



## WATER, SANITATION, ENVIRONMENT and DEVELOPMENT

### Low-cost GIS for water resources

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With personal computers (pcs) becoming both more powerful and less expensive (£0.5K-£1.5K), many organisations dealing with water resources can now use low-cost Geographical Information Systems (GIS) to improve their performance. A GIS is a computer-based package for merging, analysing and modelling data that can be displayed as maps. This can provide a rapid and powerful means of examining the many sets of data held by agencies concerned with water resources.

For a given district, datasets as disparate as population density, types of aquifer, water quality and well locations can be merged and presented as computer-generated maps, summary tables or graphs.

A good GIS will incorporate powerful analytical tools, covering general statistics, spatial statistics, image analysis and time series analysis. This allows for modelling and the examination of 'what if' scenarios for proposed developments, producing a wealth of new information for decision makers.

'Top of the range' GIS packages, such as ARC-INFO, are very expensive, falling in the £10K to £20K price range: they also require highly trained staff and costly computers (usually workstations in the £5K to £10K range). That said, the analytical power of such systems can be very useful at central government level, allowing the storage, merging and analysis of many diverse national databases.

However, at the organisational level of a water resources department, the 'top of the range' GIS may be a waste of money, given the amount of data available and the information required.

The Applied Geology Unit at the University of Hertfordshire, England, has found two low-cost GIS packages to be particularly useful for water resource management in developing countries:

- AEGIS, based on points, lines and areas linked to a database (a 'vector' GIS) costs about £150 and is very 'user-friendly', being Windows-driven. Microsoft Windows costs about £60, but is often included free of charge with new pcs. Rather than buying a database package such as dBASE IV, costing about £300, the Notepad facility of Windows can be used to compile and manipulate databases. An example of an AEGIS application, accessing the Windows/Notepad database to illustrate variations in river corridor width, is given below.

- IDRISI, a grid-based (or 'raster') GIS developed with UN support, costs about £180. It is menu-driven and relatively 'user-friendly'. Furthermore, IDRISI has a powerful image processing module, allowing the use of digital satellite images, or scanned-in aerial photographs; for mapping. A version running on Windows, due in 1994, should facilitate the swapping of datasets between IDRISI and AEGIS: that will be a major saving, as most integrated raster-vector GIS packages cost at least £4K.

Both of these GIS packages come with comprehensive and relatively easy to use manuals. Both have tutorial packages that guide new users through key GIS usages. Anybody who has been able to master a word-processor or a data base package, should be able to use IDRISI or AEGIS after only two or three days of work on the tutorials. This is an important point, often neglected: what use is a GIS - no matter how multi-functional - if nobody knows how to use it?

Horror stories abound, regarding organisations purchasing very powerful GIS packages to do relatively simple operations. Perhaps these purchasers quite reasonably assume that:

- if a GIS package is very expensive, it must be very good: a powerful and easy to use GIS that can readily tackle a wide range of problems, might be envisaged. Here a 'Buyers Beware!' warning is needed: as a rule of thumb, the more things a GIS can do, the more complex it will be: its ease of use decreases accordingly. This was particularly true of ARC-INFO, until the recent release of ARC-VIEW, a more user-friendly Windows-based version.
- if so many other major organisations have purchased a given 'top of the range' GIS, it must be good. This view is true for some GIS packages, particularly those developed in the past five years with integrated raster-vector formats. It is not so true for 'top of the range' packages that were first developed in the 1970s: these rely heavily on their historical leadership of the GIS market and on extensive marketing to maintain their dominance. Most of the low-cost GIS packages are primarily for educational purposes: making a profit is not a major consideration. For instance, the IDRISI GIS is being developed by Clark University in the USA with support from the UN Institute for Training and Research and the UN Environment Programme. Producing an effective, and affordable GIS for developing countries is the main objective of the

IDRISI project. It may be that insufficient emphasis has been given to marketing low-cost GIS packages, to make them as well known as highly advertised 'top of the range' packages. ARC-INFO is often heralded as the most widely used (vector) GIS in the world: IDRISI's status as the most widely used raster GIS in the world, gets hardly any mention.

To illustrate the value of low-cost GIS in water resource management, some examples of GIS applications are outlined below:

- Input of digital satellite images (raster format), allowing the production of, (a) regional maps of roads, rivers, settlements, land use and vegetation; (b) interpretive maps of soils, regolith, rock types, lineaments and landforms. The costs of satellite data range from £0.02 to £0.50 per km<sup>2</sup>.
- Detailed mapping using aerial photography or other thematic maps (relief, geology, hydrogeology, geophysics, etc): either as vector input using a digitising board and electronic pen, costing at least £300; or input in raster format using a scanner, costing at least £150.
- Storage and analysis of tabular data, for instance: meteorological data (rainfall, evapotranspiration); hydro-geological data (water supplies: surface, sub-surface; borehole data: water table depth, water quality, recharge rate); socio-economic data (population census; land/water holdings; local sources of income). Rapid conversion of tabular data to more readily understandable map data.

The end result of using a GIS with these datasets would be a series of maps that summarise a few key aspects of the entire dataset that might be of interest to the user. These thematic maps are produced by the GIS overlaying one set of data over another and 'sieving' out unwanted or irrelevant data. Shown below are two data sets, or layers (lineaments and regolith cover) that have been merged using IDRISI. The resulting map highlights the preferred locations for new water wells: sites where intersecting lineaments occur in areas of deep regolith. An additional GIS analysis could involve:

- interrogating a field survey database to find which local villages have inadequate water supplies;
- automatically producing a new map that only shows those new well sites that are within 5 km of villages with inadequate water supplies - thus targeting the wells that should be started first.

Up until now, the usage of GIS was somewhat elitist, often restricted to a very expensive system, with a few GIS experts, without whom the system would be virtually useless. The availability of both low-cost GIS, plus low-cost computers, makes GIS technology available to a much wider range of staff than before.

The accessibility and integrity of water resources data should also improve using a low-cost GIS on many pc's with

many users; as opposed to a 'top of the range' GIS where data is processed by a few office-based experts (often with no relevant field sampling experience). With a low-cost GIS, data can be both collected and processed by the same member of staff, enabling he or she to check for errors: this is very useful, as it is difficult and time-consuming to track corrupted data back to its source. The same members of staff can also run 'what if' scenarios for their sampling areas: this leads to a better interpretation of the GIS results because of their first-hand knowledge of the sites.

Low-cost GIS packages have been available now for the last ten years or so. Powerful low-cost computers now make these information systems affordable in developing countries - where they will be of particular value to the water resources sector, with its many disparate data sources. Major improvements in efficiency result from using a GIS to store and analyse large volumes of data, produce new maps and up-date old maps. Decision makers should also benefit from using a GIS: they can rapidly examine new combinations of data, as well as selecting only the most relevant data from an often bewildering array of tables and maps.

It has only been possible to present a very brief outline of the potential benefits of using low-cost GIS packages in the water resources sector; for further information, an FAO publication dealing with GIS and aquaculture (Meaden and Kapetsky, 1991) is very useful. Other relevant publications are those of the Centre for Earth Science Studies, Kerela, India (1991), detailing the use of GIS in low-cost surveys of land and water usage; and Asabere (1992), detailing the use of IDRISI for environmental assessments in Ghana.

## References

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- Supplier's addresses: IDRISI, Graduate School of Geography, Clark University, Worcester, MA 01610, USA. Fax: USA 508 793 8842. AEGIS, AU Enterprises Ltd, 126 Great North Road, Hatfield, Herts., AL9 5JZ, UK. Fax: UK 707 273684.