The Development, Application and Evaluation of Participatory Geographic Information System Methodologies for Improved Environmental Decision Making

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Abstract

This thesis reflects upon almost two-decades of my continued use, reflection and development of methods utilising maps as discussion tools allowing different groups views on environmental issues and development options to be more clearly understood. The overall aim of this improved participation and communication has been the identification and implementation of alternative (more democratic and informed from a wider evidence base) development choices. This improved understanding is intended to result in more sustainable outcomes from decision making processes at a variety of appropriate and relevant management scales.

The thesis is comprised of seven published papers exploring the development and application of participatory geographic information system (PGIS) approaches in the context of their utility and effectiveness in improving environmental management decision making processes and outcomes. Within this overall commonality the papers can be differentiated into four themes. Firstly, four papers assess the development of focus group based PGIS approaches to improve shared understanding and public involvement in natural resource management and pollution control in the UK and South African contexts. The second theme explored in two papers describes the evolution of mapping engagement and mixed methods approaches to widen participation to, often, disenfranchised groups or to facilitate the inclusion of local perspectives in contested or sensitive issues both from the UK. The third theme investigated in the penultimate paper is the potential for using PGIS derived data as a framework to nest different spatial and experiential scales of knowledge within a decision making process. The fourth theme from the final paper involves widening PGIS approaches to include elements of other social research methods, in this example vignettes, to stimulate the mapping process and outputs.

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Paper 7: Cinderby, S., de Bruin, A., White, P., Huby, M., & Bruin, A. De. (2012). *Analyzing Perceptions of Inequalities in Rural Areas of England Using a Mixed- methods Approach.* Journal of the Urban and Regional Information Systems Association, 25(2), 33–44.

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Author Declarations

Paper 2: I can confirm that Steve Cinderby was the main author and my part was limited to a small input on pps 144 & 145, less than 5% of the published paper.

Paper 4: I can confirm that Steve Cinderby was the main author. The secondary authors contributed less than 20% of the final manuscript.

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Co-Author Signatures 22nd July 2014.

John Forrester (Papers 2 & 4)

Paper 6: I can confirm that Steve Cinderby was the main author. My part was limited to, together with Steve, undertaking the work the paper is based on and reading through a final draft of the paper. My contribution to the written text of the paper was limited to reviewing the draft.

Paper 7: I can confirm that Steve Cinderby was the main author. My part was limited to, together with Steve, undertaking the work the paper is based on and reading through a final draft of the paper. My contribution to the written text of the paper was limited to reviewing the draft.

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Annemarieke de Bruin (Papers 6 & 7)

Integrative Chapter: Introduction

Confessions

I am a geographer. Worse than that, a map-maker (although I currently do not exhibit full-blown symptoms of cartography).

geography (dʒɪˈɒɡrəfɪ)

— n , pl -phies

1. the study of the natural features of the earth's surface, including topography, climate, soil, vegetation, etc, and man's response to them
2. the natural features of a region
3. an arrangement of constituent parts; plan; layout

(Collins English Dictionary)

The papers presented here as such represent an extended confession of my on-going interest in maps and my inability not to ask people questions! More academically (though perhaps less honestly) this can be reframed as:

This thesis reflects almost two-decades of my continued use, reflection and development of methods utilising maps as discussion tools allowing different groups views on environmental issues and development options to be more clearly understood. The overall aim of this improved participation and communication has been the identification and implementation of alternative (more democratic and informed from a wider evidence base) development choices. This improved understanding is intended to result in more sustainable outcomes from decision making processes at a variety of appropriate and relevant management scales.

Twenty years is a long time to have been studying one approach. As such the papers reflect a journey both in the development of these map-based methods, but also of my research career, interests and opportunities. This introduction is intended as an overview of that journey and how the research presented in the accompanying papers fits into the wider historical landscape of sustainable development, community engagement approaches and the increasing demands from policymakers for public participation as part of decision-making processes. This journey exists in both time and space with activities and papers reflecting my on-going interest in translating development approaches and engagement methods between developing (in my cases, African) nation contexts and an unevenly over-developed country (the UK) (Dorling, 2010; Soja, 2010; Wilkinson and Pickett, 2009; Dorling, 2011) (with residents utilising more than their fair share of global resources).

The papers also reflect, informed and contributed in some small part to, the evolution of approaches combining community engagement through linking maps and information communication technologies (ICTs) specifically geographic information systems (GIS). The development of these approaches was initially undertaken in isolation by numerous unconnected groups (for example the case studies in paper 1) with a variety of research needs and goals leading to a diversity of methodologies (Quan, Oudwater, Pender and Martin, 2001; Abbot, Chambers and Dunn, 1998; Dunn, 2007). As communication flows (linked to the publication of academic papers, conference presentations, development reports and, later, webpages) increased, these approaches coalesced around two key headings: Public Participation Geographic Information Systems (ppGIS) (Sieber, 2006); and Participatory GIS (PGIS) (McCall, 2003; Corbett et al., 2006). Whilst these approaches always represented a relatively broad church of methodologies, purposes and outcomes the headings to some extent characterised specific overall ideologies.

Development of participatory mapping and ICT approaches

PGIS grew out of development ideologies, including Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA) as "a family of approaches and methods to enable rural people to share, enhance and analyse their knowledge of life and conditions, to plan and to act" (Chambers, 1994). These approaches were geared towards empowering communities in developing countries to share and utilise their local knowledge to improve local decision outcomes, ideally for their own purposes and often enabled by outside facilitators.

Conversely, ppGIS (Craig , Harris and Weiner, 2002) was a mainly North American reaction to the 'Science and Society' debates around the positivist, reductionist, and policy-oriented outcomes of conventional GIS applications in the early to mid-1990s (Pickles, 2006). ppGIS centred on the democratization of GIS technology through the dispersal of training and technology to a wider constituency than those who had, up till then, enjoyed or harnessed the analytical and communication benefits (Monmonier, 1996) obtainable through the power of maps (Wood and Fels, 1992) and digital maps in particular.

As both approaches matured and access to digital technology in developing country contexts widened (see the Map Kibera project from Nairobi (Shkabatur, 2012)) there was increasing conformity in methods (if not underlying ethos) between PGIS and ppGIS. More recently, this increasing consensus and conformity has once again exploded, fuelled by changing technological opportunities (increasingly ubiquitous mobile computing (Stevens and Maisonneuve, 2009; Willis, Hölscher, Wilbertz and Li, 2009), web-mapping (Kingston, Carver, Evans and Turton, 2000; Kyem and Saku, 2009)). This expansion in the range of approaches has been encouraged by shifting cultural, policy and academic drivers including: Mass data from volunteered geographic information (Goodchild, 2011, 2007; Mooney and Corcoran, 2011); opportunities for crowd sourcing information (Brabham, 2009; Hsueh and Melville, 2009); a recognition of the benefits from Citizen Science (Gura, 2013; Silvertown, 2009); challenges to conventional data collection resulting from economic austerity; and possibilities for community involvement underlying calls for localism (Department for Communities and Local Government, 2011; John, 2012; Yuille, 2011; Catney et al., 2013).

PGIS in the context of participation goals

The recent proliferation n spatial participation approaches listed above reflects the on-going drivers for participation (White, 1996) in both developing and over developed country contexts. The arguments in favour of increased public participation in decision making have been characterised by Chess and Purcell (Chess and Purcell, 1999) as based on two theoretical frameworks. The first termed 'theory-based' stems from the arguments that public participation increases fairness in society permitting people to initiate dialogues, challenge and defend claims and "competence," using the best available information. The second framework, 'criteria based', pragmatically encourages increased participation if it leads to benefits for decision making agencies. These have been characterised by the UK National Council for Voluntary Organisations (UK-NCVO) (Brodie, Cowling, Nissen and Paine, 2009) as:

- The ambition of strengthening the legitimacy and accountability of governing institutions (including donors in developing countries) (at different scales) by involving individuals more directly in decisions that affect their lives.
- The belief that involving and bringing people together in local decision-making processes can empower communities and help build social cohesion.
- The opportunity to boost participant's personal social esteem, skills and self-confidence.

These two theoretical framings of 'theory' and 'criteria' overlap in different contexts. For example, in relation to risks: "Although risk characterizations are often made for the benefit only of an organization's decision maker, it is important to recognize that various other parties use them when they exercise their rights to participate in decisions either before or after the organization acts" (Stern and Fineberg, 1996). The need for public participation in risk characterisations was justified on the basis that failing to take into account multiple voices including citizens would result in the assessments and outcomes of official processes being criticised as incompetent and therefore irrelevant. "The common practice of eliciting comments only after most of the work of reaching a decision has been done is cause for resentment of risk decisions.... Many decisions can be better informed and their information base can be more credible if the interested and affected parties are appropriately and effectively involved..."(Stern and Fineberg, 1996). This justification for inclusion of different voices and knowledge's in the deliberation around choices is also applicable to many environment or development processes. Cornwall(2002) highlights "treating participation as situated practice calls for approaches that locate spaces for participation in the places in which they occur, framing their possibilities with reference to actual political, social, cultural and historical particularities rather than idealised notions of democratic practice". This framing provides a specific rationale for why mapping spatial knowledge (using PGIS) is particularly relevant for effective public engagement in relation to issues of environmental change in the actual locations in which they are occurring and with the communities affected.

The concepts of empowerment through participation (as identified by the UK-NCVO) have long been recognised as taking different forms with varying legitimacy depending on the engagement process. Table 1 presents a typology of different goals and levels of empowerment for participants building from original framings, such as the ladder of citizen participation (Arnstein, 1969). The table highlights the different ways engagement between stakeholders and decision makers can play out and the consequent outcomes from participation. One definition of PGIS (Hoyt, Khosla and Canepa, 2005) is a combination of a "computer-based information system with an interactive human process which facilitates collaborative planning efforts, but its ability to effectively empower participants is largely determined by the local context—that is, the social and political relations that link or divide individuals, groups, and institutions". This definition recognizes that equal attention needs to be given to the context within which participatory knowledge management plays a role in decision-making, as well as the limitations set by power structures and relations between the participants involved in these processes.

Increasing level of participation →					
	Inform	***Consult***	***Involve***	***Collaborate***	***Empower***
Public participation goal	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/ or solutions	To obtain public feedback on analysis, alternatives and/or decisions	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution	To place final decision-making in the hands of the public
Promise to the public	We will keep you informed	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible. We will implement what you decided	We will implement what you decided

Table 1: Spectrum of participation (International Association of Public Participation, 2007) (including elements from Arnstein's "Ladder of Participation"(Arnstein, 1969)).

This context of empowerment through public participation (including participatory GIS) relies upon underlying theories of governance, rights and accountability. This can be illustrated through examples from the UK in relation to changing concepts and framing of citizen's roles and responsibilities and consequent levels of empowerment in decision making and how they have shifted depending on the governance frameworks favoured by changing ruling political parties. Under Conservative administrations (1979-1997) in the late 1970s through to the 90s the state systems had undergone neo-liberalisation opening up governance roles for private enterprise (Morison, 2000). In the late 90s, under New Labour (1997-2010)(the era to which my papers relate), this approach was partially retrenched through a transition towards collaboration between the central state and so called third sector organisation (voluntary and not for profit groups) who acted as intermediary actors between citizens and government (Gerometta, Haussermann and Longo, 2005). This so-called third way of governance purportedly allowed for greater involvement and consequent empowerment of citizens in decision making processes (Raco, 2003) but has been criticised on a number of fronts: By citizens, who complain that their participation was in reality largely consultation on agendas over which they had little or no actual power; by academics, who highlight that despite the rhetoric of participation the third way actually resulted in increasing centralization of decision making within government agencies; and by the subsequent coalition administration, whose ideology prioritised devolution of decision making to the lowest relevant administrative level and rejected the centralization and expansion of state decision making powers (Verhoeven, 2014). The Coalition policy response of 'Localism' has aimed to devolve more responsibility to neighbourhood and community decision makers (McKee, 2014). However, despite this agenda of empowerment through increasing local community governance of decision making this new 'contract of engagement' between state and society has been criticised in terms of the social, cultural and political capital required from communities to actually be empowered through localism (Jones, Rowson and Broome, 2010).

White's (1996) framing of the different interest groups, their role in the process of participation and differing relationships of engagement (seen below in Table 2) gives us an alternative means of assessing the content of participatory processes (White, 1996). Four major types of participation are distinguished and the different types of interests in these processes from the 'top-down' of those who design and implement development programmes to the `bottom up' where participants view themselves in the interaction and what they expect to get out of it. The final column in Table 2 characterises the overall function of each type of participation. This typology is useful for identifying under differing and evolving circumstances how forms of engagement can create either opportunities for participation or conversely reinforce and emphasise existing power relations (Brodie et al., 2009).

Form	*Top-Down (View from the Agency designing the participation process)*	*Bottom-Up (View from the participants)*	*Function*
Nominal	**Legitimation** (Appear to be widening participation)	**Inclusion** (Secondary benefits (funds, status) from being seen to participate)	**Display** (Both parties only wish to indicate their inclusion in the process. Little real power transfer)
Instrumental	**Efficiency** (Agencies require participation of communities to implement schemes)	**Cost** (Communities spend time and labour implementing schemes)	**Means** (Local participation is required to ensure cost-effective delivery of benefits e.g. new facilities to communities)
Representative	**Sustainability** (Implementing agency encourages participation to ensure the suitability and hence longevity of schemes)	**Leverage** (Communities engage to shape changes and access powers for future management)	**Voice** (function of participation is to allow local people a voice in the character and outcomes of the project)
Transformative	**Empowerment** (Outside agencies agenda is to facilitate local communities decision making processes)	**Empowerment** (Local communities set the decision making agenda – and actions)	**Means/End** (Practical experience of being involved in considering options, making decisions, and taking collective action is transformative. Enabling this process can be transformative for the facilitating agency)

Table 2: Interests in participation (White, 1996)

Aims of this chapter

Chess and Purcell (1999) highlight the ideals of increased public participation as including ***multi-way communication***, ***consensus building*** and ***critical self-reflection*** – these ideals encompass the goals of many PGIS methods. This introductory chapter will signpost how the papers included in this thesis were influenced by, contributed to, or informed these changing contexts and opportunities for PGIS. I will reflect upon:

- How the papers fit within the matrix of drivers for participation (in relation to the theoretical frameworks presented above);
- their classification in terms of the level of participation (in relation to the spectrum of participation and the power relationships represented);
- and what this can tell us about the strengths, opportunities and shortcomings of the PGIS activities I have undertaken.

The papers will be presented and reflected on chronologically to illustrate how the methods evolved as my understanding of the topic and related challenges deepened.

First steps

My initial forays into what was to evolve into PGIS methods development came on the back of a Swedish International Development Cooperation Agency funded project looking at improving natural resource in communally managed lands in South Africa that ran between 1993 and 1998. The project was a collaboration between the Stockholm Environment Institute (SEI) (where I remain based) and local partners including the Institute of Social and Economic Research based at Rhodes University, Grahamstown, South Africa, and the Surplus Peoples Project, a non-governmental organisation (NGO) based in Cape Town. The project focussed on two case study areas: Peddie District in the former Ciskei homeland area (a so-called self-governing territory for the Xhosa people set up by the former apartheid government of South Africa); and Namaqualand, part of Northern Cape Province. I was lucky enough to be employed as a junior researcher to undertake field work investigating spatially the relationships between people (livelihoods), resources (and their sustainability) and management.

In Peddie, there was a selection of accessible spatial data to facilitate the analysis of these issues. These included orthophoto map sheets, a time series of air photographs, rainfall surfaces and paper topographic maps. Within the project I utilised these in a participatory manner in an attempt to answer questions of interest to the research team and also the local communities. For example, the prevailing dogma in local resource governance organisation at the time was that communal grazing of livestock was resulting in the widespread occurrence of soil erosion and gully formation. Using the time series photographs to map erosion features temporally I was able to demonstrate that whilst recent land management had not remediated erosion features the then current grazing was only resulting in historic features degrading further rather than propagating new occurrences (Ainslie, Cinderby, Petse and Ntshona, 1997).

Meanwhile, in Namaqualand, the situation with regards spatial data was very different. The district had largely been ignored under the years of Apartheid government (1948-94) in terms of data collection as the national administration appears to have largely seen the 'coloured' communal lands as economically unproductive (Rohde, Hoffman and Cousins, 2000). This paucity of information meant that the conventional spatial data analysis approach I had employed in the Eastern Cape case study was not available to me. In the absence of alternatives and encouraged by the project leader Dr Phil Bradley, I decided to investigate the use of community maps developed by stock farmers produced as part of a PRA activity. This mapping had been one output from community engagement but was not been explicitly used for analysis within the project. Instead it had been collected using PRA approaches to facilitate communication within the community and between them and the project team. This process had been facilitated by project partner Harry May of the Surplus Peoples Project to whom I am greatly indebted.

Paper 1 of this thesis, *'Geographic Information Systems (GIS) for Participation: The future of environmental GIS?'* (Cinderby, 1999), details my initial developments of PGIS methods using the Namaqualand mapping in comparison to the limited number of comparable approaches which had been reported at the time. The paper outlines the key fundamental aspects of PGIS processes namely: capturing local knowledge in a spatial framework; transforming this information into a digital format for storage, visualisation and analysis; utilising the GIS to compare and combine local stakeholder's knowledge across a geographic extent and thematically with supplementary conventionally derived or official recognised datasets; to address questions and concerns raised by the communities involved in relation to the development of official policies and strategies.

This initial approach allowed me significant opportunities and freedom within the context of the changing democracy at that time in South Africa to fulfil the potential of PGIS in terms of allowing the local communities we engaged with to collaborate and have leverage (in the framings of tables 1 and 2). The Sida project which generated the mapping was intended to have a second phase where the local participatory plans for improvements in natural resource management and livelihoods would have been implemented. This second phase could have resulted in actual empowerment through the mapping activities for communities. Disappointingly, changing priorities of the funder and the newly democratically elected South African government meant this implementation phase was curtailed and the maps remained as a communication tool only allowing better understanding in official agencies of the needs and problems of the communities we worked with.

Exporting lessons from the South

On completion of my South African work I was invited to participate in an Economic and Social Research Council (ESRC) funded project led by Professor Steve Yearley (then Sociology Department, University of York). The project built upon previous work indicating that local people had knowledge that was relevant and applicable to environmental decision making (Forrester, 1999), but a major challenge was capturing and presenting this information in a format that allowed it to be interpreted and utilised by official agencies (e.g. local councils, Environment Agency, etc.). Particularly, the project's ambition was to investigate the potential for incorporating local knowledge into environmental modelling to improve decision outcomes. PGIS was seen as a possible approach for overcoming communication barriers through the perceived power and authority of maps (Woods and Fels, 1992; Woods, Fels and Krygier, 2010). The project had the further ambition that the digital re-presentation of community map data might be a suitable method for releasing the potential of local participation in computer environmental modelling.

In paper 2, *'Facilitating the local governance of air pollution using GIS for participation'* (Cinderby and Forrester, 2005), I describe why PGIS processes outlined in paper 1 are equally relevant and applicable in a UK or industrialised country context in relation to identifying, refining and implementing environmental policies. The paper details the author's first attempts at linking PGIS to environmental computer modelling to improve the inputs and outputs from such analogues of the real world. The paper also indicates the potential to use PGIS approaches to monitor and evaluate changes in local stakeholder's knowledge resulting from education. In this case, the impact of council literature outlining the spatial extent of air pollution on local resident's perceptions of the severity and location of pollution instances.

In terms of classifying participation this project represented a spectrum of outcomes. In the York case study, the local council officers utilised the participatory information in a public consultation on the possible extent of air quality management zones in the conurbation. This consultation resulted in the adoption of a zone based partly on the resident participant's PGIS maps. This outcome represents real empowerment in both framings of the goals and outcomes from participation; local knowledge (with a supporting democratic consultation) informed the location and greater extent of attempts to control pollution in the city. This outcome continues as a highlight of my applications of PGIS in the UK and is a clear example of the 'theory' framing of the justification for participation. Meanwhile in Bristol the evaluation of whether local knowledge had been shaped by interaction with official understandings represented a different purpose for deploying PGIS methods. These purposes were more geared to the needs of the project team and Bristol City Council officers and as such do not closely match aspirations and ideals for PGIS.

The project took place in the context of attempts by UK (and other) national governments to increase community ownership of decision making powers. Particular approaches from this era (early to mid-2000s) included Local Agenda 21 (LA21), community planning and neighbourhood renewal. These overlapping policies had objectives to:

- improve well-being/quality of life in local areas;
- integrate local delivery activity;
- involve local communities in decision making.

LA21 had requirements to “prepare community strategies which would promote economic, social and environmental well-being of their areas, and contribute to the achievement of sustainable development in the UK” (Lucas, Ross and Fuller, 2003; Lawrence, 2002). All these elements imply a spatial component that could have been usefully addressed through utilising PGIS approaches. However, the UK LA21 policy relied on local authorities, rather than communities themselves, designing and implementing these strategies. I would argue that PGIS represented an under-utilised opportunity for generating these plans that could have included greater involvement from local community groups. This might have significantly increased the usefulness and perhaps the longevity of the LA21 approach in the UK by allowing diverse community knowledge to be reframed in digital GIS to address different topics and policy needs. For example, our consultations on the location and severity of pollution also generated community solutions to problems and included other information on nuisance smells. Councils could have utilised and reframed this diversity of information to address multiple local development objectives with efficient local community involvement, both for participant time consideration, but also council financial costs perspectives.

Paper 2 also lays out a classification of PGIS methods based on two axes, firstly the level of community involvement in the GIS analysis and, secondly, the degree of local knowledge incorporated into the spatial database. This classification still has relevance to today’s emerging applications of PGIS including map mash-ups, volunteered geographic information and Citizen Science.

This process of utilising PGIS approaches in different ways (e.g. for evaluation in Bristol), not always with a goal for participant empowerment, represents an evolution in the themes, methods and approaches for PGIS that I adopted as my understanding of the usefulness and applicability of these concepts evolved. These innovations in methods reflect a desire to assess how, where (in terms of environmental decision making themes rather than geographic spaces) and for whom these map based approaches can be most usefully deployed. It must also be confessed that my on-going innovation in methods as well as relating to academic stimulation also partly reflects a response to a common desire from funders for novelty.

Problems, problems…

In paper 3, '*Suspicious cartographers: some realities of research into stakeholder understanding of the causes and possible prevention of breast cancer'* (Cinderby and Potts, 2007), I discuss the evolution of PGIS methods in order to examine relative environmental risks and also conflicting environmental knowledge. The paper highlights the key ingredients of trust and time required to ensure successful participatory processes. This finding applies in general, but I think is particularly relevant to processes utilising maps that explicitly represent knowledge in a form that makes it easier for other participants to understand and therefore challenge different stakeholder's information and understanding. The paper describes another advantage of PGIS methods over other forms of discursive participation in that local, spatially explicit, knowledge is more difficult to invent or bluff than other framings of dissent that may not be based on on-the-ground 'evidence'. Participants either know where a problem is located or activity is undertaken or else they do not. The paper draws on the material from the paper 2 case studies and reports on a further application of the 'GIS for participation' methodology in relation to environmental health issues.

This project represented a follow-on from the ESRC project and expanded the range of contexts in which I had applied PGIS methods, in this instance in environmental health risk assessment. These activities were challenging in their topic and also implementation with different conflicted (both between and within) stakeholder groups. They represented the first instance in my participatory processes when mapping as an activity had broken down. As the paper reports, this failure was due to mistrust between and within the participants; with the facilitators; and also the project goals and process.

In terms of the level and goals for participation in this project, the intention had been to use the mapping for co-generation (Tanaka, Gaye and Richardson, 2010) of hypotheses to inform new understandings of potential environmental causes of breast cancer for further investigation by the medical establishment. The mapping process was intended to be a collaboration between people on different sides of an intellectual debate. As the paper reflects, the use of a participatory method, in this case PGIS, did not ensure participation which as Chambers (1994) often states cannot be forced or coerced. If it had been more successful this activity would have represented significant empowerment for community advocates and perhaps led to transformative dialogue between oncologists, patients and self-styled dissident community scientists.

New opportunities

In paper 4, '*Participatory GIS and its application in governance: the example of air quality and the implications for noise pollution'* (Cinderby, Snell and Forrester, 2008) – I further develop the linkages between environmental computer modelling and stakeholder participation in governance of these issues outlined in papers 2 and 3. The experiential limitations of local stakeholder's environmental knowledge and the consequent potential for integrating this information into the policy process are considered. The paper highlights that PGIS derived information needs to be used with caution for environmental governance and is best suited to issues where experiential information can reasonably expect to act as an analogue for official models and expert knowledge of the processes involved. However, the paper argues that even in situations where there is mismatch in expert and lay experiential knowledge the use of maps as a dialogue tool can facilitate increased shared understanding of environmental conditions and consequent policy formulation and delivery. Two potential novel future uses of PGIS are also highlighted; lay participants measuring environmental conditions, an approach that has since evolved into Citizen Science (Haklay, 2010) and remains a subject of significant potential and academic investigation; and utilising PGIS for monitoring and evaluating policy impacts using multi-temporal mapping surveys.

Listening to unheard voices

In paper 5, '*How to reach the 'hard-to-reach': the development of Participatory Geographic Information Systems (P-GIS) for inclusive urban design in UK cities'* (Cinderby, 2010), I detail the development of PGIS methods particularly targeted at including people who typically do not participate in conventional focus group events and public meetings (the eponymous 'hard-to-reach'). The methodologies described builds upon those developed in paper 4 and includes a comparison with the GIS-P approach utilised in previous papers. The paper looks at the ethical implications of using an evolution of PGIS – Rapid Appraisal Participatory-GIS approach and concludes that whilst it does not meet the strict criteria of best-practice (Rambaldi, Chambers, McCall and Fox, 2006) it still has merit for including information generated by people who would typically be excluded from public engagements and consultations, thereby broadening the range of voices included in local UK decision making.

The opportunity to develop these new methodological approaches came from my involvement in Engineering and Physical Sciences (EPSRC) funded projects investigating sustainable urban environments (the SUE programme). These multi-partner projects provided opportunities to work with new colleagues encouraging the generation of novel solutions to problems. The InSitu project (Cinderby et al., 2007) run by Dr Steve Shaw of London Metropolitan University was particularly inspiring, allowing the testing of PGIS approaches virtually to destruction. The research allowed me to work with not only the hard-to-reach but also to test mapping with children; participatory mapping inside buildings; and work with Steve on developing mobile mapping approaches for use with disabled groups (amongst other stakeholders).

In terms of meeting public participation ideals these case studies represented a continuum; the most successful resulted in local stakeholder inclusion in decision processes from which they had previously been excluded; other meanwhile merely presented reports on local knowledge for use (or not) by official agencies (for example, the National Trust property who were designing new exhibition approaches for children and ethnic minority groups). I would argue this diversity of success reflected a growing trend in the UK context of an official pragmatic recognition of the need or requirement to include the public in decision making processes without a real transfer of power or reframing of the governance in relation to the issue under consideration.

These projects fit into a particular timeframe of national and international participation policies; in the UK the LA21 process had been criticised for failing to engage with disadvantaged or marginalised groups and ignoring how to make links between regeneration and improvements in the quality of local environments within deprived communities (Lucas, Ross and Fuller, 2003). The case studies described in this paper represented attempts to build new engagement processes to overcome these deficits. I would argue (based partly on the successes of York) that greater use of PGIS (including the application of some of the new rapid appraisal approaches described in this paper) in developing, implementing and monitoring the impacts of LA21 strategies on communities linked to environmental assessments could have overcome some of these shortcomings.

In terms of the framings for participation, the approaches pioneered in this paper represent a hybrid of a theoretical right of local people to have opportunities to participate in democratic processes – which may rely on identifying engagement spaces and approaches that are tailored to the community – and pragmatic in terms of finding solutions that are more likely to be relevant to and therefore successful in addressing community needs. The academic nature of the projects restricted the participation to involvement of the public or at best collaboration (in the case of Salford, York and Blackpool).

Russian Dolls – layers upon layers

In paper 6, '*Participatory geographic information systems for agricultural water management scenario development: A Tanzanian case study'* (Cinderby et al., 2011), Iextend the development of PGIS methods described in papers 1, 2, 3 and 4 to address the on-going issues of how to incorporate different nested scales of local knowledge and information that exist across geographic space in environmental decision making. This is developed with reference to a case study in a Tanzanian watershed where differences exist across the communities that inhabit the basin in terms of their livelihood strategies, environmental conditions, access to resources and markets. However, the decision making scale for local environmental policy makers and practitioners in this context was the watershed. The challenge and methodological development opportunity was therefore how to integrate community level knowledge and variation into planning undertaken at higher geographic decision making units. Beyond this scale integration challenge the paper develops methods to identify scenarios of the possible outcomes of changes to water access through agricultural water management interventions. It describes how participatory mapping can be used in scenario discussions to link outcomes to specific locations and consequently to communities.

The opportunity to develop this nested scales approach to incorporate participatory GIS-derived community data into decision making processes at higher geographies came from my involvement in a project developed by Dr Jennie Barron and managed by the International Water Management Institute (IMWI) which was funded by the Bill and Melinda Gates Foundation. The project was considered a scoping initiative by the Foundation to investigate the opportunities for them to diversify their poverty alleviation activities into the areas of food security and agriculture. The PGIS activities at the watershed scale formed one element of a multi-layered project with other partners undertaking household studies, national assessments and regional modelling. The project gave me multiple interlinked opportunities: firstly, to develop and pilot the nesting approach to participation and data described in this paper; secondly, to test different approaches to delivering this project in three case study watersheds. These different delivery approaches included an SEI team undertaking the fieldwork and focus groups directly, as was undertaken in Tanzania; training local fieldworkers and working through interpreters as implemented in India; and finally, training local project partners as facilitators for the methodology and then allowing them to develop and implement the data collection in a Burkina Faso watershed.

The development of scenarios with local residents links the method to the approach from Blackpool presented in paper 4. The nested method described in this paper however represents a significant evolution taking the development of options from the local (as was undertaken in Blackpool) to higher administrative and decision making scales. However, as conference presentations and reviewers comments indicated, the approach represents my initial attempts at this transition and remains work in progress.

Whilst the process described fulfilled the project needs and delivered a baseline assessment of gender differentiated livelihoods and scenarios of the impacts of agricultural investment strategies, it had significant shortcomings, particularly in terms of the level of participation from the farming communities in the watersheds under investigation. The PGIS data collected from these stakeholders – who would ultimately have been the beneficiaries or casualties from any actual investment – were only included in the assessment of the baseline of current livelihoods.

This was partly due to budgetary and time constraints imposed by the project funding, but also reflects the experimental nature of this methodology. At present small holder farmers inclusion would be classed as ‘involvement’ in the graduation described in table 1 and ‘instrumental’ to ‘representative’ in terms of the power relationships described in table 2.

However, I believe this approach shows enough merit to be further developed. Ideally, I would extend the approach to include greater integration of publics and experts at the higher scale meetings with further iterations of the scenario building processes to ensure that they suitably represented the knowledge and experiences of all participants (within the recognised constraints that individual narrative scenario building process outcomes will always be unique and participant dependent (Enfors, Gordon, Peterson and Bossio, 2008)). Community groups could be included in the scenario building exercises – either in collaboration with the watershed scale experts or alternatively if more appropriate in terms of the power dynamics in a parallel session with representation from a suitable transect across the location.

This projects approach also highlighted the role different intermediaries can play in the delivery of PGIS processes and outcomes. During the project we trained facilitators for different roles in data collection and analysis. These ranged from local translators working with project team members enabling their interaction with farmers in local languages to training intermediaries to act as mapping facilitators collecting data directly from local community members or expert stakeholders. This range identified the impact such intermediaries can have on the process of participatory mapping.

Our training highlighted how important it was for facilitators (who were external to the core project team) to have a clear understanding of the purpose of the mapping, what it was trying to achieve, as well as having a clear topic guide (Bryman, 2006) to work through. This understanding of purpose empowers facilitators to stray from a mechanistic following of a guide if interesting and relevant information pertinent to the 'purpose' of the mapping begins to be discussed. The importance of this point was illustrated during the project during debrief discussions with facilitators who, when reflecting on mapping activities they had facilitated, described interesting aspects of natural resource management mentioned by participants that had not been noted in the PGIS data as they did not match the topic guide exactly.

Whilst the skills of facilitation (Chambers, 2002; Wates, 2008) can be to some extent taught they also rely on a natural aptitude. A critical dimension of PGIS facilitation relies on respecting the participants and their mapped information, regardless of whether your expert knowledge (as an academic researcher) knows of confounding data that contradicts the community members' viewpoint or understanding. This aspect has been highlighted to me in a number of contexts, often with physical scientists who I have been training to become PGIS facilitators who seem to find it particularly difficult not to contradict local experts' knowledge if it disagrees with their understanding of the problem or process being described. This element of respecting participants relates back to paper 3 and the issues of trust building.

Mixing things up

The final paper (7), '*Analysing Perceptions of Inequalities in Rural Areas of England Using a Mixed Methods Approach'* (Cinderby et al., 2012), describes a further methodological innovation of linking vignettes to participatory mapping. The vignettes method from social science utilises narratives (delivered to participants in a variety of forms including written stories, audio recordings or videos) to stimulate discussion on sensitive topics. In this case the issue was inequalities between and within the inhabitants of rural English communities. The vignette method was extended to include a participatory mapping component to ground the discussions in spatially explicit locations. The paper goes onto describe how this approach could be further extended by utilising the spatial information derived from participants in comparison to official data in a PGIS. This potential is illustrated in relation to a comparison of local residents' knowledge of the variation in conditions in rural England in comparison to official information held at a higher geographic unit. The paper builds on the problems of utilising PGIS derived information in decision making which typically occurs at scales greater than that at which local knowledge is held and expressed. The paper also describes an application of the RAP-GIS methodology developed in paper 5. This case study illustrates the benefits of the approach for scoping, but the possible drawbacks when used to recruit participants for group events.

The development of this paper was linked to my involvement in ESRC funded research grants led by Dr Meg Huby under the Rural Economy and Land Use (RELU) programme. Our interdisciplinary project investigated the interaction between social and environmental inequalities for residents of the English countryside. The initial stages of this process included collating, transforming, comparing and combining a multitude of spatial data describing environmental, social and economic aspects of rural England. A statistically robust subset of these data was then utilised to identify quantitatively the patterns of difference – *inequalities* – between these variables at a cross-section of geographies relevant to decision making scales (administrative boundaries; national parks etc.) or potentially similar physical environments such as rural uplands. This quantitative identification however can only identify difference – it cannot characterise whether this results in any real or perceived unfairness of *inequity*. The PGIS and vignette approach was therefore conceived as a way of gaining insight from rural residents on the actual experiences they have from living in the countryside and linking their knowledge to the implications of differences in the distribution of services on fictional characters representing particular relevant archetypes.

