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Accessing Geographical Information Systems over the World Wide Web: Improving public participation in environmental decision-making

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Abstract. This paper describes work carried out as part of the Economic and Social Research Council's Virtual Society? Research Programme and presents some initial developments in the field of spatial decision support systems (SDSS) on the World Wide Web (WWW). Particular attention is paid to the development of Geographical Information Systems (GIS) and web-based SDSS with the principal aim of increasing public involvement in environmental decision-making. Discussion focuses on public access issues and the implications for online approaches to public participation. Examples of three online SDSS are given covering local, regional and national scale case studies.

1. Introduction

The rise of the Internet and the WWW has created many opportunities for those involved in GIS and decision support research. In the last few years many GIS have appeared on the WWW giving the general public, or at least those with a connection to it, access to both GIS and spatial data. With this increased availability, previous criticism of GIS as an elitist technology voiced by Pickles [6] may no longer be valid. We are now beginning to witness the popularising of GIS, at least within computer user circles. However, most GIS on the web are merely demonstrations using sample data that, in the majority of cases, are not problem specific and will be of only passing interest to the user. Expertise may also be lacking on the part of the user to enable them to make full use of the system, while the delivery medium itself may not be wholly appropriate for public use. Furthermore, very few web-based systems allow the user to populate the data space with new data.

The Internet provides the opportunity to open up important national, regional and local decision making problems to a much greater audience and actually involve the public more directly in the decisions, which matter. This is not as straightforward as it seems as there are a number of questions, which need to be addressed. These are:

- development of multi-level systems to enable full access by different users;
- limitations of the Internet regarding multi-media and ease of interaction;
- danger of creating an information underclass;
- lack of commercial and political will;
- antipathy and apathy; and
- lack of understanding surrounding public and personal use of the Internet.

Public consultation and participation in the decision-making processes over the Internet is an intricate problem requiring multi-level systems depending on the characteristic of the individual user. Although it is noted that everyone should be capable of making judgements about a particular problem, it is recognised that differences in age, background, education and profession will require different approaches to the presentation of information and differences in interface complexity if effective interaction is to be achieved. How well these multi-level systems can be engineered depends very much on the complexity of the problem to which they are addressed.

The Internet is an ever evolving and rapidly changing technology. The limitations of the Internet and associated web browsers in regard to their provision of multi-media information and their ease of use can and does create certain difficulties regarding the design and building of online SDSS. Certain techniques employed within these systems may only be available when using particular browsers. The development of systems which can only operate on high specification hardware and software will limit the potential involvement of certain groups who may not have instant and easy access to the most advanced technology. Care therefore needs to be taken in the design process to always keep the needs and capabilities of the majority of end users in mind.

2. GIS on the Web

GIS, like the WWW, is also a fast growing technology and developers "can design GIS primarily for expert use or they can make them accessible to the lay professional and even to the general public" [4]. Many web sites are now available which give users the ability to access GIS packages and remotely held datasets. Web-based GIS operate by running the GIS software on a remote host site from the user's own computer. These systems provide tangible proof that many of the technological barriers to online GIS-based analysis have been overcome. Such example packages include well known commercial GIS such as ESRI's Arc/Info and ArcView which can be run from their own web servers. There are also a number of customised, problem specific systems, which provide good examples of interactive GIS demonstrations on the WWW. The Research Programme in Environmental Planning and GIS (REGIS) is one such example. This system focuses on the San Francisco Bay area allowing users to access many data layers through a user-friendly Graphical User Interface (GUI) and interactively build and submit commands to the GRASS GIS. Once commands have been submitted to the system the remote host processes them on the server machine and then returns the results to the user's own machine in the form of a graphical image or table. The REGIS web site can be accessed at http://www.regis.berkeley.edu/index.html.

Many online GIS systems are tailored to specific tasks. Public participation in local decision-making is often related to a single or specific set of issues and therefore requires a well-defined system to deal with the issues at hand. The CITYgreen initiative is an example of a GIS-based program that provides the user with the tools needed to map, measure, and analyse urban ecosystems. CITYgreen enables you to analyse how urban landscapes affect a variety of processes and issues, including household energy conservation, stormwater management, carbon storage and sequestration, and urban wildlife. With the help of CITYgreen local people can get involved with the way their communities grow and develop. This computer software is designed to help the user build a better, more sustainable community for the future. It also a collaborative system in that it allows people to work together to find constructive solutions to community design, growth, and management problems.

Another system, the East St. Louis Geographic Information Retrieval System (EGRETS), was first developed in February 1996 with the objective of collecting all digital maps created by the East St. Louis

Action Research Project (ESLARP) into an online map library. The first version of EGRETS went online in late summer of 1996. The map library contains over 250 maps containing information about people, land-use and the city. The system allows public access to this city-based geographic information for use in planning decisions. This system makes use of Java, which appears to provide a greater degree of inter-operability and a much greater enhanced appearance of user-friendliness. The EGRETS system and the ESLARP datasets can both be accessed at http://eslarp2.landarch.uiuc.edu/egrets/.

