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Public participation, GIS, and cyberdemocracy: evaluating on-line spatial decision support systems

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Abstract. In this paper we describe the development of Internet-based approaches to public participation and on-line spatial decision support systems in particular. Two case studies in developing web-based public participation GIS (PPGIS), one local and one regional, are described in detail. Results from the live testing of these systems are shown. These are discussed in the light of recent developments in 'cyberdemocracy' and conclusions are drawn about principles of on-line PPGIS and problems associated with public participation, user interaction, and familiarity with IT, copyright issues, access to the Internet, and relevant political structures.

Introduction

Traditional methods of public participation in environmental decisionmaking focus on two aspects of the planning system, the development control process and the development plan process. Development control is a process that regulates the development and use of land, and the development plan provides a strategic land-use framework for a city or region. The degree to which the public are provided with the opportunity to become actively involved in either of these processes is variable (Thomas, 1995). Public involvement in the planning system is often perceived as a 'them and us' situation with authoritative decisionmakers having exclusive access to knowledge, expertise, and power. Other participants in the process are primarily large organisations or pressure groups with vested interests, as opposed to individuals or small community groups. This can often lead to the vocal minority dominating the debate at the expense of the general population. As Healey et al (1988) state, many people, who may have equally if not more valid points to make, resist from expressing their concerns, opinions, and viewpoints.

The ability of the public to participate effectively in the planning process depends on a variety of circumstances and access to resources. It takes time, familiarity, and confidence with bureaucratic procedures, personal contacts in key places, money for campaigns, and private transport in order to attend meetings (Parry et al, 1992). All these factors play a key role in whether the public can or cannot be involved in the participatory process. Although this situation may not appear to be encouraging for participatory democracy, evidence from some countries (Howard, 1998) suggests that technology may have a leading role to play in the way the public participate in the everyday running of their communities.

The proliferation of the Internet as a communications medium over the last decade has provided many new opportunities to disseminate public information. One only has to look at the UK government's web site to realise the potential of the new medium, as nearly all UK local authorities now have some form of web presence. Although the degree of take-up varies between different local authorities, the potential for using the Internet, and in particular the World Wide Web (WWW), within the planning field is significant. Although it is recognised that social exclusion in the information society

is an important issue, in this paper we discuss the many benefits which web-based public participation can bring to the environmental planning process. Even as early as 1996, when the WWW was still in its infancy, technopositivists were prophesising a bright new future based on 'cyberdemocracy'. The Internet is central to this vision and will "generate a new public sphere supporting interaction, debate, new forms of democracy and 'cyber cultures' which feed back to support a renaissance in the social and cultural life of cities" (Graham, 1996, page 2).

Public participation using web-based GIS

Many environmental decisionmaking problems have at their core a significant spatial element. This can often be best represented within a geographical information system (GIS). A GIS is a computerised mapping and database system capable of holding and manipulating spatially referenced data. They are widely used in the field of environmental planning as a decision support tool (Stillwell et al, 1999). In this paper we explore the ways in which GIS and the WWW can be used together to provide the general public with a powerful mechanism for becoming more involved in environmental decision problems. Provision of full access to spatial and aspatial data, along with the appropriate tools with which to use it, may greatly empower the general public. This gives the public greater opportunities of engagement, at a more equal level, with those bodies legally entrusted with decisionmaking powers at local, regional, and national scales. GIS has in the past been accused of being an elitist technology, giving more power to those people already possessing it and depriving those, namely the general public, who more often than not lack such direct forms of information access (Monmonier, 1996; Pickles, 1995). It is hypothesised here, however, that public participation GIS (PPGIS) could help overcome such criticism by creating a more level playing field on which to conduct public debate.

It is recognised that the nature of information and political power goes much deeper than access to information and formal routes of involvement, digital or otherwise. Indeed, we are sensitive to the fact that there is a much wider debate about empowerment, democracy, trust, and accountability in policymaking. However, it is beyond the scope of this paper to discuss all of these issues in detail, although reference is made to them where appropriate. Rather, the technical issues surrounding Internet-based GIS for facilitating public participation are described together with a discussion of the potential implications for citizen-focused decisionmaking.

Two key issues that are raised in this paper are those of public access to the Internet and training in its use. It could be argued that possible increases in participation are contradicted by the inequalities of public issues to the Internet. Current estimates of public Internet access vary from source to source, but it is becoming clear that, over the next decade, Internet access will continue to grow, eventually becoming as widely used as other consumer electronics. Access is also increasingly being made available through open access points in public places such as libraries, community centres, and council buildings, as well as through schools, universities, and businesses. Together, these generate ever-widening opportunities to 'get on-line'.

Further issues surrounding the empowerment of the public and how they may interpret and use GIS-type tools on the WWW are also explored. Monmonier (1996) argues that the public access to GIS technology in opposing siting decisions for controversial facilities can actually put them in a vulnerable position. He suggests that the public "armed with a GIS but lacking the savvy to use the systems appropriately become vulnerable to sarcastic attacks from site advocates". It is argued here that providing public access to GIS via the Internet, through carefully designed interfaces, empowers the public in a more positive way if the mode of use is controlled to avoid

inappropriate use. Examples from several communities in the USA have returned positive results from all sides of the decisionmaking process (Shiffer, 1995). In the United Kingdom, increasing numbers of organisations are taking public participation very seriously, as public involvement and public ownership of decisions made become ever more important.