Characterising the approach and topic investigated in this paper in relation to the frameworks for participation detailed at the start of this paper is quite challenging. The process of engagement led to a number of ethical dilemmas: The project team wanted a cross section of participants and did not want to bias this, or the rural residents input into the findings, by explicitly stating what the research was investigating. Instead meetings facilitation and PGIS-vignette methodology were intended to guide people through process leading to an increased understanding of potential inequities through an exploration of, and reflection upon, participant's knowledge and experience of what it was like to live in the English countryside. As such this was more an exercise in co-investigation (Case and Hawthorne, 2013; Kindon, Pain and Kesby, 2007; Banks et al., 2013) rather than what might be more rigorously defined participation in decision making.

Figure 1 below characterises all the PGIS activities from the papers included alongside mapping undertaken by a number of my peers at comparable times. The figure highlights how my mapping work has primarily concentrated on incorporating local knowledge into decision making processes rather than facilitating community spatial analysis. Other forms of PGIS have taken other approaches the most successful in terms of combining these two aspirations (in some contexts where internet facilities are well developed) being online mapping activities. As these online methodologies and associated software continue to mature I would expect these approaches to increasingly deliver on both dimensions of PGIS community inclusion.

Future Opportunities and Aspirations

The comparison of participatory derived data to official information links the approach back to many of the proceeding elements in this thesis, however, the vignettes methods paper illustrates the continued opportunities for novelty in developing mapped based engagement methods for differing purposes.

My ongoing research indicates the increasing opportunities for PGIS hybridisation and diversification presented through new technologies or mixing of methods (such as participatory diagramming) depending on the purpose for participation and community involved in the process. The final paper on vignettes highlights one avenue that could be further developed; others include linking participatory diagramming (Kesby, 2000; Umoquit et al., 2008) to mapping; the potential of direct digital mapping including opportunities to explore the 3rd

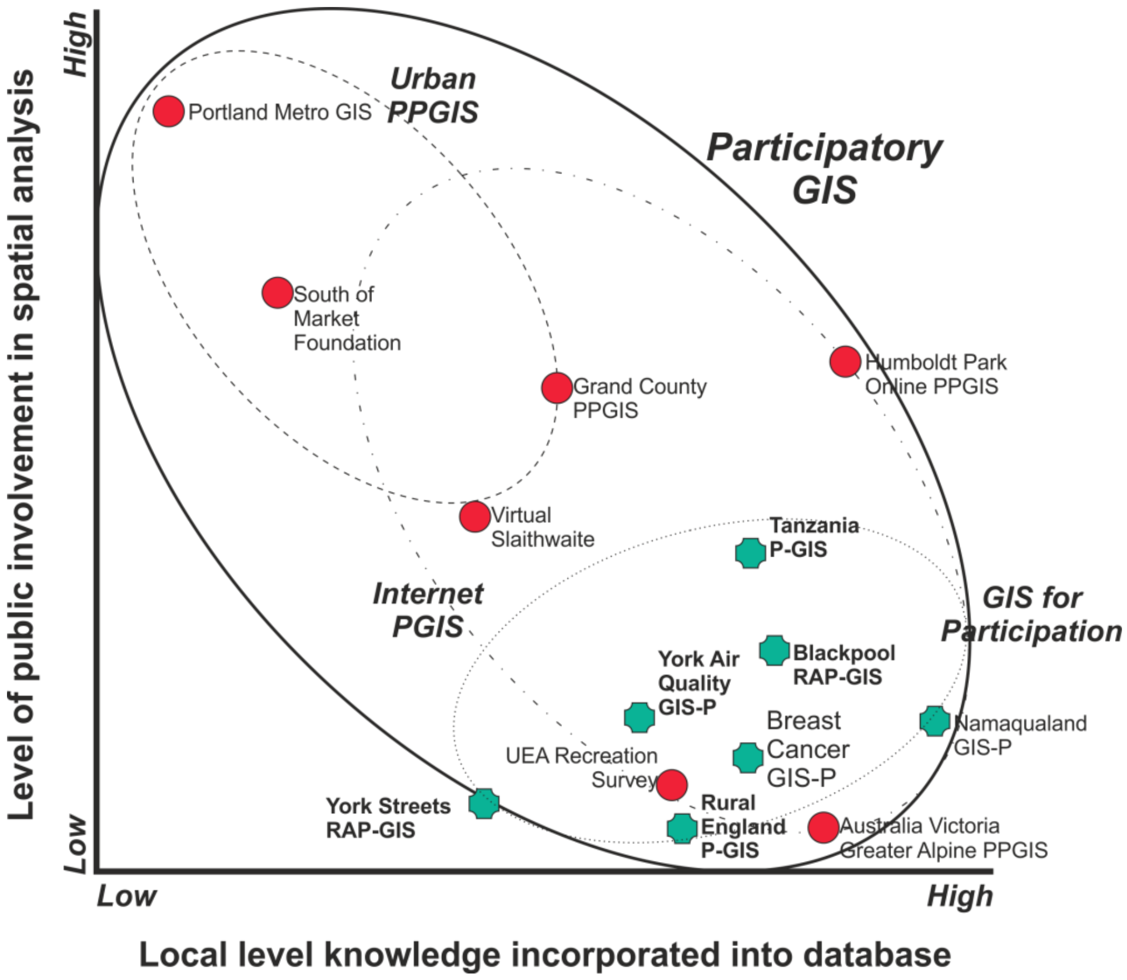

Figure 1: Updating of graph from Cinderby et al. 2005 indicating the level of success various projects have achieved at meeting two ideals of PPGIS practice.

(Humboldt Park PPGIS from Elwood (Cope and Elwood, 2009)***; Grand County PPGIS*** (Brown, Montag and Lyon, 2012)***; Australia Victoria Greater Alpine PPGIS*** (Brown and Weber, 2011)***UEA Recreation Survey*** (Bearman and Appleton, 2012)***; Virtual Slaithwaite*** (Kingston et al., 2000)***; South of Market Foundation and Portland Metro*** (Craig , Harris and Weiner, 2002)***.***

(height) and 4th (time-series) dimensions. This last opportunity is something I have begun to touch upon during my Arts and Humanities Research Council knowledge transfer grant (Improved Community Engagement using Spatial and Visualisation approaches (sei-international.org/ice-sav/).

In addition, the policy context within which the powers for participation operate continues to evolve. In the UK context this can be illustrated in relation to two particular development strands – the rise of the Transition movement and the Localism legislation.

Transition Movement

The concepts of peak-oil, the depletion of fossil fuel reserves and societies future in a post-oil world are central to the origins and agenda of the Transition Movement. Due to the slow response to these impending energy and consequent societal changes from national government the Movement's approach is to generate and coordinate concerted local action.

Resilience (Adger, 2000; Cinderby, Haq, Cambridge and Lock, 2014) is central to the concepts promoted in the Transition Towns movement literature (Hopkins, 2008). The overarching theme relevant to the PGIS approach is a move towards improving the strength of local systems to make communities more self-reliant. Self-sufficiency relies on diversity in skills and resources at the local level combined with creativity in identifying community driven solutions relevant to specific locations. This implies the generation of bottom-up solutions with 'tight feedback loops' so that the positive effects of local decisions are rapidly enjoyed rather than being delayed or diluted through longer decision making pathways.

As the papers in this thesis demonstrate, PGIS processes can provide a useful approach to developing these bottom-up solutions in a digital framework allowing the potential for increased transparency and hence legitimacy for communities. "*In the social context we cannot consider resilience without paying attention to issues of justice and fairness in terms of both the procedures for decision-making and the distribution of burdens and benefits"* (Davoudi, Shaw and Haider, 2012). Capturing, storing and reflecting on the diversity of bottom-up solutions in a PGIS could help facilitate equity and justice for communities engaging in transition processes. This would lead to significant options for real empowerment and transformative outcomes for local participants.

Localism and the Big Society

This area of social justice and the need for governance of resilience building processes to ensure fairness has implications for the latest community development focus. The UK policy direction in relation to communities is currently framed in terms of increased 'Localism' with supporting legislation (Department for Communities and Local Government, 2011) and the associated and much discussed 'Big Society' agenda. Localism is aimed at transferring decision making powers down to the lowest relevant scale with the aim of enabling communities to make decisions affecting themselves for themselves. Alongside the cut-backs in state provision it has been argued that this approach does indeed indicate a new direction in UK policy, rather than a re-working of previous goals (Taylor-Gooby and Stoker, 2011) including past attempts at sustainable development planning such as Local Agenda 21.

Specifically, the Localism Bill intends to transfer neighbourhood planning activities and decisions back to the communities affected. Rather than implementing local strategies developed by national government bodies (as was the case with LA21) the intention is for local communities to draw up their own 'neighbourhood development plan' including where they would like new buildings, developments and housing and present this plan to the relevant local authority. In order to undertake such local planning effectively, communities could utilise PGIS approaches to develop shared visions for the future – inclusively identified through participation – linked to a strategic long term goals for the community. Some attempts have been made to generate the information communities could utilise in this process through mobile phone apps (Jones and Evans, 2012; Jones, Drury and McBeath, 2011; Jones and Evans, 2011). However, at present I would argue that these attempts do not yet address the significant consensus and conflict resolution aspects that such local planning may require.

There remain a multitude of issues in relation to implementing Localism (that could probably form the basis of a complete thesis in isolation), however, in relation to the spatial planning aspects of development PGIS processes hold a clear potential to contribute. A key challenge relates to the representation of the diversity of viewpoints at the local level and the integration of different local plans at a higher decision making scale to develop a more strategic overview. Development of the nested scale PGIS methodology described in paper 6 could be particularly useful in this context. It could allow the transparent development of plans at the local community level followed by their integration at higher geographies with neighbouring communities to ensure a strategic longer term direction. The testing of development plans could be made in relation to vignettes used to develop scenarios of what a future city or town would be like for different types of residents.

However, increased calls for participation from the policy community highlight concerns over potential injustice in relation to the unequal abilities of communities to engage in these processes (Brisley, Welstead, Hindle and Paavola, 2012). Whilst PGIS provides a framework for developing local community plans it is unlikely to be widely adopted without effective (and probably sustained) support for communities to encourage participation. Such support is necessary alongside the policy context of enabling local decision making if this 'Big Society' agenda is to have real meaning for local residents. This goes against the current localism approach which emphasises the retreat of government responsibility. As Davoudi, Shaw and Haider stress *"while the existence of engaged social networks help foster adaptive capacity and enhance transformative resilience, it is not a substitute for responsive and accountable governance "* (Davoudi, Shaw and Haider, 2012) .

Conclusions

Overall, I remain enthusiastic and optimistic about the potential for PGIS in the UK context with the pragmatic caveats that at present I do not see evidence of sufficient funding to support an equality of engagement in the aspirations of Localism across all communities.

The papers compiled in this thesis demonstrate the incremental development of my PGIS methodologies through application of techniques in a variety of contexts and settings. I believe that they demonstrate I have made a significant novel contribution to the discipline of Geography and participatory methods in two complementary ways: Firstly through the development of PGIS methodological approaches for a variety of processes and purposes. This has included the translation of methods both South-North and North-South which has facilitated considerable learning for me – but also I believe added worthwhile insight to the development of PGIS approaches that I have reported on through the academic literature, websites, conference presentations, teaching and videos. The development of methods specifically aimed at engaging and facilitating the involvement of hard-to-reach or seldom heard stakeholders is I think also another worthwhile and useful contribution I have made to the broad church of PGIS methodologies. My second contribution has been through the insight obtained from the application of these novel methods in differing contexts and processes. This has included investigating the possible linkages between local stakeholder knowledge and modelling (including air quality, soil water and epidemiological); integrating vignette approaches with mapping to reveal social context and spatial distribution of issues; evaluating the use of visualisations derived from participatory mapping (2D and 3D) to better inform decision making. I believe that my work has revealed or expanded on aspects of the dimensions of space and place – fundamental elements of a geographical understanding of locations and processes.

The common theme to all the papers presented together in this thesis has been the concept of improved environmental decision making through the input of local stakeholder knowledge into the deliberations of planning, policy formulation or natural resource management. However, there remain significant challenges but also untapped opportunities that continue to excite and drive my research interests forward in this area.

I therefore remain an unreconstructed geographer and – say it loud, say it proud – a mapmaker.

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Geographic information systems (GIS) for participation: the future of environmental GIS?

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Abstract: The conventional uses of geographic information systems (GIS) in environmental management have been criticized for being undemocratic and avoiding the social dimension of these issues. To address these criticisms, new participatory approaches are being developed by the GIS community. These new techniques involve the integration of conventional spatial data and mental maps showing communities' (or various groups') perceptions of their environment and how they use resources. Case studies using these new techniques highlight how GIS is being incorporated into participatory studies. The advantages and drawbacks of using GIS for participation are discussed, with the conclusion that the techniques provide a useful new approach for environmental management.

Keywords: GIS, mental maps, participation.

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1 Introduction

The past decade's use of geographic information systems (GIS) for environmental research has largely been viewed as a critical success both by GIS practitioners and their scientific peers (Maguire *et al.*, 1991). The spatial representation of information gives GIS unique analytical abilities and endows the results it generates with added power and perceived authority (Wood, 1993). A recent criticism of this success is that it has been achieved by tackling the 'easy questions' (Harris *et al.*, 1995). Social and cultural information has largely been excluded from environmental investigations. GIS technology has been used to reinforce top-down, 'expert' analysis of development issues. The power of GIS has been accused of supporting the status quo in society by limiting information access to select groups. The GIS community is making attempts to answer these criticisms through the development of new approaches involving increased 'local' participation and the representation of multiple realities for single issues.

This paper examines the typical uses of GIS in environmental analysis and the criticisms targeted at such approaches. The new techniques being developed to address these failings are described, and the potential future applications of these GISs for participation discussed.

2 Conventional environmental GIS

For the purposes of this paper, a GIS has been defined as a means of integrating spatial and non-spatial information into a single computer system for analysis and graphical display. The system is housed and maintained within an organization and, as such, reflects its mandate.

This last organizational aspect is of crucial importance and often overlooked in assessments. Value judgements must be made in the initial selection of data and their future use and management. The basis for these judgements is often related to the ideology of the organization in which the GIS is housed. The idea of objective GIS is therefore inherently flawed (Harris *et al.*, 1995).

The methodology employed within conventional environmental GIS can be characterized as 'top down'. Outside agencies set the agenda of what the goals are and the information relevant to realizing them. The viewpoint of the analyst in this process is crucial as there is generally no single solution, and the choices to be made on data collection and analysis techniques are vital to the outcome. In some instances, various solutions to complex problems are produced based on GIS experts' perceptions of user needs (Hassan, 1995). Even in these cases, however, it is generally one agency (the operators and owners) of the GIS who have control of the range of solutions or viewpoints presented. GIS data are always produced for someone, by someone and for a purpose (Harris and Weiner, 1998).

Part of the historical justification for this exclusive process has been the high costs related to GIS analysis. This has made the systems available only to wealthy institutions rather than a wider community. This elitism based on the wealth of organizations has led to claims that GIS is undemocratic as it accumulates information into the ownership of a select few (Harris *et al.,* 1995; Dunn *et al.*, 1997). Without equity of access to the information and technology of GIS, small or less wealthy groups (both financially and technologically) have been disadvantaged in their ability to fully engage in the process by which decisions using spatial analysis have been made (Harris *et al.,* 1995).

Despite these concerns, conventional GIS has been employed increasingly widely over the past decade to investigate environmental issues. The perception of 'expert' reviewers is that, in general, these applications have been a success (Maguire *et al.*, 1991).

It may be supposed that these successes have generally been in areas where physical environmental processes are the primary factors. However, even here problems can be identified. Weiner provides a specific example of how 'top down' environmental GIS approaches can be exclusive, undemocratic and present only one answer to a problem with multiple solutions. During the former apartheid era, South Africa's Soil and Irrigation Research Institute set a maximum 12% slope angle for ploughable land. This was based on the requirements of mechanized cultivation, and GIS land suitability analyses were carried out accordingly. This slope angle reflected the Institute's viewpoint and constituency, because hand hoeing and animal ploughing, as practised by the majority of black farmers, allow cultivation on much steeper slopes. The information created by this analysis was therefore skewed as the data on which it was based excluded a large percentage of the local user base without explicitly stating that this solution represented only one of many possible answers.

This example illustrates the concerns raised over the conventional application of GIS technology to environmental and development issues; such issues cannot be addressed without reference to the users of the resource being investigated and the constraints, both social and physical, within which they operate. In order to address some of these concerns new approaches are currently being developed to integrate local expertise and perception into a GIS framework.

3 GIS for participation

Conventional GIS has been accused of not fully addressing and incorporating social issues, although this deficiency has been blamed on social priorities rather than inherent limits in the technology itself (Weiner *et al.*, 1995). GIS practitioners have created digital representations of social and natural phenomena that best reflect their expert viewpoint (Weiner *et al.*, 1995). Recently, attempts have been made by a number of independent studies to address these concerns and build what are here described as GIS for participation (GIS-P).

Three particular studies have been identified (and will be referred to here) that have explicitly attempted to include participatory techniques in the GIS process. These are:

- The Kiepersol GIS (Eastern Transvaal, South Africa) (Weiner *et al.*, 1995);
- The Namibian Wildlife GIS (Tagg *et al.,* 1996);
- The Namaqualand GIS (Northern Cape, South Africa) (Cinderby and Deshingkar, 1998).

All three have been developed in the Southern African region to engage local interest groups in the policy formulation process on a more even footing with government management organizations. The grouping of all three projects in this geographic region may be a reflection of the rapid political and social changes occurring in the area. These changes are allowing the possibility for new means of communication to be fostered and have led to increasing emphasis being placed on the democratization of the development process.

Participatory techniques have been developed as a way of enhancing local people's abilities to share and analyse their knowledge of lifestyles and conditions, thereby better enabling them to plan for the future (Chambers, 1994). Empowering people to act has been considered part of this process (Binns *et al.*, 1997). Truly participatory studies have not been intended for outsiders to learn about local conditions but instead to facilitate local people to conduct their own analysis and develop their own agendas (Chambers, 1994; Binns *et al*., 1997).

Within these overall ideals, the three studies have been developed to enhance local communities' abilities to engage in the policy development process. A number of similarities become apparent when investigating the techniques used by the three projects.

First (and obviously), the GIS-P attempts to promote 'bottom up' policy development by incorporating local concerns and knowledge within a spatial database. A technique common to all three studies has been the use of mental maps (Dorling *et al.*, 1998) of local conditions produced by different sectors of the communities being engaged. Such maps are a common technique in conventional participatory analysis (Chambers, 1994). Mental or cognitive mapping is a process by which an individual recalls and decodes information about the location and attributes of phenomena in their everyday environment (Fox, 1998). The new dimension here is the incorporation of these perceptions of the environment within a GIS database. The production of such mental maps typically involves members of the local community drawing features of interest in a workshop. The features selected for inclusion are dependent on the community group with or without guidance from an outside facilitator. Once produced, the meaning of the features represented on the maps can be interrogated during interviews, and the maps subsequently enhanced to illustrate any greater understanding thus generated.

This process is iterative and can be ongoing. For example, in Namibia the resource maps of communities will be redrawn over time. This activity will be used to monitor resources and the effects of management decisions (Tagg *et al.*, 1996). The production of the Namaqualand mental maps took place over a period of two to three months. During this time the maps were reassessed after village meetings and redrawn to take account of this greater shared understanding between the various village groups.

The use of spatially referenced base data, such as paper thematic maps or air photography, has allowed these mental maps to be integrated into a GIS. The incorporation of mental maps into a digital database allows the use of conventional GIS techniques to analyse these unique datasets. By overlaying numerous individuals', or groups', mental maps of the local conditions, differing perceptions of the importance of varying access rights to resources can be identified. This combination of different perceptions allows for the investigation of the multiple realities of a single issue. For example, in the production of the Namaqualand GIS, community groups from four different neighbouring villages independently produced maps detailing their use and access to communal grazing land (see Figures 1 and 2). By overlaying these four maps within the GIS it was possible to highlight areas of conflict on resource use, where the perceived village boundaries overlapped (see Figure 3). This process enhanced the local people's information on the way they used the local resource base. It also presented it in a form more usable and understandable by local and national government agencies, such as the Department of Land Affairs, empowering the community as they engaged in the land reform process.

Figure 1 During interviews and workshops farmers produced maps detailing their perceptions and use of the resources in the communal area of Namaqualand, South Africa.

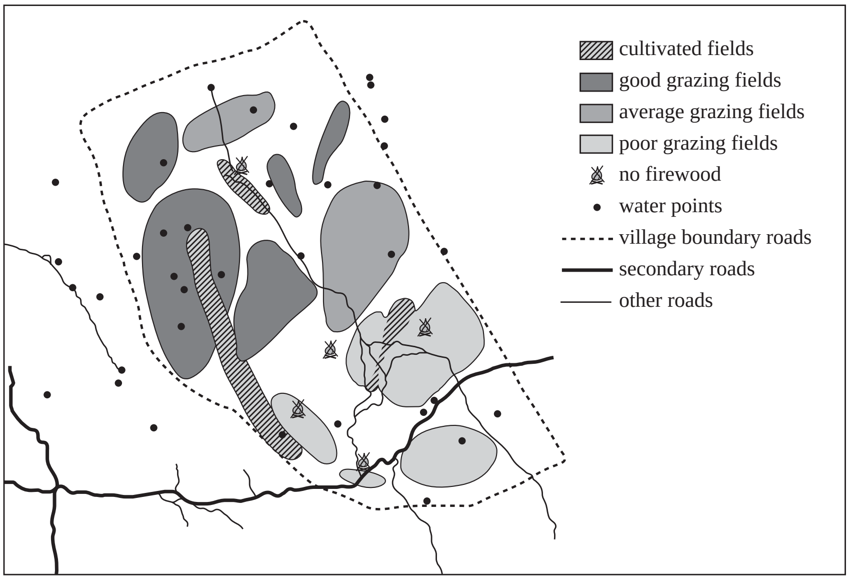

Figure 2 An example of the type of information indicated on the mental maps drawn by the Namaqualand farmers.

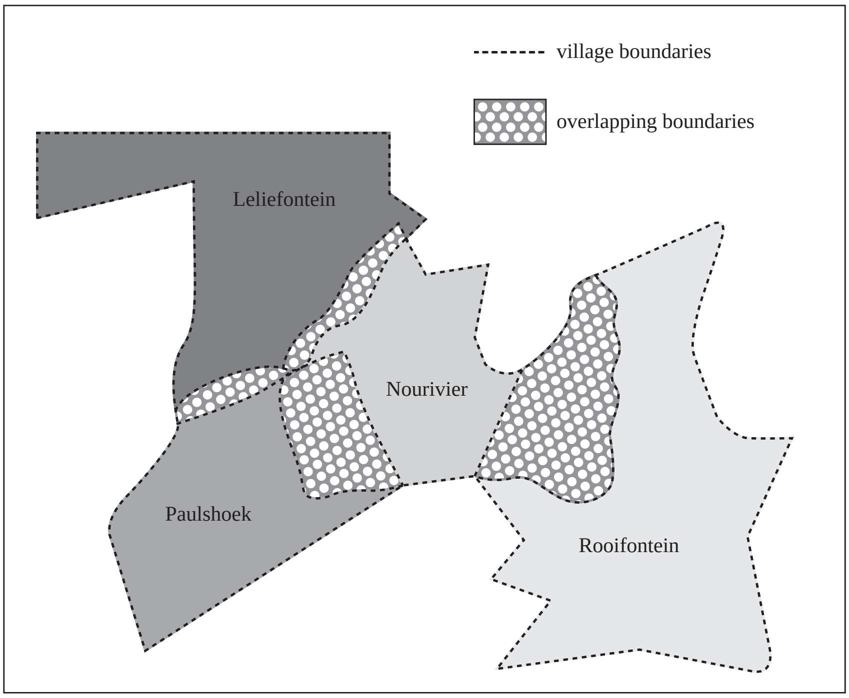

Figure 3 The 'boundaries' indicated on the mental maps of four neighbouring communal villages were overlaid.

The second common technique used in the three studies has been the incorporation of conventional 'top down' agency-produced information. In the Kiepersol GIS, a land-types map was integrated with the community's perceptual information. The mental maps indicated soil conditions as well as access rights to land for the black farmers of the area. The integration of the two types of data was useful as it highlighted disagreements within the government agency's assessment of land potential in the area and the local farmers' perceptions of the same issue. The comparison showed broad agreement between the state assessment of soil conditions and the higher-resolution knowledge of the local communities. The integration, however, highlighted the importance of land and water access as the true limiting factors to farming potential in the area, rather than soil capability. Access to land within the bantustans is partly controlled by the chief, who allocates fields to specific farmers. The mental maps revealed this, indicating how social mechanisms also affect farming practice.

In the Namaqualand GIS, information on water quality produced by a hydrological surveyor was combined with mental maps indicating water resource types and their typical use, such as a household water borehole (see Figure 4). The combination of the different datasets enhanced the understanding of both the local community and the surveyor. The mental maps indicated far more water points than had been identified by the outside agency. The maps also indicated to what use the water was being put, a factor largely unknown to the surveyor before the comparison was made. The data on water quality were useful to the local communities as various contaminants exist in the local water bodies. By highlighting where water quality is highest the use of wells for human consumption could be reassessed and the case for better water supplies made more powerfully to the provincial authorities.

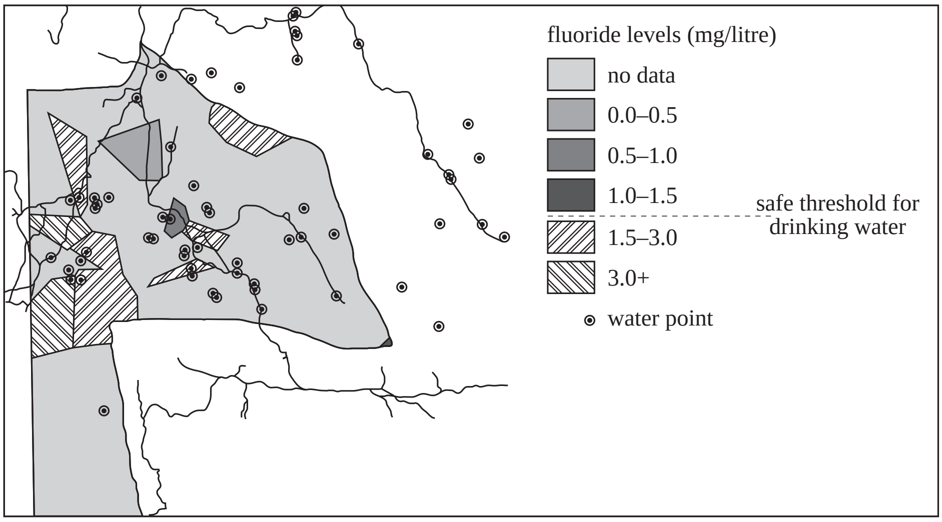

Figure 4 The combination of the local knowledge of water supplies with hydrological surveys of water quality gives a greater insight into potential health problems in the Namaqualand communities.

This combination of perceptual and conventional spatial data allows for increased communication, both internally within communities and externally with outside groups. Maps can be seen to represent a more universal visual language. The GIS-P information helps to facilitate greater shared understanding and can enhance the position of local groups when negotiating with outside agencies (Tagg *et al*., 1996).

The three Southern African case studies, despite being preliminary, have produced a number of successes. The Namaqualand GIS-P (Cinderby and Deshingkar, 1998) and the wider study of which it formed a component (Deshingkar and Cinderby, 1998) have been used by the communities involved, in collaboration with a local NGO, the Surplus Peoples Project, to support their land claims as part of the land reform process being entered into by the South African government. The results of the GIS-P also helped in the formulation of sustainable management strategies for the area, which supported the communities' claims for greater access to land and resources, such as water.

The Namibian wildlife GIS (Tagg *et al.*, 1996) has contributed to a greater understanding within the Ministry of Environment and Tourism (MET) of the Nyae Nyae communities' perceptions and use of the natural resource base. The MET has the formal power to grant management rights over wildlife to local communities. This shared understanding of resources is therefore imperative if mutually agreed and understood decisions are to be made. The GIS-P has been used in negotiations within local communities and between local communities and the MET around the issues of sustainable rural development and natural resource management. More tangibly, the same information has been used in the participatory planning of new water points.

The Kiepersol case study results are of a more preliminary nature but highlight the effect of apartheid policies on the local farmers. The maps include information on land use and quality. They also detail the effects of apartheid on the communities such as sites of forced removals, the locations of struggles over fences and the restricted access to water resources in the bantustan areas. The preliminary study is currently being built upon with the development of a GIS-P for part of Mpumalanga Province in South Africa (Harris *et al*., 1998). The extended project aims to contribute to participatory land reform and to test the alternatives for GIS-P.

4 Advantages and criticisms

The potential of incorporating participatory approaches within a GIS appears to offer a solution to the criticisms levelled at conventional 'top down' spatial analysis. These include the undemocratic nature of GIS analysis and the representation of single agency solutions to multiple reality issues.

The techniques of GIS-P are relatively new and still developing. In different locations the similar techniques and goals have been termed public forum GIS (NCGIA, 1998), public participation GIS (Harris *et al.,* 1998), and counter mapping GIS (Rundstrom, 1998). Examples of these techniques have come from Canada (Fox, 1998; Rundstrom, 1998), Central and South America (Kosek, 1998; Chapin, 1998) and Indonesia (Fox, 1998).

The development of GIS-P allows multiple viewpoints to be accommodated within a single frame of reference. Mental maps can help to describe communities' knowledge of their local environment in a form intelligible both to members of the group and to outsiders. Evidence from the three case studies investigated in this paper indicates that local environmental knowledge is often of high quality when compared with data compiled by outside specialists (Weiner *et al.*, 1995; Cinderby and Deshingkar, 1998). It also holds numerous advantages when compared with conventional spatial datasets. Mental maps contain information unobtainable from other environmental data on the social settings for resource use. This can provide insight into the various perceptions of, and access rights to, a resource by different sectors in a community.

For example, as part of the Namaqualand GIS, Landsat satellite imagery was classified to show the levels of green biomass and the types of land cover present across the four villages being investigated. When these datasets were compared with the village assessments of grazing quality, similar patterns were broadly differentiated (Cinderby and Deshingkar, 1998). The village assessments, however, contained additional differentiation based on social factors. For example, areas identified as average grazing land by farmers were found to have physical conditions that should have classified them as good grazing according to the satellite assessment. On questioning the farmers further about their classification, it emerged that additional factors had affected the 'quality' of the land. For example, for one grazing field the mental maps showed the area to be perceived as prone to jackal attacks on livestock. The actual threat to livestock was never quantified but the risk, as viewed by the farmers, was clearly indicated on their maps. For another set of fields it was found that the distance from the village made the pasture less highly rated. Keeping watch on the animals in these fields required farmers to be away from home and live out at stock posts for extended periods. Factors such as these had reduced the attractiveness of these high quality vegetation fields to the herders. This type of information is unavailable on conventional spatial datasets.

The combination of existing environmental information with that obtained from the users of the resource allows greater insight into the limitations and possibilities for its local development. By combining these multiple viewpoints visually, increased clarity of communication can result. This allows the potential for local groups to engage on a more equal footing with outside agencies.

The use of GIS-P techniques also allows for the monitoring of resources and impacts of management decisions on local communities' perceptions through time. This activity is forming part of the Namibian wildlife GIS. In Namaqualand the possibility exists to repeat the mapping exercise now that the land reform process has been implemented. This repeat mapping would highlight the effects on the resource use and access perceived by local communities. This activity could form the basis for assessing the success of land reform for communities or sectors within those communities in this semi-arid area. The use of mental maps through time could be used to assess the impact of management changes in a variety of situations. The visual nature of maps would encourage the investigation of impacts in a more insightful way than conventional techniques, such as questionnaire surveys can achieve in isolation.

Potential problems do exist with the integration of GIS within participatory studies. In order to facilitate the use of mental maps in a GIS, some type of geographically referenced base map has to be used. Although this technique has been used in conventional participatory surveys, it is unclear whether the imposition of a base map forces a certain view of the world on the surveyed group. Constraining people in this way may reduce or restrict what they would discuss if they had been given a blank sheet upon which to draw. For example, Fox cites the case of the Inuit of Canada, who organize their space based on the daily movement of the Sun and annual Arctic cycles rather than the cartographic standard north, south, east and west. The extent to which this is a factor and how it varies amongst different groups (spatially, culturally and with age and gender) is unclear and requires further investigation (Wood, 1993). Evidence from Bolivia, however, highlights the creativity of communities when producing maps (Chapin, 1998). Local communities in the region, stimulated by GIS-P activities, have developed an environmental education curriculum for children built around mapping.

Techniques exist within GIS that allow for the representation of indistinct (fuzzy) classes for handling qualitative data rather than forcing it into restrictive quantitative classes (Maguire *et al.*, 1991). Perceptions of the accuracy of fuzzy results generated on a computer in this way may represent a problem. If results are presented without building the capacity of the participating groups to understand the limitations of any analysis, then conflicts within a community could be exacerbated by the use of GIS-P. If the boundaries drawn on maps are perceived as distinct, as opposed to fuzzy, by participating communities they could polarize any conflict into arguments over lines on the map. The GIS-P should be used to drive discussions rather than as an end in itself. For example, the village extent data obtained in Namaqualand (see Figure 3) represent an indistinct boundary as perceived by local farmers as a distinct line on a map. This information has been used to develop discussions on the communal management of these shared areas. It should not be used in the same way as cadastral survey data to argue over the exact position of the boundary line between the villages.

A large number of current studies using GIS-P techniques have encountered similar problems around this issue of boundaries. Chapin describes how communities in Mosquita, Honduras, used the lines they drew on maps to lay claim to communal land and to try to prevent other groups from entering 'their' subsistence areas. This experience has led communities in Izozog, Bolivia, involved in later projects to decide against defining boundaries to their communal land. Fox reports on similar concerns from Indonesia where land managers no longer include village boundaries on the maps they produce with communities in an effort to reduce boundary disputes. It is unclear the extent to which these conflicts are caused through poor presentation of the information collected and lack of capacity development in the participating groups. It may be that the process of mapping indistinct boundaries inevitably hardens their fluid nature (Fox, 1998). The example from Namaqualand, however, indicates how careful use of boundary information can inform discussions and increase awareness as opposed to raising tensions and instigating conflicts.