The Digimap project based at Edinburgh University is an experimental system available to a limited number of Universities. The online GIS provides access to Ordnance Survey data sets which can be viewed at selected scales and downloaded in NTF format to a client machine for use in research. The system is very easy to use and once again uses Java. Digimap stands out from many of the other systems due to its ability to display the map on one side of the computer screen while allowing a choice of data layers to made on the other. Digimap can be found at http://digimap.ed.ac.uk:8081/.

Many more systems are available online and it not possible to review them all here. A good starting point to access many of these other GIS-based web sites is http://www.gisnet.com/gis/notebook/webgis.html.

3. Public access isues

Concerns over public access issues and the current low levels of public participation in local decision-making may provide sceptics with ammunition needed to devalue the potential of web-based participatory approaches [1]. It could be reasonably argued that the suggested increase in participation as a result of web-based systems is contradicted by the lack of access, which the public have to the Internet. Current estimates of public Internet access vary from source to source but it is becoming apparent, however, that over the next decade access will continue its exponential growth. A recent survey by NOP [5] estimated that 7 million people in the UK have access to the Internet. In the next 10 years it is reasonable to assume that the WWW, or whatever replaces it, will become as widely used as other consumer electronics such as television and mobile phones. Fears over a lack of access to the Internet will diminish as more organisations and communities are provided with the facilities to gain access. Local libraries and community centres are starting to gain and provide more access points. This will provide everyone with the ability to make use of online resources and hopefully increase participation in local decision making processes. The future opportunities provided by digital television will also allow greater access to Internet or similar, though more market driven, information networks.

Despite the exponential rise in Internet access, there is very little understanding concerning current and future uses of the Internet by the general public. Recent survey's have identified that online "surfing" often substitutes watching the television and the extent to which the Internet will be used for leisure and entertainment as opposed to more constructive, informative two-way interaction and use is, as yet, unknown [5]. This trend presents possible difficulties with the proposed use of the Internet for enhancing information provision and involvement concerning important decision problems.

The possibility of creating an information underclass is an issue, which cannot be ignored. Disregarding the media-driven hype about the "information superhighway" and despite the rapid spread of the Internet and its increasing popularity as a tool for information gathering and dissemination, there is and always will be certain groups of people to whom the Internet will remain an inaccessible medium. Computers remain a mystery to a large proportion of the older generation even today and the expense of the technical hardware and software required to physically access the Internet puts it beyond the

reach of lower income groups. These sectors of the population could possibly form a kind of "information underclass" in any system that uses the Internet as the main means of seeking public consultation and participation within all levels of decision making. Problems with regard to computer illiteracy will become less of an obstacle as modern society becomes more capable and reliant on dealing with information technology. The problem of ease of access to the Internet to lower income groups could be partially solved by providing access terminals in public places such as libraries, schools, community centres and council buildings as discussed earlier, but this solution is less than ideal. Again, digital television may provide the answer in the long term, as by far the greater majority of the population will have direct access to this technology in the next 10 years.

The lack of the necessary commercial and political will is a rather more serious problem. Increased public involvement in important decisions via the Internet may be seen as undermining current positions of power with the result that the inertia working against such mechanisms will be great. Politicians and business leaders are beginning to realise the Internet as a powerful information source. As soon as they realise that the interactive nature of the Internet makes it a useful means of insight into public opinion inertia may possibly turn to enthusiasm. Some local authorities are taking a great interest in web-based information and decision making and are actively developing their own systems.

Devon County Council have experimented with the use of the WWW as a medium for communicating the information contained within their development plans and as a means of soliciting public feedback on this document. The Devon County Structure Plan First Review (Devon 2011) can be accessed at http://www.devon-cc.gov.uk together with a current online public consultation exercise aimed at assessing public services for older people (http://www.devon-cc.gov.uk/bgop/question.html). Brent City Council have gone a step further in experimenting with online voting systems regarding such issues as sustainable development and allocation of financial resources. The Brent Online Public Consultation web site can be seen at http://www2.brent.gov.uk/.

County Wicklow Planning Department in Ireland has developed quite a unique web-based interactive mapping system. Features on a map of the County can be selected in relation to planning applications through three options. A map showing applications made, applications refused and applications granted can be shown for each month of the year. Each application is displayed as a small dot on the screen which can be clicked on to display information about the application ranging from the applicants name through to what type of permission is being sought. This site represents a valuable example of how the web can be used to inform the public of the County's development control system and to keep the public informed of current applications. The County Wicklow system can be found at http://www.wicklow.ie/planning/.