In contrast to traditional methods, new forms of participation are beginning to evolve, and experience from North America suggests that there are many advantages to web-based participation (Howard, 1998). A key advantage is that planning meetings are not restricted by geographical location. Access to the information about the issues being discussed is available from any location that has web access. The information is also available at any time of the day thus avoiding the problems associated with holding meetings in the evenings. The concept of '24/7' access (in other words, 24 hours a day, 7 days a week) opens up opportunities for more people to participate in public consultations. With a web-based system, the public is at the end of an Internet connection that enables them to make comments and express their views in a relatively anonymous and nonconfrontational manner when compared with the traditional method of making a point verbally in front of a group of relative strangers.

These issues are exemplified through the following discussion of three case-study examples developed at local, regional, and national scales. The findings and results from these case studies provide a solid platform from which to develop new methodologies relating to the development and implementation of web-based PPGIS as an aid to environmental decisionmaking. We argue that providing access to particular decisionmaking problems over the WWW will play an increasing role in the way future environmental decisions with a strong spatial element are made.

Case studies in web-based PPGIS

The research reported here has centred on three public participation schemes tackling environmental problems with distinctive spatial components. The spatial remit of these is each at a different scale, including local, regional, and national examples. At the local scale, the people of the village of Slaithwaite in West Yorkshire have been given the opportunity to decide on future improvements to their village. At the regional scale, tourists and local people have been asked where new native woodland should be planted in the Yorkshire Dales National Park. And, at the national scale, a scheme is being developed that may ultimately allow the population of the United Kingdom to participate in decisions regarding how and where the country's low-level and intermediate-level radioactive waste will be stored or disposed. Owing to the sensitive nature of this problem, the prototype system was not live-tested and as such no results are presented here. An earlier version of this work is discussed at length by Carver et al (1997).

Local planning

The village of Slaithwaite, in the West Yorkshire district of Kirklees was used as a test bed for public participation "Planning for Real" (P*f*R) initiatives in the area. P*f*R was developed and patented by the Neighbourhood Initiatives Foundation (NIF) as a means of involving local people in local environmental planning problems and decisionmaking. This involves the local community creating a large-scale map or three-dimensional model of the area, into which local people place flags of various colours. Written on each flag are their ideas for the places where they have put them. The colours represent different classes of problems such as 'health' or 'crime'. In this instance, the map we built by local schoolchildren at a 1:1000 scale (figure 1, over), and the P*f*R event "Shaping Slaithwaite" took place on the day of the village fair, making it

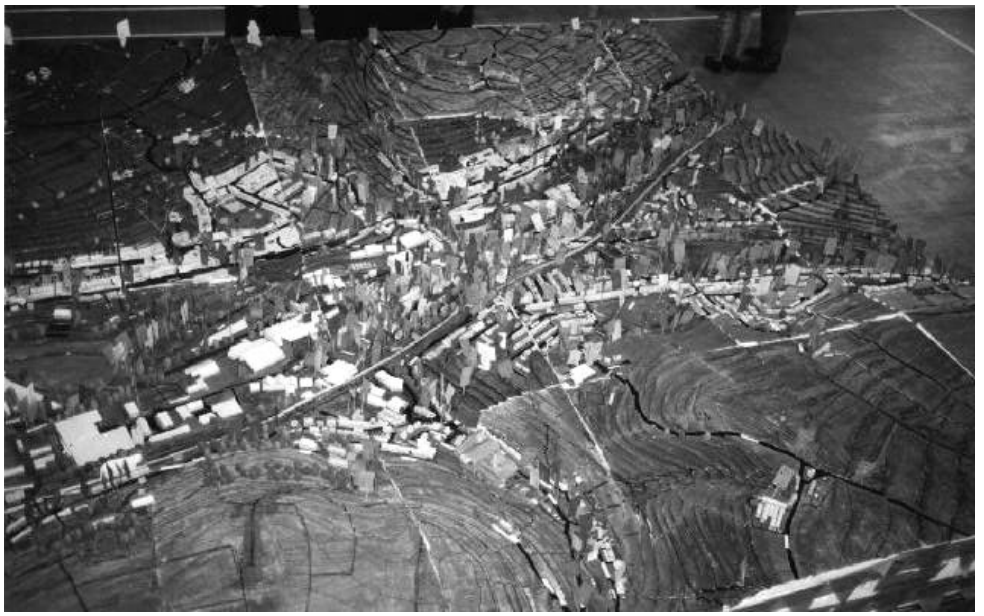

Figure 1. "Shaping Slaithwaite" P*f*R model showing coloured 'comment' flags (photograph: S Carver).

