised data enabling users to analyse specific environmental features such as pollution movements in the atmosphere. Outputs from the second, higher level are designed to be "accessible to non-experts as well as environmental specialists". Three types of remote sensing imagery (Russian high resolution, AVHRR and SAR) are used, together with ground-based data, enabling staff to identify trends over time, model processes, undertake environmental impact assessments of human activities and create digital outputs showing the current state of the environment to support environmental management and decision making. Both qualitative and quantitative outputs are produced - the former presumably aimed at the non-experts.

The level one system uses “a simple, friendly interface, based on Windows principles” (software not specified); the level two system, designed to meet specific analytical needs, is based around expert systems written in C and Clipper- which “enables us to process a greater number of different types of data, and helps reduce the risk of inaccuracies” (Kondratyev et al, 1996). The IDRISI software is used to process the remote sensing data and link it to other spatially referenced datasets.

A major limitation of the system is that it has been created without any direct line to government decision-makers- there is therefore no guarantee of action being taken. At the same time, however, such an information system can be a major asset in decision-making by providing scientific evidence of environmental degradation as a result of human activities.

Newly Industrialising Economies

When searching for parallel situations from which Kumasi might learn [urban and peri-urban GISs in particular], there are far fewer of these in Developing Countries than regional systems (which also tend to be project oriented) - whereas general purpose management-oriented systems are becoming the dominant feature in developed countries. Parallels from newly industrialising economies (NIE’s) where there are similarities in issues, but where the general situation is eased by availability of funding, good mapping and land records should provide useful lessons.

Malaysia

Kam (1996) describes a pilot GIS commissioned by the Land Surveyors Board of Peninsular Malaysia and the State Government of Penang to demonstrate GIS capabilities. After a three month inception study, a three task demonstration GIS was developed, focussing on:

1. land use potential
2. cadastral information
3. urban traffic flow / management.

A major finding of the three task study was that several agencies concerned with land and resource planning, management and administration relied heavily on a number of key datasets, which, when brought together in such a way that they could be cross-referenced, would constitute “a one-stop databank”. This database would inevitably reduce duplication of datasets and increase their efficiency of use. The study concluded that before developing GIS applications the supporting databases should first be created, thus providing a very valuable asset for the state government.

Thailand

1. Using GIS In Provincial Development Planning

Durongdej (1996) describes the development of a GIS and how it is used as a planning tool to manipulate bio-physical and socio-economic data in order to identify and overcome land use-related conflicts in Thailand. The study covered three villages in the remote Mae Hong Song province and aimed to demonstrate to the local planners (the Provincial Rural Development Committee or PRDC) potential and actual conflict areas, between both local people and central government and also between different government agencies.

Maps of land use (for 1977, 1983 and 1990 at varying scales), land suitability, soils, slope, land potential, wildlife reserves, land use planning zones, population *etc*. were entered into the GIS (using PC Arc/Info). After basic overlay analysis, map outputs were produced showing areas of deforestation and also areas prone to soil erosion. By identifying specific problem areas, planners can then recommend the adoption of selective soil conservation measures where it is needed rather than the more common method of global adoption *i.e.* each household practice soil conservation on at least one cultivated plot.

The GIS techniques also highlight areas of current and potential land use conflict between the local people and the government over land use planning restrictions. For example, two of the study villages were found to lie within designated wildlife sanctuary boundaries.

The Thai planners, when presented with these maps, concluded that bio-physical data (when used with socio-economic data) can present a better picture of the problem areas than any other means currently available. However, they did not appear from the text of the paper to have actually used GIS technology themselves.

2. Planning the Location of Services
Lan (1995) used PC ARC/INFO and ArcView to assist in planning secondary school facilities in Pakchong District in northeast Thailand. The district has a population of 148,577 and covers 1,665 sq.km. GIS analysis was carried out using existing school locations, school enrolment figures, designated catchment areas for each school and projected demand figures for secondary education. Using different sets of criteria *e.g.* access, minimum distances, six alternative plans for siting additional schools were produced. These plans will inevitably help planners to maximise benefits from investment in future schools. Once again, this is not described as an operational system, but serves to illustrate how an operational system such as that for Kumasi could be used to plan services.

Other Developing Countries

Egypt
Goossens and Vliegher (1996) present a very typical example of a GIS application which uses field information, remote sensing data and GIS to map and monitor saline and water-logged soils in Ismailia Province in Egypt. The system is then used to model and predict problems elsewhere - but no mention is made of the local users and how they may use the system to assist them in their regular work.

India

Service Provision
Tewari (1996) demonstrates, in a retrospective analysis, that GIS technology could have assisted in better service provision in rural development planning for Mysore district in India.

The GIS database covered an area of 12,463 sq.km., consisting of 1,649 inhabited rural villages and 15 towns - with total population in 1991 of 3.17 million. Various maps and population census data were input into the GIS - using AutoCAD, dBASE IV and ArcCAD. Although ArcView 1.0 had just been released and was found easy to use by the planners, more analysis than could be provided by this system was required. A location-allocation spatial decision support system (LA-SDSS) was therefore developed in order to meet the needs of the planners. (Such analysis routines are in fact incorporated as standard into present GIS software).

