

AN EVALUATION OF ONLINE GIS-BASED LANDSCAPE AND VISUAL IMPACT ASSESSMENT TOOLS AND THEIR POTENTIAL FOR ENHANCING PUBLIC PARTICIPATION IN THE UK

R. Berry*, G. Higgs, M. Langford, R. Fry

Wales Institute of Social and Economic Research, Data and Methods (WISERD) & GIS Research Centre, University of Glamorgan, Wales, UK, CF371DL - (raberry, ghiggs, mlangfor, rfry)@glam.ac.uk

KEY WORDS: GIS, Planning, Public Participation, Landscape, Visualization

ABSTRACT:

Effective information communication and public participation in the planning process are important elements for facilitating successful environmental decision-making. Previous research has demonstrated the importance of these factors for delivering benefits to a wide range of stakeholders in the planning system by increasing the transparency and efficiency of the planning process. Planning information relating to the potential visual impacts of proposed developments is particularly important in the case of wind farm planning, given the high levels of concern amongst members of the public regarding the perceived negative visual impacts of wind turbines on the landscape. However, shortcomings associated with traditional visualisation techniques used to assess such impacts have been highlighted in previous research, along with drawbacks related to the dissemination of such information to the public during the planning stages of wind farm development. This research is concerned with evaluating the potential of innovative digital landscape visualisation and Web-based approaches for addressing some of the shortcomings in these areas. This paper describes the implementation of a Web-based survey study designed to evaluate the potential of online GIS-based approaches for improving the effectiveness and dissemination of wind farm visualisations and enhancing public participation in wind farm planning. Results from the survey study add to the research literature by demonstrating how innovative visualisation and Web-based approaches have real potential for augmenting existing methods of information provision and public participation in the wind farm planning process. The findings of this study are also transferrable to other landscape planning scenarios.

1. INTRODUCTION

1.1 Wind Energy in the UK

The number of wind farms in the UK is set to increase dramatically over the next decade in response to government policy on generation of electricity from renewable sources. Based on a legal commitment to reduce carbon dioxide emissions, set under the 1997 Kyoto Protocol, the UK Government's mandatory target for the production of energy from renewable sources, of which wind will be a major contributor, is 10 per cent by 2010 and 15 per cent by 2020. Furthermore, the legally binding target for reducing the total UK carbon dioxide emission by at least 26 per cent by 2020 and at least 80 per cent by 2050, compared to 1990 levels.

1.2 Public Attitudes and the Visual Impacts of Wind Farms

Public attitudes to the development of wind power schemes in the UK have been examined extensively in previous research (e.g. Devine-Wright, 2005). Whilst there are many underlying factors that can lead to rejection of a proposed scheme, policy-makers often attribute the failure of planning applications to local public opposition, traditionally labelled by proponents as 'NIMBYism', driven partly by the perceived negative *visual* impacts of wind turbines. In terms of wind farm assessment, visual concerns can be divided into two subtly different but related impacts, namely *landscape* impacts and *visual* impacts. In the context of visual assessment, landscape impacts can refer to changes in the perception of the visual character, fabric and quality of the wider landscape whereas visual impacts are concerned with the potential visual intrusion/obstruction of a proposed wind farm from specific receptors/viewpoints, such as people's homes, parks, places of work, roads, or sensitive

historic/ecological sites for example (SNH, 2008). The term *visual impact(s)* is used in this paper for brevity when referring simultaneously to both visual landscape impacts and visual impacts respectively.

The potential visual impacts of proposed wind farms are usually systematically assessed before a planning application for a wind farm is submitted by a developer. These assessments are conducted as part of a Landscape and Visual Impact Assessment (LVIA), which itself forms part of the wider Environmental Impact Assessment (EIA) of a proposed wind farm development. Given the significance of perceived negative visual impacts, the results of a LVIA are often central to the outcome of a planning application and form an important part of public consultation exercises designed to involve the public in the planning process (Bell et al., 2005).