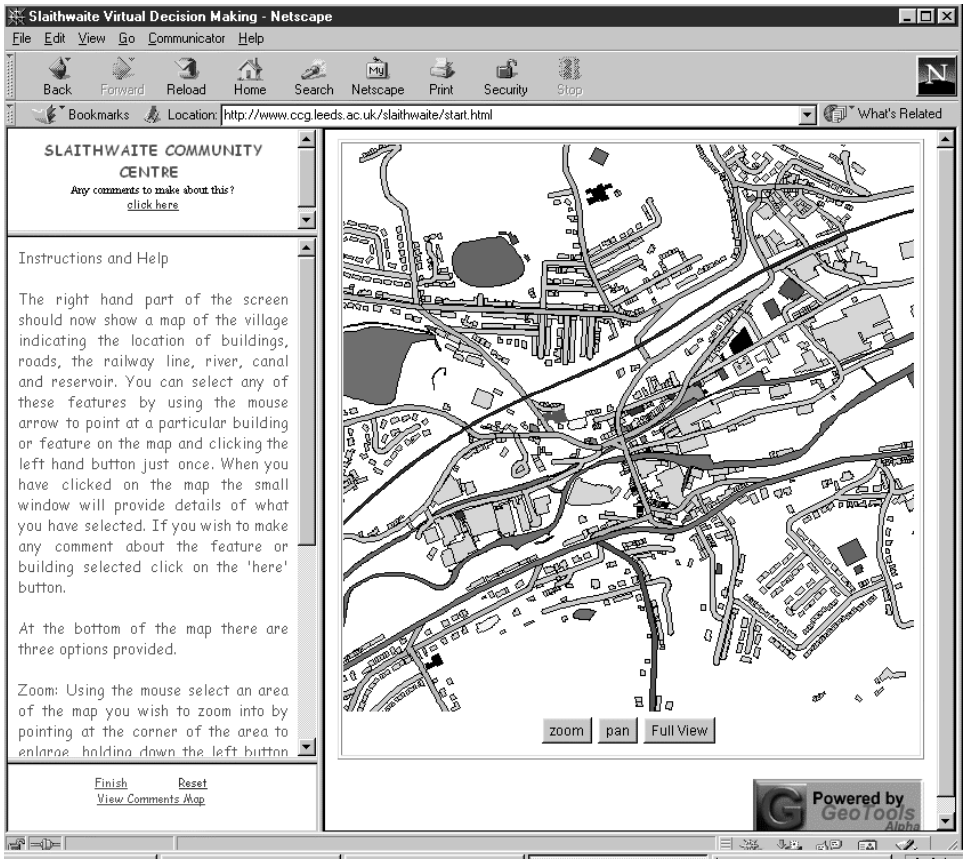

Figure 2. Virtual Slaithwaite: main map interface (source: http://www.ccg.leeds.ac.uk/slaithwaite/).

well attended by a broad range of the community. The exercise was planned as the highlight of the day with entertainment from the local brass band and choir, and information on other local projects. The event was coordinated by NIF and the information fed back to the local community and government body (CVT, 1999a; 1999b).

In parallel with this community event, a web-based version of the map was developed (figure 2), which was arguably among the first such systems available to the public that allowed a two-way flow of spatially referenced information. To facilitate access to the web application, we took eight PCs to the "Shaping Slaithwaite" event. The application provides a vector map of the area, which can be zoomed, panned, and on which features can be queried. If users feel a particular feature, or area of open ground, should be developed they can call up a form that allows them to enter their suggestions. Demographic information and information on the users' feelings about the system are also collected. The application is implemented using 'Geotools', a Java toolkit for the display and querying of GIS data files. The user responses are handled using PERL server-side scripts and HTML forms. Unlike the P*f*R map, it was decided not to allow users to view other people's comments to encourage individual and imaginative responses. However, at the end of the consultation period the system was updated to allow the public to query a map containing all the comments made by using the system at the "Shaping Slaithwaite" event (figure 3). These comments were fed into the P*f*R process.

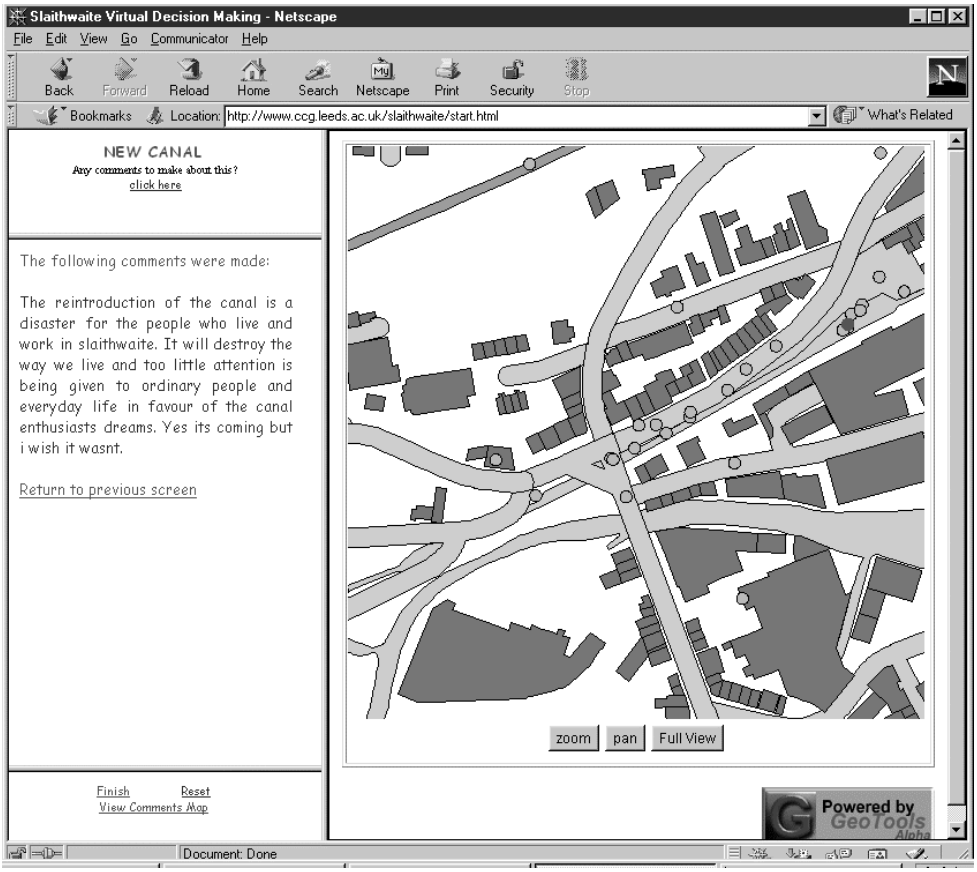

Figure 3. Virtual Slaithwaite: comments map (source: http://www.ccg.leeds.ac.uk/slaithwaite/).