The GIS and SDSS were used to prepare an action plan for the district, in terms of provision of rural services such as health, education, veterinary, and commercial banks. Much of the analysis focussed on finding the best locations for five new hospitals to supplement the ten already existing. The locations were determined using the LA-SDSS to minimise the total weighted distance of settlement-wise populations to their nearest hospital.

Preliminary analysis showed that, considering only the ten existing hospitals, the average distance to hospital was 11.2 km and the maximum was 76.6 km. When an extra five were added these distances were reduced to 9.0 km and 48.3 km respectively. However, had the GIS been used to site the ten existing facilities, it could have achieved figures of 11.2 and 48.3 kms respectively. This application clearly demonstrates the benefits, in terms of State finance and reducing travel time for local people, of using GIS is service planning.

Transformation of the Rural-Urban Fringe of Delhi
Skorn•ek and Bentinck (1996) describe applications of GIS to the rural-urban fringe of Delhi - which has many similarities in issues (land degradation and other environmental problems, population pressures, urban expansion, changes in occupational structures) and problems (limited physical and social data) to Kumasi. They highlight that it is not sufficient to make a one time assessment of land degradation because degredation refers to a process over time and to the value of land for particular uses. The authors suggest that the study needs to focus on land use change over time in relation to population - and advocate that the relevant “object” or spatial entity in such rapidly transforming rural areas is the rural village.

The Delhi peri-urban study uses IDRISI (for analysis of satellite imagery), ArcView (to produce thematic maps - a simple application, but found to be an extremely important product) and PC ARC/INFO. ARC/INFO was used to produce village by village assessments of the degree of urbanisation, based on population, population density, % of the labour force in non-agricultural sectors of the economy and % land in non-agricultural categories. This analysis, carried out for two time periods (1971 and 1991) will enable planners to identify those zones under most threat from urbanization.

Network analysis was applied to the villages in order to measure their “proximity” to the main urban centre. This analysis helps to understand the process of urban expansion and land use changes at different locations in the fringe. As villages become “nearer” to the city in terms of reduced travel times, various changes become evident *e.g.* agricultural land use changes, occupational structure of the village. In order for network analysis to be carried out in the GIS a digitised map of the existing road network must first exist, preferably with each road link coded according to road type.

In the Delhi study, travel distance (in terms of time) from each village to the outer ring road was calculated, taking onto account the "impedences" of: (a) poorly surfaced roads and (b) congested villages. Each category of road (*i.e.* highway, wide road, narrow road and sand track) was assigned an appropriate average speed and this was used as the first impedance. The second impedance consisted of an average delay in certain villages and at level crossings. Both these impedances were based on the experiences and estimations of local people familiar with the area. Although this was considered a worthwhile preliminary study, the authors admit that in order to obtain a better picture of the influence of proximity on the rural-urban transformation, the network analysis must be further refined to differentiate a number of factors, such as mode of transporation and purpose of movement.

The authors state that frequently the results from the GIS raise as many questions as it can answer - and that the answers to these questions can only be found from village level field research. They emphasise the micro-level of the GIS required, with individual and household studies, backed-up by strategic consultance with key-informants.

Mali

De Jong & Teeffelen (1996) used GIS technology (in particular network analysis) to aid rural development planning, namely the (re)location of public services, in the Koutiala District of Mali. The authors used accessibility and optimisation approaches within a GIS, incorporating details of the local transport network and population data, to relocate three of the five pharmacies. This resulted in considerable reduction of overall travel time for local people.

Existing pharmacies are close to main roads, but by shifting these from the north-south oriented arteries to the east-west arteries, there is a 50% reduction of settlements outside the three hour travel time limit and an overall 15% reduction in travel time. Also, the distribution of customers over the four pharmacies outside the capital is more even.

As in other types of GIS analysis, this technique involves many assumptions *e.g.* travel costs, acceptable distance ranges and minimum number of customers per pharmacy. Such assumptions should be discussed and approved by decision takers and/or policy makers if the results of the study are to be taken seriously and applied to service provision in such a way that local people are benefited.

Somalia

A full scale natural resource information system has been developed for the rangelands of Somalia . This differs considerably from other systems being developed as, from the outset, the aim was to develop a nation-wide system (Nimmo, 1991). [It has never been politically possible to install the system in-country due to the breakdown in national security.] The system was developed with the intention of making information held on shelves in the form of reports *etc.* available to potential beneficiaries (many of whom had not benefited from much schooling). The system is based on dBASE IV and has an interface which has been developed and tested in Somalia where traditional communication is by word of mouth and not the written word (the reason given to explain why many volumes of survey reports lay virtually untouched on office shelves in the capital to gather dust.)

Although the Somalia information system differs from that which is anticipated for Kumasi in terms of coverage and scale or detail of information required, the issue of how to develop a user-friendly interface to meet the needs of the users is common to both.

