GIS for development: a contradiction in terms?

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Summary *Is it possible to make appropriate use of GIS for "development" (here defined as the change desirable for the poor) in countries where human and financial resources may be limited? We argue that it is, and should be taught, but that there are no quick fixes.*

Introduction

Following the 1980s' flurry of activity in GIS, a number of social, political and ethical criticisms have been made of the technology and its application (Lake 1993; Obermeyer 1995; Pickles 1993; 1995; Taylor and Overton 1991), often drawing parallels with quantitative approaches adopted by geographers in the 1960s' or with forms of social control. At the other extreme, Mather and Paterson argue from their own work in South Africa for scholars to 'bridge the chasm between those who do GIS research and planning and those who think critically about its use' (1995,21). For Pickles (1995), this debate is more often one of angry polemic than of theoretical engagement. Can GIS, associated with top-down planning and control, be at the service of the needy? And if so, can this be taught?

Misleading uses and interpretations of the term 'GIS' confuse the issue, with the result that it might become a loose catch-all surrogate phrase for 'spatial technologies' (Dobson 1993). GIS-related technologies have been criticized as militaristic (Smith 1992) but critics often overrate the integration of remote sensing, computer aided design, surveying and global positioning systems, some much closer to military application than is GIS. We focus on GIS as distinct from, say, remote sensing or computer-assisted cartography. Although there are several definitions of GIS, ranging from the technologically-based to those focusing on organizational aspects (Maguire *et al* 1991), for us GIS is a means of evaluating geographical relationships through spatial analysis, database management and graphical display.

Although Openshaw (1991) eulogised the capacity of GIS to accommodate pluralistic research styles, even he may not have anticipated the recent use in South Africa of a GIS to incorporate mental maps from different interest groups to display the multiplicity of reality (Harris *et al* 1995;Weiner *et al* 1995). Such an approach is unusual, however, because computers by their very nature seem to limit forms of thought. The private sector, which designed the hardware and wrote the software for GIS in the West (Obermeyer 1995), is partly responsible for this in its eagerness to sell it as a quick technofix for development. But can GIS really support change for the better in poorer countries and avoid the trap of putting the powerless seriously at risk from GIS in top-down planning? Many doubt it, and when one of us (Dunn 1994) argued at the Annual

Conference of the IBG for the critical teaching of G1S to students from poorer countries, the reaction was largely negative. We wish here to open this debate more widely. All geographical information is problematic in its powers of representation, and we argue that GIS is merely more so by virtue of its increased technical power and mystique.

Development

The development discourse has created knowledge about and representations of the Poor of the world which Escobar (1995) and others argue is often harmful. Esteva (1992,7 quoted in Blaikie 1996) even suggests that 'you must be very dumb or very rich if you fail to notice that "development" stinks'. In this light GIS is a techno-representation readily controlled by the powerful. A GIS may be of spurious authority and map people into co-ordinates of control, but more positively it can also display areas where people are at high risk (for environmental and/or social reasons), or provide an ideal instrument for local management of a project (Yapa 1991), or make radical inputs into land reform (Harris *et al* 1995; Weiner *et al* 1995). All depends on who constructs and analyzes the information and who controls the GIS (Bell 1996).

Technology transfer

Poorer countries are not only highly diverse but have invested very differently in GIS: there are both success stories and failures. We seek to extract common threads. First, can a technology initiated and concentrated in industrialized countries be valuable where fewer resources are available? Is GIS concentrated in the North because it is inappropriate in the South, with the result that the diffusion of the technology has been slow and compilation of high quality databases difficult? Or, is it because 'the North wishes to preserve its control of "the tree of knowledge" '(Menou 1993, 29)? To what degree are those GIS systems in use outside richer countries contributing to desirable change and the proper uses of knowledge? A decade ago, cases where GIS had truly promoted desirable change in poorer countries were few (Drummond and Stefanovic 1986). Menou (1993) and Sahay and Walsham (1996) found little evidence that IT promotes 'development' or even productivity, and maintain that the potential benefits of information are based on unsound assumptions, notably that access to information has no cost implications.

Second, if GIS can be an effective tool for locally desirable change, how should it be introduced and managed to this end? We agree with D Taylor (1991) that 'Indigenous scientists have an important role to play as they have an appreciation both of GIS technology and of the development problems faced by their home countries', and would argue that they must understand both the general and the local politics of GIS and indeed of geographical information. Education and training then become central to local empowerment.