Woodland regeneration

At the regional scale, a project has been set up with the Yorkshire Dales National Park Authority (YDNPA). The YDNPA has proposed a 50% increase in the 'native' woodland in the national park over the next 25 years (YDNPA, 1995). They have not, however, fixed the locations that will be planted. Clearly, such a planning problem should involve some GIS modelling and the participation of both local communities and tourists in the decision. To involve these groups in the planning process a web-based decisionmaking environment has been developed (figure 4), centred on an easy-to-use GIS that allows the public to model a number of possible planning scenarios. This system was live-tested with the public at four different visitor centres within the national park over a spring bank holiday weekend.

Members of the public are first shown information relevant to the problem, such as the factors that might influence possible planting locations. They are then asked which factors are relevant and how important they feel their specific influences should be. A map of suitability for woodland regeneration is then generated from these inputs and stored as an example of the user's opinion prior to giving users the opportunity to experiment with the GIS. Users are allowed to regenerate the map 'on the fly' by changing their factor choices and/or changing the weighting of the factors included. A further facility allows users to 'top slice' the suitability map to identify the best areas for woodland regeneration. This allows the users to experiment with different scenarios, and see the implications of their choices (figure 5). Both the initial and the final set of factor choices and weights are recorded allowing decision maps for each user to be recreated as required at a later date.

An information system that allows users to browse in-depth information relevant to the problem is also provided. Access to this is through a tree hierarchy, with more

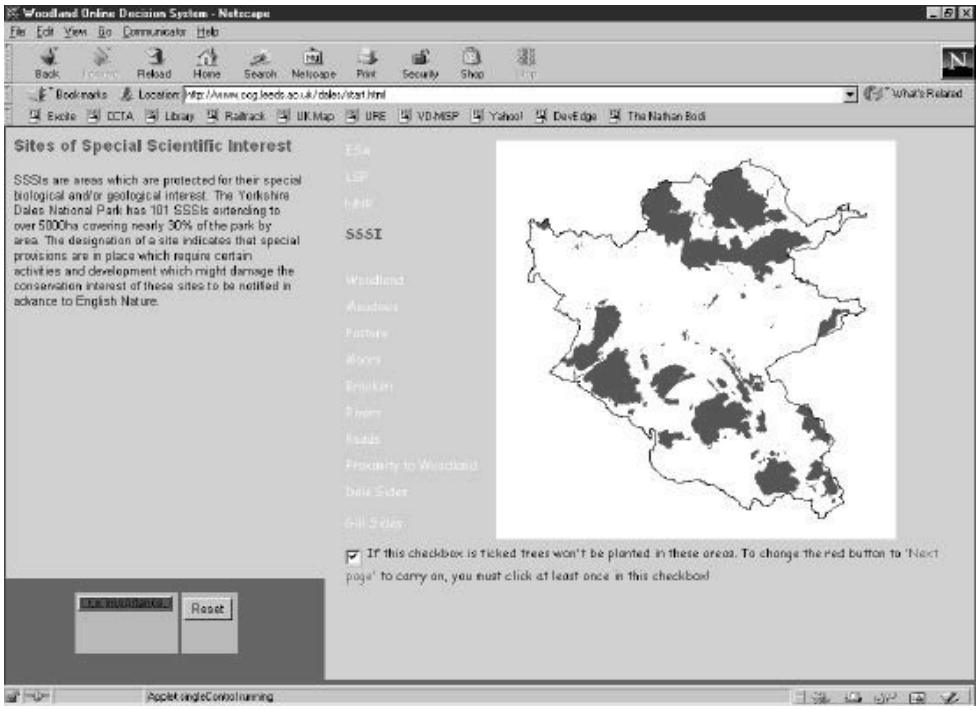

Figure 4. Factor map selection and information interface (source: http://www.ccg.leeds.ac.uk/dales/).