South Africa
van Helden (1996) describes the various stages in the use of GIS for urban management in South Africa, highlighting the contrast between those systems which are operational and those that are only at the preliminary stage of data entry. He claims that the main problem regarding adoption of GIS in South Africa lies not in supply or know-how but in the sustainable use of such systems.

Urban management is the responsibility of the metropolitan and municipal councils in the new South Africa with responsibilities including:

- co-ordinating land-use and transport policy, environmental conservation;
- supply of services (water, electricity, sewerage, drainage *etc.*);
- co-ordination of transportation, traffic matters, markets, museums, libraries, ambulance / fire services, hospitals, recreation facilities *etc.;*
- promotion of economic development; and
- the collection of taxes, distribution of government grants *etc.*.

There are basically two types of GIS application groups; land-use management, and infrastructure and utility management (*e.g.* water supply, sewerage).

Problems experienced with GIS applications were listed in rank order:

- insufficient trained personnel
- insufficient funding
- poor co-operation between departments
- incompatible software and data
- departmental rivalry
- incompatible hardware
- slow processing capacity
- poor management
- wrong software
- up-grading difficulties
- ignorance and negative attitude towards GIS
- insufficient training for beginners.

The author cites the main obstacle to successful GIS at many organisations as the inability to bridge the gap between the GIS development phase and the actual use of the GIS by decision makers. This results in a small number of end users and the GIS being seriously under-utilised, with implications for future maintenance as management is reluctant to spend money on systems that are not fully utilised.

Three main problem areas are identified and solutions proposed:

1. Technology Transfer

GIS technology should be adjusted to suit the level of GIS knowledge. There is a need for low budget, customised user-friendly application systems to ensure more efficient use of the GIS by the majority of end users.

2. Database Management

The problem of data access and supply to organisations is being overcome by creating a large metadatabase of existing data sources . This will be accessible over the internet. and will enable end users to quickly locate a data source then provide them with information on how to process and interpret such data.

3. Education and Training

The shortage of sufficiently trained GIS specialists and end-users is being overcome by the introduction of a GIS education programme which caters not only for the needs of the GIS “specialist” but also for the “end user”. The end user is typically the policy formulator (*e.g.* town planner) who has a particular problem to solve and who uses GIS as a *means to an end* to solve that problem.

Discussion and Conclusions

The pattern in the majority of the former communist and Middle Eastern examples is that they focus on developing a cadastral base, which can then be used as the foundation upon which a broader GIS for urban areas (or small nation states) is then planned. This pattern implies that the system is being planned “top down”, whereas the accepted practise in development is that it should be “bottom up”, with foundations in a thorough user needs assessment at community level, progressing upwards to higher level planners and decision makers (Falloux, 1989). However, grass roots needs in terms of land administration in many areas (including Kumasi (Holland et al, 1996)) suggest that the cadastral process is vital, not only to deal with land ownership conflicts but to define property (either private or common), thereby enabling communities to better manage the renewable natural resources (which can be overlayed onto cadastral maps using the GIS). Cadastral information seems to be a vital element in any peri-urban GIS, as little or no planned developments can legally go ahead without such information and new dwellers moving into the zone are increasingly challenging traditional customary rights.

A common and very regrettable conclusion from the review is that either implicitly or explicitly in most of the applications described the institutional aspects of the GIS have at best been of secondary importance and at worst totally neglected. Hedberg (1991) indicates in his major review of GISs that user interaction and other organisational (political and behavioural) aspects have been neglected. He believes that such issues are more important for the success/failure ratio of a GIS than the hardware, software or data aspects.

System developers should not be afraid to start with less than 100% accurate information (as long as adequate warnings are given to users and the data is not truly garbage), taking lessons from elsewhere in the system design, then aim to refine the data (and models) over time after installation.

Introductory talks to potential users, beneficiaries and contributors should be planned and run well in advance of "installation".

Protocols on which Ministries etc. are responsible for maintaining different parts of any system must be clear from the outset.

In some cases, it may be appropriate to start developments towards GIS by setting-up data centres or libraries, in themselves an asset.

Demonstration applications should be included in all GISs in order that potential users may be shown the potential of the system using local data - bridging the gap which van Helden (1996) noted between GIS development and use.

A GIS application which has been shown by several of the authors to be financially beneficial to the government/state/district and also of benefit to local people is *service provision*. Although planners should be well-versed in and have been paying attention to distance decay effects, it seems that this has not been the case - and services such as schools, clinics, pharmacies, hospitals *etc.* could be more cost-effectively operated.

References

Duronggdej, S. (1996) Using GIS in provincial planning in Thailand: a case study of Mae Kong Son Province, Proceedings of the third symposium on GIS and developing countries “The Practice of GIS Applications”, Utrecht, The Netherlands.

Evans, R. (1996) Folk memories into fixed assets. GIS Europe 5(10),32-34.

Falloux, F. (1989) Land Information and Remote Sensing for Renewable Natural Resources Management in Sub-Saharan Africa - A Demand Driven Approach. World Bank Technical Paper 108, Washington DC, USA.