Such web sites may be seen as the first steps towards empowerment of the majority through the process of cyber-democracy, but will only be successful if the public can be bothered to use them. Antipathy and apathy are possibly the worst enemies of any democratic process relying on the Internet and active public involvement. Regardless of technical advances, improved accessibility and recent political enlightenment, deep rooted dislike of the information culture and/or the despondency of the "couldn't care less" attitude will mean that complete representation is an impossibility. However, to rigidly impose this form of decision making on the public would represent the removal of the greater democracy it is attempting to nurture. Nevertheless, the freedom of choice to participate would at least be enhanced if Internet-based SDSS were made available for involving the wider public in decision making. Participation in the democratic process either by voting or through community projects is in decline. Internet-based approaches can only have a positive impact on helping reverse this downward trend.

4. Public participation

Public participation in local environmental decision-making, particularly within the UK planning system, has traditionally tended to focus on council planning meetings. This often takes place in a "them and us" type atmosphere with the authoritative decision-makers holding all the knowledge, expertise and information. More often than not at these meetings, decision-makers are positioned on a platform with the general public down below in a less favourable physical and psychological position. It is often the case in these more traditional settings that a vocal minority or activists dominate the public's viewpoint with many people who may have equally if not more valid points to make, resisting from expressing their concerns, opinions and viewpoints. As a result, the majority "rarely if ever emerge as definable actors in the development process" [3]. Traditionally, public participation has been limited to the right to know, information campaigns and the right to object through the system of local political representatives and public inquiries. The ability to define interests, determine the agenda, assess risks, recommend solutions and take part in the final decision has largely been closed to the public. The opening up of decision-making processes via web-based approaches may help push public involvement further up the participation ladder as defined by Weidemann and Femers [8]. This is shown in Fig. 1.

The use of the WWW in place of planning meetings has the potential to break down the barriers to participation by taking away certain psychological elements which the public face when expressing their points of view at public meetings. As Graham [2, p. 2] argues, the Internet 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". Considering that most people's concerns regarding their surroundings involve spatial entities (mental maps, landmarks, etc.) the use of GIS on the WWW has great potential for popular involvement. Most people now have concerns over environmental decisions ranging from the location of open cast coal sites to smaller scale developments such as the locating of a new community centre or public library. It is therefore a natural step that they ought to, and

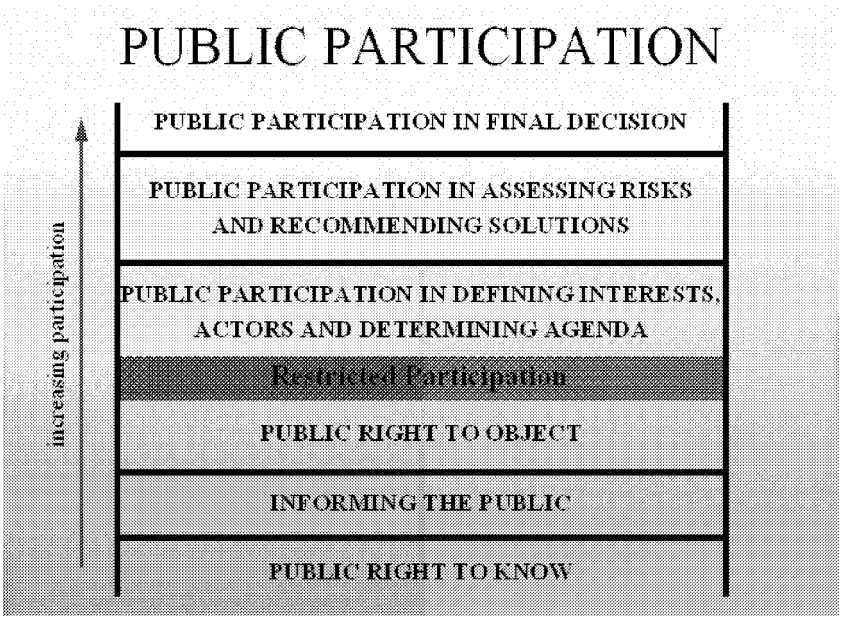

Fig. 1. The Public Participation Ladder (adapted from [8]).

indeed want to, become more involved in the planning process. Despite the shortcomings of the Internet such as difficulties of access and lack of representation, it is suggested here that it does present many opportunities for improving public participation.

5. Towards Virtual Spatial Environments

Web-based collaborative SDSS, some of which are described above, can be termed Virtual Spatial Environments (VSEs). These are based broadly around the ideas of Computer Supported Collaborative Work (CSCW). Encapsulated within vehicles for the interaction between groups of individuals it is possible to create virtual spaces that enable participants to:

(1) explore the decision problem;
(2) experiment with choice alternatives; and
(3) formulate one or more decision alternatives.