1.3 LVIA Information Provision and Public Participation in Wind Farm Planning

The limitations of photographic and two-dimensional (2D) viewshed mapping techniques traditionally used to assess the potential visual impacts of proposed wind farms in LVIAs have been highlighted in earlier research (e.g. Coles and Taylor, 1993), and the use of modern digital landscape visualisation techniques has been viewed by some researchers as a way of overcoming some of the drawbacks associated with these techniques. Recent research into the use of GIS-based digital landscape visualisations ("LV" - after MacFarlane et al., 2005) for increasing public understanding of the potential aesthetic impacts of proposed developments has shown that such techniques have real promise in this regard. (Appleton and Lovett, 2005). However, there has been very little research conducted to date which has evaluated innovative LV techniques alongside the more traditional techniques used in the

* Corresponding author.

landscape and visual impact assessment and public consultation phases of the wind farm planning process.

Increased access to information in environmental planning scenarios has been shown to have a positive effect on the planning process in terms of increasing public involvement and improving the quality of decision-making (Bush et al., 2004). The value of effective information dissemination and public participation mechanisms in the planning process are recognised by local, national and international governments and a range of policies exist to support these objectives. However, public access to LVIA information has been largely restricted to consultation meetings and/or exhibitions designed to engage members of the public in the planning process. Often, the intimidating atmosphere that can prevail at such planning events (particularly given the highly contentious nature of onshore wind farm planning in the UK), and the fact that they are temporally and geographically restricted, means that public participation, for some social groups, can be discouraged (Kingston et al., 2003).

In addition to empowering the public and improving the transparency and legitimacy of the planning process, research has shown that effective public participation at an early stage in the planning process has the potential to speed-up the decision making, thereby relieving pressure on a heavily strained planning system (Beddoe and Chamberlain, 2003). In light of legally-binding renewable energy targets and the subsequent large increases in the number of planning applications for onshore wind farms expected over the coming years, there exists an urgent need to investigate alternative mechanisms for facilitating more effective public participation in the wind farm planning process.

In recent years there has been growing interest and research into the use of Information and Communication Technologies (ICTs) for overcoming some of the previously highlighted limitations associated with traditional meeting-based participatory methods in environmental planning. In particular, previous studies have highlighted the potential of online Public Participation Geographical Information Systems (PPGIS) for increasing access to spatial/environmental information and for incorporating citizen feedback into the planning system, thereby promoting and improving public participation in the decision-making process (e.g. Carver et al., 2001).

Other recent research has concluded that a convergence of Web-based GIS and landscape visualisation techniques may have significant potential for informing the public and involving them in the landscape planning process, particularly for projects which are deemed visually sensitive (e.g. Appleton, 2003). However, there remains a lack of research focussing on evaluating the potential of Internet visualisation tools for increasing and improving public participation in the planning process for projects of this nature. Given the possible benefits that such technologies might deliver to the various stakeholders in the planning process, there is a real need to investigate this potential.

1.4 Research Aims

The overarching aim of this research is to investigate techniques for improving visual information dissemination and public participation in the wind farm planning process. Two research objectives were identified. The first objective is to evaluate the following range of traditional and digital landscape visualisation-based methods for assessing the potential visual impacts of wind farms (shown in the order that they were evaluated in the survey):

1. Zones of theoretical visibility (ZTV) mapping

2. Wireframe diagrams
3. Photomontages
4. LV - still images
5. LV - animations
6. LV - real-time interactive model

The second objective is to examine the potential of Web-based visualisation approaches for *increasing* and *improving* public participation in wind farm planning. Increasing participation can be thought of as not only increasing the numbers of citizens involved in the process but increasing the diversity of participants and widening participation to include different sections of the community that may be disenfranchised by current practices. Improving participation is difficult to define precisely but one way in which Internet-based approaches might improve current participatory practices is by creating more well-informed stakeholders who might contribute to improving the overall quality of participation through better-informed decision-making, for example.

2. METHODOLOGY

In order to evaluate Web-based visualisations there was a requirement for the survey to be conducted online, and it was felt that a remotely-accessible survey would be preferable to one accessed in controlled laboratory-type conditions. The main reasons for this were that a remotely accessible survey would likely: a) maximise the number of potential participants by permitting respondents to complete the survey in their own time and at their own convenience; b) maximise the diversity of potential respondents both culturally and geographically (The academics and 'landscape professionals' that were invited to take part in the survey were known to be based in various locations throughout the UK and world; c) provide a more realistic idea of the potential benefits and drawbacks of Internet-based visualisation compared to traditional meeting-based approaches. If supervised workshop sessions or interview type approaches had been used then this would have negated the experience of participating 'remotely' from a home/place of work. While a Web-based survey was thought to be the best approach for this research, it is important to be mindful of the potential disadvantages of such approaches, such as the possibility of multiple submissions, high drop-out rates, problems with participants misunderstanding or struggling with concepts or technology, and difficulties in trying to achieve a range of views and opinions from a cross-section of a community whilst avoiding bias and ensuring representativeness.