Fry, C. (1997) Rebuilding Lebanon on digital foundations. GIS Europe 6(2), 24-27.

Fry, C. (1996) Latvian land reform: setting the wheels in motion. GIS Europe 5(2) 18-19.

Goossens, R. & de Vliegher, B.M. (1996) Monitoring, simulation and prediction of soil salinity and water logging risk, using remote sensing and GIS on provincial level. A case study for Ismailia (Egypt), Proceedings of the third symposium on GIS and developing countries “The Practice of GIS Applications”, Utrecht, The Netherlands.

Hedberg, C. (1991) Information Systems for Land Resources Management in Developing Countries. NorAgric, Agricultural University of Norway and CDE, Oslo.

van Helden, P. (1996) Geographic infromation systems in urban management. A South African perspective, Proceedings of the third symposium on GIS and developing countries “The Practice of GIS Applications”, Utrecht, The Netherlands.

Holland, M.D., Kasanga, R.K., Lewcock, C.P. & Warburton, H.J. (1996) Peri-Urban Baseline Studies, Kumasi, Ashanti Region, Ghana (Volume1: Executive Summary and Main Report. Natural Resources Institute, Chatham, UK.

de Jong, T. & van Teeffelen, P (1996) GIS at your service : evaluating the location of pharmacies, based on transport network analysis in Koutiala, Mali. Proceedings of the third symposium on GIS and developing countries “The Practice of GIS Applications”, Utrecht, The Netherlands.

Kam, S.P. (1996) The Practice of Applications : Putting GIS into practice in developing countries. Proceedings of the third symposium on GIS and developing countries “The Practice of GIS Applications”, Utrecht, The Netherlands.

Kondratyev, K.Ya., Bobylev, V.K., Donchenko, V.K., Rastoskuev, V.V. and Shalina, E.V. (1996) Finding a solution for pollution. GIS Europe 5(8), 20-22.

Lan Do Tu (1995) Application of computer-aided techniques for planning the location of services : a case study of secondary schools in Pakchong District, Thailand. Unpublished MSc Thesis, Asian Institute of Technology, Bangkok.

Nimmo, J. M. (1991) Development of a database system for the evaluation of land resources for planning and development in Somalia. Unpublished DPhil Thesis, University of York.

Skorn•ek, J. & Bentinck, J. (1996) Transformation of the rural-urban fringe of Delhi, Proceedings of the third symposium on GIS and developing countries "The Practice of GIS Applications", Utrecht, The Netherlands.

Tewari, V.KJ. (1996) GIS applications in rural development planning and management ion developing countries, Proceedings of the third symposium on GIS and developing countries "The Practice of GIS Applications", Utrecht, The Netherlands.

2. Recent research and developments in design and development of user interfaces for the broadest range of users possible, especially of the use of GIS in contexts such as those to be encountered in Ghana, e.g. involving semi-literate Chiefs and villagers.

Developing countries are lagging behind in the computerisation process and it is to be hoped that they can benefit from the large amount of system development experience and expertise in developed countries in order to avoid costly mistakes.

Although many descriptions are published of geographical information systems (see previous section), details of the ways people interact with the computers - and whether / how the system designers have tried to enable inexperienced potential beneficiaries to interact and contribute to the systems are virtually absent. Most of the material which reaches edited journals are the results of research. Experienced staff (in GIS and the whole range of other fields) in developing countries themselves are being pressurised by peers to produce scientifically advanced material for fellow experts, producing popular and appropriate information for non experts is not" (considered meriting) (Hedberg, 1991).

Nimmo (1991) aptly states, "The user is of course the dominant component of the whole system, and his needs and capabilities will over-ride all other considerations in shaping the database system". Yet GIS is too difficult for ordinary citizens (Scholten and Padding, 1990).

Database systems in general and GIS in particular, aim to reduce reliance on computer specialists (which results in delays and restrictions and cumbersome bureaucratic procedures) (Engelman, 1988) - this is quite clearly impossible if they are not user friendly.

Although Han and Kin (1989) distinguished between GIS, database management systems (DBMS), decision support systems (DSS) and expert systems (ES) - the boundaries between these types of systems seem to be overlapping and it is useful to learn from steps towards developing UFIs to all these "information systems".

A major objective of producing a user friendly interface (UFI) is to enable unfamiliar users to sit down at the terminal and immediately begin to access information in the database without lengthy sessions of tuition or the need to study a manual. In the short term, a successful UFI would be the situation where people who have to access the data are choosing to use the computerised system rather than the printed medium of reports . Also where people who "should" be referring to available data to assist them in decision making (but who may not have bothered to look in printed reports) feel attracted or even obliged to switch on the computer. In the longer term, a successful outcome would be that decision makers felt that they must use the information.

A number of geographical information system software packages can be tailored to provide interfaces of varying degrees of user friendliness (depending on the software, the application and the skill of the programmer). However, there are many dilemmas which face developers of user friendly interfaces for any software system, whether the end user is a poorly educated member of the general public or a highly skilled scientist / technician - but experienced in a different field.