Chadwick and Seeley (1996) indicate a potential problem with the use of lay-people's perceptual information. They investigated local farmers' soil classifications in Nepal and the use of clarifications in quantifying soil properties across regions. They point out that little is known about whether the limits to soil criteria as expressed by local farmers are absolute or relative. This problem is particularly pertinent to GIS-P where multiple mental maps over a wide geographic area could be combined. The extent to which an individual's or group's perception of conditions in a location is comparable with an assessment by a different group in another (although physically similar) region is unknown. For example, does good grazing land mean the same to villagers from one location as it does to those from another adjacent location, or is it dependent on the range of conditions to which they are accustomed? Further investigation will be required to address this complex issue and it is likely that the results will be case specific. Care must thus be taken when combining perceptual information over a wide geographic extent.

As with all forms of participation it must also be considered who is participating. Communities are not homogenous groups. When engaging with them it is possible (even probable) that powerful individuals will dominate the communication. Care must be taken that the viewpoints of different groups are given equal weight, where possible, or else the characteristics of participants included should be made explicit. This issue raises concerns over privacy of the people participating. People's viewpoints are given a visual form in GIS-P systems (Harris *et al*., 1998) and could be the basis for conflict within communities. Indeed, as Harris *et al*. (1998) point out, 'a conflictual GIS would be an expectation' of GIS-P. The techniques for dealing with this issue have yet to be addressed in any of the studies reported so far.

The issues of privacy lead to concerns raised over the surveillance capabilities of GIS-P. Fox points out that customary rights within a communal area are left to the communities to decide. The process of GIS-P by its nature intends making the use of land explicit. This then raises issues of control over what occurs in these communal areas by external agencies. The use of GIS-P in South Africa highlights the alternative scenario where state control has had huge impacts on people's access to resources and livelihood strategies. In this situation, the use of participatory mapping can highlight the impact of past conflicts (Harris *et al.*, 1995) and help develop management options for the future (Cinderby and Deshingkar, 1998).

The final criticism of GIS-P is the extent to which it really is participatory. Participatory studies are intended to enable local people to conduct their own analysis, develop plans and take action (Chambers 1994). The extent to which it is possible to achieve these ideals using GIS techniques is a matter for debate. Kumar *et al.* (1997) complained that GIS is a 'social process which imposes a quantitative rather than a qualitative view of space and can lead to the worst form of positivism'. The nature of GIS technology at present still requires the extraction of data and its analysis by people skilled in its operation. However, as the case studies show, if carried out in collaboration with the communities, this analysis can assist in empowering them with information unavailable by other means (Harris *et al*., 1998).

The use of fuzzy logic for analysing qualitative classes removes the need to force this type of data into a quantitative framework for analysis. The complaints levelled at GIS seem, therefore, to be aimed not at the technology but its use. The key to the successful implementation of GIS-P activities rests with the process of partnership between spatial analysts, social scientists and local groups. The local groups set the agenda and the outside experts facilitate the analysis. This is the reason why the techniques should be described as GIS for participation rather than truly participatory GIS (Harris *et al.,* 1995). In this way the use of GIS for local planning becomes a tool to help communities in their communication internally, between local groups, and outside agencies.

5 Conclusions

As with the development of participatory techniques in other disciplines, the development of GIS-P within the spatial analysis and environmental planning community is liable to be a slow, possibly painful, process. The techniques described here represent some of the first steps in this evolution. The techniques appear to offer a new and powerful way of engaging local groups in the planning and decision-making process on a more equal footing with external, technologically endowed, agencies and organizations. The spatial representation of issues allows a unique form of communication of viewpoints on a range of issues by different sectors of society.

Conventional environmental GIS has been described as a success. This may be because it presented 'definitive' solutions to complex problems. When multiple viewpoints on environmental issues are included in the analysis it remains to be seen whether GIS will offer the same attractiveness to the decision-making process. There is a risk that it will lead to information overload. However, this democratization of spatial analysis will at least make more explicit some of the choices that have been made in achieving a decision. In this respect, GIS for participation offers some unique insights and challenges to the planning and policy process.

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Facilitating the local governance of air pollution using GIS for participation

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Abstract

This paper reports on a novel empirical approach to capturing and analysing non-professional understanding of spatially related environmental issues. The technique, Geographic Information Systems for Participation (GIS-P), has been developed in a Swedish International Development Agency (Sida) funded project and refined in an Economic and Social Research Council (ESRC)[2] funded study to use community mapping exercises in British urban centres to produce spatial representations of local knowledge about air pollution and related problems.

The paper outlines the technique, presents data from a three-city case study, and highlights important stages in the process of running GIS-P groups to illustrate the key points in the methodology. It then indicates how using spatial conceptions and representations in dealing with publics, and the (re) framing of the publics' ideas using GIS to present non-professional understanding, can contribute to not only the responsible local governance of air quality but also increased engagement between local government environmental scientists and publics.
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Keywords: Geographic Information Systems for Participation; Citizenship; Public Engagement; Lay Knowledge

Background

Geographic Information Systems for Participation (GIS-P) started as a process whereby local knowledge about an area could be discussed and then mapped for planning purposes.

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The methodology was initially developed in South Africa in 1997 to look at land resource use in communally managed villages, so it was a method of data capture—it used manual mapping techniques to capture dispersed, qualitative data into a GIS database. The benefit of capturing information in this way was that local knowledge about land use could then be compared and combined against other forms of spatial data to assist in answering questions posed by the villagers themselves and by other local policy stakeholders (Cinderby, 1999). GIS-P, therefore, originated differently to the majority of Public Participation GIS (PPGIS) methodologies mainly emanating from the US—GIS-P came from the background of participatory rural appraisal (PRA) and rural livelihoods development.

From 1998 onwards, metropolitan and city local authorities in the United Kingdom were forced by national government guidelines to identify urban areas that may be at risk from air pollution in the year 2005. In order to do this they needed to employ predictive computer models. Sheffield was one of the first to produce computer predictions of air quality and this provided an opportunity for researchers to look at what local publics thought of the model. Researchers from the Stockholm Environment Institute-York (SEI-Y), with the Sociology Department at the University of York found that the public had meaningful knowledge about technical subjects (Yearley, Forrester and Bailey, 2001).[3] Further, they found that the focus group, especially when moderated by an independent facilitator, held promise as a tool for generating policy-orientated dialogue around environmental issues (Forrester, 1999) and could provide a platform for non-experts to interact with professionals on a more equal footing. Nevertheless, the knowledge was largely created in a sphere outside of that within which policy actors and local authority scientists normally worked. Fundamentally, there were two major shortcomings:

- Public knowledge was not fed into the policy system in any useful manner and;
- Public knowledge was little understood by experts or even by policymakers.

Nonetheless, there was, as the literature suggested, a valuable local knowledge ‘out there’ if only it could be captured in a meaningful way (Irwin, 1995; Irwin and Wynne, 1996). The task, therefore, was to (re-) present this public knowledge in a way that was useful to the local authority scientific experts (and policy-makers) but which was still acknowledged as being ‘owned’ by the citizens whose knowledge it was. GIS-P held promise as a technique that might meet these criteria.

Approaches to public engagement with local environmental issues

In the last decade, many arguments have emerged for encouraging public participation, particularly in environmental policy making and management (see Forrester, 1999 for an exposition of these arguments). Some have adopted the pragmatic argument that public involvement will assist with the effective implementation of policy: when ‘users’ are

[3] Another ESRC funded project acted as a pilot to the project discussed here (ESRC grant number R000221902).

consulted they are more likely to lend their support to (or, at least, not oppose) policy measures. Others have argued that in democratic societies, people simply have a right to a participatory role. Finally, the argument has been made that people may have access to knowledge that is unknown to experts: local people may themselves count as experts about their own localities (see also Forrester et al., 2002). Such initiatives have been further spurred and legitimated by the participatory emphasis within Local Agenda 21(LA21). LA21 was important in that it encouraged people to participate in the issues affecting their localities. However, experience shows that successful LA21 and other participatory processes have used knowledgeable outside mediators to involve publics (Claus, 1995; Linnerooth-Bayer, 1995; and Wild and Marshall, 1999), implicitly recognising that while trust and communication is necessary (House of Lords, 2000) the best mediators need to be not only experts in mediation but also have a good working knowledge of the issue under scrutiny.

We found that with respect to air pollution, citizens' views of problems are consistent with expert's views (i.e. that in the perception of the problem there is little difference between expert and non-expert)—yet locals often still feel that their views, and importantly their local knowledge, are not being taken into account. In one way, this disenchantment arises over the reluctance of local authority technical officers to engage in face-to-face discussion with members of the public. Face-to-face discussion—on a level platform, such as is provided by mediated group discussions—can allow concerned citizens to raise issues of concern to the mediator and have them dealt with in a measured fashion by the mediator or technical officer as appropriate.

Computer models

Computer predictions of what might happen under certain conditions, used for generating policy actions to avoid catastrophic futures, are fundamental to our understanding of what is happening and what will happen to our environment. Scenarios of future activities are used by modellers to produce information on how the environment might look under different development pathways. These scenarios include inputs such as various climatic conditions, different policy choices, or alternative actions by individuals or 'stakeholders'. Thus, with respect to local air pollution models, the actions of local commuters, for example, influence which of these scenario paths will be followed.

The project team worked in three UK cities—Bristol, York and Sheffield—investigating how public knowledge could be communicated to, and utilized by, local authority air pollution modellers. These cities were at differing stages in the national government review and assessment of local air quality that was initiated in 1998 (DETR, 2000). The review and assessment procedure had four stages. Stage I involved assessing sources and emission levels for a number of pollutants within urban areas and was carried out by local councils. Stage II required these councils to monitor actual levels of pollutants at key points (the areas of the city where Stage I information indicated pollution was likely to be highest) and to assess the actual measured levels in comparison to the government guideline thresholds. This was carried out to determine whether areas were exceeding these thresholds. In Stage III, local authorities were 'expected to carry out an accurate and detailed review and assessment of current and future air quality' (ibid). The output of this third stage was sections of the city designated as air quality management areas (AQMAs) for which action plans to try to mitigate this pollution would have to be developed in the fourth stage of the process.

This third stage of the review and assessment procedure required city authorities to predict whether they had areas that were likely to breach the air pollution thresholds. This prediction entailed developing computer models to assess current levels of air quality across whole cities (which could not be done effectively through monitoring alone) and to predict future air pollution. These models took as inputs emission inventories (location, sources and type of pollution), local meteorology, topography and scenarios of future emission levels. In general, the models did not link directly to the monitoring also being carried out by local authorities, but instead used these point value measurements as checks on the outputs from the predictions.

The actual operation of the models can be quite coarse. For example, the latest version of the CERC ADMS Roads Pollution Dispersion Model, an assessment tool used by a number of UK local authorities, can assess a maximum of 150 road sources and up to seven industrial sources at any one time (CERC, 2001). For each road, the width and height of buildings need to be added. Obviously to do this for all urban roads is very time consuming and intensive. With only 150 road segments available, it also means that only a subset of the city roads can be modelled at a time. All of these factors result in the selection by modellers of what data are included in the model and the values of these data with the result that the consequent outputs are often quite subjective. These comments are not intended to criticise the use of computer models but merely to highlight that their use and operation is not a completely value-neutral process. This subjectivity concern is valid even before the issues of scenario development have been considered.

The three cities involved in the ESRC project had been selected because they were at different stages in the assessment of their air quality. York was at the earliest stage having performed its monitoring and modelling but not having declared its AQMA. Bristol and Sheffield were at the next stage having publicly declared their AQMAs but public knowledge in Sheffield about the process was the most advanced, it having been one of the first UK cities to model air pollution. This paper will comment on the results of using GIS-P in Bristol and York during and directly after Stage III; we did not use GIS-P in Sheffield during this research.

GIS-P bringing participation and spatial awareness together

GIS-P is a relatively new methodology that captures local stakeholder's knowledge in a spatial format suitable for incorporation into a digital spatial database (a Geographic Information System). As part of the project, it was decided to investigate the potential of this new methodology to capture public knowledge in a format suitable for use and comparison with information being produced by local authority planners and for incorporation into the computer modelling of air pollution. Citizen consultation groups with different local interest groups (residents, campaign organisations and businesses) were organised in all three cities to discuss the issue of air quality and GIS-P groups were run in two.

The GIS-P process involves four basic stages: firstly, local stakeholder framing the issue(s); secondly, spatial capture of public knowledge on the agreed issues on a hard copy (paper) map; thirdly, transfer of this hard copy data into a digital database; and finally, feedback of this transformed digital spatial data to the local stakeholders for comment, refinement and validation. This methodology falls within the broad church of PPGIS methods as laid down by Weiner et al. (2002) where delivery of public participation can include partnerships of university and community groups.

The initial phase of a GIS-P workshop involves participants discussing their understanding of the issue being investigated by the researchers. This phase is used to introduce the various participants to one another, begin to identify their concerns and knowledge and identify the key topics to be investigated spatially in the mapping phase.

The case study discussions were facilitated and guided by the researchers so the participants were not completely free to set the agenda for the meeting. The participants could, however, frame the issues as they perceived them. The researchers' framing of air pollution (based on their knowledge of the local authorities' activities) was initially concerned with the emissions from industry and road vehicles; however, local participants interpreted this issue in a much broader context. They included a wide range of additional factors including odours and noise within the issue of local air quality. The fact that the researchers were outside the local political system allowed them a more neutral perspective, and importantly, once the issue of trust as to why they were there was resolved—they were perceived as being more neutral than others from within the local authority area. The fact that this research was funded by a national research council rather than being 'in the pay of the local authority' was factor used to explain an 'academic' interest but issues of trust and local disaffection are addressable even when outside mediators are employed directly by a local authority (see the example of Leicester, UK, in Wild and Marshall, 1999).

The discussion phase of the GIS-P process was felt to be useful by the researchers for getting the participants talking together and beginning to elucidate what the group knew or felt about particular subjects. However, at this stage of the GIS-P process many of the group members were very polite with regards to each other's opinions or knowledge even if what individuals were saying was contradictory. The process of GIS-P forces groups to get past this polite stage as the mapping activity entails that opinions be translated into points, lines and areas on a map with areas of disagreement in the group quickly highlighted by division over the location, extent or classification attached to information added to the mapped knowledge. In this way, GIS-P can be seen as having advantages over other citizen consultation group discussions where the extent of disagreement may never be clear or, if expressed, resolved.

The researchers found it useful to tape-record this phase of the meeting for review later. Some of the comments which could be spatially located, for example 'road x has bad traffic smells', were extracted from these recordings and built into the GIS-P database as text comments at specific locations on the map.

The next phase in the GIS-P process involves encouraging the participants to translate their local knowledge into a spatial form through a community or individual mapping exercise. The methodology employs the use of a suitable existing geographically referenced base map printed as a hard copy at an appropriate size and resolution. These large-scale maps were placed on a suitably sized table with access on all sides and a large number of multi-coloured highlighter and finer nibbed overhead pens supplied. At a number of the meetings, a video camera was placed overlooking the table so that researchers could assess later who had mapped what and in which order. This was found to be more useful than audio recording alone that resulted in transcripts such as "it's worse over there than over here"—not the most easily spatially identifiable public knowledge!

In the case studies described here, the hardcopy maps involved printing A0 (84 cm by 119 cm) or larger sized Ordnance Survey (OS) Land Line or A–Z maps. The maps had sufficient detail and were of a size that allowed all streets to be named and individual buildings to be identified. A pilot group was used to assess the level of detail that participants preferred. Would they relate better to simplified city plans with some landmarks and key roads numbered or would they prefer the most detailed OS data on which all roads are named and all buildings and property boundaries identified? In the pilot it was found that people appreciated having access to maps with the greatest spatial detail available. This allowed them to clearly identify 'their' locality and provide highly spatially resolved public knowledge such as one side of a road junction having worse perceived pollution than the other due to a greater number of cars queuing along one side. Only the use of large scale, high-resolution mapping allows for this level of detail to be accurately captured by the GIS-P process. In addition, it was found that many participants found having access to these maps of interest in itself with people keen to just look at the maps—this was a common feature of the air pollution GIS-P citizen consultation groups.

In order to help participants orientate themselves on the maps and also assist in making people comfortable with the concept of drawing on a map and in front of the group, each individual was initially asked to identify and mark where they lived. They were given no other direction on either how to do this—what mark to make or how accurate they needed to be. A variety of mapping solutions were arrived at but none of the participants found this task impossible indicating that everyone could at least identify their home on a map.

Once participants had orientated themselves on the map, the next stage was to investigate the issues that they had identified in the first stage—spatially. The list of topics highlighted by participants were used as prompts for what themes to add to the map. If in the discussion phase traffic pollution was identified as the main air pollution problem, the initial question posed by the researchers might be—"can you mark the worst areas of the city for traffic pollution?" The next worse areas were then mapped until finally areas without traffic related air pollution were marked. No guidance was given on how to mark the information-participants were free within the group to choose how to draw their maps. Researchers only ensured that once one colour or style had been used to represent a class of problem or issue, participants were subsequently consistent—if they meant that an area was equivalent to an existing mapped area they were asked to mark it in the same style to prevent cartographic chaos.

The number of classes and the justification for differences between classes were made by the participants in discussion: a separate class would be called for if areas had similarly poor traffic-related pollution but one area only suffered at peak hours whilst another was continuous. For some of the information added to the map supplementary questions were asked by the researchers. For example, most groups marked traffic pollution down the centre line of the roads affected unless they wanted to highlight specific variation. Groups were asked how far back from the roads this perceived pollution spread—most thought it dispersed further away from the roads and indicated this with reference to side streets marking the distance down these roads they had to walk before they felt they could not sense the pollution any longer. Using these supplementary questions important detail was acquired some of which could be used later in the transfer of the public knowledge as represented on the hard copy maps into the digital GIS database.

Various solutions to the community mapping process were arrived at by the participants. At some meetings, each person took turns to mark their knowledge on the map. Some people discussed what they were going to draw on the map before making a mark (this was particularly noticeable at an all women group meeting convened in York). At other meetings one person dominated, carrying out the actual drawing, but the rest of the group were very careful not to allow anything to be added that they did not agree with and volunteered what they wanted to see added. In general, this dominant drawer was not allowed to control the content of the map but was moderated by the group. At the least successful meeting (from a mapping viewpoint), attended by local business managers, all the participants tried to draw on the map at the same time. This multi-participant overlap meant that it was difficult to determine whether there was any consensus on what was being added and little discussion over how areas compared to one another. This could be prevented through a more structured—one-person at a time—process. It could even be imposed by only supplying one set of pens if it was felt vital to the process.

Numerous studies have investigated how different groups-based on age, gender, income and education—relate to mapped data (MacEachren, 1995). A large variety of people attended the air pollution meetings with none of the participants apparently intimidated by the mapping exercise. Indeed the mapping phase appeared to make people who had been relatively quiet in the group discussion participate more fully as they wanted to see their information represented on the map and questioned some of what other participants were adding. In this respect, the GIS-P mapping exercise seems to hold advantages over many other forms of participatory planning and discussion.

Once the hard copy maps were agreed upon by the participants at the end of the meeting they were taken away and transformed into a digital format. This was done with considerable care and involved feedback from the researchers present at the meetings to the technician who carried out the digitising. Once the public spatial knowledge was available in a digital format it was possible to produce on-screen maps that represented the information in a reasonable cartographic form. The variation in classes from poor to good could be assigned shading that allowed them to be clearly differentiated from the city street base maps and gave a clear graphical representation of the gradation. In addition to the spatial information stored in the GIS database the digital framework allows for supporting comments made about locations or additional data to be appended. Photographs of streets at specific times could also be added to the GIS database or sound recordings giving relative noise levels for different locations (unfortunately there is no provision for smell or nuisance dust simulations using current PC technology).

With the data successfully captured in the GIS database the next stage in the GIS-P process was to present the digital version of their knowledge back to the participants.

This was achieved in two ways, hardcopy maps were produced or alternatively a portable computer and data projector were used to show people exactly how the data now looked. The advantage of producing hardcopy maps was that any amendments to the data could easily be indicated on the paper copy. The disadvantage was that people didn't get a clear impression of how the data was being stored or shown how comment and supporting information was being handled. This feedback stage of the GIS-P process was extremely important. It allowed for any mistakes or misinterpretations introduced during the digitisation to be identified. In addition, any visualisation techniques could be endorsed or rejected by the participants.

Due to the delay in transferring from the original hardcopy to the digital database (1–2 weeks) a cooling-off period was also allowed between the initial group meeting and the reconvened feedback meeting. If anyone had added anything to the map that they now felt to be inaccurate or incorrectly classified, they had time to reconsider it more thoroughly. In one workshop an individual who had marked pollution as extending all the way along a road on reflection felt it probably improved beyond the cars queuing at a T-junction. The reconvened meeting allowed him to reduce the size of the poor air quality polygon he had drawn. The group supported his knowledge as the street was closest to his residence. This phase of the process also builds on the level of trust between participants and the GIS-P researchers. The local participants can literally see what the researchers have done with their information, how it has been (re) framed and be informed of any future stages.

Bristol: the impact of conventional public consultation assessed using GIS-P

In Bristol, the research team examined what the impact of the Council's consultation regarding the AQMA had been on different groups of local residents. The team also examined local residents' and interest groups' perceptions of air quality and compared these to the official estimates produced by Bristol City Council (BCC).

BCC (2001) had promoted information about the declaration of the AQMA through the production of a leaflet and via the Council website. The leaflet had been sent to all houses in the areas affected and detailed the reasons why an AQMA was being declared, provided a map of the likely extent of the AQMA and the possible action plans for reducing the air pollution levels. The consultation document also contained a questionnaire designed to examine people's modes of transport, their environmental concerns and preferences for a selection of possible transport-related actions to reduce air pollution and to give general feedback.

Project researchers held groups with residents of areas with a history of air pollution problems (Avonmouth), inner city residents from within and without the declared AQMA and a cycle campaign group. In general, the BCC leaflet appeared to have had little impact on the participants' knowledge and perceptions of local air pollution. Few remembered the leaflet and of those that could none recalled the extent of the proposed AQMA and even denied knowing whether their local area was included within its boundary or not. From the GIS-P mapping activity, it became clear that the areas where public knowledge indicated that there were significant concerns from local residents regarding air quality were generally included within the boundaries of the BCC proposed management area.

Exceptions to this were on the boundaries of the area where the group often indicated zones of high pollution beyond the extent of the AQMA. However, the mapping also highlighted that the residents had specific knowledge regarding air quality that they felt would not have been included in the official modelling. For example, Avonmouth residents indicated that delivery vehicles visiting the local industrial estate were still using the village petrol station even though officially this had been prohibited and thus not modelled for. They also indicated factory sites that they felt were making unofficial emissions—that is emissions at times and levels that had not been authorised by BCC. They were concerned that these would not have been included in the official modelling process and so may have resulted in important factors being overlooked. Whilst the timing of the GIS-P activity meant that the public knowledge could not be used by BCC in the declaration of their AQMA the Council officers nonetheless seemed interested in the concerns raised through the process.

York: the application of GIS-P to identifying local air pollution

In York, the timing and application of the use of GIS-P was intended to make it more directly useful to City of York Council (CYC). CYC had completed their computer modelling work but had not declared an AQMA as the results had produced a dilemma for the local officers. The models indicated that five separate areas, each located on the city's inner ring road, would not meet the government threshold levels for NO_2 in 2005. The Council officers felt that keeping the five areas independent would limit the success of identifying and implementing management plans for the city. They had, therefore, identified an alternative AQMA; this included the five areas and linked them using the city's inner ring road and major cross-centre roads. These linking areas were selected as they showed relatively high levels of air pollution but had not breached the guideline levels, yet offered a greater range of options for air quality management. In this respect, this option could be considered the Council officers' knowledge map as it included information on their perceptions of problem areas and possible management solutions. However, the Council officers' solution was not immediately accepted by the city councillors who required greater legitimacy. Thus, CYC carried out public consultation in order to determine whether York residents would agree to a larger AQMA than that identified using the model output. The researchers became involved in this public participation in identifying and declaring the extent of York's AQMA.

Before CYC went public with its AQMA choices, two key groups for identifying local concerns of air quality were convened from residents of the three wards included within the boundaries of the five zones identified as being in excess of government targets. Residents were recruited via an extensive leaflet drop, local radio, posters placed in shops and surgeries and personal invitation. As such, they did not necessarily reflect an unbiased cross-section of the population but represented people who were either concerned about air quality or else generally represented their ward at such meetings.

Participants were given city-centre maps on which to mark their local knowledge of air quality issues. On these city-centre maps, the extent of their wards was indicated and the participants told that information they supplied for their ward would take precedent over information coming from the other groups. The concept behind this approach was that local residents should have the greatest knowledge of their area–better than that of any other resident in the city. The maps produced were taken away, converted into a digital database, and combined into a single draft map. The information obtained at the meeting on other issues of air quality such as noise, smell and nuisance dust was maintained in the database but not included in this draft map. This decision was made to focus attention on the identification of the boundaries of the AQMA using the criteria of air pollution as defined by national government.

At the reconvened meeting, residents were asked—road-by-road—to agree or modify the draft-combined map. Disputes over the classification of particular areas were resolved at the meeting through debate (sometimes quite heated) between the participants. At the end of the meeting consensus was reached by the participants on their final combined map for the city-centre air quality, seen below in Fig. 1.

After the residents' meeting, a number of additional citizen consultation groups with particular sections of York's population were held in order to identify any additional areas of concern to residents. Whilst these meetings resulted in greater detail about specific pollution gradients and gave great insight into how people determined the areas they marked on the map, in general they added no new areas to those already identified from the ward meetings' consensus map.

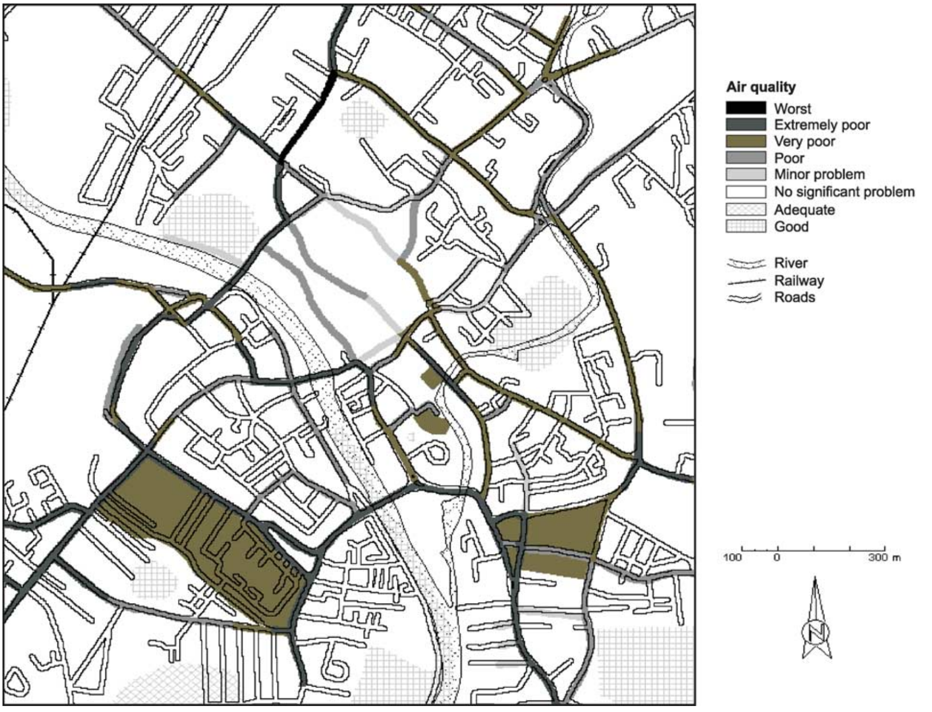

Fig. 1. The York city-centre residents combined GIS-P map of air quality.

The maps were utilised by the researchers in collaboration with CYC in number ways. Firstly, the public knowledge presented on the GIS maps was used directly to identify additional sites to monitor air pollution levels using long-term passive samplers. Areas identified by the residents as having particularly poor air quality that had been omitted from the initial Council monitoring were singled out.

Secondly, the maps were examined by traffic-modellers collaborating with CYC in the design of transport models for the city. They were interested in using the public knowledge presented on the maps to determine the number and location of segments that roads should be split into to model traffic flow. In this way, the knowledge incorporated into the GIS-P mapping could directly feed into the modelling process.

Thirdly, the consensus map from the ward meeting was used in a wider consultation with York residents. The consensus map was reclassified with the areas in the worst three classes of air quality combined into one class. The public knowledge map already included the five areas identified by the model as being in excess of government thresholds, indeed these five areas were consistently in the worst classes of air quality mapped at all the citizen consultation groups showing a remarkable parallel between expert assessment of problems and citizens' conceptions of similar problems. The reclassified combined map produced a more extensive area than that identified by the Council's modelling activity or the Council officers' perception map.

The re-classified map was included on a questionnaire sent to nearly 5000 York homes and approximately 1000 businesses. The map was one of three options for the possible extents of the city's AQMA. The other two options were firstly the five discrete zones identified by the model and secondly the Council officer-knowledge map which linked these five zones together.

The results of the questionnaire survey were an overwhelming endorsement of the AQMA identified through the GIS-P process. From the residential questionnaires, the return rate was 14%—a very high public response rate for CYC surveys (according to the Council marketing & communications officers involved). Of these 695 returned questionnaires, 63% of residents endorsed the selection of the GIS-P derived map as the AQMA for the city. The response rate from businesses was estimated lower by CYC at only 5%. However; of the 51 returns received the majority of businesses (47%) were in favour of the larger AQMA identified by the citizen consultation groups. The full breakdown of the questionnaire responses can be seen below in Table 1.

Table 1
York air quality questionnaire responses

	Map A (computer model AQMA)	Map B (council officers AQMA)	Map C (GIS-P AQMA)	No answer	Total
Residents'	49	181	441	24	695
responses	7%	26%	63%	3%	
Business	17	5	24	5	51
responses	33%	10%	47%	10%	
Total	66	186	465	29	746
responses	9%	25%	62%	4%	

This endorsement by the wider York population of the GIS-P derived map resulted in the public knowledge-derived map being declared the official CYC AQMA.

Discussion

A number of alternative approaches to developing public participation in decision-making utilising GIS have been attempted; the majority of studies reported in the literature have come from the USA (or US based researchers working in developing countries), where the techniques of PPGIS have predominantly been developed and promoted. GIS-P falls within the range of techniques that can be described as Public Participation GIS as set out by Weiner et al. (2002).

An ideal form of PPGIS could be where neighbourhood residents collect their own spatial data and process it themselves using GIS software (Sawicki and Peterman, 2002). A gradation of different levels of success in meeting these two ideal components of PPGIS occur in the case studies reported in the literature and can be represented graphically (see Fig. 2).

The highest level of public involvement in GIS analysis involves community groups being given equipment, software and training to allow them to perform the spatial queries they want for their neighbourhoods. Examples of this include the Portland Metro GIS, USA (Bosworth et al, 2002). Here, the regional government supplied residents with a variety of data and software facilitating access to the 'official' city mapping—but allowing

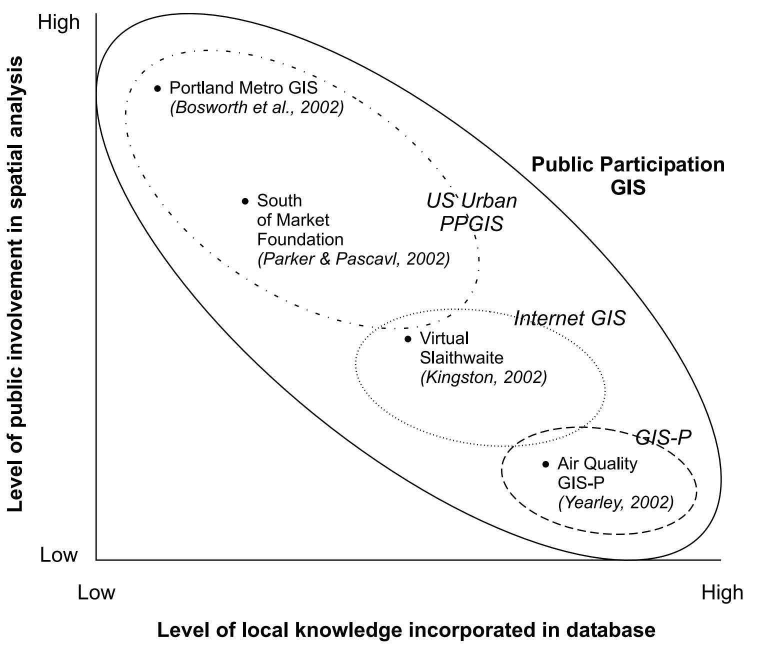

Fig. 2. The level of success various projects have achieved at meeting two ideals of PPGIS practice.

stakeholders to perform their own analysis and interpretation. This was the most extreme form of public participation in the *use* of GIS. In the strictest sense—this could be the true definition of public participation GIS as the community themselves perform the spatial analysis.

Intermediate levels of use involve collaboration between community groups and university or local authority organisations. Here the community groups are in charge of the questions being posed to the GIS database but an intermediary from another organisation performs the actual spatial analysis. The South of Market Foundation GIS in San Francisco is a good example of this model (Parker and Pascual, 2002). Here a local campaign group collaborated with the local city-planning department to investigate the community concerns over housing permits.

The UK web-based approaches to PPGIS such as the Virtual Slaithwaite planning exercise (Kingston, 2002) contain facilitator mediated local knowledge. Whilst this approach was collecting spatially located public-knowledge, it differed from GIS-P in that participants did not have the opportunity to add information graphically but purely in a textual framework (information which was also captured during the GIS-P process).

The air quality GIS-P case studies described above represent the lower end of the gradation of community participation in the spatial analysis. Here, the researchers identified the issue under investigation (due to their knowledge of relevance of the topic to local and national government policy). The spatial analysis was all performed by the researchers—with only the results being passed back to the participants for querying.

On the second axis of PPGIS lies the incorporation of local knowledge into a digital spatial framework for comparison to conventional data. On this axis, the Portland Metro GIS can be located on the lower end of the axis. The GIS predominantly used official council data with local residents only requested to send corrections (on a council form) if their local knowledge indicated there were omissions or errors in the Metro data.