Third, how can useful GIS be developed when the main market for software remains in the private sector in rich countries? Many ascribe the failure of IT in poorer countries to a focus on the technology rather than on appropriate local application. This 'technology-led' focus suits the purveyors of hardware and software but may lead to misuse of IT systems, to their under-use, to the conception by users of data as objects rather than constructs, or to the exploitation of IT as a symbol and/or realization of status or power.

In industrialized countries, GIS may be used as little more than an expensive mapping tool and the promotion of a single 'objective' discourse. But in poorer countries, non-appropriate use may mean project failure or, worse, the legitimation of a destructive developmentalism (Mather and Paterson 1995).

Applications of GIS are excessively driven by software suppliers (Clark 1992), so that 'serious difficulties are encountered as a result of the mismatch between the organizational cultures that is implicit in the information management ideology of the suppliers and that of the receiving organization' (Masser and Campbell 1991, 61). Institutions themselves have geography, and no GIS can be separated from its cultural context, least of all that of the institutions within which it operates. According to Michael Thompson (cited in Blaikie 1996, 18) "institutions are the facts".

Some manufacturers make donations to organizations in poorer countries, as with the donation of ARC/INFO to the United Nations Environment Programme (GRID project) in Nairobi (Hastings and Clark 1991). GIS was given an impetus at the National Malaria Research Programme in Durban, South Africa when free copies of AutoCad and ArcCad were won in a competition. However, despite good intentions, over-commitments meant that staffs were unable to provide the technical support required (pers comm, Carrin Martin). Similarly, to increase a vendor's hold on the market, organizations are offered cheap GIS software to provide a "start-up" base (compare the recent CHEST software deal for ARC/INFO in the UK). Market opportunities for other, perhaps more appropriate, cheap or public-domain software are then restricted.

The key issues are (a) technical, (b) data and (c) organizational, the last being the most important and intractable. They are not mutually exclusive: issues of data quality and availability, for example, are important in both a technical and an organizational sense.

Technical issues

For both computer hardware and software, the key requirements are: (i) user friendliness, with minimum system management and a user interface written to reduce users' initial unfamiliarity (perhaps using menus and windows); (ii) low costs, since financial support for expensive systems may be impossible to justify.

An investment in GIS still represents a considerable initial financial outlay, even if the system eventually proves cost-effective. Furthermore, GIS requires a certain minimum of hardware, usually peripheral equipment (printer, plotter, digitizer or scanner etc) in addition to, say, a basic micro-computer.

Support networks in the same country or region are essential, since problems with IT require an immediate or rapid response, and there are certain minimum requirements. First, software must be upgraded over time, and hardware maintained and serviced. Introduction of equipment in a rapid or uncontrolled way inevitably creates problems and specialized hardware maybe unfamiliar. Systems must be introduced slowly to allow time not only for technical training but also for networks of spare parts to be developed. Second, help from software vendors is needed. In rich countries this is acquired through established networks by telephone, fax or e-mail, which may be is unavailable elsewhere. Informal support networks are effective, but local software support groups or centers may take time to become established. Third, after training, people need to maintain and extend knowledge and skills through, for example, adequate library facilities or conferences.

Data

The techno-science paradigm of GIS in its first phase must be reworked in the South. Remote sensing offers a great deal in environmental and land-cover mapping, but socio-economic data require expensive field surveys, raise issues of ethics and power, and are often both scarce and of questionable quality. In particular, there is a lack of spatially-referenced datasets, such as basic registration data for health studies. Too often**,** dubious census data are accorded the same status as a carefully ground-truthed map from a satellite image. The cost of converting data into a digital format must also be considered, a problem addressed in China where school students are digitizing data (International GIS Sourcebook 1993), simultaneously building up digital banks of spatial data and learning to construct it.

Even where datasets exist and can be converted to a digital form, there will be inconsistencies in geoforencing systems or geographical scales, and difficulties in the sharing of data and the coordination of information flows between users. Data-sharing may be especially problematic in environments which are not "information-driven" and in which bureaucracy presents particular obstacles. Competitiveness and empire-building prevent the free flow of data because common goals are not shared.

Where resources are restricted, people must decide whether they can justifiably utilize poorer-quality data in systems which generally assume accurate datasets and high degrees of spatial resolution. The answer clearly depends on the ultimate objectives of a project. If, for example, the construction of a GIS enables the display of multiple realities (Harris *et al* 1995), or if it yields a generalized solution for which high levels of accuracy are not required, then we can support the use of less precise data. Examples include the use of rasterised data (in rectangular cells) for mapping and modeling changes in vegetation cover at small geographical scales, or the production of the *Atlas of Women and Men in India (*Raju *et al* in press) which incorporates comments on data construction and quality.