In describing the development of a UFI for a rangeland database covering the whole of Somalia, Nimmo (1991) lists the following requirements:

* a quick and easy-to-use method of communication between the user and the interface (menus and or a mouse)
* screen displays which are clear and concise
* messages and instructions which are self explanatory
* help information readily available for all interactions
* errors must be easily recoverable
* a tutorial to demonstrate the use of the system
* a full manual and technical documentation should be available for reference (designed to be used only rarely - maybe for up-dating the interface).

Nielsen and Molich (1989) quote “five golden rules” for the process of interface design:

1. know the user
2. involve the users during the design
3. co-ordinate the total user interface
4. empirical measurements of user performance
5. iterative design to remove usability problems.

In the case of the system under development for the Kumasi peri-urban area, it is not certain exactly who the users will be - although the situation is more stable than that facing Nimmo (1991) in development of the Somali Land Resources Database System when political upheaval made it almost impossible to ascertain who (and in hindsight, if anyone) would use the system. In the case of Kumasi, several different types of users will make use of the system - clearly the village chiefs will have very different needs, expectations and data needs from planning officials etc. Also, in order to keep the system up-to-date, data entry operators and others may need to have tailored UFI’s.

Hedberg (1991) presents the following list of likely users of such GISs:

- Operators
    - scientific
    - data entry
- Customers
    - planners and decision makers
    - external research communities
    - information carriers (extension workers and journalists)
    - end-users (farmers and local organisations).
- System Developers
    - in-house
    - external consultants
    - vendors

Although we can assume that the latter of the three main groups will not require a tailored UFI, it is clear that serious consideration should be given to developing more than one UFI (as suggested by Liu Yue et al (1991)) - and perhaps using subsets of the main database on systems for use by local chiefs etc. (henceforth termed the village-based system)- although it is critical that issues of data protection (reliability, security and integrity) (Oxburrow, 1986) are not jeopardised by extracting elements of a core system.

The development of more than one system should allow the development of a more user-friendly system for the village-based system. UFI's are widely acknowledged to be developed at the expense of speedy system operation (Hastings & Clark, 1991) - but if only a subset of data need be processed, this could become unimportant. The village-based system may have to be developed in a local language, perhaps using an expert system as an interface between users and the computer - as this is more akin to questioning an extension worker (which would be common experience) than using a menu based system (Nimmo, 1991). Development of an expert system, using the GIS as part of the "knowledge base" and an inference engine (Jackson, 1990, Lucas,P. & van der Gaag,L. (1991), would enable a UFI to be developed which could simulate having an expert beside the user at all times interacting as in a conversation using a natural language interface (Oxburrow, 1986).

Burrough (1991) describes steps towards an intelligent GIS recognising that GIS are powerful toolboxes in which many of the tools (including the models) are unfamiliar to the intended user. "GIS lack information about how they should be used so that a user, when confronted with a given problem……….has little or no idea apart from seat-of-pants intuition." There is a huge amount of expertise in the world about how to use GIS, models of climate, groundwater movement, crop simulation and soil erosion - this need to be formalised into a knowledge base next to the GIS to help the user choose the appropriate procedures and tools to solve the problem within the constraints of the data (quality, cost and accuracy). "A really intelligent GIS would be able to carry out error propagation studies before a major data crunching operation to estimate if the methods and data chosen are likely to yield the results intended. It would report to the user where the major sources of error come from and would present him with a set of options with which he could achieve better results. These options are:

a) use better methods
b) collect more data
c) improve the spatial and/or temporal resolution
d) collect different data
e) use better models
f) improve model calibration."

Burrough (1991) suggested that the intelligent GIS should include an estimate of the costs of any improvements, in order that a rational decision could be taken. Also, "The system would also be able to indicate situations in which the results were *much better* than expected: in these cases important savings on data collection and processing could be made without loss on information."

Burrough (1991) admits that no current commercial GIS can link all kinds of models and GIS - it requires technological advances in data structures, use of expert shells etc. and his paper was intended as a vision for the future - which has not yet been realised.

Examples of attempts to integrate local knowledge into an information system are rare, a notable exception being Yapa (1988 and 1991) where mechanisms for incorporating local knowledge are used to encourage local participation. Yapa (1991) lists five components needed for a local information system:

1. a GIS with standard overlay and map query procedures;

2. a set of simple techniques for modelling such things as population growth and soil erosion;

3. a database of the local physical and human geography in maps, reports or digital form;

4. a mechanism for incorporating indigenous knowledge of the regional geography, local resources, diseases, remedies and so on;

5. a system that encourages the participation of local people, in providing inputs to, and using

Yapa (1991) concludes " As far as is feasible, it is useful to conduct the operations of the information system in the local vernacular language." This may only be required for the village-level system - or for both the peri-urban wide and village systems, depending on the local administrative language.

Nimmo (1991) recommended that a UFI should include demonstration applications which could be run to show potential users some of the system capabilities - this seems a very useful concept to incorporate into the Kumasi system, which would assist in bridging the gap between GIS development and use highlighted by van Helden (1996).