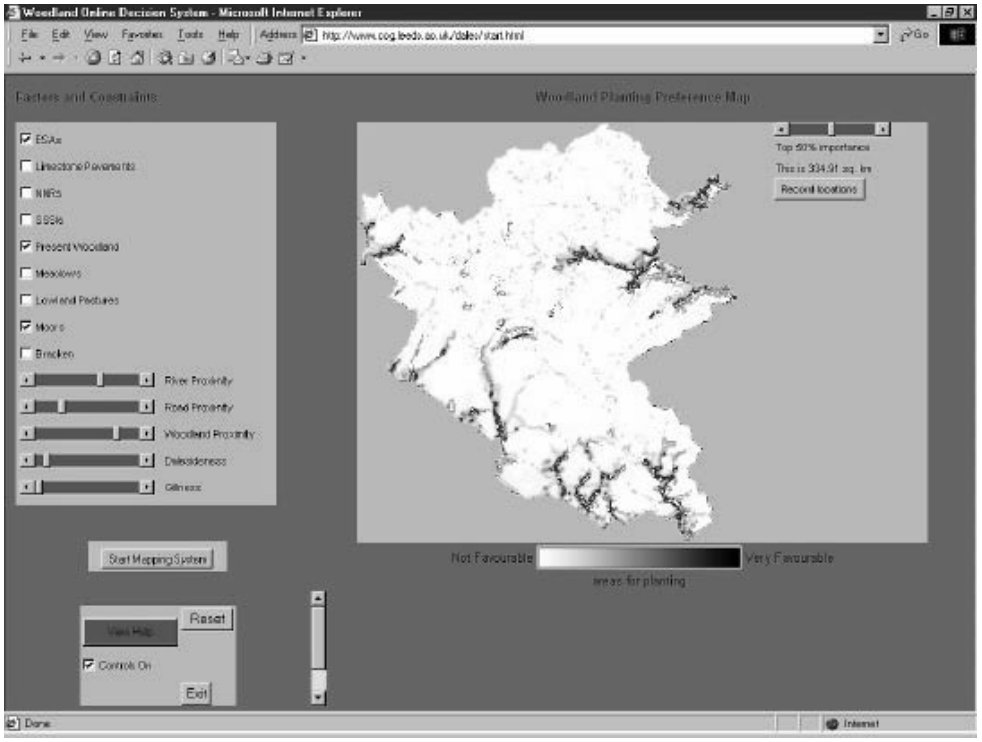

Figure 5. Main map interface showing user controls and selection of best areas (source http://www.ccg.leeds.ac.uk/dales/).

detailed information on each subject further down each branch of the tree. The tree system was designed to encourage the exploration of information to a level of detail the user felt comfortable with. Should the user be interested, meta-information is also provided on how the spatial data have been derived, their quality, and how the system works.

As with the Slaithwaite system, demographic and usability data are collected from each user. The system has been implemented entirely in Java and JavaScript to facilitate its distribution as a stand-alone package. The software was designed to be fully controllable from the invoking html pages, allowing its use on a wide variety of projects.

Results from case-study experiments

Users

Results available for the Slaithwaite study suggest that, among certain sections of the population, the web-based system was found to be both useful and popular. At least 126 people used the system, largely during the "Shaping Slaithwaite" event. However, there is still a considerable skew in the people prepared to use such systems, even when easily available. There is a strong male to female bias (7:3) amongst users. The occupation information (figure 6, over) collected in the user profiles suggests strong weighting toward those in professional/managerial and educational positions, whereas the age distribution (figure 7, over) shows a heavy skew towards schoolchildren. The latter is partly a result of educational trips to local primary schools made by us prior to the event, and partly reflects the inability of schoolchildren to use the three-dimensional map, which was too high and wide for them to reach. Although data were not

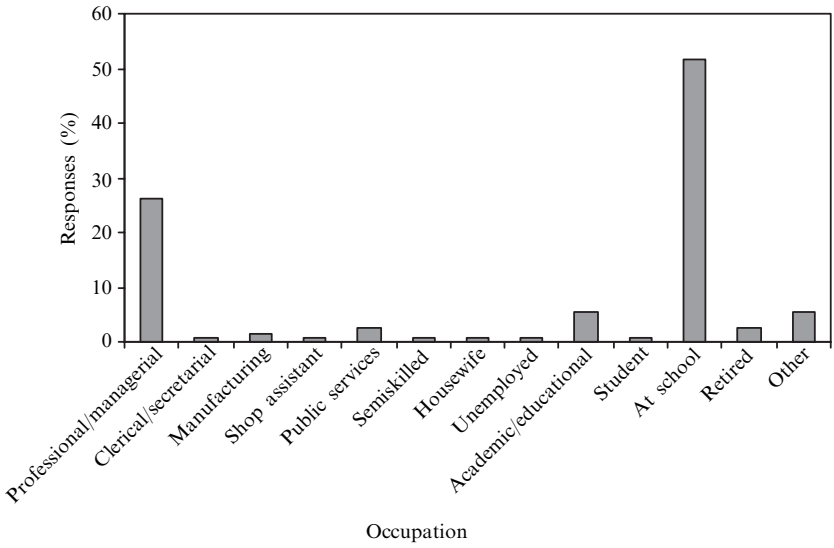

Figure 6. Virtual Slaithwaite: occupational breakdown of users.

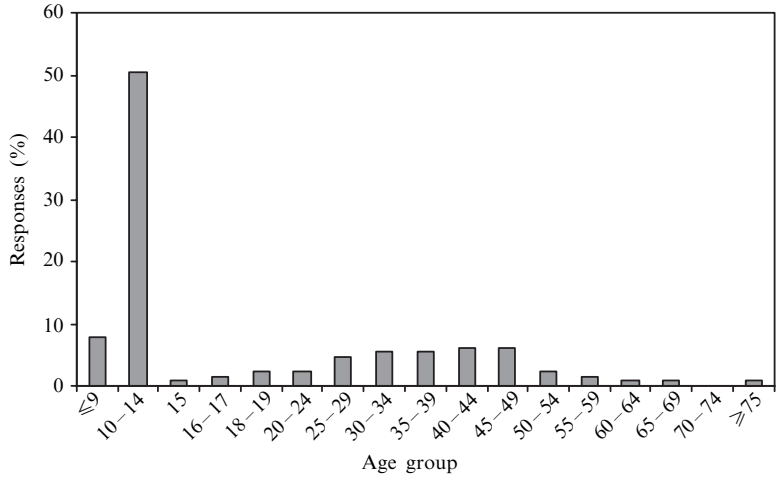

Figure 7. Virtual Slaithwaite: age structure of users.

collected on the mobility of the users, it was clear at the event that the PC-based maps also attracted a number of adults who found the three-dimensional map difficult to use. Given the age distribution of the users it may be worth noting that once the age data were stripped from the comments, it was impossible in most cases to guess the age of the users from their suggestions, reflecting the genuine interest of all the users in their local environment.