The San Francisco residents' GIS contained local knowledge about the issues of gentrification and business displacement. This information was superior to that held by the city authorities and helped the local residents in their negotiations over zoning.

The air quality GIS-P database is at the extreme of the range of local knowledge capture. All the participatory information in the GIS came from the local stakeholders who attended the meetings. The participants supplied all the classification information, locations identified and type of issues captured.

This type of public participation—where the GIS are used to facilitate participation but the participants are not directly responsible for their creation, maintenance or analysis justifies the title GIS for Participation. GIS-P sits within the continuum of PPGIS techniques—but differs in the level of local information captured using the technique. As can be seen in the figure, many PPGIS techniques differ from the GIS-P process in that they do not explicitly attempt to collect public-knowledge and perceptions in a spatial framework. Instead, they allow participants to reanalyse existing official data for themselves or correct information with local knowledge where the participants have superior understanding of the locality. US researchers have realised the need for a GIS-P approach within the range of PPGIS techniques where communities collaborate with outside experts in the GIS process (Casey and Pederson, 2002). They question if "we might, also, better employ resources by establishing town meeting types of events where the what-ifs can be depicted with groups of residents providing their input, and facilitators and GIS technicians mapping the community's feedback"—the GIS-P approach.

In general, at our GIS-P meetings the participants reached consensus on what was added to the hard copy maps and subsequently stored in the GIS database. None of the participants appeared to have a strong disagreement about what was indicated on their group maps. If they had disagreements they were not voiced. This may have been due to the nature of the issue being addressed—an issue of common good. If the issue had been more contentious, such as allocation of resources or location of unpopular land uses, then strong disagreements within groups may have occurred. In principle, such disagreements can be accounted for on the hard-copy map with differing classes assigned to the same area or disputed locations given greater or lesser weight through the numbers of participants agreeing or disagreeing with the category allocated to that region. These aspects of community mapping are being further investigated by the researchers in a new ESRC project (Public Involvement, Environment and Health: Evaluating GIS for Participation, ESRC grant number L144250045).

The outcome of incorporating GIS-P into the Stage III consultation process in York was the declaration of a larger AQMA than that identified by computer modelling. The increased public participation in the identification of this larger AQMA, which resulted from the use of GIS-P, was validated through consultation with the wider city population. This endorsement indicates that GIS-P derived information can gain wide public acceptance. The level of interest in the questionnaire (reflected in the higher than normal response rate) perhaps indicates a greater sense of ownership of the AQMA by York residents. In turn, this may be due to the AQMA being derived in a participatory manner and hence better reflecting the level of concern that residents felt over the issue of air quality than had been captured in the computer modelling process alone.

In contrast, in Bristol the level of interest in the public consultation regarding the AQMA had been moderate. The indication from people who attended the citizen consultation groups (who showed an above average level of interest in the issue) was that the consultation process had not made any impact on residents' perceptions of the location and level of air quality problems. The people at the citizen consultation groups also queried the derivation of the AQMA and the Council's willingness to tackle the problem indicating that they did not feel ownership of the problem or management of the issue.

Overall, the use of the GIS-P process offers the potential for greater participation in local decision making on a range of issues. A large number of local authority decisions relate to issues that can be investigated in a spatial framework. These include aspects of access to resources, environmental management and human physical and social well-being. GIS-P enables public knowledge to be captured in a form that is intelligible, comparable and useful for government planners and scientists. An important point is what a social (US and other readers read 'cultural') anthropologist might call 'conceptual reflexivity'—that is to ensure that we 'render people's conceptions back to themselves' (Strathern, 1987) in order to test the fit of our reframing of their knowledge, this is necessary for accuracy as well as for trust-building. GIS-P provides us with a meaningful way of doing this. It also allows it to feed into the policy and planning processes in a remarkably direct manner.

This capture process also incorporates the social context of this knowledge that can never be attained through computer modelling: the assessment of noise pollution by members of the York Cycle Campaign highlighted open space near busy roads as having problems with traffic noise. They did not mark city centre roads even though they believed them to be just as noisy. When questioned further about this they commented that even though the levels of noise were comparable they felt it was more polluting in a park area than in a city centre where they expected noise levels to be high. This social context of the kind of information captured through GIS-P could be very important for deciding local governmental priorities and could not be identified through the computer noise models now being developed for local authorities. This is just one example of how greater public participation through the wider use of GIS-P could lead to improvements in local government decision-making.

Conclusions

The outcome of incorporating GIS-P into the Stage III consultation process in York was the declaration of a larger AQMA than that identified by the computer modelling. This larger area should allow for greater flexibility in determining action plans and could result in larger parts of the city benefiting from improved air quality. The result, therefore, is that the York practice—using GIS-P—is ‘better’. GIS-P can contribute to responsible local governance, specifically in this case over air quality, but potentially for a range of spatially related issues.

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Suspicious cartographers: some realities of research into stakeholder understanding of the causes and possible prevention of breast cancer

Steve Cinderby and Laura Potts

In this paper we are interested in gaining better understanding of how communities of interest participate effectively in risk governance, particularly when the dominant discourse has tended to be dominated by science practitioners rather its publics. One approach used to illuminate this understanding was the technique of participatory geographic information systems (specifically an approach termed geographic information systems for participation (GIS-P)), which was used here as a means to improve communication about possible environmental risks of breast cancer. The merits and outcomes of applying this technique are investigated and the implications for wider participation in contentious 'scientific' issues discussed, with close examination of the mutual suspicion that persisted among the different communities of interest concerned about breast cancer causation.

THE AETIOLOGY OF BREAST CANCER remains highly disputed. The identification of genes linked to an increased susceptibility of an individual to breast cancer (BRCA1 and BRCA2) has focused public and research attention on the inherited determinants of the disease. Preventive advice, such as that given in the National Health Service (NHS) Cancer Plan (Department of Health, 2000), focuses solely on individual lifestyle factors: diet, alcohol consumption, obesity and exercise.

There is, however, also a clearly articulated discourse emphasising risks from chemical exposures that disrupt the metabolism of oestrogen in the body (Davis *et al*, 1998; Krieger, 1989; Davis and Bradlow, 1995; Sasco, 2001). These risks are coherently summarised in "State of the evidence" (Evans, 2003), a document that collates and reviews the available literature, and argues for a precautionary approach to protect women from such hazards.

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Such evidence is hotly contested by other scientific experts: researchers engaging with the claims of the breast cancer/environment social movement on the possible causes of breast cancer are often regarded as 'dissidents' within the scientific community (Potts, 2004b). The controversial aspects of the breast cancer argument are akin to other areas of scientific uncertainty (for example, power lines and leukaemia, Gulf War syndrome). Hillman (2004: 25) suggests such arguments are in fact "really about response to risk, not about the science".

Against this context, breast cancer remains the commonest cancer in women, and the incidence continues to rise in the over-developed world; more than 40,000 women a year are diagnosed in the UK (Cancer Research UK, 2003).

Public participation

The research referred to in this paper derives from two projects funded by the Economic and Social Research Council's Science in Society programme.[1] The research was carried out in four locations across the UK between 2000 and 2004. One specific aim of the research was to create opportunities that could facilitate a productive dialogue among a range of

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scientific positions about environmental risk of breast cancer. The researchers' hope was that the communities of interest involved in the project might move towards a consensus on a precautionary approach to strategies for risk reduction. We were concerned with "the specifics of 'science in action'" (Irwin, 2001: 75), by staging hearings in which the debate about environmental risk of breast cancer could be aired.

These communities of interest, or stakeholders, included environmental and health social movements (individual activists and non-governmental organisation (NGO) officers), research scientists, breast cancer nurses, oncologists, policy-makers and politicians, concerned local citizens, women with breast cancer, and epidemiologists. Importantly, we worked with these communities of interest in a specific geographical locality, choosing an urban and rural area, and one where there was already expressed concern about possible environmental causes for a very localised raised breast cancer incidence, and a demographically stable area.

We were seeking the 'contextual' and 'situated' knowledge, "very much rooted in the community rather than being provided by official institutions such as government and industry", which Irwin and Michael (2003: 101), too, see as a vital resource. "While science emphasizes generalization, facts and the need for objectivity, 'contextual knowledge' gives weight to local factors, personal views and subjectivities" (Irwin and Michael, 2003: 101).

In particular, our research sought to initiate a forum where symmetry of expertise was a guiding principle and "vertical solidarities" (Gaventa, 2002) could be established. These solidarities were to be informed by an understanding in practice of the degrees of trust and communication already existing within other communities of expertise. In and through this process, we explored further the usefulness of geographic information systems for participation (GIS-P) (described below) as a tool for the mediation of knowledge claims about environmental risk and as a contribution to the legitimation of "citizen expertise" (Potts, 2004a).

There are both pragmatic and principled rationales for public participation in scientific controversy, and it is not always easy to disentangle the two different strands. As Fischer (2000: 142) has claimed, "participation is a political virtue in and of itself", insofar as it is underpinned by a democratic ideology, and reflects the pluralistic, "public interest politics" (Fischer, 2000: 112). However, this principled position does little to address the power relations that pertain in terms of governance, particularly if the participation is invited by the governors, rather than demanded by the governed. We acted as mediators for the governance of perceived risk, engaging groups in "popular epidemiology as participatory praxis" (Fischer, 2000: 155; Brown, 1992), by encouraging communities of interest to make their voices heard.

The pragmatic rationale that dominates much contemporary policy thinking must also yield to criticism: it rests on an instrumental assumption that 'the public' will be more accepting of decisions about governmentality if they have been involved in the processes, and that those processes are somehow 'transparent'. While 'the public' is hardly homogeneous, and the practice of 'transparency' is subject to an infinite regression of contingencies (as Irwin and Michael (2003: 127) have shown), there is also a fundamental cynicism about this rationale. It is predicated on the citizen-subject as malleable within a social world still determined by the 'real' experts, politicians and scientists.

We are reluctant to be associated with such dubious practice, but the suspicion with which the project was, on occasion, received, demands that we do acknowledge at least the possibility of unwitting complicity in these processes. Furthermore, as Renn (2003: 374) states, "the popularity associated with the concepts of two-way communication, trust-building, and citizen participation, however, obscures the challenge of how to put these noble goals into practice"; as we will reveal below, such challenges proved more formidable than we had anticipated.

Nonetheless, our aspirations were to promote participation in epidemiological enquiry, to legitimise citizen expertise, and to contribute to better understanding of the aetiology of breast cancer. Our use of the GIS-P tool for these purposes rests on its ability to establish a more equitable dialogue among official experts and other participants. GIS-P has proved a useful tool in establishing such dialogues in a wide variety of contexts, including natural resource management (Cinderby, 1999), assessments of air quality (Cinderby and Forrester, 2005a; 2005b; Yearley *et al,* 2003) and urban redevelopment. Participants have ranged from computer modellers in a UK city to stock farmers in South Africa.

Mapping the local hazards and producing a collective map, acts as a conduit between the stakeholders involved. As Irwin and Michael argue (2003: 117), "Given the differences in knowledge, discourse and routines that characterize different social worlds" (such as pertain among, for instance, women with breast cancer, policy-makers, oncologists, research scientists), "a key analytic issue is how these interact. One means is through 'boundary objects' … that facilitate coordination across social worlds". While the maps as we used them are clearly not discourse free, they have proved to be useful tools to these ends, as we explain below.

Thus the methodology of GIS-P is essentially phenomenological; we are looking "to understand individuals and their problems within their own sociocultural context and the particular 'logic of the situation' to which it gives rise" (Fischer 2000: 178). The GIS-P process yields particularity: the knowledge generated is clearly situated (to use Haraway's (1991) term). The particularity of the situated knowledge claims made in this work augments the findings of projects investigating environmental risks of breast cancer elsewhere, such as on Cape Cod, Massachusetts (Brody *et al*, 2005), Marin County (Marin Breast Cancer Watch, 2005), Long Island New York State (Breast Cancer Action, 2002; Brenner, 2002), and a recently established collaborative National Institute of Environmental Health Sciences (NIEHS) multi-focused investigation (McCormick *et al*, 2004).

GIS: a tool for better participation?

Participatory geographic information systems (PGIS) are a set of methodologies designed to legitimise non-official stakeholders' knowledge of particular concerns. They are designed to make the stakeholder knowledge comparable with official spatial datasets and communicate information more directly and successfully to policy-makers. GIS-P (a particular methodology within the suite of PGIS approaches) was developed by Cinderby (*et al*) as a tool for accessing different, non-official, perceptions and knowledge of environmental issues. The goal of GIS-P is not merely to capture this knowledge for its own sake, but to assist in communicating these viewpoints among different stakeholder groups and among the stakeholders, policy-makers and recognised official experts. This communication aspect is one of the essential elements of GIS-P.

The visual and spatial nature of the GIS-P information collected and presented is one of the key advantages of the approach over more conventional means of engaging with stakeholders and other approaches for provoking discussions between groups. These discussions hopefully lead to a greater shared understanding among different groups and allow official experts and policy-makers to grasp the concerns and knowledge of various non-official viewpoints. This enhanced understanding is intended to lead on the one hand to improved communication of the experts' knowledge of the issue to other stakeholders by addressing the concerns captured in the GIS-P database. Alternatively, it might lead to a revision of the expert knowledge based on unrecognised or untapped local environmental expertise and information.

GIS-P moves beyond community mapping through a variety of spatial modelling techniques, which can include visualisation techniques to improve the representation and understanding of stakeholder perceptions from those drawn on the paper maps by the focus groups

GIS-P moves beyond community mapping through a variety of spatial modelling techniques. These can include visualisation techniques to improve the representation and understanding of stakeholder perceptions from those drawn on the paper maps in the focus groups by the participants. In addition, it facilitates the comparison and modelling of stakeholder knowledge with statutory and official expert spatial databases. This comparison can include combining different data together to generate new information that complements the stakeholder viewpoint and improves the communication of this knowledge to experts. It can also include comparing different stakeholder knowledge to help identify the areas of consensus and therefore highlight the actual and perceived areas of contention, which can be useful in focusing discussions on real differences of opinion or understanding.

Mapping local knowledge

To assess the effectiveness of GIS-P as a technique to aid communication about possible environmental causes for breast cancer a number of different case studies were investigated. These formed part of the locality-based hearings mentioned above.

The first case study (Pilot), which constituted the pilot project, was carried out in a northern English former industrial city. The participants were members of the local breast cancer support group, a voluntary organisation run by survivors of the disease for women at all stages of the condition. The group members all lived in the city and many were born and bred in the local area.

The second case study (Hearing 1) was located in a prosperous conurbation in northern England. Participants included environmental campaigners, breast cancer patient representatives and local breast cancer nurses. They were drawn from a dispersed range of localities around the city. Most had migrated into the locality, some quite recently.

The third case study (Hearing 2) was convened in a Welsh town with people based in the surrounding rural communities. The participants came from a wider range of backgrounds, and included an epidemiologist, a local politician, and public health personnel. The majority had been resident in the local area for a longer period than those attending the second case study.

The final case study (Hearing 3) was held in a Scottish community with an existing concern about elevated incidence of breast cancer in the local school and possible environmental factors involved. The Health Board was investigating the possible causes of the cancer and collaborating closely with the school. The research team was keen to investigate the additional local knowledge of the village residents to determine whether this could assist in identifying any possible causes for the high number of breast cancer cases amongst the school employees.

At all the hearings, participants were provided with large (A1 or greater) paper maps of the local area. The sources for these maps ranged from the coarsest data set, the OS 1:50,000 Land Ranger series through the OS 1:25,000 Explorer series to 1:15,000 street map level data. A mixture of datasets was available to assist participants in orientating themselves and identifying features. For participants at the Pilot, this included colour air photography.

These datasets were chosen as a compromise between the physical size of the paper datasets, to ensure that they fitted on the tables available at the venues, and the detail present on the maps. From previous participatory mapping exercises carried out by the facilitators it was recognised that the majority of participants appreciate having high levels of detail on the base maps provided to them so that they can identify very specific features. For example, participants have identified one particular side of a 5 metre wide road as experiencing air pollution problems for pedestrians.

To facilitate people's orientation on the maps, one of the first activities in the participatory mapping session involved participants roughly indicating their place of residence. At all the hearings this was achieved by all the mappers inviting participants to use the maps by drawing on them, and to identify features on the datasets. Most participants did this independently; however, at the Pilot and Hearing 3, where people had longer-term connections with each other, more spatially aware individuals assisted those who were struggling to orientate themselves.

At all the hearings, a discussion phase (which directly preceded any mapping) produced a wide range of factors (some environmental, others what might be termed lifestyle) that could be possible triggers for breast cancer. These included: air pollution from household cleaners, industry, transport, incinerators and landfill sites; water pollution, including pesticide run-off from arable farming and industrial emissions; chemical pollution from hormone replacement therapy (HRT), personal deodorants, industrial processes and agriculture; and low-level radiation from river and coastal sediments contaminated with waste from nuclear power and recycling sites.

Participants exhibited a wide range of levels of expertise in terms of their understanding of potential environmental pollution links and breast cancer, but, significantly, the level of understanding did not necessarily correlate with the local knowledge that the participants possessed. Once they had successfully orientated themselves on the base maps, participants were invited to begin locating the factors that they had identified as being possible environmental risks for breast cancer.

Local knowledge

The most obvious factor in the success or failure of participatory mapping is the level of local knowledge enjoyed by the participants — how much they know about what and where things are happening in the space they inhabit, and how they are able to bring this to bear on the issue being discussed. While GIS-P presents opportunities for participants to learn more about a locality from each other, pre-existing knowledge seems to be a prerequisite for productive mapping.

This differential level of local knowledge was an important factor in the resulting variable success of the participatory mapping. At Hearing 1, whilst the participants were eloquent in their understanding of the possible causes of breast cancer and had obviously considered the problem in detail before the hearing, they did not have enough confidence in their local environmental knowledge to map where these problems existed in their neighbourhoods. This was compounded by the fact that the participants came from a wide geographical area and many had only been resident in the locality for a limited period.

The wide distribution of the participants resulted in the paper base map used at the hearing being of a smaller scale than that used at the other hearings. In addition, the dispersed residence of the participants meant that the overlap of their local areas was relatively low as they physically knew different places. This meant that additions to the map were solo efforts with no reinforcement or contradiction from others.

By contrast, at the Pilot hearing, whilst the participants had not considered in great detail the possible environmental causes of breast cancer prior to the meeting, they had significant and extensive local knowledge. The majority had been born and raised in the locality. This meant that they not only had a detailed spatial understanding of their current environment, but also a temporal knowledge, which allowed them to highlight the location of demolished factory sites, mine-waste dumps and historic extents of air and water pollution.

The Hearing 1 participants' lack of extensive local knowledge was reinforced by a reluctance to take part in the mapping exercise at all; this was not blatant or outspoken, but it was both emphatic and determined. Their comments on the process indicate that, in part at least, they did not wish to be associated with the localised activity proposed by the researchers because it seemed too local, too specific, and prevented them from addressing what seemed to be regarded as the larger, grander issues. In this way, we surmise that they were anxious to assert their status differently, as having greater expertise, and the authority to make knowledge claims on behalf of others, and in relation to a much less defined sense of place — much as scientists or policy-makers do within accepted practice.

Thus the evidence from the hearings indicates, perhaps obviously, that there is no substitute for local knowledge when performing participatory mapping and GIS activities, and, indeed, that it is a necessary component of the process. This knowledge is difficult to bluff, meaning that participants struggle to 'make it up' off the cuff at the meetings. This could be seen as an advantage of using participatory mapping as it means that eloquence cannot be used as a substitute for knowledge and experience. The language in which participants present such knowledge is indicative of that local social capital: sites are marked on the map, or drawn to fellow participants' attention as confident assertions, and do not rest on speculation or suspicion.

Trust and time

A further key to the success of the participatory mapping was the level of trust exhibited between the facilitators of the hearing and the participants, and among the participants themselves. This can, in part, be attributed to the time invested by the participants and the facilitators in the process, but our experience suggests that trust is also contingent on the relationships within the group process and is hard to engender without a certain level of goodwill from both sides.

The level of trust between facilitators and participants can, in part, be attributed to the time invested by them both in the process, but trust is also contingent on the relationships within the group process and is hard to engender without a certain level of goodwill from both sides

These observations are informed by analysis of Hearing 1, where participants were deeply suspicious of the mapping exercise, and asked a number of questions (seen in Table 1) before approaching the task. Despite the answers designed to allay concerns, there remained deep suspicion of both the process and the usefulness of the GIS-P mapping, and of how it would be used. Despite continued encouragement from the facilitators, only a few participants joined in the mapping exercise. The remainder drifted away to discuss other issues with the facilitators individually, or to examine the supporting material displayed at the meeting.

This experience contrasted sharply with Hearing 2. Participants at this hearing came from a similar range of backgrounds to those from Hearing 1, including health professionals, epidemiologists and environmental campaigners. The hearing followed the same pattern as Hearing 1 with a discussion phase followed by a description of the participatory GIS methodology. Yet at Hearing 2, all the participants exhibited enthusiasm for communicating their knowledge and concerns through the use of participatory maps. The mapping exercise generated debate amongst the participants helping them to understand better each other's viewpoint and knowledge,

Table 1. Questions and responses between participants and facilitators at Hearing 1 regarding participatory maps

Question from participants	Answer from facilitators
Who is the map for?	Initially for the participants, to share their understanding and knowledge. Subsequently to be decided in discussion with the participants depending on the nature of the information presented. Potentially to be used in discussions with breast cancer health professionals but only with explicit agreement from the mappers. The key point emphasised was that it would still be the participants' information, that this was a participatory rather than an extractive process, so the uses to which the data was put would be decided and agreed upon together.
How would the data be stored and presented?	Data would be stored in a GIS database and also as digital transcripts of what had been said. Neither of these would be for release.
What purpose would the map serve?	It was repeated that the map was a means of collecting the participants' local knowledge of possible environmental hazards that they felt might be linked to breast cancer causation. The map would be used to communicate their knowledge and concerns to other stakeholders, health experts and policy-makers.

indicating their confidence in their own understanding of environmental concerns. It also demonstrated that they were interested to hear other and differing opinions and trusted both the process and their fellow participants to discuss and debate the points openly.

Participants at the Pilot and Hearing 3 already had existing relationships with each other that ensured a high degree of trust and mutual respect. The Pilot participants were all women attending a breast cancer support group; by the nature of these relationships a high level of trust, respect and openness existed between them. The facilitators made initial contacts with the group through a junior female researcher who lived locally. This helped bridge the initial divide between the facilitators and the participants as the junior researcher could discuss local conditions and events with confidence and personal knowledge. In addition, the facilitators made a number of visits to the group, which ensured that the participants started to develop a more trusting relationship than can easily be engendered by a single meeting.

The Hearing 3 participants were all residents of a small village and, consequently, some had a certain pre-existing familiarity with each other. As the meeting was held to discuss the possible causes of a 'cluster' of breast cancers centred on the local primary school, the participants not only had existing community bonds but were united in a common cause to identify whether there was a real local risk. The facilitators and mapping process were seen as potentially helping to answer their health and environmental concerns. The academic background of the research team, rather than invoking suspicion, as at Hearing 1, appeared to grant a level of trustworthiness to the facilitators in the eyes of the participants, so they were viewed as a resource to be used to answer the community's questions. The participatory mapping was very effective in capturing the villagers' knowledge of environmental concerns in their community and for prompting discussion among the mappers.

The success of GIS-P at the Pilot, Hearing 2 and Hearing 3 highlights that, where trust exists among participants, participatory techniques can be highly successful for communicating information and increasing understanding of viewpoints amongst all the participants. However, the experience of Hearing 1 also indicates that trust between participants and facilitators can be hard to generate. The experience from the Pilot indicates that time invested from all sides can be critical to this process.

Environmental understanding

Participatory mapping was employed by the facilitators as a tool to improve the communication of different groups', or individuals', understanding of the possible environmental causes of breast cancer. The process of drawing information onto maps allowed people to focus on what and where their concerns were located. The visual identification of concerns also allowed outside official experts to gain a greater understanding of the participants' viewpoints. As the US work has demonstrated, participatory models contribute to the development of:

> new norms for environmental health research: public empowerment that goes beyond mere involvement in advisory boards, a shift away from purely investigator-defined research to joint activist-scientist definition of research problems and integration across disciplines. (Brody *et al*, 2005: 3)

These UK hearings highlight how different levels of environmental knowledge can clearly be communicated among participants, between participants and facilitators, and between participants and external official experts through the use of GIS-P, laying the foundation for more extensive epidemiologic research. In the case of some work in the USA, this has prompted the establishment of "environmental or biological sampling programs for endocrine-disrupting compounds in drinking water and household air and dust and the application of geographic information systems for surveillance and historical exposure assessment" (Brody *et al*, 2005: 1).

At Hearing 3, the participants produced maps highlighting the environmental concerns they felt might be linked to the possible localised 'cluster' of breast cancer incidence. These highlighted old mine waste, polluted water courses and possible historic radiation contamination. The maps were shown to the local Health Board, which was already investigating the possible causes of the cancer incidence amongst the village school employees. The Health Board experts found the maps useful in that they quickly and clearly communicated the concerns and knowledge of the village residents. Through this communication the health experts were able to go through each problem identified and describe why they felt there was no vector from the problem to causation for breast cancer.

For example, the map highlighted villagers' concerns about a polluted stream on the edge of the village; health experts indicated that the type of pollution identified, the location of the stream and the fact that the water from the stream was not used for human consumption, meant that it could not be linked to an increased risk of breast cancer in the community. This demonstrated an ideal use of GIS-P: to allow different viewpoints to be clearly communicated and discussed, leading to a resolution or to the identification of future areas of research.

In contrast, at Hearing 2, the GIS-P process was limited by the lack of engagement from official health experts. The participants demonstrated impressive local knowledge allied to an understanding of how the environmental hazard they were indicating could be linked to the causation or increased risk of breast cancer. These included: radiation from nuclear power generation trapped in marine and riverine sediments; air pollution from landfill and incinerators; and chemical pollution from pesticide spraying and residues. In this case, the maps could not be directly used to start a dialogue over the official understandings of the risks identified by the participants, and so the process was, in this respect, incomplete.

A lack of engagement from the official health experts was the biggest stumbling block to the successful implementation of the GIS-P methodology during the Hearings and Pilot. While, as we have shown, the participatory mapping technique proved useful in a variety of ways, it had been intended to bridge the communication divide between the health establishment and dissident experts' or lay participants' viewpoints. In all but the Hearing 3 example described above, it failed to meet this goal because of the absence of policy-makers and high-level, local health or environment personnel from any of the Hearings.

On trust and suspicion

O'Neill (2002: 18) has identified that "we have massive evidence of a culture of suspicion" in relation to "risk societies", a "current supposed crisis of trust" (O'Neill, 2002: 16) that pertains in many different spheres of public and private life. Such mutual suspicion inhibits the potential for establishing sound governance and for finding common ground in relation to contentious issues, such as that with which we are concerned here. As Walls *et al* (2004: 146) have shown, "levels and patterns of trust deployed by lay publics" are often overly simplified; rather, as they assert, "trust is … multi-faceted, potentially dynamic, and dependent on a range of contextual variables" (Walls *et al*, 2004: 135). (The same might be said of suspicion, too.)

We will attempt to identify some of those "contextual variables" and to resist the seductive tidiness of over-simplification in trying to understand what went on in the hearings we have described above. The findings in our research indicate that the range of stakeholders were suspicious to varying degrees and about a wider range of topics than we had anticipated, and, indeed, about us as researchers, and the research process itself. As a participant said, "people think sociologists are communists" (dissident scientist, Hearing 2)!

Participants' suspicion about each other, and about those who were not physically present but nonetheless were known to have a crucial role in the debate, were expressed as both general and specific anxieties: a "wariness of each other if you've got different views" (NGO officer, Hearing 1) and a "fear of reprisal" (health service worker, Hearing 1). While these comments suggest personal disquiet and suspicion, we also heard criticism of political structures that inhibited debate and participation in it. As a 'dissident scientist' said in Hearing 2, "it's the class structure of intellectual analysis; until we can break through this, there will be no policy change … we have to fight them with their own weapons — using data — but the balance of power is against getting it". Interestingly, there was no evidence that one community of interest was more or less suspicious than another; nor did such sentiments seem in any way to be related to the status or social capital of the participants.

The project was set up explicitly to "bridge differential understanding of environmental risk" of breast cancer; naively perhaps, we had not foreseen that the gulf between communities of interest was based on inhabiting such different world views that they were barely prepared to countenance being in the same space together. A stark and depressing example of this ideological rigidity was evident in the refusal of a national NGO officer to sit next to the chief executive of a national charity, even though the seating at this final (non-GIS-P) Westminster Hearing was organised strictly in alphabetical order.

Such incidents suggest that bringing together those with opposing views on contentious issues demands extensive time and resources preparatory to the hearings themselves. As an anonymous reviewer of this paper suggests, a valid objective for the research might be to raise scientific understanding of the causes of breast cancer; s/he asks whether, in this context, participants ever noted an interesting point made by another participant, and suggested this was an area for productive research. Such a scenario was, indeed, how we had hoped (and perhaps expected) the discussion at the hearings might develop, but, alas, this was not the case.

Communities of interest with different views about the causes of breast cancer, and about the nature of appropriate evidence, remained divided, on both ideological (see Potts, 2004a) and epistemological grounds. More successful open dialogue was had in less public settings than the hearings, such as a discussion set up between an epidemiologist and research chemist, who explicitly acknowledged having learned from each other's views in that encounter.

After the difficulties we encountered with Hearing 1, when policy and health service personnel failed to attend after indicating acceptance of the invitation, we put considerably more effort into personal contact to support written invitations. We also conducted several one-to-one interviews with key stakeholders, using an open, loosely structured schedule to investigate concerns and issues.

These revealed some interesting perspectives on the nature and grounds of the mutual suspicion, which, it appeared, was based on a sense that the 'other' was not looking at the question of environmental risk in the 'right' way, as well as accusations of the vested interests at play. This would seem to support the view that social trust is based on similarity in basic values, as argued by Earle and Cvetkovich (1995) and Siegrist and Cvetkovich (2000) (both cited in Walls *et al*, 2004), or, as we claim, is essentially ideologically premised. (These observations will be addressed in a forthcoming paper by Potts, Dixey and Nettleton.)

Several participants located their comments in a wider political context, where errors of judgement had been made in the past. Thus a dissident scientist claimed that science and government are "nervous about making mistakes" (Hearing 2), for political reasons, while a public health worker was concerned that the public easily misunderstand and take on 'wrong' information: "it's difficult not to confuse people and cause panic" (Hearing 2).

Issues of trust and its absence have often been presented, particularly in government papers, as being one-sided and a one-way traffic: what is of concern is the public's trust in the experts and the policy-makers. Our research shows clearly that the salience of trust is in its dynamism, and that it certainly is not one-sided. Indeed, the levels of scepticism exhibited by the policy-makers, public health personnel, oncologists, physicians and local authority personnel created a major stumbling block to our planned opportunities for dialogue through the GIS-P process.

The problems we experienced in this regard were twofold: firstly, the work to promote participation was far more demanding than anticipated, and we encountered well defended reluctance, as well as unexplained refusal. Secondly, we were not able to dismantle all the fences and defences among claim makers, despite providing "new spaces for science", and an "agora" (Gibbons, 1999) for the "non-confrontational and even-handed dialogue" about the issue of environmental risk of breast cancer that we had intended. Since members of the same team have effectively used similar approaches and methods to engage participants on other issues, we conclude that the nature of the topic for discussion acted to deter those 'experts' from participating.

Irwin and Michael (2003: 57) state that trust "is regularly presented as a fixed entity rather than a more fluid set of social relations"; examining the social relations pertaining in the hearings gives some insight into the processes shaping trust and suspicion there. Such social relations are fluid across time, but are also shaped by a range of situational contexts and the dynamics among players in those contexts. Some of what appeared to be suspicion may, then, be better understood as a reluctance to be seen to be identified with a particular position in relation to the question of environmental risks of breast cancer, because of the impact that may have on the individual's, or his/her group's, relationship to its public.

Thus one hearing participant explained a reluctance to make knowledge claims in the GIS-P session on the basis that "[an environmental NGO] can't be absolute but government and scientists can" (NGO, Hearing 1). This comment further suggests how the relative authority and confidence of the different participants in the three hearings is most often predicated on their (or their group's) relative social capital.

This is, however, notably not the case in relation to the 'dissident scientists', who boldly asserted their responsibility to speak out, and their determination to do so. This prompts us to claim a particular role for these dissidents, as the key catalyst for change, and perhaps, too, as the important discursive link in this debate: their ideological and political positioning gives them common ground with the activists, while their fluency in scientific discourse grants them some legitimacy with the researchers and other, more mainstream scientists. Certainly the evidence from the USA suggests the key value of their contribution, through community-based participatory and collaborative research, to better policy-making and regulation of environmental hazards (Brugge and Hynes, 2005).

The levels of scepticism exhibited by the policy-makers, public health personnel, oncologists, physicians and local authority personnel created a major stumbling block to our planned opportunities for dialogue through the GIS-P process

Popular/lay epidemiology and policy-making

The first hearing participants' reluctance to take part in the mapping exercise can be seen as a refusal to identify themselves as 'local', or as having local knowledge. For the researchers, significant value had been invested in the 'localness' of the enquiry; locating ourselves within a tradition that is critical of policy founded on the general, without regard to specific populations, we were concerned to provide opportunities for local knowledge, and 'lay' knowledge, to be given voice, to be heard and legitimated within the broad frame of the debate about environmental risks of breast cancer. This is the 'contextual knowledge', situated in a locality, which Irwin and Michael (2003: 101), too, see as such a vital resource: "While science emphasizes generalization, facts and the need for objectivity, 'contextual knowledge' gives weight to local factors, personal views and subjectivities".

Certainly, there is evidence from citizens' juries (Loka, 2004) and other means of "participatory praxis" (Fischer, 2000: 155) of impact on policy development, but, as Irwin and Michael (2003) and Fischer (2000) (*inter alia*) have identified, this emphasis on the local is also ideological, deriving from beliefs in the rights of communities to have a say in the governance of issues affecting them, and the rebalancing of traditional power relations that still tend to pertain in social and science research. Hearing 3 worked better because it arose directly out of local concerns — more in the manner of Brown and Mikkelsen's work with residents near the Love canal waste site in Massachusetts (Brown and Mikkelsen, 1997).