GIS bears a dual relationship to “Appropriate Technology” (AT) - on the one hand contradicting it (high cost and required expertise) but also it complements AT because the tools of GIS are useful for uncovering “local resources” (Yapa, 1991) (could strengthen Chiefly, community-based, land and NR management, as recommended by Holland et al (1996).

References

Burrough, P.A. (1991) Intelligent Geographical Information Systems, Paper presented to the UNEP conference on GIS in the CIGAR Institutes, Nairobi, January 1991

Engelmann,U., Wallenbert,H., Kohl,U. & Geesken,E. (1988) Management of clinical data in urology. Experience with integrated personal computers and a relational database. British Journal of Urology 61, 527-530.

Han,S.Y. & Kim,T.J.K (1989) Can expert systems help with Planning. Journal of the American Planning Association 55, 296-308.

Hastings,D.A. & Clark,D.M. (1991) Int. J. Geographical Information Systems 5(1), 29-40.

Hedberg, C. (1991) Information Systems for Land Resources Management in Developing Countries. NorAgric, Agricultural University of Norway and CDE, Oslo

van Helden, P. (1996) Geographic infromation systems in urban management. A South African perspective, Proceedings of the third symposium on GIS and developing countries “The Practice of GIS Applications”, Utrecht, The Netherlands.

Holland,M.D., Kasanga,R.K., Lewcock,C.P. & Warburton,H.J. (1996) Peri-Urban Baseline Studies, Kumasi, Ashanti Region, Ghana (Volume1: Executive Summary and Main Report. Natural Resources Institute, Chatham, UK.

Jackson,P. (1990) Introduction to Expert Systems. Addison_Wesley, Wokingham, UK.

Liu Yue, Liang Zhang, Chen Xiaogang & Zhou Yingming (1991) Int. J. Geographical Information Systems 5(1), 73-84.

Lucas,P. & van der Gaag,L. (1991), Principles of Expert Systems. Addison_Wesley, Wokingham, UK.

Newkirk,R.T. & Wang,F. (1990) A common knowledge database for remote sensing / geographic information system in a change detection expert system. Environment and Planning B: Planning and Design 17.

Nielsen,J. & Mollich,R. (1989) Teaching User Friendly Interface Design Based on Usability Engineering, SIGCHI Bulletin 21 (1):45.

Nimmo, J. M. (1991) Development of a database system for the evaluation of land resources for planning and development in Somalia. Unpublished DPhil Thesis, University of York.

Oxburrow, E (1986) Databases and Database Systems. Chartwell-Bratt, Lund, Sweden.

Scholten,H.J. & Padding,P. (1990) Work with GIS in a policy environment. Environment and Planning B: Planning and Design 17.

Yapa, L.S. (1988) Computer-aided regional planning: a study in rural Sri Lanka. Environment and Planning B: Planning and Design,15, 285-304

Yapa, L.S. (1991) Is GIS an appropriate technology? Int. J. Geographical Information Systems 5(1), 41-58.

Yeh, A. G.-O. (1991) The development and applications of geographical information systems for urban and regional planning in the developing countries. Int. J. Geographical Information Systems 5(1), 5-27.

Annex 1 - Emails sent re Software

ILWIS
Thinkspace
IDRISI
Tydac (re Spans)
MapInfo
Map Factory
ERDAS Imagine

Annex 2 - Internet Searches and WWW pages Browsed

Altavista
Compuserve
Yahoo
Infoseek

GIS WWW Resource List(www.geo.ed.ac.uk)
GIS World (www.gisworld.com)
(www.geoplace.com)
Magnum Project (www.wins.uva.nl)
MapMaker (www.ibmpcug.co.uk)
NCGIA (www.ncgis.ucsb.edu)
GRASS (www.regis.berkeley.edu

United Nationa Centre for Regional Development (uncrd.or.jp/library.html)

Maine Univ (umesve.maine.edu/guidelines.html)
GISDECO (www.frw.ruu.nl/gisdeco)

3. **Participatory GIS, Multiple Realities and Multimedia Representation**

This paper reviews a number of applications concerning the role of participatory GIS in development studies. It also examines how recent developments in mulit-media GIS are useful for representing the qualitative data derived from such studies.

Initiative 19 of the NCGIA, begun in February 1996, focuses on *GIS and Society* and addresses some issues which are particularly relevant to the Kumasi periurban study. These include:

- In what ways have particular logic and visualisation techniques, value systems, forms of reasoning, and ways of understanding the world been incorporated into existing GIS techniques, and in what ways have alternative forms of representation been filtered out?

- How can the knowledge, needs, desires, and hopes of marginalised social groups be adequately represented in GIS-based decision-making processes?

One of the four research projects which arose from the Initiative 19 Specialist Meeting, held on 2-5 March 1996, was entitled "Local Knowledge, Multiple Realities and the Production of Geographic Information: South Africa and West Virginia Case Studies" (Weiner et al., 1996).