Exploration of the decision problem is an essential part of the user's learning process. Having direct and easy access to the information relating to a decision problem is a key element in learning about its various facets. In this context, information should be available on both the spatial and aspatial aspects of the decision problem. These are likely to take the form of maps and other forms of spatial data (aerial photographs, satellite images, etc.) as well as other media such as text, sound, images and video (see [7]). These should work together to convey the historical and policy context of the decision problem as well as its physical, social, cultural and economic setting. Existing community and individual ideas and/or perspectives on the decision problem should be presented where known. Through learning about all aspects of a decision problem, the user should begin to modify existing ideas and generate new ones. These can be fed back into the information space as and when appropriate.

Experimentation with the choice alternatives is another essential part of the learning process. Feasible solution alternatives can be identified and fed into the decision space, while unfeasible or conflict generating alternatives discarded. The "What If?" approach is fundamental to many exploratory analysis in GIS. As such, systems should allow client users to:

(1) test basic theories/hypotheses regarding their decision alternatives;
(2) develop decision models and/or pathways applicable to the decision problem; and
(3) approach consensus and/or compromise through comparison and trade-off with other users' ideas.

Formulation of decision choices should aim to maximise consensus and minimise conflict. In this manner it maybe possible to identify the best compromise solution. Communication and feedback to all users is essential at this stage (and also through the whole decision process) to inform users how and why particular decision alternatives have been identified. Maximising consensus throughout the decision process will help maximise the acceptability of the final decision and so minimise any adverse reaction.

The VSE architecture, which is required for this kind of participatory, and collaborative decision-making processes comprise three essential elements:

– virtual spaces for interaction;
– user-adaptive interfaces; and
– access to relevant information/data.

The virtual spaces for interaction should include both private and open group discussion "rooms" where users can interact by sharing ideas, exchanging views and contribute information. These can support both active and passive modes of participation in the form of "speakers" and "listeners". One of the advantages of VSEs in this context is that they avoid the kind of stand-offs characteristic of public planning meetings. The WWW is anonymous and, as discussed above, its use has the potential to break down the psychological barriers to participation that the public may face when expressing their points of view at public meetings.

User centred adaptive interfaces are essential if VSE are to be accessible to the whole population. It is recognised that the level of education, profession, age and social background will effect the level of understanding of a problem and user interfaces need to take this into account. Initial user profiling and subsequent user feedback can help indicate the most appropriate level of language and technical complexity incorporated within the interface, information system and decision support elements of the system. With highly spatial decision problems, the most appropriate interface maybe the map itself.

Access to relevant information is essential, without it the decision problem cannot be adequately addressed. This may be a problem for certain types of decisions or geographical locations where data are scarce. However, data alone are also not enough. Spatial and aspatial data should conform to minimum standards regarding use and format. These are:

- use of data model and formats appropriate to the decision problem;
- use of spatial scales and resolution appropriate to the decision problem;
- provision of detailed metadata and lineage describing the datasets, its source and method of compilation; and
- use of appropriate methods of visualisation, integration, analysis and interpretation.

The use of intelligent spatial agents may be important in ensuring that new users and those unfamiliar with spatial science and GIS do not use inappropriate datasets and/or analyses. It is recognised that the community of users do themselves represent a potentially vast source of local knowledge and information, both spatial and aspatial. For this reason VSE architecture should enable the community to further populate the decision space with their own information. This gives rise to the concept of the "community as database". Clearly, this is important, but does need to be carefully monitored to ensure security is not breached and that property rights of the contributing parties are safeguarded.

6. Current developments

The research currently being undertaken as part of the ESRC's Virtual Society? Research Programme aims to critically examine the role of GIS and the WWW in enhancing current decision-making processes and infrastructures. In particular, the research will focus on what role GIS and the WWW will play in improving public participation in local environmental decision making. Specific objectives in addressing these aims are:

(1) build on current work in developing the ideas and theory of participatory decision making and cyber-democracy with specific reference to the potential role of GIS-based VSEs on the WWW;
(2) develop example proto-type GIS-based VSEs on the WWW using real environmental decision problems covering different spatial scales, locational settings and social/institutional contexts;
(3) conduct extensive online experiments using prototype VSEs to analyse user responses, evaluate the potential of these systems in democratising the decision making process and assist in the development of new theory in participatory decision making.

Three case study scenarios are being undertaken in this on-going research project at the local, regional and national level. At the local scale, a small community in the Colne Valley in the West Yorkshire District of Kirklees is being used to test public participation in an online version of the "Planning For Real" tool developed by Neighbourhood Initiatives Foundation (NIF). The second case study covers a much larger area in Yorkshire and Cumbria. The Yorkshire Dales National Park represents a more regional/strategic type of scenario, which involves more than just local communities of people living within the park itself but a wider set of actors and stakeholders including tourists and visitors to the area. Here, online VSEs are being developed to encourage residents and visitors to participate in decisions regarding the reforestation of parts of the national park. Finally, a national scale case study is under development, which addresses the public's role in decisions regarding the siting of radioactive waste disposal facilities.