During three days of testing the woodland regeneration web site in the Yorkshire Dales National Park, over 200 people used the system. From this, a total of 125 valid responses were extracted from system log files. Initial results from the case study are provided below and show an increase in the proportion of middle-aged people who used the system. Figure 8 illustrates that school students again appear very comfortable using the system. Observations made of people using the system revealed that it was often the children in family groups who operated the system while their parents made suggestions about which factors and constraints to set and the comments to make.

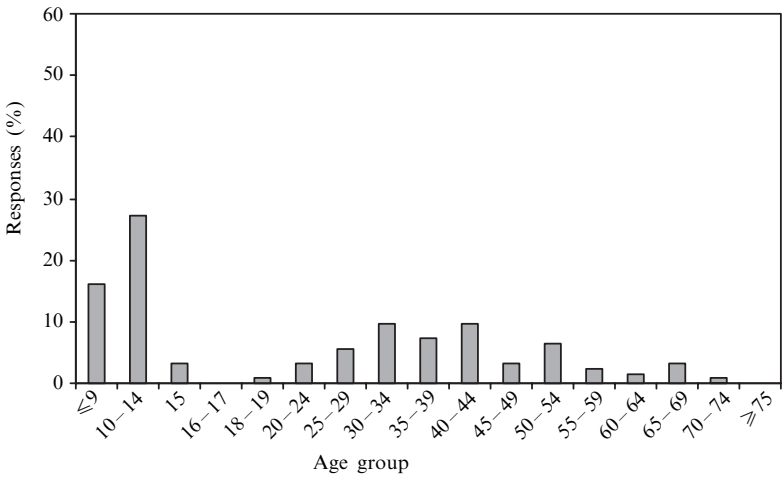

Figure 8. Woodland regeneration web site: age structure of users.

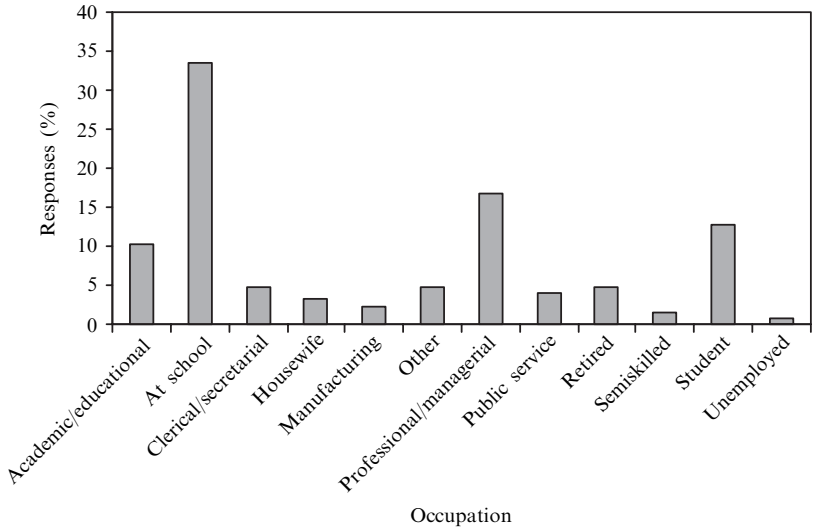

Figure 9. Woodland regeneration web site: occupational breakdown of users.

Figure 9 shows that, excluding school children, the largest group of people using the system was from the professional/managerial sector. This is not a surprising result considering the systems were located in the national park visitor centres, which attract many such visitors with their children.

User interaction

During the "Shaping Slaithwaite" event, we had the opportunity to watch the public using the system. There was a high degree of proficiency in map usage amongst all the users observed. Users who could not immediately locate the area they wished to comment on simply found a prominent building or road and moved along the path that they would on the ground, querying features by clicking on them until they reached the area. Far more problems were actually experienced in using the computers themselves, particularly the mouse-controlled interface. When one of the research staff was not available, this was, more often as not, rectified by the younger members of the community, who either taught those with difficulties or entered data for them. All users

seemed to prefer the fact that they could type any amount of information on any subject into the comment areas. This is in contrast to the P*f* R scheme which limited contributions to a few lines which were classified into categories based on the types of problems estimated for the area by NIF.

Similar observations were made of people using the woodland regeneration web site during live testing at the Yorkshire Dales National Park visitor centres. Not surprisingly, very similar patterns of use have emerged, with users showing a high degree of spatial awareness and the dynamics of family groups being led by adult input through their children using the system. A high degree of agreement is also noted in the composite map drawn by combining all the individual decision maps generated by users of the system over the bank holiday weekend. This map is shown in figure 10. The map shows that there is general agreement among participants that woodland should be concentrated on the steeper ground of the dale sides. The darker areas of the map identify those areas where the greatest numbers of participants agreed that new planting should take place, with the darkest areas representing the choices of over 95% of users of the woodland system. These areas are broadly in line with the favoured locations for planting suggested by the YDNPA.