Conclusion

The use of GIS-P as a tool for encouraging communication among different stakeholders in the debate over the role of environmental hazards in the causation of breast cancer highlighted the advantages and drawbacks of the technique. In particular, we can conclude that the relationships among the participants are crucial to the reliability and validity of the GIS-P results; this suggests the need for facilitators to establish a consensual context for the deliberative processes, if the group has no pre-existing cohesiveness.

We want to assert the sound intentions of the projects we report here, even while acknowledging the limitations of the process we used to achieve our aims. This extract from a review of Edward Said's last works by John Higgins (2004) provides an elegant commentary on what we tried to do, and the nature of the difficulties we encountered:

> Said had an uncommon talent for finding a common ground. While this was undoubtedly a matter of charm and personality, it is also important to recognise the intellectual effort that goes into this at the deepest level. Identifying and occupying such common ground are not easy tasks because they are activities that can involve a questioning rather than a fortifying of self, and usually mean giving up the sense of security that comes with the absolute denigration of your opponent. Finding common ground became, for Said, the expression of a fundamental moral and political principle …

Lacking the charm, personality and talent of Said, which were perhaps unanticipated requirements to bring together the communities of interest involved in this work, our intellectual effort was considerable. However, we were surprised by the extent to which the participants were reluctant to step into the difficult terrain, to give up the security of entrenched ideological positions, to question their own views and beliefs, and to see the 'others' in this debate as perhaps not wholly misguided or mal-intentioned.

Thus we conclude that it will take more than innovative participatory processes to open up deliberative discourse about contentious scientific issues. While the broad socio-political context of public debate will inform how specific issues are aired and heard, it is also the case that the characteristics and dynamics of different claim makers shape the outcomes from GIS-P. By locating this discussion of our research within a frame of trust and suspicion, we imply the necessity for addressing these issues explicitly in public debate, thus revealing the dynamics of the social processes by which trust and risk are positioned and negotiated by different communities of interest.

Note

1. Public Involvement, Environment and Health: Evaluating Geographical Information Systems for Participation; an Economic and Social Research Council Science in Society programme, award number L144250045, July 2002–January 2003; John Forrester, Steve Cinderby and Paul Rosen, Stockholm Environment Institute, University of York; Laura Potts, York St John College; and Rachael Dixey, Leeds Metropolitan University, UK. Divided We Stand: Bridging Differential Understanding of Environmental Risk; an Economic and Social Research Council Science in Society programme project, award number RES-151-25-0024, October 2003–December 2004; Laura Potts, York St John College; Steve Cinderby, Stockholm Environment Institute, University of York; Rachael Dixey, Leeds Metropolitan University; and Sarah Nettleton, University of York.

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Participatory GIS and its application in governance: the example of air quality and the implications for noise pollution

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Participatory GIS and its application in governance: the example of air quality and the implications for noise pollution

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ABSTRACT Participatory GIS (geographic information systems) is designed to use community mapping exercises to produce spatial representations of local knowledge. The ideals of Participatory GIS revolve around the concept of public participation in the use of spatial data leading to increased community involvement in policy-setting and decision-making (Weiner *et al*., Community participation and geographic information systems, in: Craig *et al*., *Community participation and geographic information systems*, London: Taylor & Francis, 2002). This paper reports on findings from two case studies, one relating to assessments of air quality and how Participatory GIS has been used in the UK to improve local government policy, and the second on assessments of noise pollution. It concludes by discussing a caveat on the use of Participatory GIS for environmental governance, which is that, ideally, only issues on which participants are likely to have direct experiential knowledge should be targeted.

Keywords: citizen knowledge; community participation; GIS; environmental policy

Introduction

A geographical information system (GIS) can be defined most simply as "a computer system for capturing, storing, checking, integrating, manipulating, analysing and displaying data related to positions on the Earth's surface" (Maguire *et al*. 1991, 10). GIS has become a powerful tool for analysing the world around us and has generally been considered a success in this role by practitioners (ibid.); however, the spatial nature of the tool and its representation of the "real world" forces us to consider whose "reality" we are considering (Martin 1996).

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For example, the same area of land may be considered “waste ground” by local residents, a “brownfield site for redevelopment” by a planner, an “urban wildlife reserve” by a conservation group or a “recreation area” by local teenagers. All these realities relate to the same physical space, but what gets included in the spatial database influences how the area is officially designated, what policies are then relevant to it and hence its future development.

Given these issues, the use of Participatory GIS (PGIS) has become more popular. It is designed to produce spatial representations of local knowledge via community mapping exercises. The ideals of PGIS revolve around the concept of public participation in the use of spatial data leading to increased community involvement in policy setting and decision-making (Weiner *et al*. 2002). The goals of widening and enhancing public involvement in decision-making are increasingly forming part of local, national and EU thinking on governance (Pavan-Woolfe 2001). PGIS also allows the needs and concerns of those most vulnerable to environmental problems to be targeted, documented and presented, through the use of both mobile units and on-street mapping exercises, and through sessions held in areas that are of poor environmental quality and are also socially disadvantaged. The method has proved successful at engaging with hard-to-reach groups (see Forrester and Snell 2007) and, whilst this paper does not explicitly explore this issue, it is important to note the usefulness of the approach for engaging with a range of stakeholders, especially given the increased interest in environmental justice and equity (see Bulkeley and Walker 2005).

The main focus of this paper is a case study that reports on research findings from York and Bristol, based around a UK national government policy set out by the then Department for Environment, Transport and the Regions in 1998 that required local councils to measure, monitor and model air quality in their cities. A variety of different pollutants had target levels assigned to them and government legislation required councils to determine whether the pollutant concentrations in the areas under their control were in breach of these threshold levels. For areas predicted to be in excess of the threshold, management plans would have to be developed to try to reduce concentrations to below target levels. As part of this process, computer models of air quality were used to estimate current and future concentrations of the pollutants. This paper details how the PGIS information complements the technical (“official”) data being generated by UK authorities on these issues, and then goes on to discuss the lessons from this case study, considering whether this methodology can be transferred to the assessment of noise pollution.

The paper concludes by analysing the potential benefits of greater utilisation of PGIS for assessing local knowledge and concerns about environmental issues. This is counterbalanced with an examination of the risks of policy being driven too greatly by stakeholder information alone.

Background

PGIS methodologies

Various approaches to the implementation of PGIS have been developed over the past decade. These can be characterised as belonging to one of two main approaches; the first has been led by the US “GIS in Society” approach to

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citizen engagement with GIS, and the second has come out of the use of GIS as a participatory appraisal tool by development organisations (Weiner *et al.* 2002; Ghose 2003; Cinderby 1999; Sieber 2004). The methodology developed within the case studies described in these papers concentrates on collecting, visualising, comparing and combining public understanding of environmental problems with official, conventional, spatial data on the same issues. The PGIS methods described in our study concentrated on identifying stakeholder knowledge and understanding of the issues being investigated. The researchers mediated access and use of the GIS and complementary data. Thus, visualising the two ideals described by Wiener as axes on a graph, the approach used in these case studies could be viewed as scoring highly on the axis of incorporation of stakeholder knowledge but low on the axis of participant access to GIS technology and data (Cinderby and Forrester 2005). This failure to supply GIS technology and data to the participants, whilst compromising the project's achievement of the ideal goals of PGIS, did not seem to impinge on the success of the study's main aim – namely improving governance through stakeholder engagement with the assessment of air quality.

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Computer models and environmental issues

Many environmental issues are difficult to assess through monitoring alone: air quality monitoring stations can only give information on individual pollutants for particular locations at the specific time (or period of time). This approach identifies pollution levels at specific points (both spatially and temporally); to create complete coverage of a city's air quality using monitoring alone would require either a large quantity of measuring stations to be placed across the entire urban extent for a specific time period, or, alternatively, transporting a more limited number of stations around the city to produce complete spatial coverage over an extended period of time. Computer models have gained popularity for assessing environmental concerns, as they allow conditions to be estimated across geographic areas. Models estimate pollutant levels by identifying the key factors driving the distribution of the problem. Once these factors and the relationships between them have been set, the next challenge is to populate the model with information for those factors. The model can then be used to calculate the levels of the environmental problem for any location for which the driving factor parameters have been set.

Computer models can also be used to investigate the implications of scenarios of possible futures. By modifying the driving factor parameters according to a prediction of their future condition, the implications of these changes for the problem being assessed can be estimated. For example, the implications of a change in road speed for noise levels can be predicted through the use of computer modelling techniques.

Computer models of environmental problems are therefore tools that can provide timely, cost-effective estimates for useful spatial extents (in the management and policy context). They have therefore been widely adopted to assess policy and management options for environmental pollution issues, as they fulfil the pragmatic information needs of decision-makers. However, while undoubtedly useful, such models give rise to concerns over the figures used in the models and the assumptions made which led to those figures being used as a proxy for environmental realities (Cinderby and Forrester 2005). Perception of the accuracy of the model output, thus, is dependant both on the reliability of the detailed data on environmental processes that are used and the accuracy with which they are represented within the model itself.

Public engagement and environmental issues

A "stakeholder" is understood in this paper to be "any person or community who has a concern in a process or in a geographical area through residence, work, or interest . . . stakeholders involve a whole range of actors from statutory agencies through to individual citizens" (Forrester *et al*. 2004, 4). There is a whole range of reasons that support the use of stakeholder engagement in the process and delivery of governance. Stakeholders can be used in the problem definition, option generation, target development, and evaluation stages of policymaking and delivery. The benefits are bidirectional – benefiting both policymakers and experts and the stakeholders themselves. In short the benefits relate to the use and application of experiential knowledge (Darier *et al*. 1999; Wynne 1996; Burningham and Thrush 2001), and a clearer understanding (for all involved) of how problems are perceived, prioritised and framed by different stakeholders, experts and policymakers (Darier *et al*. 1999; Macnaughten *et al*. 1995; Forrester 1999; Ravetz 1999). At their best, these benefits can result in improved learning, raised awareness and access to information (on the part of stakeholders and policymakers and experts), and improved relations between these two groups (Local Government Management Board [LGMB] 1995; Wild and Marshall 1999; Roberts 2000). Stakeholder involvement can be successfully used in the understanding and measurement of environmental problems. Experiential knowledge can complement expert-led knowledge, and in some cases plug gaps in it (Wynne 1996). As noted above, experiential knowledge can provide more comprehensive and acceptable results than a purely expert-driven approach (Leitmann 1999).

Despite the importance attributed to experiential knowledge there are limitations to its use; for example, Snell (2004) finds that when stakeholders (in this case local residents) are involved with option generation, or decision-making, they are unlikely to make choices that will negatively affect their immediate quality of life to any significant degree, and they are likely to attempt to optimise their quality of life in the decisions that they make. Equally, stakeholders are often more likely to prioritise immediate social needs over more long-term environmental considerations, and may conceivably suggest policy options that are unfeasible (structurally, politically or economically).

It is also suggested that there is "no one indigenous technical knowledge" but rather competing knowledges (Mosse 2001). Also, Mosse suggests that gaming occurs during stakeholder engagement – stakeholders may sometimes present problems in terms of what they perceive is on offer to them (ibid.). This may result in problem definition, solutions or indicators that represent what stakeholders *think* will benefit them the most, rather than what will be most beneficial. Also, and important to note, stakeholders will only have limited knowledge of any particular issue.

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Methodological approach

The case studies reported in this paper were generated as part of an Economic and Social Research Council funded project (grant number R000238534) and the PGIS methods employed within the project explicitly set out to collect and analyse local community knowledge and understanding of air quality issues. These activities were an explicit response to previous studies in which

> In case after case it has been found that "expert" accounts of physical realities have conflicted with local people's knowledge and that rather than the local knowledge being routinely inferior and defective, it has commonly proven more sensitive to local "realities". (Yearley *et al.* 2001, 349)

Thus, this project was undertaken in order to address two concerns identified in a previous ESRC project:

- public knowledge was not being fed into the policy system in any useful manner;
- public knowledge was little understood by experts or even by policymakers.

The methods employed were derived form these earlier ESRC projects, and these developments are reported in detail in Cinderby and Forrester (2005) and will not be elucidated in detail here; in summary, they involved a two-stage "focus group" type meeting with participants selected for their interest in the issue of air quality and their particular local knowledge. Although this selection procedure obviously introduced bias into the results generated, it did ensure that the participants had thought about the issue in advance. Later stages of the project investigated whether the more general populace agreed with the PGIS participants in order to check how representative the findings had been.

The first phase of the meeting involved group discussions that revealed the participants' varied knowledge and understanding of the issue. This was followed by a group participatory mapping exercise in which the issues raised in the first phase of the meeting were represented on a large-scale map of the locality (see Figure 1).

This participatory map was then digitised by the research team and displayed in the GIS using appropriate visualisation techniques – "appropriate" based on the information gathered from the participants. For example, noise pollution was described by participants as diminishing to background levels beyond a certain distance from its origin. However, on the participatory map, only the noise pollutions

Figure 1. Participants mark their local knowledge and concerns on a large-scale local map.

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origin was represented. In the GIS, visualisation techniques were used, such as buffering and diminishing colour intensity, to represent the diminution of noise with distance – the extent of the buffered zone being determined by what was said by the group rather than "just" by what they drew on the map (see Figure 2). The resultant GIS datasets were returned to the participants to ensure that their views had not been misrepresented, and also to allow for the inclusion of any additional, post-meeting reflections.

Concurrent with the PGIS focus groups, local council officers were performing computer modelling of air pollution across their cities. Maps of air quality were calculated using the CERC ADMS[1] road dispersal model. The modelled pollutants included nitrogen dioxide, particulate matter (PM_{10}) and carbon monoxide. The concentrations of these pollutants were estimated for specific time periods – including the target year of 2005.

Findings

The project reported on here collected and collated information from the case study cities on local stakeholders' knowledge and perceptions of air pollution together with the official council model estimates and monitored data. How do the two types of information compare? What does this mean for the governance of pollution?

The participants in the PGIS focus groups were encouraged to discuss their understanding and experience of air pollution in the local environment. Unsurprisingly, they did not describe their understanding of pollution problems in terms of nitrogen dioxide levels or PM_{10} concentrations. Instead, they described pollution from traffic, for industry and agriculture, smells, and noise problems, amongst others. They also described the impacts that pollution had on them. These included stinging eyes and sore throats, coughing, asthma attacks and a general reduction in quality of life. The participants also moved on to talk about what could be done to improve matters.

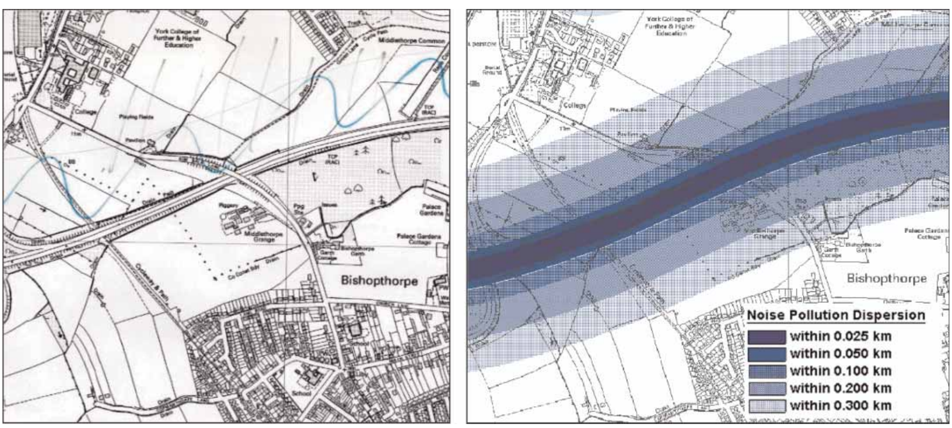

Figure 2. The original participatory map indicating noise pollution origin and extent (left) and the resultant visualised GIS dataset (right).

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In the mapping phase, the focus groups' participants indicated their knowledge of point sources of pollution: primarily local factories. In York, participants were concerned with smell rather than the type of pollutants being appraised by the council process. The primary industrial sources they indicated as problems included the local sugar and chocolate factories. In contrast, in Bristol, participants in Avonmouth were concerned about the type and level of pollution being generated by the local industrial estate, which included incinerators and chemical plants.

The participants also indicated dispersed pollution, which, for York, was related to roads and traffic density levels. In Bristol, industrial sites were also indicated as areas of concern. The groups decided on their own classification schemes, rating dispersed pollution from "very bad" or "worst", through to intermittent problems and, finally, good air quality. In addition to air pollution in its more traditionally recognised sense, many of the groups also included issues of noise levels on their maps. They indicated where noise levels were too high and how far away from the origin of the noise the problem spread. The noise issues indicated in York and Bristol were related to road traffic levels – neither of the locations was described as having industrial noise pollution sources that were a problem.

The final maps of air quality incorporated in the PGIS database represent the participants' experiences and understanding of pollution in their cities. The Bristol PGIS databases were compared with the information generated by the council modelling of areas that were likely to exceed the government targets for nitrogen dioxide in 2005. This area represented the proposed boundary for the air quality management area (AQMA) for the city. When one compares the maps from Bristol residents with this boundary, only one of the areas rated as having air quality problems falls outside the proposed AQMA.[2]

In York the PGIS air quality data compared well with the detailed council modelled assessment of nitrogen dioxide problems (see Figure 3). The PGIS focus groups were held before the council released the findings of their review so the participants' views were not influenced by the "official" technical data. The

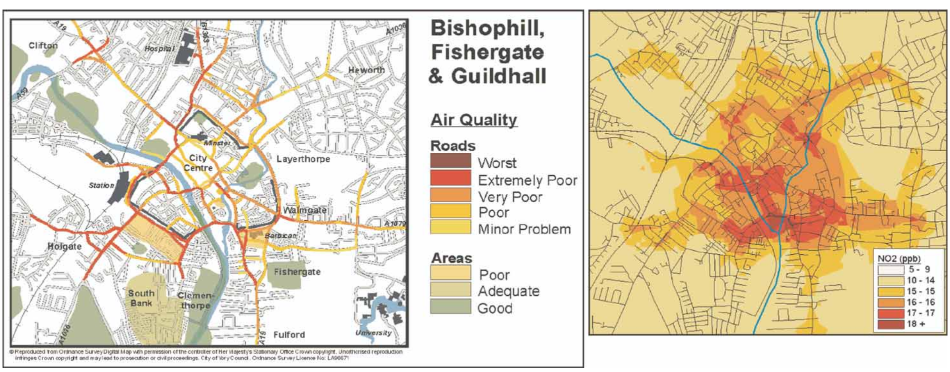

Figure 3. Participatory GIS output maps for inner city York and corresponding predictions of nitrogen dioxide levels from the City of York council ADMS model.

same areas that were rated as having high pollution levels were identified on both maps and the gradation of pollution for other areas was similar with a few exceptions. The level of detail on the residents' maps was impressive. For example, differing levels of poor air quality were indicated depending on the layout of road junctions and the proximity to traffic flows from one side of a street to another. The maps showed gradations of pollution along roads depending on the distance traffic queued back along them from traffic lights. Pollution levels were shown on the PGIS maps to vary depending on how constrained or well ventilated the area was.

The information on air pollution represented on the PGIS database was generated from the participants' experiences of pollution from around the cities in question. People had indicated areas where they could smell the fumes or had suffered direct physical effects. However, the PGIS maps also contained information based on surrogate data; for example, people felt that where traffic levels were high and/or traffic flow was congested, air pollution must be high – using their experiential knowledge of traffic and linking it to their understanding of pollution levels to generate the classification captured on the maps. Similarly, the computer models divided the city's road networks into segments and estimated the spatial distribution of traffic volumes for these segments. This traffic volume information was linked in the computer models to data on the characteristics of the vehicle fleet, and pollutant emission factors by vehicle type, to generate pollution levels from transport. So the computer models and PGIS maps were generated through similar processes and used similar types of information.

This similarity in the process and distribution of the assessment of air quality between the two datasets meant that the PGIS maps proved useful to the council officers in their efforts to get a policy "output" that agreed with their assessment of the problem. Further, the database in York was used to identify additional sites for monitoring where participants had indicated that pollution levels were high but little or no assessment had taken place. Overall, the PGIS process improved the governance of the problem through improved monitoring, and potentially enhanced the modelling data.

The air pollution problems experienced in both cities were linked to traffic density. However, if the air pollution issues had not been related to traffic but to some other emission source and pollution chemistry – for example the formation of ground-level ozone – then would the two maps have agreed? The indications are that this is actually unlikely. Participants had generated their maps for air pollution issues in general, rather than for specific pollutants. This implies that if the pollutant of concern had been ozone (O_3) rather than nitrogen dioxide (NO_2), the participants' PGIS would have remained the same. At this point, the level of agreement between the computer model outputs and the PGIS datasets would have broken down.[3]

If it is found that the public's experience does not tally directly with the expert evidential understanding of the issue in question then this too can be addressed. The improved clarity and understanding with which experts can interpret the maps of citizen-derived data may help to improve communication between the two groups. This form of participation could, in itself, help to improve local environmental governance.

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Applicability of PGIS to noise pollution

The next major local environmental issue on which national and local government are extensively using computer modelling is noise pollution. Computer mapping and modelling of noise levels are ongoing (Noise Mapping, England) and policies are likely to be driven by their findings. Maps are being developed nationally as the first stage in identifying management areas for noise under the new EU Directive on Environmental Noise (European Union 2004). PGIS could offer a complementary approach to developing, or at least prioritising, noise abatement.

The findings in York and Bristol indicate that local residents have useful experiential knowledge of noise problems and that this experiential knowledge is compatible with and can be presented in a comprehensible "evidence-based" form to experts. The information on noise from both cities indicates that people using each city have a spatially refined understanding of where they consider noise a problem. For example, in York participants indicated certain roads as having noise problems. When pressed as to why those areas were considered problematic despite other areas not being marked, respondents stated that their choice was due to the context of use: for example, areas that people used for recreation (such as parks adjacent to roads) had a lower threshold for noise than other areas. Thus, the actual noise level was preceived as the same, but the extent to which it was deemed problematic was not. This shows one benefit of PGIS mapping over simple qualitative monitoring or modelling. Similarly, on other areas of city pavement, the exact same traffic flow along a relatively short length of the same street could be deemed acceptable or too noisy depending on the proximity of the pedestrain to the traffic. Hence, the citizen GIS mapper is taking into account physical infrastructure such as surrounding buildings, width of pavement resulting in proximity to traffic, and other complex issues to provide refined and detailed pictures of noise problem areas.

These examples show two interesting aspects of noise as an issue for assessment and governance through PGIS. One is the possibility of using PGIS information to guide priority-setting for noise policy (i.e. rather than for noise assessment as such). Initial information on the noise maps produced for the UK indicate that large areas of the country's cities are likely to breach EU targets for noise. If areas that were identified through PGIS as problematic were prioritised for noise reduction then this would concur with public concerns on this issue. This approach could focus the amelioration policies on specific areas of the cities rather than trying to target every area identified as having a technical problem. Secondly, the detailed information from the PGIS database linking focus group transcripts to specific spatial locations could be utilised to find solutions to some of the perceived problems.

Obviously, one caveat to this approach to the governance of the noise problem through PGIS exists. Participants only mapped certain areas of cities as having problems even though they agreed that noise levels were just as high elsewhere. For some of these non-problem noisy areas people made comments such as: "Well, you would expect that to be noisy; it's next to a busy road." This acceptance of noise by city residents should not mean that areas breaching thresholds should not be improved. This is particularly the case as some of the areas not mapped include some the poorer inner-city residential areas.

The potential for PGIS in the area of noise pollution is high. Human perceptions integrate the problem in a way that noise-monitoring struggles to achieve (Department for Environment, Food and Rural Affairs [DEFRA] 1999). Residents have good experiential knowledge of the problem. The PGIS information gives the social context of the noise and indicates solutions for some of the problem locations. Using intermittently reconvened focus groups, PGIS could be used to monitor the impact of noise policies on public perceptions of the issue. This approach would indicate whether remediation measures were effectively reducing noise pollution. However, such an approach may just show participants' threshold for noise diminishing as their level of exposure is reduced. That is, as places became quieter, the threshold for problem noise would become lower.

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Conclusions

Can PGIS assist in the governance of local environmental issues? Jankowski and Nyerges (2001) identify three ways in which human decision-making abilities could be enhanced through the use of information technology (see also Brown *et al*. 2000):

1. Help decision-makers formulate, frame or assess decision situations by identifying the salient features of the environment, recognising needs, and identifying appropriate objectives by which to measure the successful resolution of an issue.
2. Provide support in enhancing the abilities of decision-makers to obtain and analyse possible impacts of alternative courses of action.
3. Enhance the ability of decision-makers to interpret impacts in terms of objectives, leading to an evaluation of alternatives and selection of the preferred alternative option.

Jankowski and Nyerges refer here to the use of information technology in group meetings. However, the outcome of the PGIS process could be fed into the decision-making process at key points to address these same concerns. PGIS could be used to frame local environmental problems and set locally resonant objectives on which to measure the success of policies to resolve environmental problems. It has been shown in the case of air quality how local knowledge of the issue was helpful in identifying where additional monitoring, which had not been identified by the council officers, was useful. In addition, local knowledge could have been employed to develop the structure of the road network model to make the results more closely reflect local concerns, possibly leading to a more accurate assessment of the pollution levels. PGIS can also provide alternatives for action plans from different stakeholder groups. These can be analysed, using conventional computer models, to assess the impacts such possible scenarios would have on meeting the desired objectives – and any unforeseen consequences. Further, if policies are set to achieve certain objectives for particular stakeholders groups, these group-specific action plans may be taken into account or may even suggest particular courses of action. Finally, PGIS could be used to assess the impact of mitigation measures on public perceptions of the environmental problem in question.

The findings presented above back up previous research that suggests that stakeholder knowledge can be limited (Snell 2004; Burningham and Thrush 2001; Mosse 2001), and that, whilst it can complement problem definition, option generation and decision-making, it cannot replace the role of expert knowledge. The caveat to the use of PGIS for environmental governance is that, ideally, only issues on which participants are likely to have direct experiential knowledge should be targeted. However, the technique might still be used to address cases where local knowledge and experience *do not* match the scientific understanding of the issue. In these instances the participatory maps are still valuable as they became a tool for creating dialogue between experts and residents, encouraging mutual learning about local concerns and scientific understanding.

The findings also back up the view that stakeholder concerns can be quite specific and localised, as opposed to providing an overview of local issues and problems. Whilst PGIS for noise pollution provides valuable information about the social context of noise, the changing nature of this context must be understood, as should the possibility of bias and utility maximisation amongst stakeholders (discussed by Mosse 2001 and Snell 2004).

These caveats aside, noise pollution in particular is the most likely upcoming candidate to benefit from increased public participation in its governance through the use of PGIS approaches.

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Notes

1. CERC: Cambridge Environmental Research Consultants; ADMS: Atmospheric Dispersion Modelling System.
2. This exception was an area that people felt had poor air quality caused by high volumes of slow-moving traffic. On comparing the council's data with the PGIS map it became clear that Bristol's computer modelling had indicated high NO_2 for this area. However, the area was an industrial and commercial district. The lack of a residential component meant that the area could not be included under the national government guidance.
3. However, that is not to say that there wouldn't be a potential overlap between evidence- and experience-based knowledge on ozone. Ongoing work being carried out with respect to crop damage caused by low-level ozone (see http://www.york.ac.uk/inst/sei/APS/about-atmos.htm) would indicate that engagement with an appropriate group – i.e. rural farmers – would show some level of agreement between technical assessment and local perceptions of damage caused by the pollutant.

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How to reach the 'hard-to-reach': the development of Participatory Geographic Information Systems (P-GIS) for inclusive urban design in UK cities

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Sustainable development and successful urban regeneration ideally require engagement with the affected communities. Existing methods employed by policymakers and planners often fail to reach significant segments of communities, the so-called 'hard-to-reach'. This paper describes the development of an innovative participatory GIS methodology specifically aimed at overcoming the barriers to engagement experienced by these groups. The application of the method is illustrated with reference to three recent case studies carried out in UK cities. The paper will then discuss the novelty of this approach in comparison with other participatory engagement techniques. The ethical implications of the technique are also discussed.

Key words: *UK, urban regeneration, Participatory Geographic Information Systems, 'hard-to-reach' communities, inclusive urban design*

Introduction

Urban design is expected to play a critical role in implementing the UK Government's urban policy agenda, in which the sustainable development of cities is seen as a key generator of national prosperity, as well as a more inclusive and equitable society. As global competition intensifies, a network of accessible, safe and attractive public spaces and walking routes oriented to leisure and tourism becomes an increasingly important feature of the 'liveable' city. In response to this economic imperative, there has been considerable investment in improvements to the public realm.

As post-industrial cities are re-configured to accommodate visitors there is, however, a real possibility that the new infrastructure will create isolated enclaves of affluence. These may give physical expression to urban inequalities and do little to promote social cohesion. Local Authorities and Regional Development Agencies are consciously trying to reconcile the desire to create urban environments that are attractive to high-spending consumers and public policies that prioritise social inclusion and equity.

This paper will present the methods and findings from two recent Engineering and Physical Science Research Council (EPSRC) funded projects: Inclusive and Sustainable Infrastructure for Tourism and Urban Regeneration (InSITU) (www.insitu.org.uk) and Design and Implementation Support Tools for Integrated Local LAnd use, Transport and the Environment (Distillate) (www.distillate.ac.uk). Both projects developed Participatory Geographic Information Systems (P-GIS) techniques (Cinderby 1999 2007 2008; Cinderby and Forrester 2005) to rapidly assess and integrate local concerns, knowledge and design ideas into the urban development process. These techniques will be discussed in relation to their evolution and application in three UK city case studies. In particular, the potential application of the P-GIS approaches described to include the voices of so-called 'hard-to-reach' groups

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in the policy and design process will be considered. The relative novelty of these approaches in comparison with other participatory engagement techniques will then be considered.

The case studies

The three case studies presented are a health walk development in inner-city Salford, public perceptions of streets and squares in York city centre and the development of transport options for a Blackpool suburb. These case studies will be used to illustrate the evolution of the P-GIS methodology and techniques.

Engagement of 'hard-to-reach' groups

Bickerstaff and Walker (2005) have highlighted the high priority given by the Government to the need to foster 'civic engagement'. Especially since 2000, there has been a considerable expression of concern to respond appropriately to 'declining public participation in political processes' and 'growing public distrust of authority and expertise' (cf. House of Lords 2000; House of Commons 2001; Institute for Public Policy Research 2004).

On the ground the local authorities and organisations involved in our case studies identified engaging with so-called 'hard-to-reach' groups as a key area. Defining such groups is obviously problematic, contentious and possibly divisive; however, across numerous local authorities the people they struggled to engage with included:

- people from Black Minority Ethnic communities
- asylum seekers
- people with disabilities
- young people
- older people
- people living in areas of deprivation or on a low income.

Identified problems that may be exacerbating the lack of engagement by these groups include language barriers, cultural differences, time and ability to attend public meetings even if they were interested in the issue. A particular remit of the research presented here was to investigate whether the use of P-GIS would encourage greater engagement from these target groups.

What are P-GIS?

A variety of terms exist in the literature and amongst practitioners for the GIS-based approaches that have developed with the overall aim of supporting public participation. In the US the common nomenclature for such approaches is Public Participation GIS (PP-GIS). Largely independently the concept of Participatory GIS (P-GIS) emerged from participatory approaches to planning and spatial information and communication management often in developing world contexts (Rambaldi and Weiner 2004). In addition to these two widely adopted titles, alternative nomenclature for activities with similar goals include: Community Integrated GIS, GIS for Participation (GIS-P) (Cinderby 1999) and Web P-GIS (Kingston 2002 2007). For the purpose of simplicity, in the remainder of this paper all flavours of community-focused public participation utilising GIS technology will be referred to as P-GIS.

Commonalities between the various P-GIS techniques include the overall goal of empowering communities within decisionmaking processes, either within decisions being taken by the community or, more commonly, decisions being taken by outside agencies that will affect the community concerned (Pascual and Parker 2002). Overall P-GIS represent a flexible suite of tools with different approaches relevant to particular contexts and issues.

In order to capture local stakeholder knowledge, participatory mapping is often employed as a data-gathering technique to feed into P-GIS analysis. Participatory mapping utilises suitable base maps (cartographic maps, air photographs or satellite images) presented at an appropriate scale that are then annotated by community groups. The visual nature of participatory mapping removes, to some extent, the barriers of literacy and, to a degree, language (although potentially introducing a new barrier for visually impaired people) that other forms of engagement, such as focus groups or questionnaires, require. One of the benefits of P-GIS is that the maps become the focus of participation. This removes the drawbacks present in public meetings where the most vocal or confident people can dominate discussions (unless carefully facilitated; Carver *et al.* 2001; Cinderby and Potts 2007). Large-scale maps and detailed air photographs of urban areas do not require high degrees of literacy to interpret. Evidence from previous work carried out by the author have indicated that all age ranges, including even young children (approximately six years old) can locate themselves on a map if orientated, guided and encouraged through the process by facilitators and other participants.

Whilst P-GIS approaches have proved useful in a variety of contexts, the drawback of the majority of commonly employed techniques from the UK, Europe

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and North America in relation to engaging with 'hard-to-reach' communities is that they involve attendance at organised public meetings and discussion groups. For P-GIS to be successful people are required to become actively involved in the local decisionmaking process through investments of time, knowledge and skill development. Whilst online participation may be seen as one potential way of overcoming these limitations and has been used successfully in a number of contexts (Bosworth *et al.* 2002; Carver *et al.* 2001; Groundwork 2009), for 'hard-to-reach' communities it potentially introduces a new set of barriers to participation. These include access to computers and broadband, installation of software or plug-ins in order to visualise browser content and the technical capability of particular age groups.

Methodology development and results: overcoming the barriers to participation for the 'hard-to-reach'

On-street engagement

The option of taking the mapping exercise to the participants through the use of on-street events presents an opportunity to overcome the barriers of public meeting attendance identified as a drawback of many P-GIS approaches. The hypothesis behind employing on-street mapping with members of 'hard-to-reach' communities is that people do not have to commit a significant amount of time or effort to participate and that therefore a different range of voices will emerge. The three case studies all utilised on-street activities in an attempt to test this hypothesis.

In Salford, on-street events were held at a health centre, alongside a parade of local shops and at a community fun-day event. These venues allowed pensioners, children, teenagers and young adults from a low-income community to communicate their local knowledge and preferences for the proposed walking route to the research team. The on-street events were carried out under a large gazebo to attract attention. In total, from three half-days of on-street activities, approximately 120 people participated and 200 individual comments were captured. Of these, approximately a quarter of comments were obtained from children and teenagers, a 'hard-to-reach' group the project team were particularly interested to engage with.