6.1. Virtual slaithwaite

The local case study is based on a 2 by 2 km block of land centred on the village of Slaithwaite in West Yorkshire. This is currently the focus of a community led consultation process run by NIF, which aims to examine the sustainable development of the village and the wider community within the Colne Valley. This is being co-ordinated by the Colne Valley Trust (CVT) who are working in partnership with Kirklees Metropolitan Council to develop a planning strategy for the village and its community.

The NIF is a National Charity, founded in 1988, with the main aim of maximising the participation of local people in decisions that affect their neighbourhoods and their quality of life. The founding director, Dr Tony Gibson, devised "Planning For Real"® (PFR) in the 1970s and it is now extensively employed by the NIF fieldwork team. NIF has continued to develop and adapt this primary tool to meet both local and strategic consultation needs and as an essential process in community development programmes. NIF fieldworkers usually facilitate the process using large 3D scale models of the local area.

The PFR initiative in Slaithwaite has involved building a 6 by 6 metre 3D model of the village. This was used to allow local people to gain an overview of the local area, identify the location of issues or problems and put forward suggestions in an attempt to bring about improvements. This was done by placing markers onto the physical model onto which participants have written comments or suggestions. The exercise took place over a single day in June 1998 during which local people could see the model and make their contributions. A large and representative number of local people was ensured by combining the PFR exercise with the village fête at which the PFR model was a central feature. All markers were collected at the end of the exercise and the results collated by NIF. These are being used as a means of public feedback into the planning process. Figure 2 shows the physical model in use at the Slaithwaite village fête.

The Slaithwaite PFR exercise has provided this research project with an ideal opportunity to test out new methods of public participation by running a parallel initiative over the WWW. Using the same 2 by 2 km block of land centred on Slaithwaite the project has developed a virtual model of the village using GIS principles. This has allowed the local community to interact with a virtual Slaithwaite in a similar way to the PFR model. A Java map applet is used to present a "bird's eye" view of the village that is colour coded according to the features shown. These include building type (residential, community, commercial or industrial), transport features (roads, paths, canal, railway), water features (river and reservoirs) and open space (rough ground, farm land, amenity). The user can zoom and pan through the Java map applet to reveal greater detail or move to a different area, respectively. The map is also "clickable" such that the description of the feature clicked on with the mouse can be displayed. Once a feature has been clicked

Fig. 2. Slaithwaite PFR model (photograph: Steve Carver).

on, it is possible for the user to enter a comment or suggestion pertaining to that feature into the map database. Figure 3 shows the Java map applet.

Several web access terminals were made available adjacent to the PFR model on the day of the Slaithwaite village fête and visitors were encouraged to use by the physical and virtual versions of the PFR model. Although the actual PFR event took place on the 6th June 1998, the Virtual Slaithwaite web site is still online and is continuing to gather responses. The web site is also being used to feedback results of the PFR exercise to the local community.

A number of potential advantages over the existing physical approach to PFR are noted in the virtual PFR model. These can be summarised as follows:

- ability to customise the map image or display by adding or removing data layers;
- ability to interactively zoom and pan through the map data;
- ability to interrogate map features to retrieve a description and/or other attributes;
- ability to instantaneously add new attribute information to the map database;
- ability to profile users;
- longer residence times of the virtual PFR model (i.e., is available for much longer);
- faster collation and turn around of results from the PFR exercise; and
- availability of the PFR web site to disseminate results and feedback from the PFR exercise.

Responses collected using Virtual Slaithwaite have been collated and analysed ready for feedback into the planning process. The type of responses range from single word comment to extensive problem descriptions and detailed solutions. These can be viewed on the Virtual Slaithwaite web site as a dot map and associated comments. This is shown in Fig. 4. Much valuable qualitative community based information can be gathered by this route. Users of the system are required to provide basic information