2.1 Study Area

The Fforch Nest Wind Farm, a proposed development of 13 wind turbines near the village of Gilfach Goch, South Wales, UK, was chosen as the case study wind farm for this research (Figure 1). The wind farm project, and its immediate locality fulfilled a number of criteria in terms of study area suitability. It was a 'real' planning application, the author was familiar with the area and landscape, and the proposed wind farm was a highly contentious and well-publicised issue locally. Also, with a combined population of around 5,000 it was thought that the three villages in close proximity to the wind farm could potentially generate a high number of survey respondents from the public. Importantly, there was also broadband Internet connection in this area although the exact number of residents that were connected was unknown. Within this locality, the exact extent of the study area in which visualisations and landscape models would be produced was designated as a 24km² area which included including the proposed wind farm

site in the north east corner and the three villages in the south west corner (Figure 1).

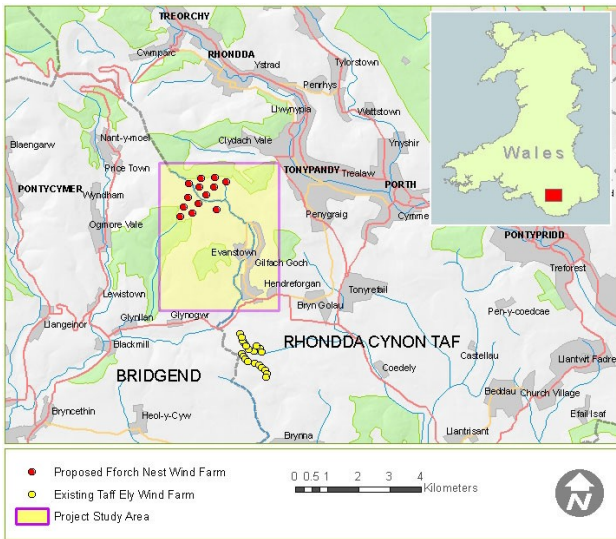


Figure 1. Map of the study area in Wales, UK.

2.2 Survey Design

The survey was split into four main parts: 1) introduction; 2) gathering of background information on participants (incl. age, ICT literacy, familiarity with study area landscape, previous experience of wind farm consultations); 3) visualisation tool evaluation (ease of interpretation, effectiveness for showing landscape and visual impacts, perceived accuracy); 4) participation-related questions (effectiveness of online visualisations, comparison with meeting-based LVIA dissemination, potential for Web-based LVIA for improving public participation).

The survey was designed so that each visualisation tool was evaluated in sequence in keeping with the philosophy of designing a linear survey where the participant is taken on a pre-defined route through the questionnaire. The visualisations were evaluated using closed-ended questions with five-point semantic difference scale responses. Due to the limitations of using a five-point ranking scale and the inherent subjectivity involved in evaluating the various visualisation tools, free-text questions were included to support and bolster the quantitative analysis. Free-text questions were also used to allow participants to expand on their responses to the closed-ended questions they submitted in the Participation Questions section of the survey.

Survey participants from a number of distinct groups were targeted in this research. In addition to the obvious inclusion of members of the public in the survey, it was also decided to include other relevant 'expert' groups so that variations in responses between different groups could be analysed. The following groups were identified for inclusion in the survey:

- *Academic*: Professional researchers in relevant fields such as PPGIS and LV.
- *LVIA*: Wind farm developers and experts and professionals directly involved in preparing LVIA material for use in wind farm planning applications and public consultation scenarios.
- *Gov*: Local and government planning officers and related planning officials.
- *Public*: Members of the general public.

- *Students*: A cohort of geography and GIS students from the University of Glamorgan.