The second case study was carried out in York during a late September 2006 weekday afternoon. A pension payment day was picked in an attempt to encourage participation from the elderly and the event continued until early evening to ensure children and teenagers returning from school could make their contribution. The City of York Council, who were partners in this case study, were particularly eager to engage with these two different interest groups. During a three-hour period over 30 people participated, with 69 per cent of comments from women and 28 per cent of the comments from teenagers, which the Council found impressive. However, unfortunately only 3 per cent of the comments were from the elderly. Overall this level of participation in such a short and specific time slot at one physical location was considered a relative success by the project team and Council.

In the final case study Blackpool Council specifically requested engagement with young people and those with mobility issues. In order to maximise the potential involvement of these interest groups the on-street activities were carried out on different days and time slots. In total 151 people participated with 31 under the age of 20 years (approximately 21% of participants). The full breakdown of the age range and gender of participants can be seen in Figure 1. These correspond to a group who would typically not attend conventional consultation exercises held by the Council. In terms of people with mobility issues, approximately seven people (5%) who clearly had mobility issues (as manifested through the use of walking aids or wheelchairs) participated. In addition to this direct participation a number of other people made reference to family members with mobility issues and the consequent problems they experienced in the local area.

The on-street approach had a number of advantages for encouraging the participation of particular age ranges and groups, including those who often fail to participate in conventional engagement techniques. Firstly, people did not have to make any special arrangements (childcare, transport to the venue, etc.) to participate in these events. Secondly, the time commitment for participating was less than 15 minutes (and in many cases only two or three) making it easy to fit around everyday activities. Thirdly, the one-to-one conversations between participants and facilitators meant that people did not have to justify their comments or knowledge to their peers, as would be the case at a public meeting. This was potentially less intimidating for participants without the confidence or language skills to communicate effectively in group discussions. This perceived advantage of on-street individual or small group (two teenagers, for example) participation is also a potential disadvantage of this approach as it prevents any broader discussion or

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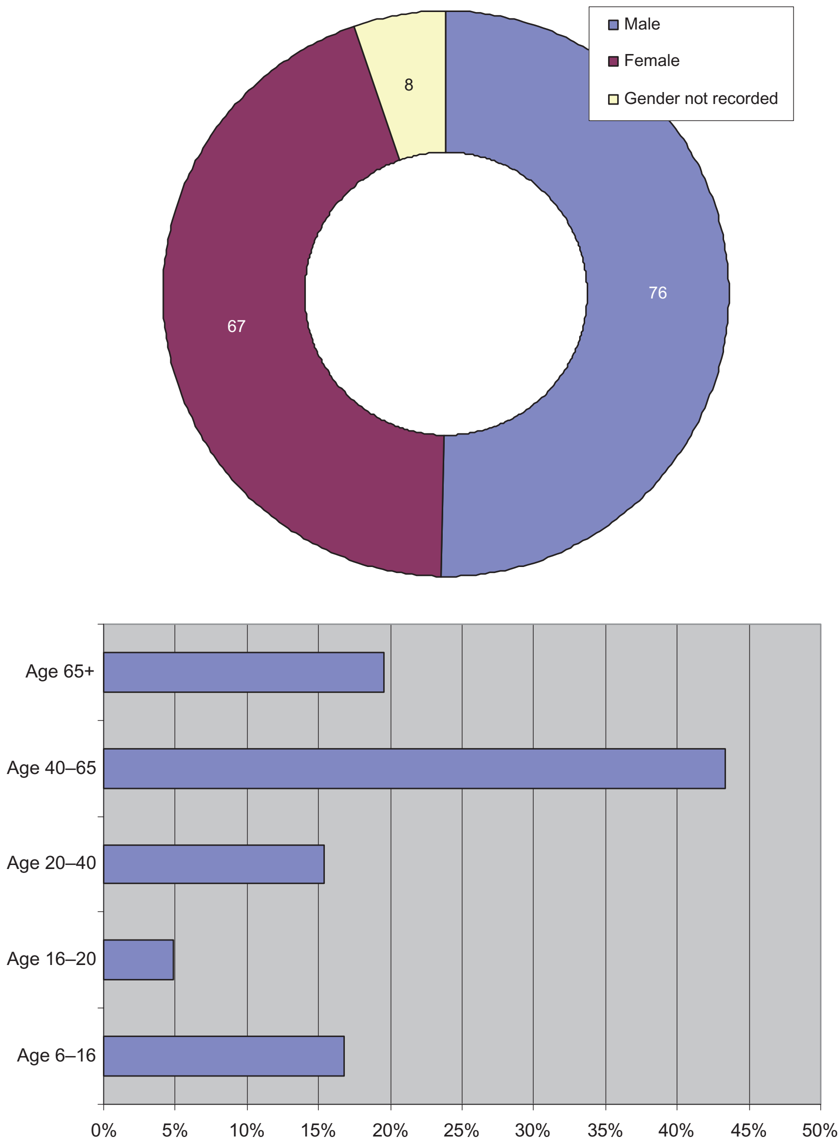

Figure 1 Gender and age distribution of participants in the Blackpool case study

snowballing of conversations occurring between participants. Also unless the facilitators have some local knowledge of the area with which to vet comments, participants could potentially communicate falsehoods that would not pass muster if presented to other members of the local community. Finally, the use of in-situ on-street mapping allowed people to physically engage with the area in a way that would be impossible using conventional approaches. Participants could point at particular features of concern, take facilitators to 'have a look' at the problem and reflect on the space around them. Maps could be orientated to match the real world, aiding people who struggled with map literacy. This in-situ aspect added greatly to the on-street dimension of the mapping and helped to clearly link the comments made to the maps.

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Structured queries

The Salford case study was primarily developed as a scoping activity to investigate whether on-street participatory mapping would be a suitable technique in an urban UK context. The initial indications were positive, with a high level of engagement from a cross-section of the community in a relatively short period of time. The results generated were appropriate for conversion into digital GIS files and allowed further spatial analysis to be performed to highlight key findings.

However, a variety of problems were identified in relation to this initial on-street consultation. The primary problem was that facilitators were not using a consistent set of questions with all participants. Whilst a broad topic guide had been developed, the main focus of the first case study had been on testing whether on-street mapping would encourage engagement from the 'hard-to-reach'. This lack of a well-formulated topic guide led to different types of information being mapped by participants, depending on which facilitator they engaged with. For example, one facilitator particularly concentrated on the local historical information, whilst another emphasised questions regarding access and design around the health walk route.

In the second case study, investigating York public squares, the on-street approach was further developed to overcome the deficiencies identified from Salford. A more fully populated topic guide (Bryman 2008) and structured set of questions were developed to ensure consistent engagement. The questions related to the participants' use of the existing public-realm space, their preferences and ideas for near-future improvements. Structured queries ensured that information could be more consistently coded and themed within the digital spatial database. The revised approach also included the collection of additional information regarding the participants' demography, which was then associated with their mapped information. In York, the demographic information collected included participants' gender and age range, allowing for the development of a digital database that included the option of coding the spatially referenced comments by these attributes. In future additional demographic information could be collected (as appropriate), such as the home postcode of participants, allowing for tagging of information with a variety of socio-economic discriminators.

An example application for this type of participatory data for York city centre can be illustrated with reference to Figure 2. These maps visually represent the areas of consensus and potential conflict within the public-realm spaces of the city centre. For example, the maps indicate unanimous positive views for the city-centre fountain (with only positive comments for this location) and equally ubiquitous disapproval of the current toilet block (with only negative views). These views were based on a mixture of design issues and functional usage. Alongside these extremes were locations with mixed opinions about the current use of space. The rise of on-street *al fresco* dining in the main street was praised as adding vibrancy and a continental air by some participants, but equally criticised for taking up public space and blocking pedestrians by others. For some spaces the range of views was associated with the age of participants; the demographic coding of the spatial data allowed this aspect of the data to be interrogated and visualised. For example, one particular square was highlighted as requiring improvements to make it more accessible and prominent by middle-aged participants, but was similarly praised for being private and secluded leading to its use as a meeting space by teenage residents. This result highlights how different stakeholder groups, including in this case the 'hard-to-reach' teenage community, can vary in their use and perception of the same physical space with consequent important implications for urban redevelopment and regeneration.

Participatory mapping approaches

Various approaches to on-street mapping were trialled during the case studies. The initial case studies in Salford and York utilised flags and stickers to locate spatially the people's comments (see Plate 1). The use of such resources and sensitive facilitation removed the necessity for participants to draw or write, thereby allowing less literate groups (children or adults) to communicate their knowledge effectively. These visually stimulating approaches also appeared to encourage participation as the flags, stickers and colourful maps drew attention to the consultation. On a number of occasions facilitators were asked 'what's all this about then?' or queried as to whether the map was a game or treasure hunt with a prize! Whilst they may have initially been disappointed with the answer that we were simply there to hear their views with no prizes on offer, these people usually became intrigued enough to participate in the mapping.

The drawback of these novel mapping approaches was that spatial information was primarily recorded as points, due to the physical restrictions of using flags and stickers, even if the information the participants were attempting to communicate was in relation to an area or specific zone. Similar concerns have been

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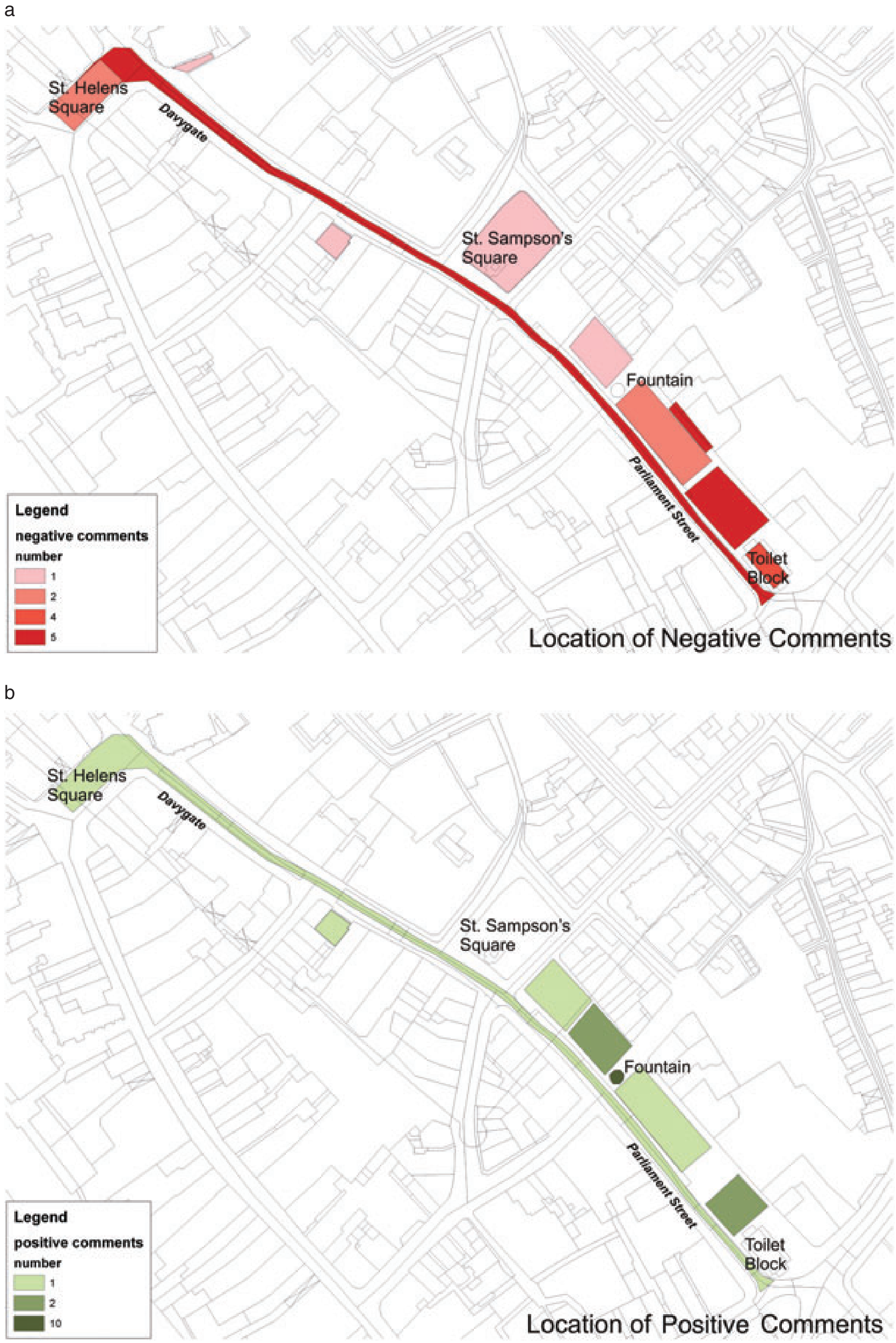

Figure 2 The co-location of positive and negative comments with regards public spaces in York city centre

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Plate 1 On-street mapping utilising flags in Salford (top) and York (bottom)

expressed with online mapping interfaces (Carver *et al.* 2001). This point recording was perceived as a significant drawback as the initial data captured were spatially inaccurate and required considerable post-processing and interpretation to effectively represent to others, through the GIS visualisations, the viewpoint and knowledge the participant had tried to communicate. In our case studies the facilitators were also the GIS technicians and used their expert judgement to translate points into their relevant areas if appropriate. Points were not linked directly to existing spatial units, such as OS Master Map polygons, but instead specific new polygons were digitised to represent the participant's information

In order to overcome this point-data problem, the Blackpool case study returned to the use of full participatory mapping with people being asked to draw directly onto a base map (Cinderby 1999). However, in a break with conventional communal mapping each person was given a fresh individual map to annotate. Structured queries were again utilised to ensure consistency. The Blackpool case study revolved around the generation of ideas from the local residents and neighbourhood users for options to regenerate a local shopping precinct. The study particularly concentrated on the options for improving transport links and sustainable transport (walking, cycling and public transport) infrastructure in the local area.

Each individual was given an A3-sized base map of air photograph imagery. The zone under consideration for scheme development had a mask applied to bleach it out from the photograph in an attempt to focus participant's comments on this area. This mask also facilitated mapping by making any annotations made on the map relatively easier to see even on full-colour imagery. This clarity was particularly useful for the elderly and those with sight problems. A mixture of colour versus black and white base maps was employed to assess participants' preferences. Whilst the younger participants showed a slight tendency to select the colour base maps, overall there appeared to be no strong preference amongst participants.

In the GIS database the specific extent of the case study area was split into discrete, uniquely coded zones based on the location of comments received from the participants. In a linked database the specific comments received from each participant were then recorded and coded with the spatial zone to which they related. Each participant's map was also allocated a unique identification number and the age and gender of its authors recorded. This further refinement ensured that the different viewpoints and knowledge of young people, the elderly, men and women could be investigated individually in the GIS providing a demographic framing to the participatory spatial data.

Conversion and analysis of on-street maps

The true utility of P-GIS revolved around whether value could be added to the information, collected through the on-street participatory maps, through additional digital spatial analysis. Value here is in terms of the communication of the community's viewpoint and perceptions to an outside audience.

The results from all the case studies indicated that the use of GIS could add considerable value to the information collected from communities. For example, in Salford the information collected was utilised in a number of ways to inform the development of the health walk. One of the key concerns communicated by a cross-section of participants was the fear of crime

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experienced by the community at a number of locations along the walk (see Figure 3). These fears were related primarily to concerns of being isolated and unobservable by the wider community at certain points along the walk. The community's historical knowledge influenced these perceptions with memories at particular locations of mugging and crime incidence. By converting the paper participatory maps into a digital format it was possible to compare within the GIS these community concerns with official information on the incidence of crime. The indices of deprivation (ODPM 2004) indicated that the neighbourhood of the health walk had a higher incidence of crime than those surrounding it. This highlighted that the residents had some justification for their personal safety concerns. However, the local police crime incident data indicated that the reported crime for the neighbourhood occurred along the major road that bisected the community and formed one section of the health walk.

This GIS analysis indicated a number of potential issues in relation to the development of the walk. The IMD data indicated that the area the walk was being planned for had relatively high crime levels in relation to those neighbourhoods surrounding it, indicating that the local residents had reason to be fearful of crime. However, the residents' fears of crime were located at different places from the officially mapped police incident data. There are a variety of possible explanations for this. Firstly, the spatial location of community crime concerns may have been unjustified and based purely on fears or local urban myths. This would require further investigation with the community to clarify. Secondly, the official police data may not have included crimes in the areas that the community were concerned about due to lack of reporting by victims. Thirdly, the official data may have been spatially inaccurate with crimes occurring on the remote, off-road parts of the health walk path identified in police records coded to the nearest road name. Alternatively, a combination of all these factors may have been occurring. Irrespective of which explanation was correct, the GIS analysis indicated that in order for the health route to be successful, in terms of public use, the community's perceptions of crime fears would need to be addressed. From the walk development aspect, the specific outcomes included the need to trim and maintain overgrown vegetation to improve community surveillance of the route, the fixing of street lighting and the need to enhance the visual attractiveness of the path. Without these changes, regardless of whether the community's fear of crime was justified, the route would not be successful in encouraging more walking and physical activity by the community as people would continue to avoid significant sections of the route.

The information generated through both the other case studies also indicated the utility of further GIS analysis. The use of a digital database allowed maps for specific 'hard-to-reach' groups to be produced, ensuring the viewpoint of specific members of society could be communicated. The use of GIS also allowed the positive and negative views held by the community for the same physical space to be clearly represented. The case studies highlighted the potential of on-street P-GIS to deliver improvements to the input communities could make to local development issues.

Rapid appraisal participatory GIS

The term 'rapid appraisal participatory GIS' (RAP-GIS) has been developed to describe the above methodologies, specifically, incorporating the use of in-situ on-street events, utilising individual and group participatory mapping, with individual's input structured through the deployment of specific queries, and the resulting information converted into a digital format within a GIS for further analysis and visualisation.

Comparison of RAP-GIS and conventional P-GIS outputs

In the York street spaces case study, the opportunity was taken to compare the use and outputs from a conventional P-GIS approach with those generated through the RAP-GIS method. A group of eight randomly selected York residents who were members of the Council's Standing Panel were recruited to attend an evening focus group. They undertook a transect walk through the city-centre locations under discussion and then participated in a 90-minute focus group utilising participatory mapping to capture the spatial comments they made with regard to the urban spaces. The questions used by the facilitators were based upon the same queries used in the on-street RAP-GIS exercises.

The outputs from the P-GIS focus group were comparable with the RAP-GIS information in terms of the content, development of ideas and range of viewpoints expressed by the participants. The information differed in terms of the depth of understanding of key points generated due to participant interaction and the opportunity for supplementary in-depth questioning by the facilitators. In addition, digital recording of the discussion allowed the facilitators to analyse the development of discussions in far greater detail.

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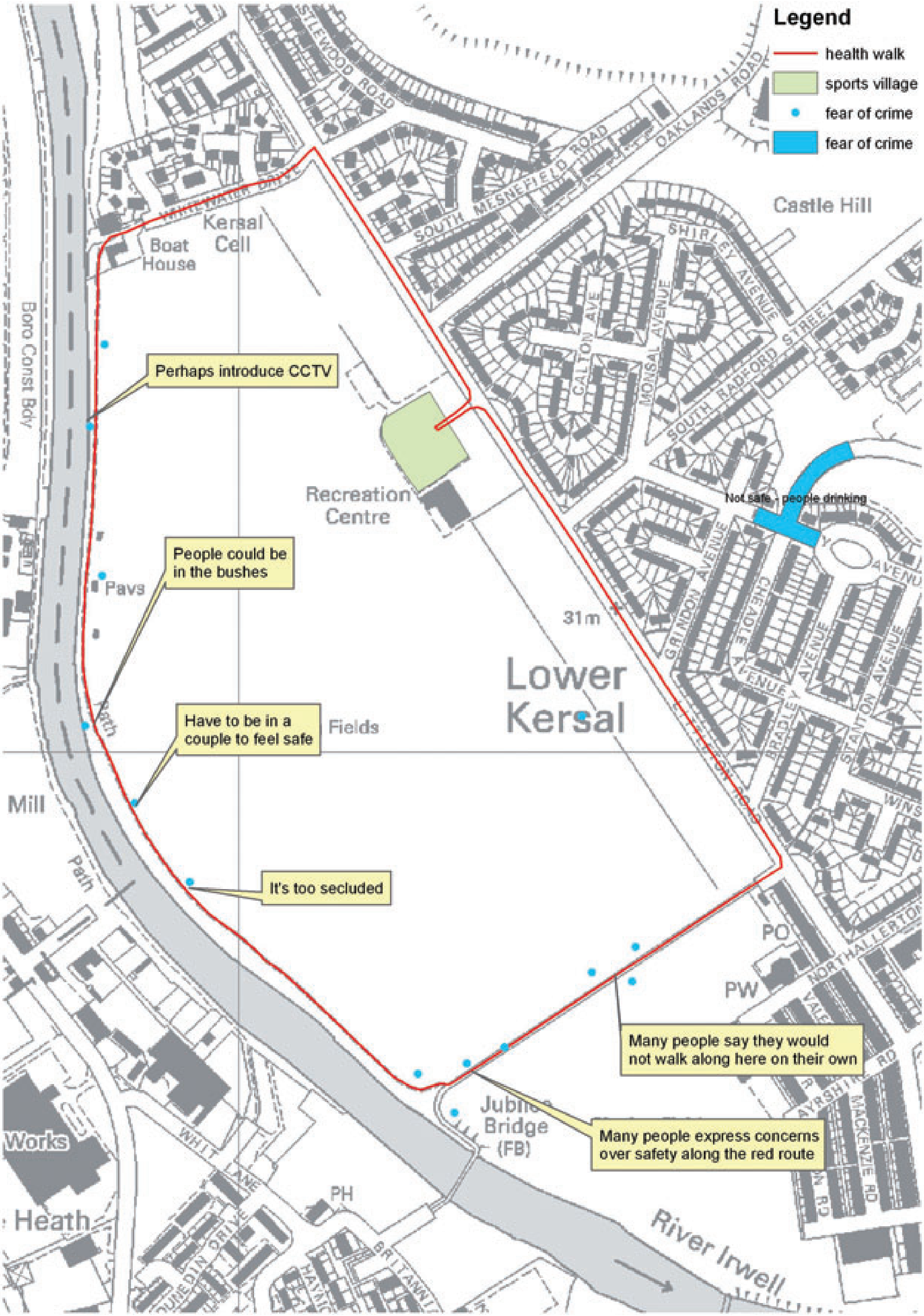

Figure 3 Salford residents crime fears along the proposed health walk route

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This comparison indicates that whilst the RAP-GIS process can generate similar comments and ideas as P-GIS, it does not necessarily lead to the same in-depth understanding of the underlying assumptions and justification for those ideas. RAP-GIS did have the advantage that the specific comments annotated on the maps are attributable to one individual and can be linked to the demographic profile information held in the database. With conventional group participatory mapping it is hard to attribute particular annotations to specific individuals. In addition this attribution would not always accurately identify the origin of the annotations if they were generated by the group as a whole. RAP-GIS also led to a different mixture of participants taking part, including young people and children who would not be easily recruited using a Council panel. Considerable additional effort may be required to facilitate the effective inclusion of the range of participants who can be reached through RAP-GIS using alternative approaches. In addition a greater number of people can participate in a relatively short time-period than could be accommodated by any conventional P-GIS methodology.

Other differences between the RAP-GIS approach over existing participatory methods are that it is relatively cheap and easy to organise and undertake. No venues have to hired, participants do not have to be invited and no reimbursements need to be paid. New additional costs that may be incurred include the purchase of a suitable gazebo and associated permits to erect these in public-realm spaces. However, compared to meeting organisation, these are relatively minor in terms of time and expense.

Obviously the 'chance' nature of on-street participation results in a relative lack of control over whose opinions are canvassed. This can be adjusted for by carrying out on-street engagement at various times and locations, thereby allowing a wider mixture of participants or encouraging engagement from a particular constituency of interest (e.g. setting up the maps at local teenage hang-outs). The on-street events can also be promoted in advance to allow residents the chance to actively decide to attend. The collection of demographic information and home postcode (which can be linked to socio-economic group) allows for filtering of the on-street data to ensure a suitable sample (according to the purpose of the exercise) has been recorded.

The RAP-GIS process is most similar to the existing Planning for Real (PfR) approach, including online consultations such as the Virtual Slaithwaite (Carver *et al.* 2001; Kingston 2007); however, there are a number of significant differences in the methods and outcomes. PfR (Neighbourhood Initiatives Forum 2009) has similar aims to RAP-GIS, generating ideas and comments from the local community using a novel engagement tool. A 3D map of a neighbourhood is the basis for discussions and community comments are recorded using flags placed on the map. However, once collected these flags are removed to concentrate on the ideas collected – the link to their spatial location is severed and not explicitly used in any analysis.

Virtual Slaithwaite aimed to build upon this approach and was a pioneer of online P-GIS consultation. A digital map was used with virtual flags to post comments. Online mapping consultations (for example, Groundwork 2009) have since built upon the Slaithwaite approach and utilise clustering techniques to identify comments by type of participants and spatial location. RAP-GIS generates similar information but without the potential barrier for 'hard-to-reach' communities of requiring internet access and computer literacy.

The above comparison highlights two key findings with regard to the utility of the RAP-GIS approach. Firstly, the technique seems capable of generating comparable data to conventional P-GIS but with less underlying depth. Secondly, a larger number of people can participate in the same time period, including those classed as 'hard-to-reach' participants, than would be possible with conventional methods. These two findings indicate that the RAP-GIS approach may be particularly well suited to the scoping phase of any participatory process where the viewpoints of a wide cross-section of stakeholders are ideally required. This may usefully be followed up with more in-depth methods with the proviso that, unless carefully and flexibly designed, these follow-ups may again exclude further participation from particular target groups, including young people, or people from deprived communities.

Ethics of RAP-GIS

Obviously the use of any community participation technique raises ethical considerations and RAP-GIS attempts to reach those who typically fail to engage with conventional consultations potentially more than most. In the area of participatory GIS, best-practice guidelines have been suggested by Rambaldi *et al.* (2006). These include the following key themes for consideration:

- Who participates?
- Whose voice counts?

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- Who identifies the problem?
- Who controls the process?
- Whose reality?
- Who own the outputs?
- Whose analysis and use?

Ultimately . . .

- What has changed?
- Who has benefited?
- Who is empowered and disempowered?

The RAP-GIS technique fulfils only a subset of these best practice ideals. The case studies presented here indicate the technique was successful in increasing participation from groups who would typically not engage in conventional consultation exercises. The approach was particularly successful with teenagers and children. However, in terms of who participates and whose voices get heard, there is less control than would be the case at a conventional group meeting where particular stakeholders or representatives of specific interest groups could be invited by the organisers. With the RAP-GIS method, participation is dependent on who is in the vicinity of the on-street activities at the times they are active. Sufficient pre-publicity may overcome this drawback, especially if targeted at specific audiences; however, demographic data from the York example, run during the working day, indicates a bias at this event to participation from women. This indicates that some groups may not be available at specific times, showing the importance of running events throughout the day or at weekends. There is also the possibility that the on-street event could be 'hi-jacked' by specific interest groups through mass attendance. This problem is not unique to RAP-GIS and is a factor in a number of consultation methods, including online and postal questionnaires (for example, the BBC Radio 4 2006 Christmas Repeal online voting was hijacked by pro-hunting campaigners, or the postal votes for Radio 4 'Person of the Year 1997', which were allegedly manipulated by the Labour Party to promote Tony Blair).

The voices of different groups can be clearly differentiated using the RAP-GIS technique as the demographics of the participants are recorded in the database. This ensures that the specific views of different groups can be highlighted in the visualisation of results. However, the target 'groups' identified have so far been selected by outside agencies (e.g. City of York Council or Blackpool Council) rather than being self-selected by the communities involved. For example, within the under-16 age group, individuals may associate themselves with specific cultural groups and not see themselves as a homogenous subset of society.

The recording of personal and demographic data alongside the participatory maps also raises ethical considerations of data confidentiality and privacy. For example, one option is to record the home postcode of the participant in the database. This would facilitate the cross-referencing of the data to numerous geo-demographic databases including the IMD, Experian Mosaic and Census. The perceptions and preferences of participants could then be analysed in terms of the deprivation score for their home locality. This kind of analysis could be powerful for identifying involvement from deprived communities but adds an additional ethical complication to the informed consent process.

The locations and issues mapped during the RAP-GIS engagement are identified by the participants, although the general theme and the geographic extent of the consultation are controlled thematically by the facilitators through the structured queries and physically by the extent of the paper maps used to capture participants views. In Blackpool, a smaller scale Ordnance Survey map was available to capture additional information beyond the extent of the individual air photos to overcome this limitation.

The outputs from the process are analysed, owned and controlled by the facilitators of the RAP-GIS process. This does not fulfil the criteria of best practice suggested above; however, this limitation was communicated to participants during the consultation so that at least they were informed and gave their consent for this to occur. This limitation is similar to many on-street survey techniques where information is captured quickly: individuals may not feel they have significant time to consider and discuss the full implications of their participation. One option to overcome this drawback is to feed back the results from the on-street phase of RAP-GIS. This feedback could be through the use of widely distributed mailshots or questionnaires, further on-street events or specific presentation to particular local forums. Such feedback could canvas an even wider range of opinion to ensure general popular support, or more specifically in the case of local forums, legitimacy for the RAP-GIS outputs. The mailshot approach was used successfully by Cinderby and Forrester (2005) with earlier P-GIS findings.

Overall the RAP-GIS process fulfils some of the criteria under the guidelines for best practice, but it is more extractive and less participatory than the ideal presented by Rambaldi *et al.* (2006). However, the technique is designed to highlight concerns and gen-

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erate ideas that will hopefully benefit communities (or specific groups within them such as the elderly or mobility impaired). The tool could be said to empower communities through assisting them in the generation and communication of their knowledge and ideas for their local neighbourhood, a process they may typically have practically been excluded from in the past.

Conclusion

Rapid Appraisal Participatory GIS shows particular promise as a new technique for engaging with local communities in a way that encourages participation from a wider cross-section of society than may be the case for more conventional consultation exercises. The new approach overcomes some of the drawbacks identified with existing P-GIS methods in terms of time and commitment to the engagement process. In addition, the methodology is relatively quick and cost-effective to implement in comparison with conventional P-GIS and other engagement methods. The on-street, in-situ, multi-temporal nature of the approach allows researchers to get a clear first-hand impression of the issues participants are communicating via the mapping. The added utility of converting the resulting information into a digital database allows further in-depth analysis of community concerns and ideas. The use of GIS analysis and visualisation helps to ensure the particular viewpoints of specific groups – for example, the young or elderly, or mobility impaired – can be assessed individually to ensure that specific issues and concerns are addressed in urban development schemes. The RAP-GIS approach holds the potential to ensure greater effective and inclusive engagement with local communities over development and regeneration issues occurring in their neighbourhoods, particularly from stakeholders conventionally considered 'hard-to-reach'.

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Participatory geographic information systems for agricultural water management scenario development: A Tanzanian case study ☆

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ABSTRACT

One of the keys to environmental management is to understand the impact and interaction of people with natural resources as a means to improve human welfare and the consequent environmental sustainability for future generations. In terms of water management one of the on-going challenges is to assess what impact interventions in agriculture, and in particularly different irrigation strategies, will have on livelihoods and water resources in the landscape.

Whilst global and national policy provide the overall vision of desired outcomes for environmental management, agricultural development and water use strategies they are often presented with local challenges to embed these policies in the reality on the ground, with different stakeholder groups.

The concept that government agencies, advocacy organizations, and private citizens should work together to identify mutually acceptable solutions to environmental and water resource issues is increasing in prominence. Participatory spatial engagement techniques linked to geographic information systems (commonly termed participatory GIS (PGIS)) offers one solution to facilitate such stakeholder dialogues in an efficient and consultative manner.

In the context of agricultural water management multi-scale PGIS techniques have recently been piloted as part of the 'Agricultural Water Management Solutions' project to investigate the current use and dependencies of water by small-holder farmers a watershed in Tanzania. The piloted approach then developed PGIS scenarios describing the effects on livelihoods and water resources in the watershed when introducing different management technologies.

These relatively rapid PGIS multi-scale methods show promise for assessing current and possible future agriculture water management technologies in terms of their bio-physical and socio-economic impacts at the watershed scale. The paper discusses the development of the methodology in the context of improved water management decision making.

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1. Introduction

Sustainable development relies on understanding and balancing the bio-physical requirements of the environment with the socio-economic development of people reliant on the resources in question (Degroot, 2006). Successfully balancing this environment–human interaction should ensure the long-term sustainability of natural resources for future generations whilst promoting human welfare and prosperity for current inhabitants (Reid et al., 2010; Daly, 2006).

For agricultural systems in particular, such environmental management and development takes place at a variety of scales from actions undertaken by farmers in specific fields through regional land use policies to national or global investment trade agreements (Falkenmark and Rockström, 2010).

Sustainable development of resources also implies that those affected by decisions are (to lesser or greater extents) involved in generating them (European Commission, 2003; Daly, 2006; Potschin and Haines-Young, 2006). An on-going challenge for environmental researchers, decision makers and water managers has been to assess the impact changes in agricultural systems resulting from policy or investments shifts will have on livelihoods and water resources in the landscape.

This paper reports on outputs generated from the AgWater Solutions (http://awm-solutions.iwmi.org) project managed by the International Water Management Institute (IWMI). The project

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aimed to help unlock the potential of smallholder farming by focusing on agricultural water management (AWM) solutions – not just technologies, such as water harvesting and drip irrigation – but also the necessary supporting policies, institutions and business models.

One activity within this project has been the development and piloting of participatory geographic information system (PGIS) techniques to facilitate decision making that integrates the knowledge of local stakeholders from individual communities with information from environmental managers at the watershed scale – the environmental decision making scale. This paper discusses the development of these PGIS methods in relation to a specific Tanzanian case study concentrating on assessing current livelihood activities linked to possible future development scenarios.

2. Study area

The study area selected for development of a watershed scale assessment of agricultural water management and linkages to livelihoods in Tanzania was around the Mkindo watershed. This watershed (Fig. 1) is a sub-catchment of the Wami–Ruvu basin and has an area of 913 km^2. It is located in the Mvomero district in Morogoro Province and drains directly into the Wami river, whose drainage area is approximately 40,000 km^2.