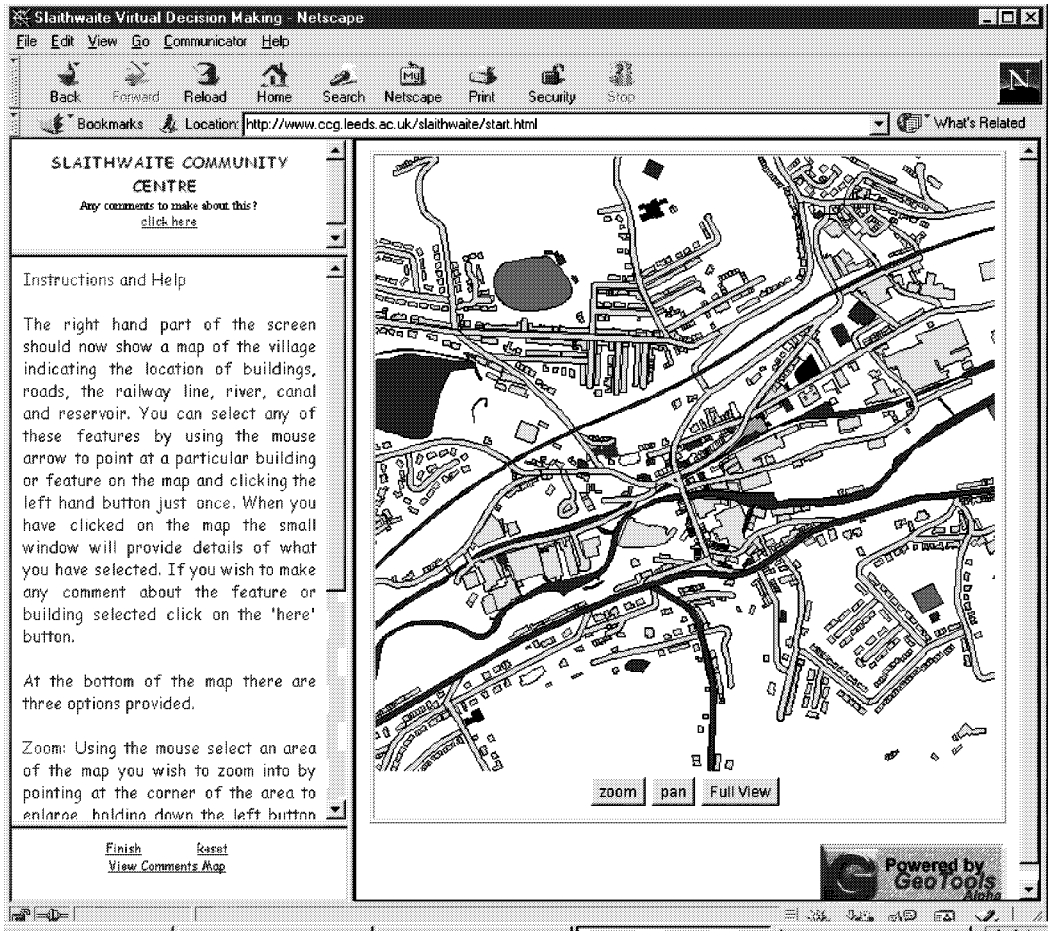

Fig. 3. Virtual Slaithwaite Java map applet (source: http://www.ccg.leeds.ac.uk/slaithwaite).

about themselves before being allowed to use the system. This includes gender, age group, occupation and postcode. This information is invaluable in helping to analyse, categorise and filter responses.

6.2. Reforestation in the Yorkshire Dales National Park

The Yorkshire Dales National Park covers approximately 1769 km^2 of nationally important upland landscape in the hills and dales in Yorkshire and Cumbria. Proposals are current being put forward in the Yorkshire Dales National Park to increase natural forest cover in the park by 50% over the next 25 years [9]. These plans are in line with Government policy for all National Parks. A prototype VSE is being developed in collaboration with the Yorkshire Dales National Park Authority (YDNPA) which aims to solicit the opinion from park residents and visitors about the extent, character and location of the areas to be reforested. Clearly, this is an important issue that will affect the character of the park landscape into the next Millennium.

Users of the VSE in this case study will be able to obtain an overview of the proposals through the examination of relevant maps. These will show the location of existing woodland, location of former woodlands, terrain, suitable soils and geology, relationships to existing land use patterns, relevant policy