Participatory appraisal exemplifies the problem of the appropriate data type and source for GIS. A substantial literature, both formal and informal, argues for people's participation in the construction of data, quantitative and qualitative, relevant to understanding their own situation, and for a whole battery of new techniques to elicit and present such information (Khon Kaen University 1987; McCracken, Pretty and Conway 1988; Chambers 1994; Stewart 1995). Such knowledge facilitates a micro-level planning which can implement much more relevant interventions than the top-down approach could ever hope to do. But this new orthodoxy largely eschews GIS, regarding IT as integral to that power knowledge which is essentially urban-based, hi-tech, capital-intensive and "expert". Because Participatory Appraisal rejects techniques or technologies which are complex, expensive or time-consuming, the worlds of IT and rural poverty have slipped by each other. The ethics and politics of access to and control of knowledge are sensitive and difficult for all knowledge constructed with the help of local participants, whether or not such knowledge reaches a GIS. The new orthodoxy is contradictory and problematic but still represents an advance (Blakie 1996) because of its grassroots engagement, and it should use GIS when appropriate.

Like Connor (1994) we see computers as a valuable complement to Participatory Appraisal and cannot see why they should be mutually exclusive. We call therefore for the development of GIS software which will allow, for example, for the mapping of the variety of different 'spaces' revealed in a village appraisal exercise, such as the cognitive maps reproduced in Mascarenhas and Prem Kumar (1991) or the watershed maps of Parmesh Shah (1995), which enable local control. Sketch maps are an important source of insights into multiple realities and conflicting interests. Subject to the availability of sufficient memory, "appropriate" software might also incorporate a multimedia element to allow the storage of location-specific data such as graphs, photographs, video clips and sound- tracks. One notable achievement here is a participatory GIS for land reform in post-apartheid South Africa in which local socio-cultural understandings derived at the village level are integrated with conventional thematic information (Harris *et al* 1995;Weiner *et al 1995).* Although at a preliminary stage, this work demonstrates how GIS can include the interests of the disadvantaged.

Organizational issues

"The world is full of working, functioning information systems" (Bell 1996,4) and a key question is whether GIS can improve those in poorer countries. Clearly IT can only succeed when written into the relevant social, political, institutional and economic contexts. One problem is that GIS displays relationships much less easily than attributes and Mather and Paterson (1995), in their use of GIS to assist the restructuring of education in post-apartheid South Africa, emphasize how dangerous the invisibility of power relations could be in such a case. One answer is to integrate a technology such as GIS, both inside an organization and in terms of a wider infrastructure, as did Lakshman Yapa (1991) in Sri Lanka. GIS must be part of an organization's overall, long-term activities and goals not just a quick fix for a single issue (Bell 1996). Conversely, configurations of hardware and software should be designed to address a range of problems. The sustained application of GIS requires careful feasibility planning or human and computing resources will be wasted.

Optimal integration of the technology with the existing infrastructure will depend on optimal distribution of resources. For example, national or regional centers with telecommunication networks for data transmission may be appropriate for handling large environmental databases, while local projects call for distributed knowledge and resources and urban planning may need to link district with national material (Hutchinson and Toledano 1993). Any GIS must be designed for its physical infrastructure, which in poorer countries may not offer reliable electricity supplies or voltage, or meet the need for air-conditioning or dust-free environments, or offer the physical security that facilitates the wide use of technology.

Srikumar Chattopadhyay (1993) describes a project in Kerala (India) to map the environmental resources of every plot of land and create a database to support 'sustainable development'. In each *panchayat (*the smallest unit of local government), a team is trained to construct basic data, including the location of boundaries, transport and communication facilities, services such as schools, clinics, temples and shops, economic resources such as industries and natural resources such as water bodies, forest or wasteland. Meanwhile a technical team maps the local geology, geomorphology, land use and such focus of environmental concern as areas subject to flooding, landslides, soil erosion and other forms of degradation. The results are then merged in a GIS.

This experiment is self-aware. It seeks to empower villagers by providing each *panchayat* with a detailed map of their resources with some suggestions for interventions. The latter are then worked into short-, medium- and long-term action plans in consultation with the people, and a Panchayat Development Society (comprising local technical personnel, village elders and representatives of non-government organizations) is established with a brief to initiate projects. Each *panchayat* will also have a Land and Water Resources Inventory and Monitoring Group to ensure people's continued participation in the monitoring and control of their resources. The total cost averaged Rs 1500 (about £30) per km2 or £600 per panchayat.