The long term average maximum and minimum temperatures of the Mkindo catchment are 32 °C and 20 °C with an annual average rainfall of 900 mm/a. The elevation of the catchment ranges from 2300 masl on the upper part to 360 masl at the foothills (Mkindo village). The topography of the catchment varies, with the Nguru mountains associated with well drained sandy soils and relatively gentle slopes on the lower section dominated by loamy clay soils.

The rapid change in elevation and subsequent gentle slope has resulted in undulating river networks on the lower slopes with permanent wetlands in the southern parts of the catchment.

3. Methods

The assessment of livelihood and future development scenarios utilised PGIS techniques to capture information in a spatial framework.

3.1. What is PGIS?

A variety of terms exist in the academic literature and amongst practitioners for the GIS based approaches that have developed with the overall aim of supporting public participation. In the US the common nomenclature for such approaches is Public Participation GIS (PPGIS) (Carver, 2001; Rambaldi et al., 2004; Sieber, 2006). Largely independently the concept of participatory GIS (PGIS) emerged from participatory approaches to planning, spatial information and communication management often in developing world contexts (Corbett et al., 2006). In addition to these two widely adopted titles, alternative nomenclature for activities with similar goals include: Community Integrated GIS (Corbett and Keller, 2004), GIS for Participation (GIS-P) (Cinderby, 1999) and Web PGIS (Kingston, 2007; Kingston et al., 2000; Kyem and Saku, 2009)). For the purpose of simplicity, in the remainder of this paper all flavours of community-focused public participation utilising GIS technology will be referred to as PGIS.

The wide range and flexibility of approaches that PGIS represents are particularly appropriate to environmental management in which at different scales different decisions have to be made. However, a significant deficit exists in current PGIS methodologies applications for environmental decision making, namely the scale and extent of data generated through community scale participation (Rambaldi et al., 2006b; Kok et al., 2007). Best practice of PGIS highlights the need to collect information at the level of communities (Aberley and Sieber, 2002; Dunn, 2007). This approach enshrines the principles of truly *participatory* GIS where the issues being assessed and mapped originate from, and are controlled by, the local community themselves (Rambaldi et al., 2006b; Cinderby,

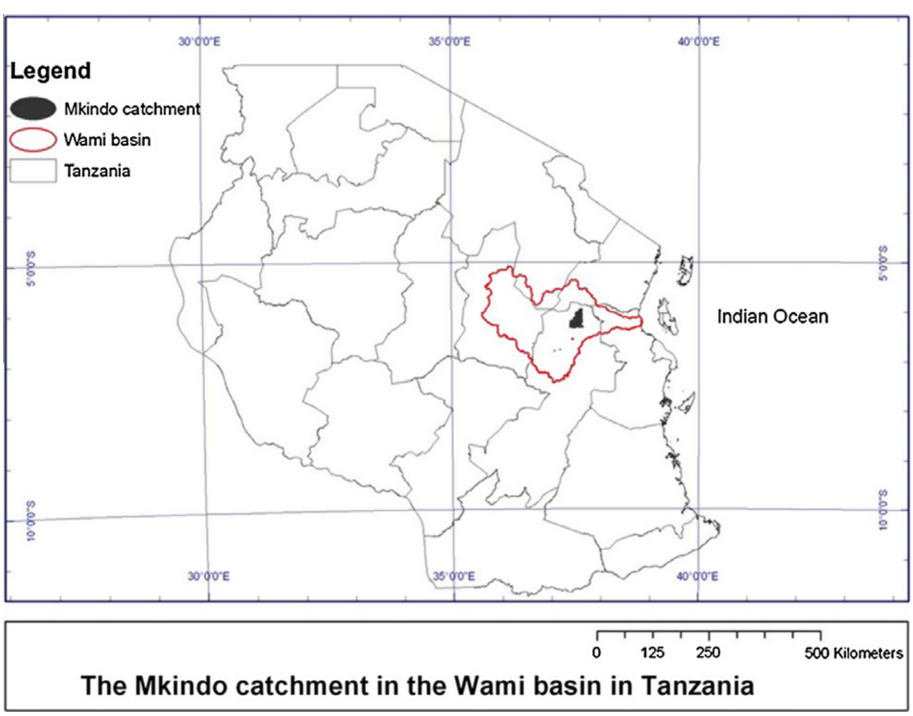

Fig. 1. Location of Mkindo case study area, Tanzania.

1999). However, for environmental decision making this community scale may be inappropriate or inefficient in terms of understanding environmental conditions or delivering comprehensive strategies (Saqalli et al., 2009). This is particularly the case at the watershed scale where upstream users decisions on resource use have direct consequences on the options available downstream (Kojiri, 2008). Potschin and Haines-Young (2006) identify needs for transdisciplinary tools in landscape analysis which would serve practical needs in society whilst supporting the sustainable management of cultural landscapes. One of the current methodological challenges therefore is to develop approaches that embody the principles of participation but which operate over greater geographic extent. This challenge of nesting information generated at different scales by participants with differing extents of knowledge (both spatial and experiential) is similar to that identified for multi-scale scenario development by Kok et al. (2007). Planned and applied well, public participation can generate important and surprising insights that contribute to the design of policies better suited to achieving their intended goals (Patel et al., 2007; Cinderby and Forrester, 2005). In this capacity however the information generated through participatory processes needs to occur at scales equivalent to that over which the policy or decision making process will operate (European Commission, 2003).

3.2. Multi-scale PGIS assessment of current livelihood strategies and future scenarios

This paper details an attempt to develop such a multi-scale process in order to inform environmental decision making. The assessment aimed to analyse how access and control of assets differed between the various livelihood strategies present in the watershed including a differentiation by gender. Existing methodologies could have been applied to produce such information including household or farm surveys and community questionnaires. However, to undertake such surveys across the entire 900 km^2 watershed would have required significant investment of personnel, time and consequently project finance (Saqalli et al., 2009). The goal of the methodology development was therefore to include and embed information generated by communities (Kadigi et al., 2007) in assessments at higher geographic scales in a time and cost-effective manner.

The nested approach comprised two complimentary activities: participatory mapping at the community (or village) scale, the results from which were used as inputs to a second mapping activity undertaken with ‘experts’ at the watershed scale, followed by the development of scenarios of what might result from specific investments in water management. A flow diagram highlighting the interrelationship between these activities and the outputs generated can be seen in Fig. 2.

3.3. Baseline assessment of livelihoods

3.3.1. Livelihood definition

Livelihoods are the means people use to support themselves and are an outcome of how and why people organise to transform the environment to better meet their needs through technology, labour, power, knowledge, and social relations (Manyatsi and Mwendera, 2007). A livelihood can be defined as “the capabilities, assets (including both material and social resources) and activities required for a means of living” (Chambers and Conway, 1992). This definition has since been extended to include concepts of sustainability (Scoones, 1998). The sustainable livelihoods concept links the combination of assets and activities that holistically can constitute a viable livelihood strategy for an individual or family. Within this case study the focus has been on understanding the asset status of Mkindo basin residents’ livelihood strategies in relation to their current utilisation of, and dependencies on, water.

Frameworks have been developed to facilitate this understanding and set out the elements of a livelihood together with the inter-linkages between them. For this study a subset of the UK Department for International Development (DfID) sustainable livelihood framework was utilised (DfID, 1999) to assess the current and future livelihood options available to farmers and other residents primarily in relation to water management. The DfID framework identifies five livelihood assets or capitals: human, natural, financial, physical and social. The basis for this assessment was that knowledge of the asset status of the poor is fundamental to understanding the options open to them, the strategies they could adopt, the outcomes they aspire to and how vulnerable existing and future strategies would be to potential environmental, financial, political or social shocks.

3.3.2. Community scale activities

To assess in detail the range of farm based livelihoods active in the watershed a survey of communities across the study area was

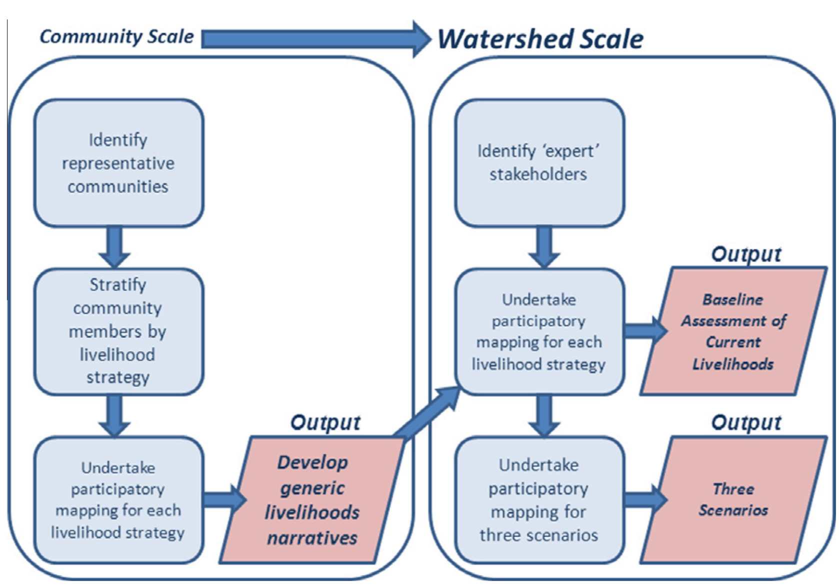

Fig. 2. Overview of nested PGIS activities and outputs.

undertaken. Survey locations were selected after discussions between the project team and the district authority. Communities were identified based on criteria including: their position in the watershed (both upstream and downstream; upslope and downslope); accessibility of surface water; access to different water management technologies; the range of farm based livelihood strategies present in each location (including crop producers and livestock specialists) and ease of engagement (both physical access and existing linkages to village institutions). In total four communities (Fig. 3) were identified.

Each community was visited to introduce the research team and project objectives. Community mapping exercises were undertaken with local stakeholders representing the main livelihood approaches specific for each village with additional women-only groups to assess any gender specific livelihood dependencies. The predominant livelihoods present in each community were identified in discussion with the village councils. Mapping was undertaken on simplified, village centred topographic maps and overseen by trained facilitators using a standardised set of questions. In total 125 individuals participated across the four communities including 77 women who were included in livelihood strategy groups (together with men) and in specific women only mapping activities.

The community mapping was undertaken, not to produce the definitive assessment of livelihoods across the watershed, but rather to provide a representative sample of strategies in detail. These were used to develop generalised 'narratives' that provided an overview of the current situation across the watershed. Narratives were developed for three key livelihood strategies present in the watershed; farmers concentrating on rainfed agriculture with some additional supplementary irrigation, farmers utilising formal irrigation technologies such as lined gravity fed canals and farmers specialising in livestock with some additional crop production.

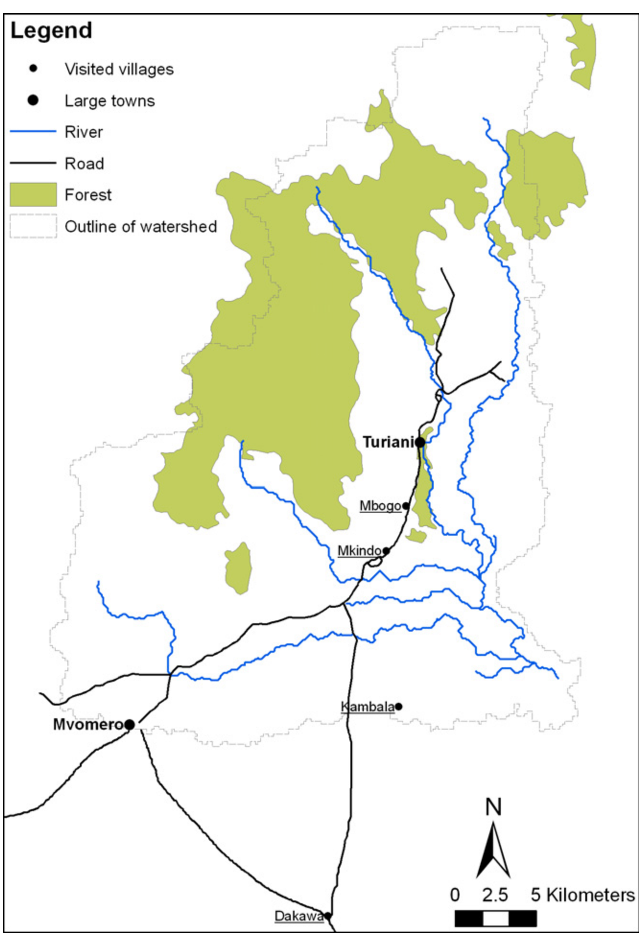

Fig. 3. Location of four communities surveyed in the Mkindo case study.

The narratives fulfilled three complementary purposes: They helped inform the project team and facilitators. Secondly, the narratives were utilised in the 'expert' mapping to ensure that results generated were grounded in information presented by communities living in the watershed. Thirdly, they were incorporated into the final descriptions of livelihood strategies and their dependencies on water generated by the research team.

3.3.3. Watershed scale assessment of livelihoods

The next challenge in the assessment was to move up to a higher (larger extent) geographic scale – the environmental decision making scale of the watershed (Reed, 2008). To facilitate this expansion, six experts were identified representing a cross-section of water management, agricultural extension and forestry disciplines. Alongside this multi-disciplinary assessment (White et al., 2009) the pre-requisite for participation was that invited experts had personal knowledge of the whole (or majority) of the watershed.

Narrative and map overviews for each livelihood strategy were presented individually to the expert participants highlighting the resources utilised; the incomes and products these strategies generated; their relative reliance on water; the inputs made in terms of fertilisers, pesticides, etc. and their resilience. This community derived information was used as the benchmark from which to identify the livelihood strategies being adopted by all communities across the watershed – beyond the four surveyed in detail.

The aim of the expert mapping was to produce a consistent map of livelihood strategies that existed across the whole watershed. For each of the three main livelihoods identified at the community level the experts were asked to map locations: Where that specific activity was being undertaken; to describe and locate what other resources were utilised by people participating in that strategy (for example, livestock grazing, vegetable gardens, forest resources, fish ponds, etc.); estimate how many people in the watershed undertook these activities (as a proportion); describe the cropping patterns, inputs (fertilisers, pesticides, mechanization) particularly focussing on the water management aspects; estimate the yields and how they varied across the study area; and in relation to the outputs discuss their usage in terms of cash income generation, household food or other applications. The experts were then asked to describe the challenges related to the livelihood activities including issues such as market access, crop storage and processing of production, human capital issues (diseases), finance issues and physical asset issues (e.g. mechanization, absence of farm roads, etc.). Finally the experts were asked to consider from their perspective how resilient (particularly in relation to environmental but also social and financial stresses) they considered each livelihood approach to be. The discussions were streamlined by presenting the community derived narratives at the beginning, asking the experts to focus on the differences between what was found in the four communities and what in their experience occurred in similar livelihood strategies across the watershed. They for example identified areas where yields were higher and described a different cropping pattern in which farmers concentrated on producing traditional fruit and root crops in the forest margins. The outputs from the community and expert level activities were taken away for post processing in the GIS and analysed qualitatively to produce a consistent watershed scale livelihood assessment.

3.4. Future scenarios

The Millennium Ecosystem Assessment (2005) defines scenarios as "plausible, challenging, and relevant stories about how the future might unfold, which can be told in both words and numbers.'' They should not be confused with forecasts or projections which are typically derived from model outputs instead each scenario is one alternative image of how the future can unfold (Raskin et al., 1998). Scenarios can be used to identify future opportunities and threats thereby assisting decision makers in determining more desirable pathways for future development (Tress, 2003; Kok et al., 2007; Patel et al., 2007; Biggs et al., 2007). Scenarios should also identify key issues and their possible implications that might otherwise be overlooked or dismissed and reflect the reality that the future is not pre-ordained but instead dependent on human actions and choices.

In the context of agricultural water management a variety of scenario pathways could have been developed based around changes in socio-economic or ecological systems. However to be effective scenarios need to have a focus and context. The AWM Solutions project's aim was to identify options for investment in agricultural water management technologies with the overall goal of improving rural livelihoods of small holder farmers – possible changes in water management were therefore used as entry point for scenarios.

The research team (including the local academic project partners) developed three possible starting points in terms of technologies that might be introduced or expanded in the Mkindo watershed. The three starting points can be seen in Table 1. They were developed based on knowledge of probable future developments in the watershed, possible challenging developments for small holder farmers and promising technologies identified by the wider project activities. From these starting points the expert participants were asked to develop believable stories of future outcomes based on driving forces operating in the watershed and region alongside the uncertainties of how these forces might change into the future.

The experts were asked to describe and map the locations of livelihood stakeholder groups in the watershed who would potentially benefit from the intervention, be unaffected by it, or experience negative impacts or dis-benefits. The mapped baseline information for each livelihood strategy was utilised to ensure the scenario information could be spatially interrelated for further analysis. The experts were then asked to identify factors that would improve the outcomes of the investment, factors that would moderate the dis-benefits identified and factors which would compromise the success of the changes in water management and utilisation. Finally the experts were invited to develop each scenario into a full storyline explaining the outcome of the particular starting point for the residents of the Mkindo watershed and surrounding district.

The resulting map outputs were converted into GIS files and assessed in combination with the recordings of the expert participants' discussions to develop the three full project scenarios. The qualitative analysis focused on the direct effects of these different scenarios on livelihood strategy groups and on the impacts (positive and negative) on their livelihood capital assets using the DfID framework (1999).

A semi quantitative analysis was also done to quantify possible changes in agricultural production resulting from each AWM investment to illustrate the relative magnitude of the implications of the scenarios. This assessment was a bridge between qualitative and quantitative scenarios (Alcamo, 2009). Information on foreseen changes in livelihood distribution and cropping extent in each scenario, and the associated detailed baseline community derived information on yield and number of harvests were modelled in a spreadsheet to produce semi-quantitative estimates of production changes.

4. Results

4.1. Baseline assessment

The baseline PGIS activities with experts and communities provided an overview of the locations and resources utilised by the different livelihood strategies practised across the Mkindo watershed. The map outputs for the three livelihoods are presented in Fig. 4.

Of those relying on crop production, 75% depends on rainfed agriculture and only 25% of the farmers have access to some sort of irrigation facilities (comprising lined and unlined canals and pumps). The minority who has access to formal irrigation achieves per harvest yields up to double the amount than those relying on rainfed agriculture and the irrigation schemes allow these farmers

Table 1
Summary of three scenario starting points and outcome narratives.

Starting point	Outcome summary
Scenario 1	
• Expand irrigation in mid-section of watershed (Mkindo area) • Expanding the area of irrigated land for paddy rice production • Using canal systems and pumps to irrigate larger area currently under rainfed agriculture	• Secured employment and job security • Ensures good supply of grains, root crops and fruits • Improved livestock products
• Small-scale storage of rain water for livestock watering • Construction of dams or ponds in the drier lowland areas where livestock is kept • Similar technology to that utilised in northern semi-arid Tanzania • Water storage used to improve livestock productivity and management	• Maintains harmony between farmers and pastoralists • Sustainable 'natural' resource management • Implemented ''Kilimo Kwanza'' • Reached the goal of making Morogoro especially Mvomero district ''a national food store''
Scenario 2	
• Intensify agriculture in mid-section of watershed (Mkindo area) • Expand small scale production along river network using pumps • Diesel pumps near the river network and lower technology (treadle) groundwater pumps in the drier rainfed areas	• Conflicts increase: • Between farmers and livestock keepers • With communities upstream and downstream
• Drainage channel for livestock watering • Development of a drainage canal from Mkindo river to the lowland livestock area • Used for improved livestock production (Kambala region)	• Polluted water courses • Increased water use may lead to the drying up of Mkindo and Diwale river • Increased incidence of disease such as malaria, bilharzia and typhoid
Scenario 3	
• Large extension of irrigation schemes into dryland (rainfed) area	• Fundamental shift in communities way of life from subsistence food crop production to cash crops
• Development of extensive diversion of surface (river) water to lowland area • Large expansion in crop production area (Dakawa, Kambala region) • Concentrated on higher value cash crops	• Area becomes net importer of food • Negative environmental impacts due to changing river courses • An increase in poverty gap from land owners to labourers

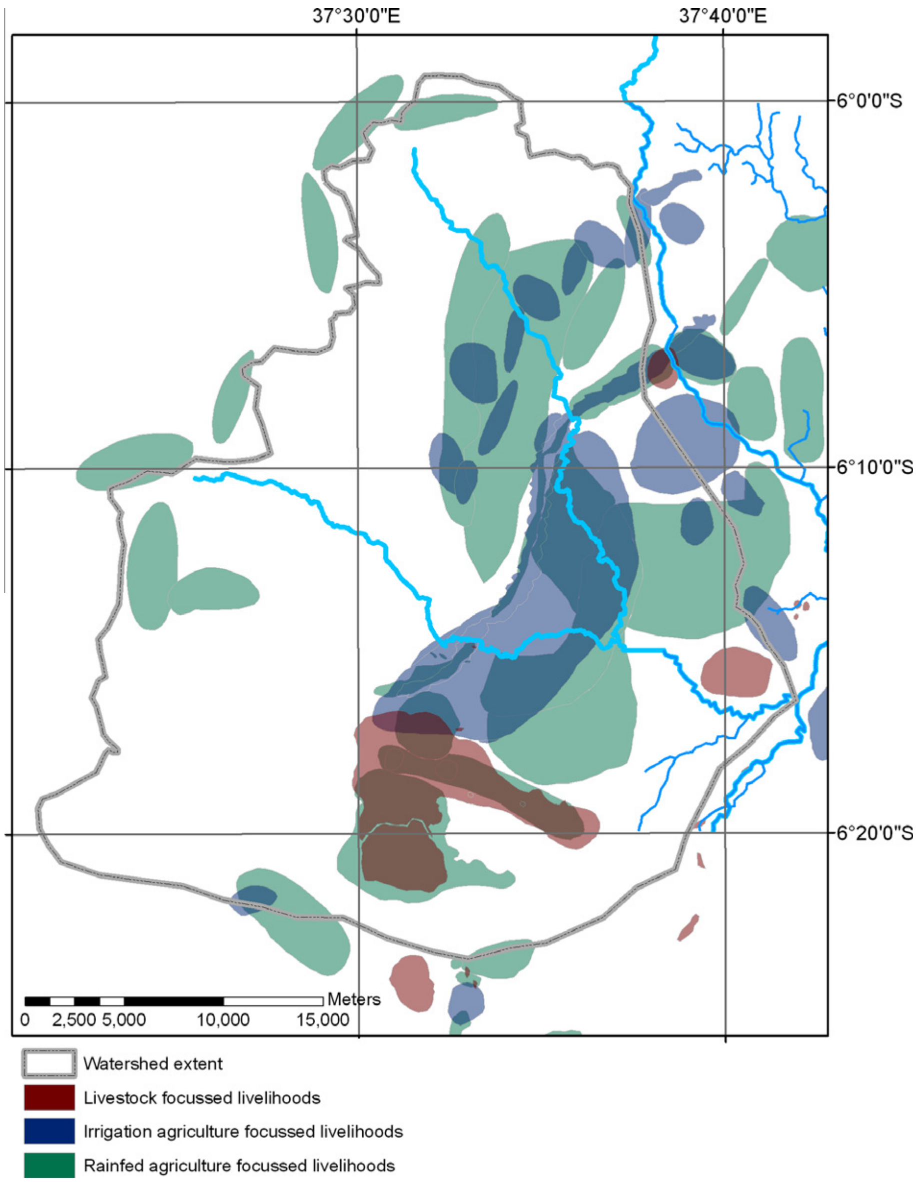

Fig. 4. Example PGIS map of farming livelihood activities in the study area.

to harvest at least twice per year. Within the group that has access to some sort of irrigation large differences exist in yields depending on the efficiency of the canals at delivering water (the physical livelihood assets), the ability to buy fertiliser (the farmers financial livelihood assets) and the training levels and organisation of the famers (the social assets of this livelihood group). These differences demonstrate how changing just the physical infrastructure in a watershed will not necessarily lead to the maximum benefits from this investment. Instead the whole livelihood strategy, including other assets, has to be considered to ensure schemes reach their full potential.

Most crop farmers in the area keep some animals as part of their livelihood strategy and as part of this continuum livestock keepers cultivate some farm land as part of theirs. Livestock keepers' crop production is entirely rainfed and does not provide sufficient food for households. Livestock keepers make up around 10–15% of the population in the watershed according to the experts. For livestock and their keepers access to water is a major challenge. During the dry season when those water points they are dependent on are depleted and access to the rivers is restricted because of the farm land surrounding the water streams. Another challenge is the quality of the grazing land due to an increasing number of cattle on a decreasing amount of pasture.

In terms of financial security the farmers with access to formal irrigation schemes are, perhaps unsurprisingly, the wealthiest. However, as they are dependent on rice production as their dominant source of income, those farmers who still rely on rainfed cropping were considered more resilient overall to environmental and social shocks. This was due to the diversity of their income sources which included grazing livestock and undertaking other small businesses. The PGIS mapping indicated that the pastoralists, in terms of both their income levels and access to natural resources, are the most vulnerable communities in the watershed. The maps illustrate how the pastoralist's access to resources is constrained by the physical setting of the watershed and the locations of existing crop production areas.

The PGIS process also highlighted the problems people in Mkindo face, including a lack of physical infrastructure, poor market access, deficiencies in agricultural training and human health issues related primarily to waterborne diseases.

4.2. Scenario assessment

Three scenarios were developed reflecting a range of possible future changes affecting different stakeholders as summarised in Table 1. The project team thought the differences between starting points 1 and 2 were quite subtle. Both expanded irrigation in the mid-section of the Mkindo watershed to improve the livelihoods of rainfed farmers in this area and both asked participants to consider the impact of improved livestock watering in the drier downstream part of the study area but used different technologies to achieve these two aspects. However, according to the expert participants, the outcomes were very different. For scenario 1 the endpoint for most residents was seen as beneficial with the watershed becoming a food production centre for the rest of the country. The alternative technologies introduced through scenario 2 brought about a variety of social and environmental problems to different groups within the watershed.

Assessing the scenarios through community and 'expert' mapping allowed the specific location of beneficiaries and dis-beneficiaries stakeholder groups to be highlighted, as seen in Fig. 5. This figure illustrates how differently the scenarios were perceived in terms of their effects on the Mkindo residents.

The scenario outcomes have also been summarised for rapid assimilation by decision makers in terms of their impacts on various environmental and societal aspects. This summary can be seen in Table 2.

Assessing the scenario outcome maps in terms of land use change along with the expert's assessments of potential changes in yields of crops and livestock made it possible to generate a semi-quantitative analysis of the relative differences in yields between the three scenarios (see Table 3). The results show clear differences in terms of land use and livelihoods that expand. They indicate that the most beneficial outcome in terms of agricultural productivity may be converting the area from small-holder farming to intensive cash cropping. In terms of maximising the benefits for the agricultural yields of existing residents the analysis indicates that the expansion of the formal irrigation combined with improved livestock water points could result in the greatest improvement.

Table 3
Semi-quantitative assessment of productivity implications from participatory scenario outcomes.

	Change from baseline to scenario		
	Scenario 1	Scenario 2	Scenario 3
Relative change in crop extent and productivity	++	+	++++
Cash crops (including vegetables)	– – –	++++	+++++
Maize and rice	+++	+	– –
Root and fruits	++	+	–
Sugar	–	– –	
Overall change in livestock grazing extent/productivity	+++		–

5. Discussion

5.1. Methodology development

In the past PGIS has proved useful for assessing livelihood strategies with individual communities in a variety of contexts and set-

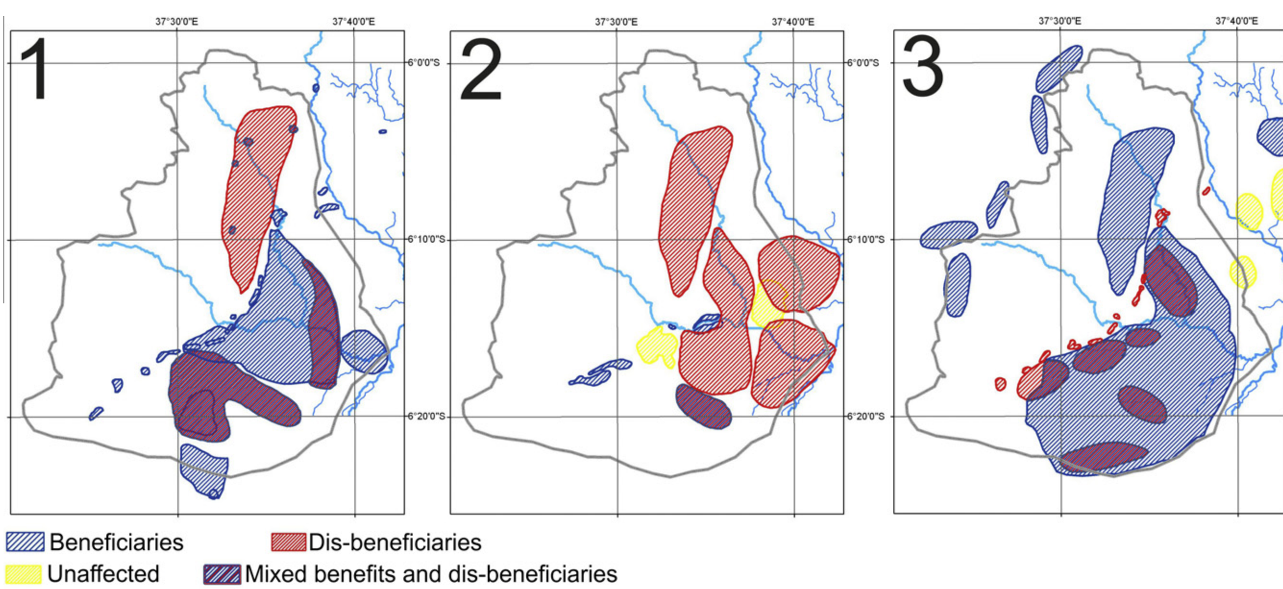

Fig. 5. Outcome maps for the three scenarios (described in Table 1) indicating the location of beneficiaries (blue), dis-beneficiaries (red), unaffected groups (yellow) and mixed outcomes (purple). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 2
Summary scenario technology of impacts.

Technology	Social impacts			Environmental impacts		
	Equity	Gender	Poverty reduction	Water quality	Water quantity	Natural resources
Gravity based furrow system for paddy rice production	+/–	–	+	–	–	–
Diesel pumps – irrigating from rivers	+/–	+	+	–	–	–
Livestock watering ponds	+	+	+	NA	+	+
Livestock watering canal	–	+	+	NA	NA	–
Large scale irrigation for cash crop production	–	NA	Unclear	–	–	–

tings around the world (Corbett et al., 2006b; McCall, 2006b). This Tanzanian case study shows that nesting mapping and outputs generated at differing spatial scales can successfully produce relevant information at spatial extents that are most useful for environmental management decision making and policy settings.

Undertaking village level mapping as a starting point allows for specific detailed information, often only fully understood by communities themselves, to be embedded within this process (Dunn, 2007). This has the advantage of grounding the information provided at higher spatial extents by 'experts' within this more detailed knowledge generated by the communities (Corbett and Keller, 2004). Village generated information can inform the discussions between facilitators and experts ensuring that important questions for communities are addressed. The information also helps streamline the expert mapping process as the discussions build upon rather that repeat the community-generated results. Tapping into local community knowledge and discussing this information with that of local area experts also provides a credible form of quality assurance which can carry weight with local policy-makers (Swetnam et al., 2010).

The use of nested, interlinked, participatory mapping ensures that the process of identifying livelihoods across a watershed is relatively rapid – both for the communities and the experts. This rapidity is important for both small-holder farmers and experts who both have many competing demands on their time. The described PGIS approach appears to offer a reasonable compromise in terms of the information generated and the time and financial investment required of the participants and project funders.

The PGIS mapping allowed a useful comparison (for decision makers and investors) to be made between the current distribution of livelihoods and land uses and the possible outcome of future investments. Obviously if a different group of experts had attended the meetings the scenario outcomes may have varied. However, that does not invalidate the findings as the narratives generated are internally consistent and represent a plausible view of possible futures.

Alongside these benefits, some difficulties were encountered when combining the findings from different participant groups (community and expert) at the changing scales of assessment. The community level data was rich in detailed thematic information regarding the specific farming activities, opportunities and constraints experienced by the residents in the villages surveyed. The knowledge of the experts was by comparison less nuanced by personal experience but more extensive in terms of geography and thematic breadth. This difference in the levels of detail led to some disagreements between the two scales of knowledge when the experts discussed the narratives of the community level. For example, the experts disagreed with some of the findings of problems being experienced by pastoralists in the watershed – dismissing them as exaggerations. Manipulation of community mapping for territorial or resource gain has been reported (Kyem and Saku, 2009). However, in the context of this process this seems unlikely, as there were no assets or policy processes for participants to stake a claim upon. In addition there were some mismatches between the information supplied verbally in the expert meetings and that drawn on the map. Scenario 2 was not well liked by the participants on the day, primarily because of potential negative environmental impacts. However, analysing what was drawn onto the maps along with the information supplied by the experts on possible yield improvements indicated that this innovation may actually be beneficial for small holder farmers livelihoods (see Tables 2 and 3).

In the few cases where a conflict between the two nested scales occurred, typically the expert level data was used for the identification of locations whilst the community generated thematic information took precedence. In future evolutions of this nested PGIS methodology more iterations of the development of this final data could be useful. This would be particularly the case if disagreements are especially contentious or the uncertain information is vital to the decision making process. Ideally further iterations could include mixed participants of experts and communities. Although this iterative approach would erode some of the described advantages in terms of rapidity and small costs it could provide a useful backstopping of the results.

5.2. Use of outputs in decision making

Similar to other scenario analyses (Wollenberg, 2000), the nested PGIS method described here aimed to improve the information available to decision makers about the current systems structure and drivers of change through the generation of scenarios and analysis of the implications of these scenarios . By embedding community knowledge into scenarios, linking the generation of scenarios to the environmental and socio-economic reality on the ground; and presenting the implications of the scenarios for communities, people and their livelihoods in a visual (mapped and summary table) form (Bocco and Toledo, 1997) new information was generated and made available to policy makers in a follow-up stakeholder dialogue in Morogoro, 12–13 August 2010.