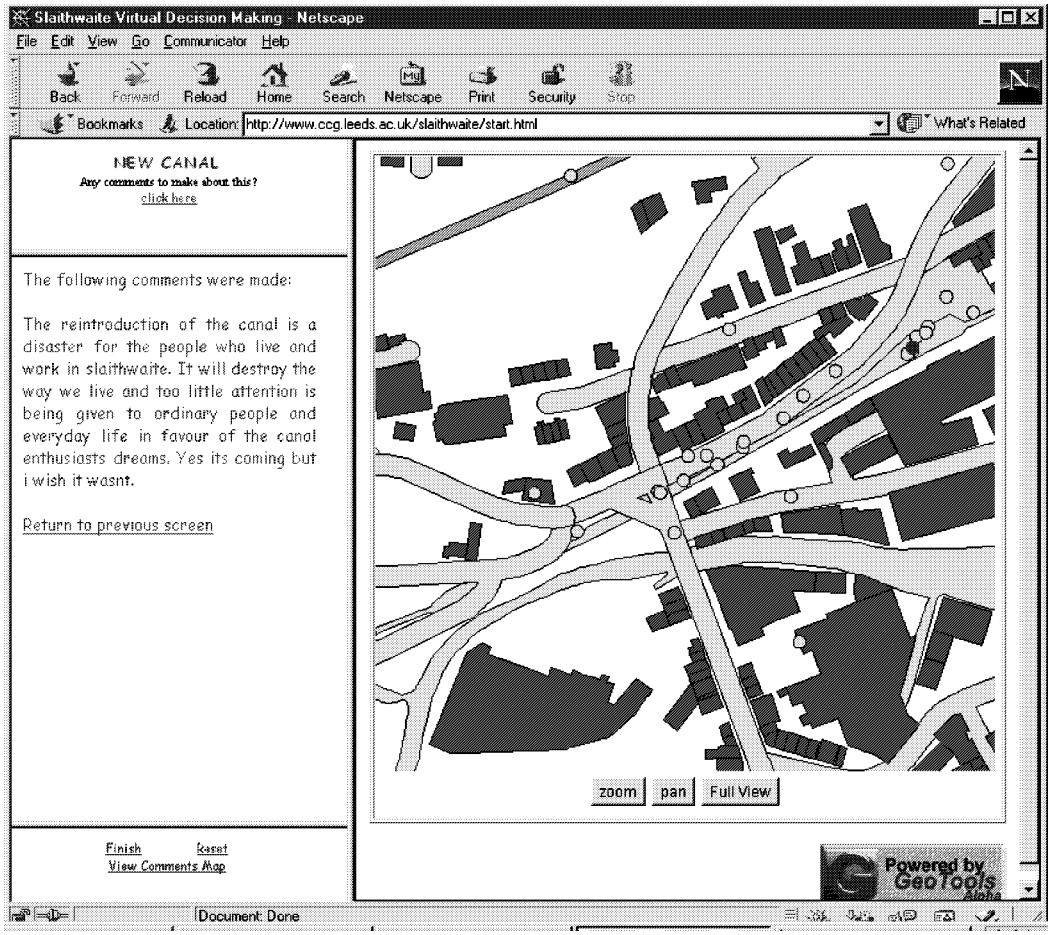

Fig. 4. Comments dot map and sample comment (source: http://www.ccg.leeds.ac.uk/slaithwaite).

boundaries, visualisation of alternative reforestation plans and the evaluation of known or hypothesised impacts. When the VSE prototype is up and running users will be in a position to generate new reforestation plans or identify exclusion zones where other land uses have priority. Once individual decisions have been made, users of the system will have the ability to place their decision maps in a virtual depository where they can be viewed in the context of other user's maps and those generated by the YDNPA. This will help define areas of conflict and identify consensus through the employment of compromise mapping techniques such as multi-criteria evaluation. One example is the ability of the virtual system to anticipate and model the visual impacts on the landscape over various timescales. This will provide interested parties with an insight into what the reforestation plans may look like after specified years of tree growth.

6.3. Radioactive waste disposal

A system already exists which demonstrates the use of a GIS-based Spatial Decision Support System on the Internet for siting radioactive waste disposal facilities in Britain. This is called the Open Spatial Decision Making (OSDM) web site and can be accessed at http://www.ccg.leeds.ac.uk/mce.