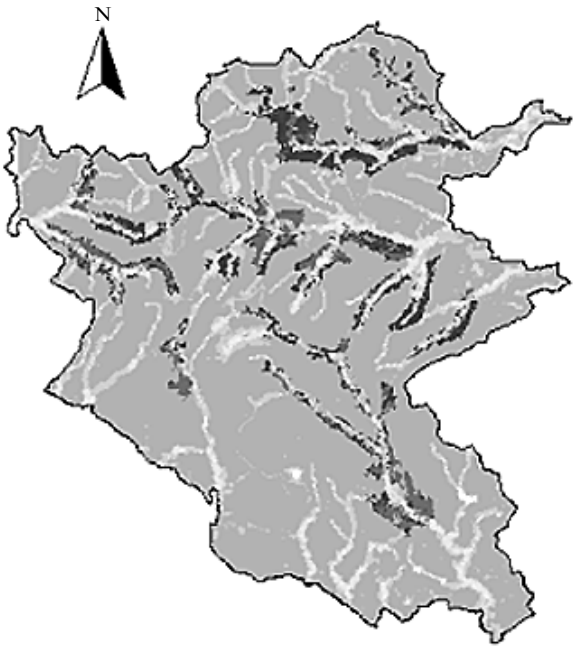

Figure 10. Composite decision map. The darker the shading, the larger the percentage of composite user choices.

Problems encountered and issues raised

Both of the case studies that were live-tested have provided useful feedback in relation to how people interact with on-line systems. This will enable future systems to be upgraded and improved. The ability to observe the public taking part in the case studies has been useful, and important lessons on user interface design and user dynamics have been learnt. Three main areas of difficulty that have been identified are IT training, Internet access, and copyright.

IT training requirements

In terms of specific difficulties relevant to the systems being developed in this research, one of the main obstacles has been the general lack of familiarity with the technology involved. In particular, many people, especially those from older age groups or manual trades, had never used a mouse before. A much smaller number of people had difficulty in understanding the map itself. This provided very useful insights into how system improvements could be incorporated into subsequent versions of the on-line systems and also in the wider area of how people perceive a two-dimensional map (MacEachren, 1995). However, it is understood that this will become less of an issue as more and more people become familiar with using computers and maps through work, leisure, or education.

Access to the Internet

The number of people accessing the Internet is increasing. NOP Research Group estimated that there were 7 million UK users in December 1997 (NOP, 1997), with market saturation approaching within a decade. A survey in 1999 estimated that the Internet was attracting 10 900 new adult users in Britain every day (NOP, 1999). The research also showed that around 10.6 million adults accessed the Internet at least once during 1998. This is a 48% increase compared with 1997. Although these figures suggest that the Internet, and in particular the WWW, is becoming mainstream, there is the potential that an information underclass is being created. One method of combating this is the provision of public access terminals in libraries, community centres, and even local public houses. Free local telephone calls for Internet access will also help to alleviate some of these problems.

Another development that may also circumvent the computer-literacy problem is digital television. It is envisaged that over the next 5 years digital television channels devoted to Internet-type access will provide a direct portal to the types of on-line PPGIS systems described here without the need for a computer and Internet connection. Analogue broadcasting is due to be phased out by 2010 in the United Kingdom. This effectively means that the majority of households will have a digital television and, hence, should have access to Internet-type channels, some off which may well be focused on public services such as on-line voting, public information, and participatory democracy.

Copyright problems

Although many of the technical obstacles that were first encountered have been overcome, an important legal issue remains unresolved. This relates to the copyright covering the actual data that are central to the system. The ownership of all the different pieces of information and data within an on-line system can cause major problems. Any system that is map based could potentially therefore be tied up in complex copyright and legal issues. The major problems encountered so far relate to Ordnance Survey (OS) maps being distributed via the Internet (Ordnance Survey, 1997; 1999). The OS is the United Kingdom's national mapping agency that holds the copyright over most maps. The financial burden of having to pay copyright fees for digital map data is a strong disincentive to develop on-line PPGIS solutions to local decision problems, especially for a public organisation such as a local authority or trust with limited funds. The copyright issue is probably the single most important factor that will, under present conditions of information copyright laws, prevent publicly funded organisations and projects in the United Kingdom from developing web-based GIS.

Principles of web-based PPGIS and the role of geographical space

Web-based PPGIS is in its infancy in the United Kingdom. Although many UK local authorities have shown an interest in implementing such systems within their planning procedures, only a small number have made any steps towards carrying out such a strategy. In light of our research in *real* decisionmaking problems, a set of PPGIS principles have begun to emerge which could be used as a guide to implementing a web-based PPGIS strategy. An on-line system should:

(1) allow the public to explore and experiment with the data and information sources which are available and provide the opportunity to formulate different scenarios and solutions to decision problems;

(2) be understandable by all sectors of the community who wish to be involved and not tied up in technical jargon;

(3) provide information and data that are both explicit and bipartisan; and

(4) foster a high degree of trust and transparency that can be maintained within the public realm to give the process legitimacy and accountability.

One way of addressing the final principle is through maintaining web-based PPGIS by publishing summaries of public inputs and demonstrating how these have been used to develop policy and to make decisions which themselves are then available for public scrutiny and comment. Such 'living systems' may well go a long way to fostering continued participation and wider acceptance of planning decisions.