2.3 Visualisation Development

ZTV Map: A ZTV map was created by applying the viewshed function in ArcGIS to a vector point shapefile representing the positions and heights of the proposed wind turbines. The base elevation of the turbine towers was interpolated from a 5m RADAR DEM and a 'viewer' height of 1.8m was incorporated into the viewshed calculation. The resulting viewshed layer was then appropriately banded and symbolised into a ZTV layer.

Photomontages and Wireframe Diagrams: High-quality photographs of the site, captured from a number of locations in the study area using a tripod-mounted 35mm single-lens reflex (SLR) camera with a 50mm focal length lens, were imported into Resoft Wind Farm software and used as the basis for producing the wireframes and photomontages. A total of 12 sets of wireframes and photomontages were produced showing the potential visual impact of the proposed wind farm from representative locations throughout the study area (Figure 2).

LV: 3D Nature's Visual Nature Studio (VNS) 2 landscape visualisation software was used to create a digital landscape model of the study area and export still images, animations and real-time output (using the Scene Express extension) for evaluation in the online survey. VNS is arguably the best software currently available for creating sophisticated LVs from a wide range of 'real-world' spatial data. Though many LV software packages (including VNS) incorporate a 'ready-made' library of models and images for representing surface features above the terrain, both natural and man-made, external 3D modelling software is often required to create the models representing these features. In this project, for example, a combination of Google SketchUp and Lightwave 3D modelling software were used to model the buildings and wind turbines.

With the recommendations from previous studies (e.g. Appleton and Lovett (2005), and the aims of the project in mind, the approach taken for landscape modelling adopted in this research was not to create the most highly realistic LV possible, but to create the most detailed and objective audience-orientated visualisations feasible within the constraints imposed by time, knowledge and experience, cost, software, hardware and Internet considerations (e.g. bandwidth/display restrictions dictating quality/quantity of LV-derived output). Figure 3 shows an example of the final LV model, looking north-west towards the proposed wind farm development from the south-eastern corner of the study area (Figure 1). Numerous visual outputs were rendered from the landscape model in three different formats; a number of still images (from 100 viewpoints) and animations (mixture of 20 fly-throughs and walk-throughs), and one real-time interactive 3D model

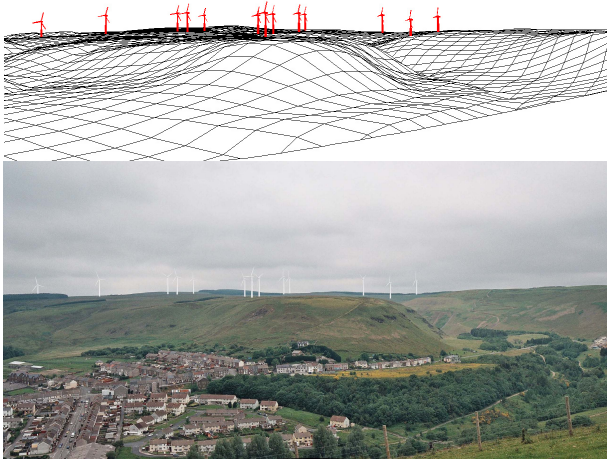


Figure 2. Example wireframe and corresponding photomontage



Figure 3. Rendered LV model of the study area

2.4 Web Survey Development

The Web survey was developed as a single website development project in Visual Studio 2005 using ASP.NET web pages and an SQL database to store participant's responses. The general architecture of the Web survey application is shown in Figure 4. The visualisations, stored as media files on the Web server, are delivered to the end user as images (or a map layer in the case of the ZTV map) linked to an interactive Web map of the study area, designed and developed using ESRI ArcIMS Internet Map Server development software within Visual Studio. When a mouse pointer hovers over a viewpoint on the Web map a JavaScript window appears that displays viewpoint information, including a textual description of the location and the height of the viewpoint (or animation track) above ground, and, in the case of the 3D animations, the file size of the animation download. The user then clicks on a hyperlink in the JavaScript window which opens an 'image page' showing the appropriate visualisation from that particular viewpoint (Figure 5). The real-time interactive 3D NatureView model, rendered from VNS model using Scene Express software, is downloaded as an .exe from the Web site. When a user has finished using each visualisation tool, questionnaire responses are posted to an SQL server database residing on the Web server.