<u>Kanawha Valley case Study</u>
The West Virginia case study focuses on Kanawha Valley, one of the largest industrial chemical complexes in the world and known locally as "chemical valley". Here there is considerable potential for environmental catastrophe and numerous cases of chronic illness so access to relevant information for risk management is considered essential. The aim of this research is to consider how people gain access to geographic information and how the representation of that information effects the perception and management of risk.

One specific objective of the research is to examine how GIS incorporates *multiple realities* of space and environment. Different groups of people have different perceptions and ideas regarding existing or potential health risks and the spatial distribution of cancer clusters. This knowledge is derived from the local people using individual and participatory workshops.

Local knowledge from the community is derived mainly from mental maps and oral histories. Much of this information is aspatial and quantitative *i.e.* in GIS terms it is *spatially fuzzy* in the sense that it does not easily fit into the spatial primitive paradigms of point, line and polygon employed by GIS. In this project mental maps are generated by the use of tracing paper overlaid on 1:50,000 topographic maps, shaded relief maps and boundary-transect walks using GPS. Local knowledge (and experience) is then recorded directly onto this map base for use in the GIS.

The question now raised is how to include this range of local knowledge- in the form of narratives, oral histories, anecdotal information, sound, text, mental maps, images, *etc.* - into the GIS in order to maximise community participation and to ensure that the "voices from below" are incorporated into the process of risk assessment and management.

The research then considers several approaches to managing this diverse range of data in a GIS. These include:

1. GIS-interactive multimedia (IM)- data enquiries are handled using *hotlinks* based on the hypertext approach. The user simply clicks on an icon and the associated text, table, image or video clip is displayed.

2. Hypermaps - here the GIS design is more complex enabling the user to undertake spatial search functions and retrieve the multiple media objects found within the search parameters.

<u>Kiepersol, Eastern Transvaal, South Africa</u>
The Kiepersol locality in South Africa is a rural area with a long history of apartheid forced removals and the people there have suffered from loss of access to land, water and biomass resources. The major objective of this research is to contribute to the democratisation of land and agrarian reform in South Africa by incorporating local knowledge into the GIS in order to complement the more traditional top-down agency driven data. As with the Kanawha Valley study, community participation represents the key element in extracting non-conventional behavioral and cognitive information from the local community.

The issue of *multiple realities* and how they are represented in GIS is central to the research. Multiple perceptions of the world certainly exist (*e.g.* difference between "expert" and "local" knowledge of an area) (Aitkin and Michel, 1995) and Mark (1993) calls for the design of a GIS that is capable of incorporating the many ways in which users (in particular, non-Western societies) conceptualise space and the phenomena around them. The GIS must therefore be able to represent multiple realities capturing the everyday experiences of diverse social groups.

A previous study, conducted in June/July 1993 (Weiner *et al.*, 1995), involved setting up village workshops with several different groups of people (men and women, with and without access to land) in order to extract their knowledge regarding the history of forced removals, their perceptions of land quality, the location of "better soils" and other relevant aspects of land use and land potential. The mental mapping exercise was based on field interpretation of hard copy 1:50,000 topographic maps. This raises the issue of how to encode spatially fuzzy local knowledge. By tracing a user's perception of space onto an already existing topographic map a particular scale of analysis and Cartesian interpretation of space is imposed. However, this type of digital representation is necessary if the local knowledge layer is to be integrated into the GIS and compared with other spatially referenced layers to assist in land management and planning.

Figure x is a mental map showing community perceptions of agro-ecological space. When these perceptions are overlaid onto an official land type map (originally published at 1:250,000 scale) it is obvious that the different representations are a product of scale (the farmer's knowledge is very detailed) and the different perceptions of agro-ecological potential.

One discussion arising from the NCGIA Initiative 19 Specialist Meeting focussed on the possibility of developing an alternative GIS known as GIS2. Such a GIS would be developed with community participation and incorporate non-conventional knowledge types.

Harris and Weiner (1997) elaborate on this concept by referring to a *community-integrated GIS*. Such a GIS:

- is not agency driven, top-down, and privileged toward expert knowledge;
- assumes that local knowledge is valuable;
- broadens the access base to digital spatial information technology;
- incorporates socially differentiated multiple realities of landscape;
- integrates GIS and multimedia;
- explores the potential for more democratic spatial decision-making through greater community participation; and
- assumes that spatial decision-making is conflict-ridden and embedded in local politics.

Community-integrated GISs should be *issue-driven* in that local knowledge and desires are embedded as layers in the GIS. This implies that the GIS should not rely solely on the cartographic map as the main method of spatial representation but should incorporate other forms of representation and other media such as narratives, photographs and animation. Multimedia systems hold considerable potential for incorporating such community-based knowledge into the GIS.

OTHER PGIS CASE STUDIES
Cultural Survivial Quarterly.