A series of technical issues also need to be considered when implementing an on-line PPGIS and these are discussed in greater detail in Kingston et al (2000). The time it takes to download information is currently an important issue, particularly if people are accessing from home over a slow telephone connection. The type of web browser being used will also affect the users' experience of participating on-line. Although much of the GIS technology is hidden from the user, an understanding of how to navigate around a map and understand the map legend can cause problems for some people. Much research has been carried out into perception and understanding of maps (Keates, 1996) which can be of great use when designing map interfaces for public use.

The results from the case studies undertaken by the authors have shown that spatial scale can have a significant effect on the manner in which the public respond to particular decision problems. In local situations, by far the greater majority of local people are very interested in those decision problems that pertain to their area and thus affect them directly. As spatial scale increases from the local to the regional and, ultimately, to the national scale less and less people are interested in the issues despite the fact that in some situations, for example nuclear waste disposal, the actual decision problem becomes more important and more complex. Only people who are already interested in the problem at the national scale may participate. This is termed here the inverse-scale effect. However, as siting or other decisions are made at regional and national scales, the problem and its on-the-ground ramifications returns to the local scale, thus generating the same majority level of interest.

Conclusions

It is suggested that for particular planning problems, participatory on-line systems will become a useful means of facilitating access to data and planning tools such as on-line GIS, and therefore informing and engaging the public. These will provide common-place mechanisms for the exploration, experimentation, and formulation of decision alternatives by the public and thus have the potential to involve the public more closely in the planning process. The types of systems discussed in this paper hide the complexity of the GIS behind friendly, easy-to-use graphical user interfaces while still retaining

the ability to build up several scenarios or proposals based on particular decision choices made by the individual. We have argued that the provision of open access to particular decisionmaking problems over the WWW will play an increasing role in the way that future planning proposals and environmental decisions are made. The practical development and testing of these systems has helped to direct the future of public participation in decisionmaking by pioneering the use of GIS on the WWW for multiscale environmental problem solving.

Although the research has addressed many issues concerning the feasibility of developing on-line PPGIS and its role in the cyberdemocratic process, a number of key issues still need to be addressed. These include issues concerning access to the Internet, public understanding of spatial problems, and accountability within the decisionmaking process. The most important issue relates to access; if the public do not have easy access to a web-based PPGIS the whole process becomes ineffectual. It cannot be assumed that everyone will have web access. A great deal of thought needs to be given to this fact. How will people access a web-based PPGIS? Will there be suitable public access points, and if so where should they be located within the community? How do planning authorities ensure that information reaches local people and that genuine responses from local people are acted upon? How do family and other group dynamics help shape responses?

As stated earlier, certain types of maps may be difficult for the layman to understand. Standard cartographic techniques may need redefining and new approaches developed. Although simple maps showing roads and building outlines may be understandable, other formats, such as choropleth maps of income or unemployment, may not. Research is required into public perception of spatial problems and means of representation.

One final issue not covered thus far concerns accountability. What organisational aspects might ensure that the community is well represented and that few people are marginalised? It is possible for one group within a neighbourhood to take control and use a web-based PPGIS to promote their interests over the interests of other groups. There need to be effective ways of protecting the interests of the minority. How do we ensure that those in power will act on the decisions and outcomes from a web-based PPGIS process? If the process is community led there could conceivably be no impact upon those in power as local officials have no responsibility to take on board the proposals of local people. Contrary to this outcome is that, if the community viewpoint, opinion, and proposals are ignored by those in power, it is the community that has the ultimate power to give rise to changes through the ballot box. With this in mind local politicians may be more receptive to the types of issues raised by a community-led web-based PPGIS process. A high degree of trust and transparency needs to be established and maintained within the public realm to give web-based public participatory processes legitimacy and accountability. There is still very little research on the level of trust the public place on information they come across on the Internet. Some preliminary research recently undertaken by us suggests that some sectors of society place more trust in information on the web than in certain magazines or newspapers. However, a great deal more work is required in this area. If nobody trusts the information on the Internet, what use is it?

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APPENDIX

This appendix contains just a few of the present examples of GIS uses on the Web that are aimed at the public.

MetroMap displays community/government information for Portland, Oregon, that can be layered by the user or used to generate lists of boundary information; MetroMap, Metro, 600 NE Grand Avenue, Portland, OR 97232-2736, http://www.metro.dst.or.us/metromap/

The United Kingdom's Brent Council offers a number of map-based on-line information services; LA 21 on-line consultation, Brent Council, London, http://www2.brent.gov.uk/recycle.nsf

Friends of the Earth offer a number of map-based searches for local environmental problems; Friends of the Earth, 26 – 28 Underwood Street, London N1 7JQ, http://www.foe.co.uk/

Planning applications in County Wicklow can be browsed on-line by using the interactive mapping system; Wicklow County Council, Eire, http://www.wicklow.ie/planning/

An early on-line GIS system that allowed for public participation is "Open spatial decision-making on the Internet", Centre for Computational Geography, School of Geography, University of Leeds, Leeds LS2 9JT, England, http://www.ccg.leeds.ac.uk/mce/

Our present research, which extends the work discussed above, can be found at the VDMISP project page; "Virtual decision-making in spatial planning", Centre for Computational Geography, no date, School of Geography, University of Leeds, Leeds LS2 9JT, England http://www.ccg.leeds.ac.uk/vdmisp/

The MIT Computer Resource Lab have a number of on-line spatial projects; Computer Resource Laboratory, Room 9-514, Department of Urban Studies and Planning, Massachusetts Institute of Technology, 105 Massachusetts Avenue, Cambridge, MA 02139, USA, http://gis.mit.edu/projects/