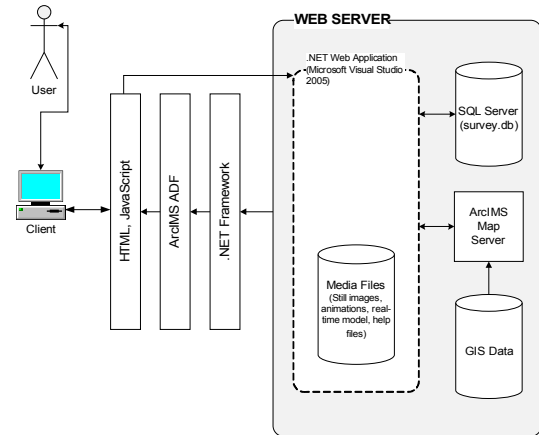


Figure 4. General architecture of the survey website

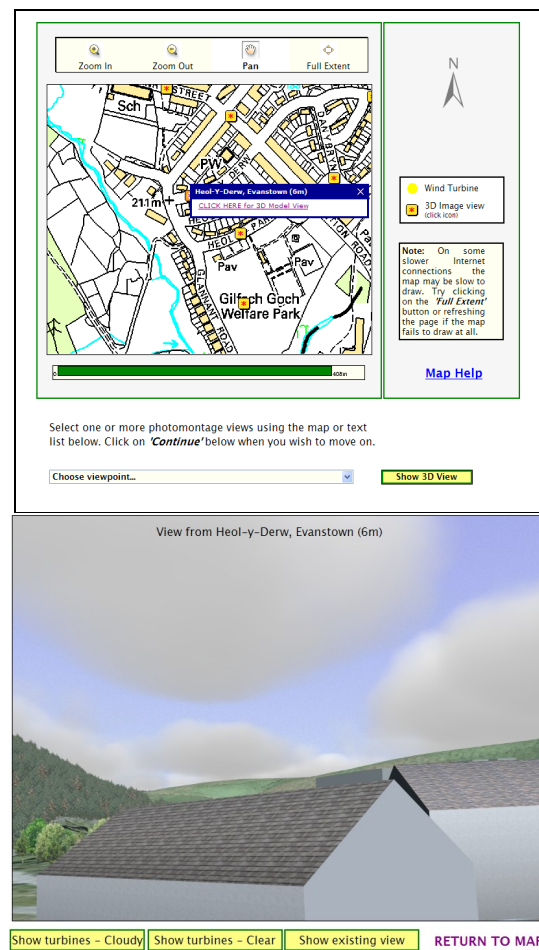


Figure 5. Web survey map interface (top) used to retrieve visualisations (in this case a still LV image).

3. RESULTS & DISCUSSION

Of the 162 respondents that started the survey a total of 115 (71%) completed it. The breakdown of respondents by group type was as follows: *Students* (47.8%); *Public* (20%); *LVI*

(13%); *Gov* (6.1%); *Academic* (13%). Of the total respondents in the *Public* group, 70% lived in the study area.

3.1 Visualisation Tool Evaluation

The quantitative five-point ordinal data extracted from the database of the responses to the closed-ended semantic difference questions was analysed by plotting the tabulated frequencies of the responses as histograms. The responses to the other closed-ended questions in the 'public participation' section of the survey were also analysed in this manner. The themes that emerged from an analysis of the free-text qualitative responses help to bolster and explain some of the quantitative findings. Selected results from the visualisation tool evaluation are summarised in Tables 1 & 2.

Table 1. Mean overall scores regarding effectiveness of the visualisation tools for showing potential impact on visual landscape character

Tool	Responses	Mean Score	Variance
ZTV Map	115	2.53	0.90
Wireframe	115	3.12	1.14
Photomontage	115	4.22	0.82
3D still	115	3.74	0.93
3D animation	112	3.96	0.84
3D model	27	3.27	1.00

Table 2. Mean overall scores regarding effectiveness of the visualisation tools for showing the visual impact from specific locations

Tool	Responses	Mean Score	Variance
ZTV Map	115	2.77	1.00
Wireframe	115	3.44	1.26
Photomontage	115	4.30	0.65
3D still	115	3.80	1.07
3D animation	112	4.05	0.90
3D model	27	3.23	0.98