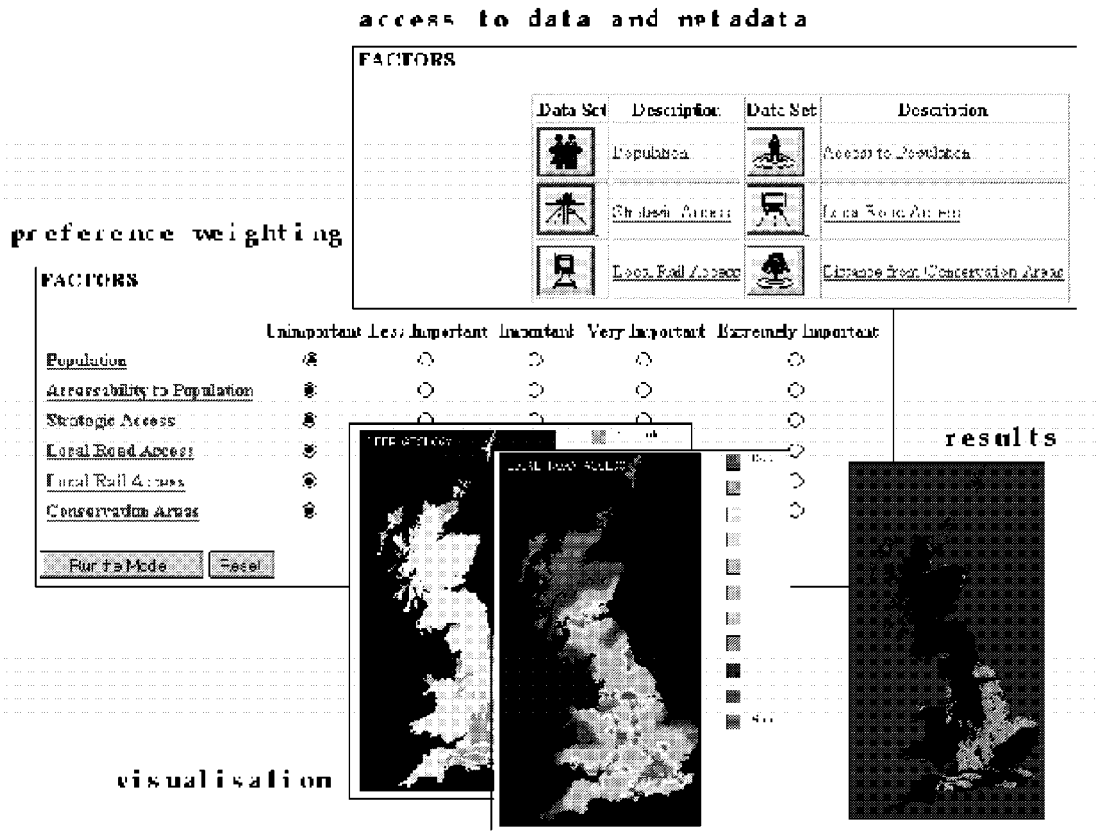

Fig. 5. OSDM web site (source: http://www.ccg.leeds.ac.uk/mce).

The system allows users to access background information relevant to the problem, access GIS datasets (digital map images) and information about these data (source, relevance, etc.) and use these to identify suitable sites according to the users own ideas to what factors are important in the siting process. This site identification process is carried out by the user choosing site constraints and weighting each of the given factor maps. Selected screens from the OSDM web site are shown in Fig. 5.

The system is extremely easy to use and requires no prior knowledge about GIS or SDSS. A key to the success of this and other such systems is to develop them in ways which hide the GIS and technical details behind a well designed GUI. All responses are mouse driven using clickable icons and buttons. The system consists of:

(1) a data viewer menu giving access to the GIS data sets;
(2) a data selection and preference weighting menu allowing users to select and weight individual factor maps and then submit a site search request;
(3) a results display menu which allows users to view the resulting site search image and provide feedback; and
(4) a final menu giving the user a chance to provide feedback both on the system and on their own views regarding the radioactive waste disposal problem.

This system is being updated and developed further in line with the two previous case studies to provide a three tier approach to the use of VSE's at local, regional and national scales. Both the new radioactive waste disposal web site and the Yorkshire Dales National Park reforestation web site will be accessible through the ESRC project web site at http://www.ccg.leeds.ac.uk/vdmisp/ in due course.

7. Conclusions

This paper has described how the rise of the Internet and the WWW has created opportunities to increase public participation in environmental decision-making by providing web-based GIS. Some examples of how geographic information can be made available to the general public by using the Internet and the WWW have been described. Several of these systems have been highlighted in this paper to illustrate how this has become possible over the past few years together with an introduction to how these systems maybe developed to become more collaborative in nature.

It needs to be recognised that access to the WWW is still relatively limited although the potential for mass access and market saturation appears to becoming a reality at least in the medium term. The provision of public access points in council offices, libraries and community centres etc. are likely to help overcome these concerns in the shorter term.

GIS on the WWW provides a platform for more general use of a technology which to the unskilled user otherwise appears as an unfriendly medium. The types of systems being developed in research being undertaken by the authors hides the complexity of the GIS behind friendly, easy to use GUI's while still retaining the ability to build up several scenarios or proposals based on particular decision choices made by the individual. This paper has argued that providing open access to particular decision-making problems over the WWW will play an increasing role in the way future environmental proposals and decisions are made. The practical development and testing of these systems will help direct the future of public participation in environmental decision-making by using GIS on the WWW.

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References

[1] C. Bryan, R. Tsagarousianou and D. Tambini, Electronic democracy and the civic networking movement in context, in: *Cyberdemocracy: Technology, Cities and Civic Networks*, R. Tsagarousianou, D. Tambini and C. Bryan, eds, Routledge, London, 1998, pp. 1–17.
[2] S.D.N. Graham, Flight to the cyber suburbs, *The Guardian*, April 18, (1996), 2–3.
[3] P. Healey, P. McNamara, M. Elson and A. Doak, *Land Use Planning and the Mediation of Urban Change*, Cambridge University Press, 1988.
[4] J.E. Innes and D.M. Simpson, Implementing GIS for planning, *Journal of the American Planning Association* **59**(2) (1993), 230–236.
[5] National Opinion Polls, One in twenty five British households now linked to the Internet (1997) http://www.maires.co.uk/.
[6] J. Pickles, ed., *Ground Truth: the Social Implications of Geographical Information Systems*, Guildford Press, New York, 1995.

[7] M. Shiffer, Interactive multimedia planning support: moving from stand-alone systems to the World Wide Web, *Environment and Planning B: Planning and Design* **22** (1995), 649–664.
[8] I. Weidemann and S. Femers, Public participation in waste management decision-making: analysis and management of conflicts, *Journal of Hazardous Materials* **33** (1993), 355–368.
[9] Yorkshire Dales National Park Authority, *The Dales Woodland Strategy*, YDNPA, Leyburn, 1995.