There is considerable literature discussing the role of GIS in society. More recently attention has focussed on how GIS may be used to help empower communities by encouraging participation in GIS projects. This is in contrast to the traditional top-down "expert" knowledge approach favoured by so-called GIS development projects. By broadening the number of social groups which have a say in the development and operation of the GIS then the single scientific or agency-driven representation of reality is replaced by multiple realities from the different groups represented. Again, we are brought back to the issue of how to represent qualitative forms of data in the GIS *e.g.* non-Euclidean sketch maps, cognitive and mental maps, narrative and oral histories, pictorial and moving images. Let us now consider the latest technological developments regarding GIS and multimedia.

GIS and Multimedia

The traditional cartographic map is designed to communicate quantitaive spatial information and is often characterised by a high level of abstraction with the use of symbols which may be confusing and difficult for the inexperienced map user to interpret. According to Blades and Spencer (1987) "large proportions of people are not very competent with maps and often avoid using them". Qualitative spatial data, on the other hand, is much less abstract and can greatly enhance the value of information contained in the GIS.

The technology is now available to allow the integration of both qualitative and quantitative spatial data in a GIS- such a system is termed a *multimedia* GIS. Laurini and Thompson (1992) defined multimedia as:
"a variety of analogue and digital forms of data that come together via a common channel of communication".

One of the first developments linking multimedia data sources to a spatial information system was the Domesday project (Openshaw *et al*., 1986). Other applications include urban planning (Schiffer, 1993), environmental impact assessment (Fonseca and Gouveia, 1994) and tourism (Georgia *et al*., 1994).

The data sources which may be manipulated using multimedia tools include: graphics (vector, raster, image), full motion video, text, and sound.

In order to integrate these diverse data types an appropriate data structure is required. One such structure is the *hypermap* concept as defined by Wallin (Wallin, 1990). The term multimedia hypermap is used when the diverse data types are structured using the concept of spatial hypertext (Parsons, 1994). Parsons (1992) developed a prototype multimedia hypermap of the Covent Garden area of London designed as an information system for tourists. He investigated different tools for displaying multimedia data types and designed an interactive, user-friendly interface to ensure quick access to the data.

Fonseca and Gouveia (1994) use multimedia GIS for environmental impact assessment (EIA), recognising that the use of video and sound can greatly improve the understanding of environmental spatial phenomena. They have developed a prototype multimedia GIS for EIA of the 25 hectare site affected by Expo'98 in Lisbon. An icon-based interface enables the user to explore the information interactively by the use of the *living map* concept. The user simply clicks on part of the Expo'98 basemap, for example on the landfill area to give access to a video sequence of the solid waste dischage into the landfill area. Other multimedia operations which are activated by this point and click method on the basemap include: fly through an aerial photo mosaic, viewshed analysis from marked points, superimposition of synthetic video on natural images to assess different scenarios, and 3D visualisation. Multimedia technology is particularly appropriate to the EIA process as it enables the user to view the same information in different contexts thus providing him with several alternative solutions or scenarios to the problem.

References

Aitkin, S.C. and Michel, S.M. (1995) Who contrives the “real” in GIS? : Geographic information, planning and critical theory. Cartography and Geographic Information Systems 22(1): 17-29

Blades, M. and C. Spencer (1987). How do People use Maps to Navigate through the World ? Cartographica 24(3): 64-75

Fonseca, A. and C. Gouveia, 1994 Environmental Impact Assessment using Multimedia GIS. EGIS 1994.

Georgia, P., S. Spiros and T. Atanasios (1994) “Athena: Integrating GIS and Multimedia Technology; the Design of a Tourist Information System for the County of Attica, EGIS 1994.

Harris, T. and Weiner, D. (1997) Empowerment, Marginalization and “Community-Integrated” GIS. Draft paper submitted to Cartography and Geographic Information Systems.

Laurini and Thompson (1992

Mark, D. (1993) On the ethics of representation or whose world is it anyway? Proceedings of NCGIA Geographic Information and Society Workshop, Friday Harbor, Washington, Nov.11-14, 1993.

Openshaw, S., C. Wymer, M. Charlton 1986 A Geographical Information and Mapping System for the BBC Domesday optical disks. Trans. Inst. geogr. N.S.. 11,3,296-304.

Parsons (1992)

Parsons, E., 1994 Visualisation Techniques for Qualitative Spatial Information. Proceedings of the European GIS (EGIS).

Schiffer, M.J., 1993. Augmenting Geographic Information with Collaborative Multimedia Technologies. Proceedings of Autocarto 11, Minneapolis, USA.

Wallin, E., 1990. The Map as Hypertext. First European Conference on Geographical Information Systems, Amsterdam, Holland.

Weiner, D., Warner, T., Harris, T.M. and Levin, R.M. (1995) Apartheid Representations in a Digital Landscape: GIS, Remote Sensing and Local Knowledge in Kiepersol, South Africa. Cartography and Geographic Information Systems 22(1):30-44.

Weiner, D., Harris, T.M. and Burkhart, P.K. (199?) Local Knowledge, Multiple Realities, and the Production of Geographic Information: South Africa and West Virginia Case Studies”. Initiative 19 Specialist Meeting.