Training and expertise

Human resources and expertise underlie all organizational, data and technical issues. At Durham, we recognized the shortage of skilled staff in South who can make well-judged, practical use of GIS technology, and we have therefore developed a full-time postgraduate modular programme in Geographical Information for Development. This is targeted at those from poorer countries and is "primary", directed training which is UK-based. Despite the disadvantages of training away from home, students do gain from each other and from a training programme free from the intrusion of other commitments. Our objective is to educate professionals, not train technicians, by exploring appropriate uses of GIS in the context of other geographical methods. Choices of hardware and software must be informed. The course also explores, for "physical" and for "human" applications, what types of knowledge and forms of analysis are appropriate where resources are restricted.

Such training must not entail a "blind" (and illusory) transfer of technical skills. Users must understand the ethics, limitations and applicability of systems such as GIS: 'True technology- transfer happens when it is accompanied by knowledge and understanding of the reaches of the tools the users have been given' (Guevara 1989, 16). 'A technical outlook itself imposes a specific range of constraints…. The analyst is a key issue' (Bell 1996, 60, 74).

The uses and abuses of GIS should be taught *with a health warning:* "these results may damage your understanding". Students should not only learn techniques and applications (which is what most want!) but be exposed to the debates which have been generated and to thorny questions of 'geographical information for development': from multiple realities to discourse as power; from GIS to life histories; and from geomorphology to indigenous knowledge and control. We must all learn the politics of geographical information, but geographical information is like biological warfare: learning defense against it means learning how to use it. Our course, for instance, cannot render IT innocuous and we recognize that professionals with a grasp of the politics of IT could exploit its power for their own ends. We can only seek to raise awareness. At Durham, many students find it difficult to come to terms with that part of our course which is devoted to the nature and construction of data, no doubt due to the success with which GIS has been promoted as a technological fix.

The test of overseas training is what students can achieve on their return home. Our aim is to contribute to a sustained, growing base of local knowledge and technological development where our students themselves train professionals in GIS. Clearly one provision is that students return to an environment in which a "critical mass" of equipment and software is already in place or about to be purchased (van Teeffelen 1991). Some of our students, for example, are funded by international agencies in order to return home to instruct others, using systems provided by the same funding agency. In addition to primary training, secondary training is needed, as by short courses at home such as we have offered where we have funded links, in Nigeria, Brazil, Bangladesh and Mexico. Geography Departments in universities in poorer countries are slowly developing their own GIS programmes, notably in China where training is taken particularly seriously and is now extended to other poorer countries (International GIS Sourcebook 1993). Ironically, then, true success will come when we self-destruct because all training can be provided locally in the South.

Conclusions

Poorer countries are not victims of an exploitative system of technology-transfer from the North. Such a prejudice is perpetuated by talk of "cyber science and star wars application" and "Third world scholars [who] cannot afford even the most basic of hardware and software materials" (Pickles 1995, 453). This greatly undervalues the high levels of skill in countries such as India and China, where low-cost GIS packages such as Themaps and Pursis have been written. The potential for South-South collaboration is substantial and in India, IT is already a major growth sector.

For us, IT is 'appropriate' if it fulfils an objective, which cannot otherwise be meet and if it can help to achieve the goal of desirable change (Emmanuel 1982). It could be argued that GIS technology in some ways may be more useful to poor countries since many issues of poverty relate to large scale problems requiring integration of large spatial dataset. The availability of remotely sensed data and other national and international databases can facilitate action. There are dangers, but they are those of the discourses in which GIS is incorporated and, particularly, sold. Under appropriate control and with informed use, GIS have the potential to contribute positively.

Ideally, local knowledge and local control or at least accountability should be incorporated. A GIS should never be used as a "quick fix" strategy; rather its introduction should be slow, with long-term or medium-term training programmes, directed at real needs, and the design should be relevant to local conditions. Training and education are core issues and we argue that the "health warning" approach has more to offer than either standard "high tech" training programmes or courses run by software vendors.

GIS is a tool of power. Like all geographical information, GIS has the potential to reduce social inequities or to exacerbate them, both within countries and in terms of a wider North/South divide. GIS can be subversive or it can empower a techno-elite (Clark and Worobec 1996). But we agree with Yapa (1991, 52) who argues that GIS may also be an instrument for 'discovering' local resources contextually and that the full implementation of appropriate technology is not possible without access to a GIS because it is the knowledge of the region (and the ability of the GIS to enhance this knowledge) that makes appropriate technology a viable alternative to the current modes of development.

In our view GIS could become a tool in the service of the poor rather than a further technological instrument for their control. To that end, we want to launch the debate in *Area,* and expect a strong response.

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