- Photomontages were rated highest overall in all in each of the four evaluation areas (ease of interpretation, landscape and visual impacts and perceived accuracy).
- LV-based outputs were generally felt to lack the 'realism' of photomontages.
- Animated LV was rated more highly than static LV for assessing potential landscape and visual impacts.
- Problems with usability were a major issue with regard to dynamic LV-based visual tools, particularly navigation of the viewer position using the real-time LV model.
- There were marked differences in awareness of uncertainty/inaccuracy between different stakeholder groups (e.g. LVIA experts and the Public).
- There are indications that differences may exist in the perception of LV imagery between 'locals' and 'non-locals'.
- Each visualisation tool was found to have its own benefits and limitations and the availability of a wide range of visualisation was generally found to be desirable.
- The results of the visualisation tool evaluation have reinforced the findings of previous research in this area.

Photomontages were consistently ranked highest in each of the categories. Respondents' familiarity with photographs and their perception of the 'real-world' realism and accuracy which they conveyed meant that they were readily understood and were felt to best reflect the character of the landscape, however many respondents thought that they were temporally limited in the sense that they were only accurate at the time of data capture and some drew attention to the time and effort necessary to produce photomontages and saw this as a major limitation especially if wind farm plans needed to be altered and quickly re-visualised. Another limitation of photomontages highlighted

by many respondents was that they are a static representation of a 'moving impact' (i.e. wind turbines). Although the animations were not rated as effective as photomontages for assessing landscape and visual impacts, due the lack of real-world detail in the landscape model, the animated turbine blades and animated camera paths were thought to be a significant advantage. For this reason, LV animations were generally preferred over LV still images. LV stills however, were easily interpreted although lack of landscape detail, particularly in the foreground of the images meant that they were rated less highly than photomontages for assessing landscape and visual impacts, as they were unable to pick up on subtleties in the landscape. However, the ability to show viewpoints in varying atmospheric conditions was thought to be beneficial as was the large number of viewpoints available.

It was clear that usability problems relating to navigation within the real-time LV model contributed to the low overall rating of the tool. Respondents found it difficult to navigate to specific locations using the real-time LV model which impaired its ability to show visual impacts. However, respondents found the model more useful for assessing changes in the visual landscape character as many felt it gave them a useful overview of the layout of the proposal in the context of the wider landscape. The ZTV map was rated lowest in each of the four evaluation criteria. Some respondents (particularly in the *Public* group) found the ZTV maps difficult to interpret, although those more familiar with ZTV maps (*LVIA* experts) thought they were a useful tool when used in conjunction with the other types of visualisations. Overall, the general consensus amongst respondents was that the different visualisation approaches were complimentary and the availability of a greater number of visualisation tools was viewed positively although some exercised caution that processes, limitations and uncertainties in the visualisations must be properly conveyed to the public, especially in the case of the newer LV-based visualisations.

3.2 Public Participation Evaluation

Some of the main findings of the public participation section of the questionnaire were as follows:

- The majority of participants thought that the incorporation of Internet-based visualisation tools into the EIA stage of the wind farm planning process would help to:
 - Increase and widen public participation in the planning process through improved presentation and access to LVIA information.
 - Improve public participation in the planning process by creating more well-informed participants.
- Participants indicated that the availability of Internet-based visualisations such as those demonstrated in this research would make them more likely to participate in the planning process.
- The majority of respondents that had previously attended wind farm planning meetings/exhibitions thought that Web-based LVIA information was more effective for showing the potential visual impacts of a wind farm than traditional LVIA material presented at such events
- A number of potential advantages and disadvantages of using Internet-based visualisation and participation techniques in the wind farm planning process were identified. Usability, IT/Web literacy and access to the Internet emerged as significant issues in determining the success of future online visualisation-based participatory Websites.

The findings of the public participation section of the Web survey has provided new and encouraging evidence to support the use of a visualisation-based PPGIS for increasing and

improving public participation in onshore wind farm planning in the UK. Confirming the findings of other studies that have explored the benefits of such technologies (e.g. Harrison and Haklay, 2002), survey participants were optimistic regarding this potential and generally gave strong support for the development and implementation of these technologies in a real-world planning context. Despite concerns over the marginalisation of some social groups, the majority of survey respondents felt that participation by a wider audience would be encouraged with the availability of such systems. This work has therefore helped to address one of the key elements of the current PPGIS research agenda, which is the need to gauge the potential levels of uptake of PPGIS initiatives by the public.

A significant finding of the survey was that the majority of participants who had previous experience of viewing LVIA information at a planning event preferred Internet-based visualisations to those presented using 'traditional' media. This is in contrast to other related work by von Haaren and Warren-Kretzschmar (2006) who found that citizens' favoured meeting-based material over interactive visualisations made available on the Web. However, the limitations of Web-based LVIA information were recognised and discussed (e.g. bandwidth and display size issues and the problem of communicating uncertainties in the data), and the main theme to emerge from an analysis of respondents feedback was that the majority viewed both meeting and Web-based approaches as complimentary. The consensus was that a combination of the two approaches would be advantageous for assessing the potential visual impacts of proposed developments, which supports the findings of von Haaren and Warren-Kretzschmar (2006) in this respect.

4. CONCLUSIONS

Using as a case study a real-world wind farm proposal in the UK, this original work has demonstrated that there is real potential, and, importantly, enthusiasm amongst 'experts' and members of the public alike, for innovative digital visualisation and communication techniques to enhance, but not replace, current methods of visual information dissemination and public participation in the wind farm planning process in the UK. Whether the UK planning system seizes the opportunity to contribute to the development of such approaches by helping researchers move prototype projects into the real world remains to be seen, but it is hoped that this work has provided extra motivation for doing so. Information and communication technology is poised to play a significant part in the future of wind farm/landscape planning but further technical and theoretical challenges need to be overcome before its central role in the planning system is realised.

REFERENCES

Appleton, K. 2003. GIS-based landscape visualisation for environmental management. *PhD Thesis, School of Environmental Sciences, University of East Anglia, UK.*

Appleton, K., Lovett, A. 2005. GIS-based visualisation of development proposals: reactions from planning and related professionals. *Computers, Environment and Urban Systems*, 29(3), pp. 321-339.

Beddoe, M., Chamberlain, A. 2003. Avoiding confrontation: Securing planning permission for on-shore wind energy developments in England: Comments from a wind energy developer. *Planning, Practice & Research*, 18(1), pp. 3-17.

Bell, D., Gray, T., Haggett, C., 2005. The 'social gap' in wind farm siting decisions: Explanations and policy responses. *Environmental Politics*, 14(4), pp. 460-477.

Bush, I., Gillson, A., Hamilton, M., Perrin., M. (2004). Public participation - Drawing the boundaries. *The Chartered Institution of Water and Environmental Management Conference - "Delivering Sustainability: Challenges and Lessons*, London, 30th January 2004.

Carver, S., Evans, A., Kingston, R., Turton, I. 2001. Public participation, GIS and cyberdemocracy: evaluating on-line spatial decision support systems. *Environment and Planning B: Planning and Design 2001*, 28(6), pp. 907-921.

Coles, R. W., And Taylor, J., 1993. Wind power and planning: the environmental impact of windfarms in the UK. *Land Use Policy*, 10(3), pp. 205-225.

Devine-Wright, P., 2005. Local Aspects of UK Renewable Energy Development: Exploring Public Beliefs and Policy Implications. *Local Environment*, 1, pp. 57-69.

Harrison, C., Haklay, M., 2002. The potential of public participation Geographic Information Systems in UK environmental planning: Appraisals by active publics. *Journal of Environmental Planning and Management*, 45(6), pp 841-863.

Kingston, R., Evans, A., Carver, S. 2003. Public participation via on-line democracy. *Planning support systems in practice: Advances in spatial science*. S. Geertman and J. Stillwell (Eds.). Springer-Verlag, Germany, pp. 45-64.

Macfarlane, R., Stagg, H., Turner, K., Lievesley, M., 2005. Peering through the smoke? Tensions in landscape visualisation. *Computers, Environment and Urban Systems*, 29, pp. 341-359.

SNH (Scottish Natural Heritage (2008). Environmental Assessment Handbook. <http://www.snh.org.uk/publications/online/heritagemanagement/EIA/appendix1.shtml> (accessed 17th June 2009).

Von Haaren, C., Warren-Kretzschmar, B., (2006). The Interactive Landscape Plan: Use and benefits of new technologies in landscape planning and discussion of the interactive landscape plan in Koenigslutter am Elm, Germany. *Landscape Research*, 31(1), pp. 85-105.