The use of PGIS maps allowed for a clear communication of the potential beneficiaries of any scheme alongside the locations of stakeholders or communities for whom the proposed 'improvements' might deliver negative consequences. This balanced communication of benefits and risks is a useful output of the mapping process. Further development of the GIS database (beyond those delivered here) could enable decision makers to further interrogate the maps helping to identify factors that could maximise the benefits, or equally important mitigate any problems, resulting from an investment in agriculture water management.

The semi-quantitative analysis of yield changes provided additional support to the assessment of the different future pathways in a clear concise format. Such summaries utilise the detailed information provided by the participants and can help to produce a more comprehensive level of understanding of the findings for decision makers or investors. Whilst converting qualitative data into a semi-quantitative format of yield estimates presents certain methodological and ethical challenges (Cinderby and Forrester, 2005; McCall, 2006a) it could provide a useful communication tool to understand the trajectories and extent of changes resulting from scenarios.

The expert level data provided general spatial areas indicating zones where developments were likely. This type of area data can be used in more detailed analyses of spatial implications of each scenario. Participatory maps could be combined with supplementary spatial data such as classified satellite images of land cover (Cinderby, 1999) or in spatial computer models. Linking detailed PGIS information on current and future livelihood strategies and land management activities to computer modelling offers the opportunity to enhance our understanding of environmental and social processes and their interaction. For the Mkindo watershed these findings were further assessed with hydrological modelling (Bruin et al., 2011). Such a powerful combination could be further refined with the aim of providing a cost effective toolkit for developing planning decisions that are both environmentally sustainable and socially appropriate.

5.3. Policy implications of findings

The findings from the scenario exercise highlight how changes in agricultural water management interventions could result in very different outcomes in terms of livelihood impacts, environmental degradation and poverty alleviation. In particular the scenario results indicate that multiple different irrigation interventions (for example livestock water points and diesel pumps) in the same watershed have the potential to improve the livelihoods of a wider number of beneficiaries than a single improvement alone.

This finding was reinforced at the follow-up stakeholder dialogue held in Morogoro where 85% (11 out of 13) expert participants (comprising specialists in livestock, agricultural development, natural resource management, water resources, farmer training and forestry) agreed that multiple agricultural water management interventions in a single location bring more positive impacts than single interventions.

The scenario results show that significant changes in water management are likely to result in unexpected and unintended negative consequences for at least a subset of the population. Water resources are finite within a catchment. Changing the intensity of use or allocation of water between groups can obviously result in some stakeholders having less water available or decreased access to support their livelihoods. This was confirmed with the hydrological modelling which indicated that increased irrigation in the mid-catchment area results in up to 20% lower surface water flows (Bruin et al., 2011).

Similarly localised improvements in the levels of crop and livestock production for some stakeholders may result in lower prices for other crops and hence incomes for other communities. The spatial nature of the scenarios also indicates how localised environmental degradation could for example result from intensifying grazing around particular water delivery schemes or through pollution associated with diesel pumping of water. The visual nature of the PGIS data makes it easier to communicate these negative social, economic and environmental consequences to investors and decision makers encouraging their consideration of mitigation measures when introducing changes in water or resource management (Barron and Noel, 2011).The analysis of scenarios also infers that technological interventions in isolation are unlikely to generate the full potential benefits possible with a particular agricultural water management technology unless combined with a range of social and institutional improvements.

6. Conclusion

The use of PGIS to help inform decision making on agriculture water management at the watershed scale shows significant potential. The techniques described above offer a rapid way of investigating the interaction of water and natural resource management with rural livelihoods, despite some of the challenges with matching up different spatial levels of information. Linking detailed PGIS information generated from the nested scale approach described in this paper to computer modelling offers the opportunity to further enhance the understanding of environmental and social processes and their interaction. This can be a specifically useful and cost effective toolkit for decision makers and investors when developing planning decisions that are both environmentally sustainable and socially appropriate at a watershed scale.

The baseline and scenario results of the Mkindo case study indicate that there are opportunities in the watershed to improve livelihoods through AWM interventions. The technologies explored in the scenarios will have different social and environmental impacts and affect different groups of people. Multiple different AWM interventions (for example livestock water points combined with irrigation schemes) in the same watershed have the potential to improve the livelihoods of a wider number of beneficiaries than a single improvement. It can be concluded that the PGIS method described in this paper improved the information available to decision makers about the current systems structure and drivers of change. It provided a useful means to facilitate decision making that integrates the knowledge of local stakeholders from individual communities with information from environmental managers at the watershed scale.

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The full project reports for the baseline and scenarios are available from the SEI website (http://www.york.ac.uk/sei/projects/current-projects/water-management/).

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Analyzing Perceptions of Inequalities in Rural Areas of England Using a Mixed-methods Approach

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ABSTRACT: *This paper describes the findings of the Social and Environmental Inequalities in Rural Areas project which investigated both dataset and methodology development to investigate this issue from an interdisciplinary viewpoint. The research utilised mixed methodologies to examine how rural residents experienced and perceived conditions in the 21st century English countryside. These included a rapid appraisal participatory mapping to generate a baseline of local concerns and recruit participants for in-depth discussion groups. The group meetings then combined vignette techniques from social qualitative research to investigate local knowledge of inequalities and adapted them to include participatory mapping to capture participant understandings in a spatial framework. The stakeholder supplied information was then analysed in a participatory geographic information system and qualitative software to investigate whether place plays a role in perceptions of unfairness or injustice and how residents are differentially affected by rural conditions. These novel mixed participatory methods are described and linked to highlights of the findings of the participatory geographic information system analysis of local stakeholder's perceptions of inequalities in rural England.*

INTRODUCTION

Tickamyer (2000) conceptualises space in three ways: As *place* – a specific locale comprising a hybrid of biography and topography (Hall, Lashua, & Coffey, 2006); as *relational units* developed to organize our ideas of place including comparing between them; and as *scale* – the size of these relational units used to make comparisons. By comparing places using different relational unit's inequalities between locations operating at a variety of scales can be identified. The term 'inequality' in this case (as used in this paper) refers simply to the spatial dispersion of a distribution, following precedents set by Litchfield (1999) and Kokko et al. (1999).

Why do we give precedence to inequality resulting from gender, race or class but fail to give equal consideration to spatial categories (Tickamyer, 2000; Dorling, 2011)"type" : "article-journal", "volume" : "29" }, "uris" : ["http://www.mendeley.com/documents/?uuid=3e5680c8-4445-45d0-bad6-e9e2fd2d160a"] }], "mendeley" : { "manualFormatting" : "(Tickamyer, 2000; Dorling, 2011? The achievement of sustainable rural development implicitly depends on the spatial distribution of social, economic, and environmental goods and services that are needed to maintain, reinforce, or improve the vitality of rural areas. The need to understand inequalities in the distribution of environmental conditions across different social groups is highlighted in the UK Government Sustainable Development Strategy (HM Government, 2005) and plays a key role in the work of the Environment Agency and other government bodies (Warburton, 2006; Coleman and Duarte-Davidson, 2007; Defra 2008). There is a growing recognition that to achieve real improvements in rural conditions it is not sufficient simply to consider levels of poverty and environmental quality. The gaps between rich and poor, and between good and bad are at least as important (Boyce, 2007; Hills et al., 2009; Wilkinson and Pickett, 2009). However, there is little research to date that investigates specifically rural inequalities from the necessary interdisciplinary perspective.

A society can be considered well-ordered when designed to advance the good of its residents and effectively regulated by a shared public conception of what is considered just. The challenge in identifying concepts of justice is whether they are based on the actual distributions of resources or instead derived from normative principles of what should or could be (Jasso & P.H. Rossi, 1977). That is to identify whether the unequal distribution of a resource only identifies a difference in location or rather implies unfairness or injustice (Le Grand, 1991). The use of participatory geographic information system (PGIS) methods offers the potential to investigate, in a spatial framework, how actual distributions of resources interact with resident's normative principles of a fair or just allocation of goods and services (Dorling, 2010; Soja, 2010).

This paper reports on the findings from a project that attempted to look at concepts of place across relational units at different scales to identify both quantitatively and qualitatively the distribution, magnitude and effect of spatial inequalities on rural residents of England in the 21st Century. This research is used to illustrate the development of novel mixed method approaches incorporating the use of PGIS techniques to help identify perceptions of injustice that may be applicable in a wider range of contexts, places and communities.

A QUANTITATIVE ANALYSIS OF INEQUALITIES

The Social and Environmental Inequalities in Rural Areas (SEIRA) project (www.sei.se/relu/seira) was organised in interlinked phases. Initially, spatial datasets of social, economic and environmental conditions in rural England were derived from existing national datasets and then this information was used to identify and measure inequalities quantitatively.

Rural England was identified according to the official UK government rural-urban definition (Bibby and Shepherd (2004)) which was based on population density and linked to settlement morphology. The definition was generated for spatial units called Lower Layer Super Output Areas (LSOA) that were used to analyse the outputs of the 2001 national census. LSOAs are consistent in terms of population size (with a mean of 1596 residents) but vary dramatically in spatial extent in rural England with an average area of 18.3km^2 but a maximum size of 683.7km^2 (National Statistics Online, 2007). In total there are 6027 rural LSOAs in England representing approximately 3.9 million households. LSOAs are ideal for analysing social and economic information which is made available for these spatial units, but represent methodological challenges when incorporating environmental data collected on a different geography (Huby, et al, 2009).

The SEIRA project compiled a large number of social, environmental and economic datasets and then selected a subset of thirty-two individual variables for further analysis. Statistical techniques were then applied to this subset to extract underlying factors representing conditions of rural England. Four factors were identified (as seen in table 1): 'Disadvantage' incorporated income deprivation together with poor education and employment opportunities, mental well-being issues, fuel poverty and problems related to access to housing, such as affordability; 'Remoteness' was an indicator of areas further away from schools and leisure activities and where farming was often subsidised; 'Richness' indicated areas that had a high diversity in vegetation and wildlife and where house prices and business activity tended to be high; and, 'Pollution' was an indicator of where air quality was poor and crime problems existed. Inequalities in these factors between LSOAs in different administrative geographies, for example English counties, were then quantified (Huby, et al, 2009b).

RESIDENTS PERCEPTIONS OF INEQUALITY

However the spatial data and quantified measures of inequality only revealed differences between locations. Were the distributions of goods and services identified from the quantitative data distinguishable from personal experience? More importantly, did people living in rural England perceive an *unfair* or *unjust* distribution of social, economic and environmental resources? In short, could there be an *inequitable* distribution of resources (Walker, 2010) in rural areas? In order to answer these questions it was necessary to better understand the experience, knowledge and perceptions of rural residents.

To facilitate this discussion groups were organised in four counties distributed across England namely: Northumberland, South Yorkshire, Buckinghamshire and Devon (see Figure 1). The first three of these exhibited the highest levels of relative inequality among their LSOAs in terms of both environmental-ecological and socio-economic conditions. In order to include the perceptions of residents from southern England, Devon was also identified on the grounds that this county was the most unequal relative to the other counties in the South West. Within these counties specific locations where the LSOA factor data indicated relatively poor social and economic conditions but high variation in terms of the physical environment were identified as target communities for the qualitative fieldwork.

RECRUITING PARTICIPANTS: TRYING TO AVOID THE USUAL SUSPECTS!

The project wanted to encourage participation from a wide range of residents and avoid only speaking to the so called 'usual-suspects' (who are active in their local areas and typically come forward to represent their communities' viewpoint). The researchers felt engaging with a potentially wider mix of views would increase the understanding of the various ways participants

Table 1. SEIRA quantitative factors and underlying variables

Factor 1 Disadvantage	Factor 2 Remoteness	Factor 3 Richness	Factor 4 Pollution
1a. Educational disadvantage 1b. Income deprivation 1c. Low mean incomes 1d. Poor mental well-being 1e. Low employment 1f. Fuel poverty 1g. Barriers to housing	2a. Further from primary school 2b. Environmentally sensitive agriculture 2c. Lot of farmland 2d. Further from secondary school 2e. Few sports and leisure activities 2f. Good quality rivers 2g. Little local work	3a. High probability of badgers 3b. High house prices 3c. High bat species richness 3d. High business activity 3e. High land-cover diversity	4a. High PM10 pollution 4b. High NO2 pollution 4c. High crime rates

Figure 1. Location of case study sites for discussion groups

Figure 2. RAP-GIS mapping being undertaken at markets to aid participant recruitment

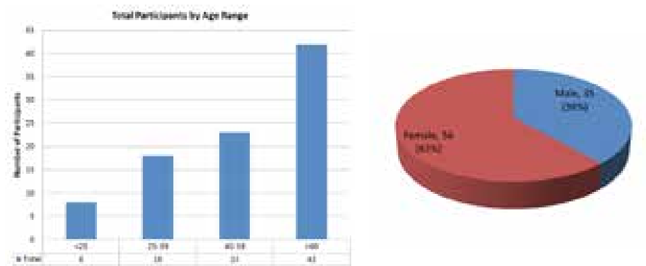

Figure 3. RAP-GIS participants age and gender profile combined from two events

understood and thought of the issues of unfairness in relation to rural inequality.

In order to identify participants for in-depth discussions a variety of approaches were tried, including contacting existing community groups (such as the Women's Institute, the community church organisations and local sports teams); putting up posters in the villages inviting people to contact the research team; and direct contact with people via recommendations from existing participants.

The project team also utilised a version of the Rapid Appraisal Participatory-Geographic Information System (RAP-GIS) methodology (Cinderby, 2010). This method was designed to engage with people who would not typically attend an organised meeting through barriers such as time, work or family commitments, disability, confidence and suspicion. The RAP-GIS approach involved taking the mapping to the community – rather than expecting them to come to a meeting. In this case the technique was taken to the street at local markets in the fieldwork villages.

In each market the research team set up a stall with a colour A0 sized map of the local area mounted on thick foam. Passers-by were encouraged to come across for five minutes and share what they thought of the local area. The project was introduced by the researchers and participants were each given two numbered coloured flags (yellow and blue – to avoid issues of colour blindness) and asked to identify one location they would recommend or thought was good in the local area and another (using the alternate coloured flag) they felt had a problem or something they would like to see changed or improved. Participant's comments (numbered to match the flags) were recorded on clipboards alongside their demographic and contact details. This 'off-map' recording of comments meant that future participants could not be overly influenced by previously supplied information, although obviously the colour of existing flags indicated thematic clusters of 'goods' and 'bads'. RAP-GIS in progress on one of the markets can be seen in Figure 2 above.

The technique proved useful for getting a wide demographic balance and large number of participants illustrated with data from two three-hour long events held in Buckinghamshire (see Figure 3). The project specifically did not attempt to engage with under-18 year olds due to the relative sensitivity of the inequality issue. This rapid data collection and engagement methodology provided an opportunity for the team to invite the passers-by to more in-depth meetings at later dates. Their contact details were collected and followed-up later with telephone calls confirming the dates and availability of people for discussion groups or in some cases individual interviews.

IN-DEPTH DISCUSSIONS OF UNFAIRNESS

From the outset, the aim of the fieldwork was to get a wide range of participants involved, but not a statistically representative

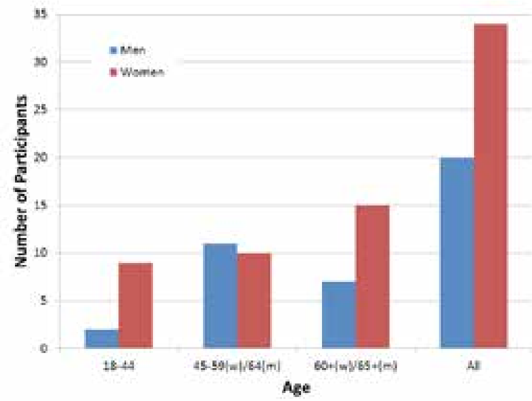

Figure 4. Age range of discussion group participants

sample. The intention was not to generate a survey of how the population of rural England thinks about inequity and injustice. Instead, rather it was to understand how the participants in this fieldwork expressed their ways of thinking and concepts around issues related to unfairness in the distribution of social, economic and environmental goods and services.

In total fifty-four people attended the discussion groups. Their gender and age breakdown can be seen in Figure 4. For most participants of the fieldwork the concepts of inequality and inequity were relatively alien to their everyday thinking and discourse. In order to guide people through the two-hour discussion groups, a three-step process, illustrated in Figure 5, was developed starting with an orientation exercise and leading to in-depth debates on the concepts of unfairness.

The orientation exercise simply asked participants to mark on a map where they lived, worked, shopped and went for leisure. It was designed to get them used to looking at, and comfortable with, marking locations on the supplied A0 British Ordnance Survey 1:50K topographic map centred on the village in question.

Let Us Tell You A Story...

Once participants had located themselves on the map the discussions moved onto identifying their knowledge and experiences of rural living through the use of vignettes linked to a participatory mapping activity.

Vignettes were originally conceived as a short description containing a controlled amount of information upon which interviewees responded (Nosanchuk, 1972; Wilks, 2004) but allowing them to build their own interpretation and meaning into those response (Finch, 1987). The narratives often took the form of moral dilemmas (Barter & Renold, 2000; Finch, 1987; Gould, 1996; Graves & Frederiksen, 1991; Hughes, 1998; Hughes & Huby, 2002; Jenkins, Bloor, Fischer, Berney, & Neale, 2010; Sim, Milner, & Love, 1998; Taylor, 2005; Wilks, 2004) with the vignette keeping the framing of these issues consistent and allowing some control and direction to be introduced by the researcher (Alexander & Becker, 1978) They have been used in a wide variety of contexts including large surveys where they are used to generate consistent data that can be analysed quantitatively (Nosanchuk 1972; Rossi et al. 1974). In qualitative research they are designed to allow normative issues to be discussed in a way that is equivalent to the complexity of everyday life (Finch, 1987).

The vignettes used in the SEIRA project were constructed to gain comments on the options available to different rural residents housing and lifestyle needs. One involved a family moving from an urban area that had childcare and transport requirements. The other was constructed around the story of a young woman on a low income hoping to move out from their family home but wanting to stay in a rural location. The vignettes were built to incorporate aspects of the quantitative factors (described in table 1) that were important for determining patterns of inequalities.

These vignettes (seen in full below in table 2) were employed in order to allow people to discuss conditions in their locality in relation to the needs of hypothetical characters rather than having to describe their own personal situations. This has the advantage of making the questions less personal and broke away from the limitations of participant's personal experience and circumstances. The variety of different content in the two vignettes was designed to discourage participants from replying purely on their own experience but necessitate them to consider conditions from an alternative using their local knowledge of environmental, social and economic conditions.

The vignettes were read out loud by the research team to avoid any issues of literacy amongst the participants. There were also paper copies available for people to refer to during the mapping component of the vignette responses.

Can you mark that with a sticker?

Vignettes have previously been used in face-to-face interviews, focus groups, postal and self-administered questionnaires; and presented via video-tape, audio recordings, newspaper reports, rap music and through photographs (Hughes, 1998). Lieberman (1987) turned the approach on its head by getting participants to compose narratives she termed vignettes rather than respond to existing text. The novelty of the application of vignettes in this research was their combination with participatory mapping and GIS. Participants were requested independently (and without conferring) to identify and mark with a sticker places that might be suitable locations to meet the requirements of the hypothetical characters. They were then asked to explain in turn why they had marked the specific locations.

Is this a fair distribution?

The final stage of the discussions concentred on whether the patterns of opportunities and problems identified through the vignette mapping were just for the actual people currently living in those localities – was there any inequity for rural residents. These discussions proved very fruitful for understanding the normative framework of the participants in relation not just to their own circumstances, but thanks to the vignette, those for other people with differing needs and choices.

Table 2. Vignette narratives used with participatory mapping (the numbers relate to the variable descriptions in Table 1). Elements marked *** were customized to each location with relevant and appropriate detail.

Vignette One—Health and Safety	Vignette Two—Leaving the Nest
"Mr. Adam Regis (32 years old) and his wife Mrs. Janet Regis (30) are moving to the local area so that Adam can take up a new job with the local council in *** as a transportation planner. He will be paid approximately $***K for this new role [3b, 3d]. They have two children, George, six, and Chloe, two. Janet cannot drive so ideally they would like a house somewhere with facilities or public transportation links [2a, 2d, 2e]. The family is moving from Manchester and would like somewhere safer [4c] and healthier [4a, 4b] to bring up their children. They enjoy being outside (walking and cycling) [2c, 2f, 3a, 3c, 3e] and would ideally like somewhere with facilities for the children [2e]."	"Sarah is 23 and still living at home with her parents in ***. She has always lived at home [1g] as she has struggled to find work locally [2g, 1e] and could not afford to move out [1g]. Sarah has recently started a more secure job in *** with an income of $17K per annum [1b] and now feels she would like to move into a place of her own. She realizes she cannot afford to buy locally [3b], but would like to rent. She would like to stay near her family, but doesn't know if this is possible or affordable. Sarah drives to work but would like to save money by taking public transportation."

ANALYSIS AND RESULTS

The discussion groups were recorded and transcribed for further analysis in a qualitative software package. They were then coded using a structure, collaboratively defined by the research team, which evolved as the process developed using a grounded theory approach (Bryman, 2008; Ritchie and Lewis, 2007). The findings from the vignette responses, participatory mapping information and the in-depth discussions of unfairness can be grouped into themes related back to the quantitative factors seen in table 1. The 'richness' of living in a rural environment was described in relation to the beauty of the countryside, low pollution levels, but also linked to risks associated with these qualities such as river flooding. The increasing 'remoteness' of rural settlements was highlighted in relation to the availability (or more often lack) of services such as schools, doctors, shops, banks, libraries and post-offices. This was a major concern and linked to the increasing inaccessibility of key services for many residents by any means other than private transport. The high levels of perceived safety and relatively low crime were considered important benefits of rural living and were related to a strong community spirit and cohesion felt to exist in these locations. This could be considered the inverse of the quantitative 'pollution' factor. The lack of affordable housing was a concern across the country, particularly in relation to the options available to young people's ability to live in villages. This was seen to be connected to the rise of tourism and rural second homes leading to less people living fulltime in villages. This depopulation was seen to be leading to a reduction in employment opportunities and an increase in seasonal or tourist related work that was low paid. These issues equate to the 'disadvantage' factor. These findings gave increased confidence that the identified quantitative factors had resonance with everyday life in rural England and were consistent with the experiences of people residing in the countryside.

Analysing these views more deeply identified the normative framework that participants were using to generate their perceptions of inequity. This framework included: the nature of the inequalities (typically in services); for whom these inequalities had an impact (mainly children, the elderly and those on low income); and the impact these inequalities had on peoples quality of life (such as increased isolation and lack of available facilities).

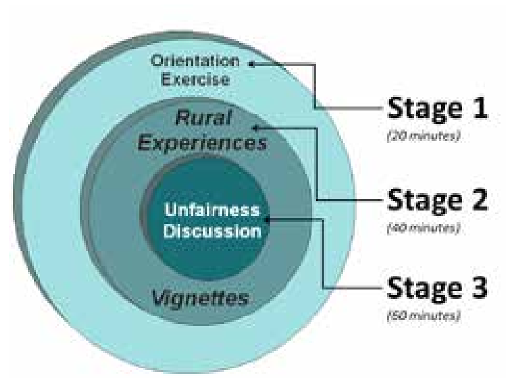

Figure 5. Illustrating the nested stages and timings of the discussion groups

VIGNETTES LINKED TO PARTICIPATORY MAPPING

The spatial component of the vignette responses linked to participatory mapping makes it possible to compare participants' perceptions of rural conditions with the four factors generated in the first part of the project. By classifying the characteristics of places that led to locations being identified as suitable or not suitable for the vignette characters into four themes similar to the quantitative factors the qualitative information can be compared to the quantitative findings. This comparison should be considered a pilot of this methodological approach as the original data collection had not been explicitly designed to undertake such an assessment. Nevertheless it did reveal some interesting, although tentative, findings and is included here to demonstrate the potential of the technique.

Considering the 'remoteness' quantitative factor, this was first grouped nationally into quintile classes. The locations identified

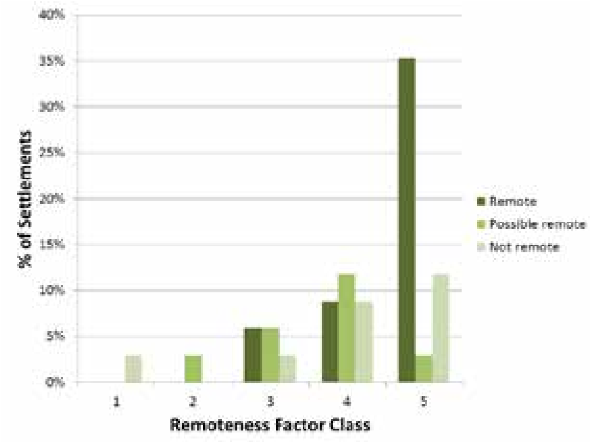

Figure 6. Correlation between Northumberland participants perceptions of remoteness and quantitative factor class (1 = least remote; 5 = most remote)

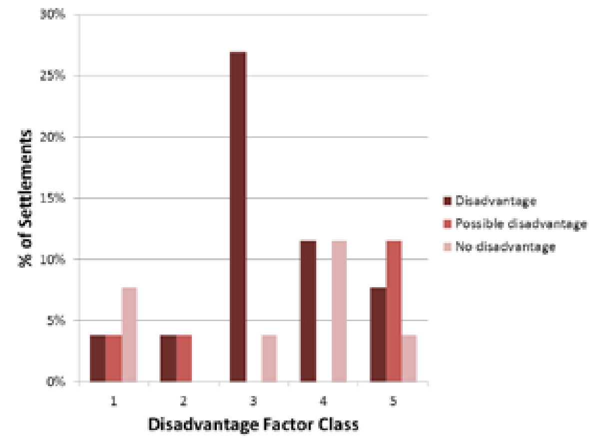

Figure 7. Correlation between Northumberland residents perceptions of disadvantage and the quantitative factor class (1 = least disadvantaged; 5 = most disadvantaged)

from the vignette responses in Northumberland were then coded as remote based on whether people had described a settlement as lacking all services including shops, schools and leisure facilities (these issues corresponding to some of the components of the 'remoteness' factor); or possibly remote if there were only problems in relation to a subset of these facilities, for example, far from primary and secondary schools.

Figure 6 correlating participant's perceptions with the factor class indicates that the locations identified quantitatively as remote and lacking facilities resonated with the personal experiences and local knowledge of the Northumberland participants.

Undertaking a similar correlation between the 'disadvantage' factor and Northumberland experiential information there is far less agreement as seen in Figure 7. The quantitative classes include issues such as educational disadvantage, low incomes and levels of employment, barriers to housing, poor mental health and fuel poverty. The participants did not describe locations in these precise terms but instead referred to a lack of affordable housing but also villages that were suffering from what was often described as deprivation. The spatial variations in these perceived problems of deprivation were high, meaning neighbouring villages could be quite different in terms of their relative affluence. This fine grained differentiation was not picked up with the quantitative data based on a standard population base unit of analysis, the LSOA.

This indicates that whilst census based social and economic data can usefully differentiate between areas it will also (perhaps obviously) mask variations operating on a finer geographic scale. In relation to the issues of inequality, inequity and possible policy responses, this leads to some considerations discussed in more detail below.

BENEFITS OF A MIXED METHOD APPROACH

The mixed method approach to assessing inequality and inequity in rural England described above generated a variety of advantages to our understanding of these issues and possible interventions to ameliorate them.

The RAP-GIS method proved useful for attracting a relatively large and varied sample of participants. The concepts of inequality and inequity were specifically not raised in the RAP-GIS questions as it was felt that it was an inappropriate method, due to the very benefit of its short, speedy nature, to discuss this potentially contentious and sensitive issue. However using the approach proved beneficial to the project for a number of reasons.

It allowed the team to make contact with a wider cross-section of the local population than might otherwise have been case through the other engagement techniques employed to recruit participants for the in-depth meetings. The actual up-take of attendance at the meetings from RAP-GIS participants was quite disappointingly low. Of the fifty-four participants less than ten were recruited through this approach. This low uptake may have been a result of the time delays of a few weeks between the on-market events and the subsequent discussion groups. It may also reflect the strength of the method in engaging with people who are not enthusiastic for attending meetings, what UK local councils often call the 'hard-to-reach' (Cinderby, 2010). However as the intention of using the approach was to recruit people unlikely to respond to more conventional methods in some ways even this low uptake could be viewed as a success.

Despite this relatively disappointing number of recruits, the RAP-GIS generated useful information and provided a spatial snapshot of wide cross sections of residents' viewpoints on the positive and negative aspects of their local surroundings. For the fieldworkers this was particularly useful as it allowed them to quickly tap into current issues and concerns in localities they were unfamiliar with. This scoping proved beneficial for the facilitators during the discussion groups as it gave them some initial understanding of the local environment and politics.

PGIS linked to vignettes proved particularly beneficial in helping to generate the projects qualitative findings. The vignettes forced participants to consider current conditions from differing viewpoints other than their own. This included an existing young resident on a low income but also an incomer moving from a large urban conurbation. The technique proved popular with the participants with one woman asking humorously when the Regis family were moving in as they would fit in nicely to the local village.

The first step in utilising vignettes (as with any research method) is to be clear on their purpose. Qualitative vignettes do not provide an accurate forecast of the individual participants' behaviour but rather give insight into their interpretative framework and perceptions (Jenkins et al., 2010). Responding to the SEIRA vignettes encouraged people to discuss conditions of income, employment, transport and housing without first person reference to their own situations. One participant responded afterwards by saying she had never thought about the local area in this way before. However, whilst the participants described conditions in relation to the needs of vignette characters, their viewpoints and framing of the problems indicated their specific experiences and local knowledge (Taylor, 2005).

The response to the Sarah vignette also proved interesting as it contained less detail of her personality and lifestyle making it more ambiguous (Finch, 1987). This led participants to infill this information based on their ideas of what a 23 year old woman would be interested in and want to live. Details of Sarah's social life were deliberately not included in the narrative but were imagined by many participants. As Barter and Renold's (2000) state, this 'fuzziness' can be a strength of the vignette approach. Participants assume that the protagonist is exposed to the same group norms as themselves and so explicate those norms in their responses to the narratives. However, disjunctions between participants' experiences and vignette descriptions can lead to the methodology breaking down if the differences are too great (Hughes & Huby, 2002). This may have been an issue for younger participants when dealing with the 30-something Regis family or for older people trying to empathise with Sarah's housing predicament.

The advantage of the vignette method in relation to inequality and inequity research is that by projecting situations onto hypothetical characters and asking the interviewees to consider the options open to the protagonist's, sensitive data can be obtained in an indirect, non-confrontational manner (Barter & Renold, 2000). This is especially the case when also combined to participatory mapping (Cinderby & Forrester 2005; Cinderby & Potts 2007)) which has been shown to deflect direct confrontation with participants focussed on interacting with the map as much as with each other.

Gould (1996) recommends that attempts are made to establish the internal validity of vignettes. Researcher bias in creation of vignettes is reduced by basing factors incorporated into the narrative on a systematic review of the research (Taylor, 2005). We attempted to generate this validity in two ways. Firstly, the factors (see table 1 and 2) affecting the vignette characters were identified as being significant issues for socio-environmental justice in the English countryside by the quantitative spatial data analysis and literature (for example State of the Countryside (Countryside Agency, 2004)). Secondly, the specific vignette narratives were trialled at a project workshop with UK Environment Agency staff in Bristol and through a preliminary focus group held in a rural village local to the research team. To make the details in vignette pertinent to local conditions they were also modified to make them more realistic for participants. For example, Adam Regis's salary was modified to make it feasible (with an additional lump sum deposit) to buy a rural property, but not made so large that this would not prove challenging in the local property market. This meant considerably different salaries for South Yorkshire as opposed to more affluent Buckinghamshire.

Jenkins (2010) speculates that participant's responses to vignettes may be more considered and elaborate interpretation of a moral dilemma than would occur in every-day life. In the SEIRA vignettes we would argue the inverse happened with people taking the task less seriously than they would if they were really being asked by someone (particularly a friend or family member) to recommend places to live. This is not to say that people did not consider their responses carefully, more that there were obviously no real world consequences resulting from their recommendations. However, the focus groups setting did entail participants explaining the reasoning behind their selected locations to the wider audience. This meant they had to justify their local knowledge (Cinderby & Forrester, 2005), particularly when identifying failings in locations that made them unsuitable for the vignette characters as places to live.

The consistency of the vignette content also meant that some of the stimulants behind discussions were kept constant between groups and locations. This makes the technique similar to a survey and led to the results from the different meetings being easier to compare and generalise (Finch, 1987; Hughes & Huby, 2002). A weakness of the approach has been identified as being that participant's give lowest common denominator of morality responses (Barter & Renold, 2000). That is, the least offensive response to the implications of the vignette. The link to participatory mapping may overcome this drawback to some extent as the necessity to explain why the location was suitable or unsuitable necessitated making and explaining differences between places. These differences could be considered disparaging for communities and participants did remark that they didn't mean to criticise particular villages and their inhabitants, just the conditions would not suit the Regis's or Sarah.

The issues of inequality and their possible inequity include concepts of change both in the places and people who inhabit them, what Hall, Lashua and Coffey (2006) term animate geography. The use of the vignettes and mapping allowed us to tap into this living geography with people's perceptions of current fairness relating to the way conditions and the distribution of services had changed. If shops had closed and bus services reduced over time this downward trend added to the feelings that these changes were unfair for remaining residents – particularly for the young and elderly – who still lived in now isolated places. The vignettes helped participants consider conditions for people living lives different than their own. Linking this to participatory mapping helped people concentrate on the current and past distribution of social, economic and environmental resources and how these actual, rather than abstract, changes related to injustice, the animate geography of rural England.

The use of RAP-GIS, PGIS and vignettes in the context of inequality and inequity research presented a number of ethical concerns. The research deliberately excluded young people from the discussions, even though they were a focus for much of the perceived injustice, as it was felt too sensitive an issue for this age group and ethically challenging for the researchers. Posters and invitations to the discussion groups did not mention inequality or inequity as they were considered loaded terms and off putting for a lay audience. To compensate for this ambiguity, participants were all given a briefing and consent form at the start of the group meetings with the option to withdraw. Nobody indicated to the researchers that they had been invited under false pretences.

The nature of the material generated from the vignette when linked to mapping of actual places poses particular ethical concerns. It may not be beneficial to communities that may already have significant social or economic problems to be labelled as deprived or isolated. In the project this was overcome by only presenting anonymised results back to the participants. However, this approach significantly weakens the value of the data to future research or policy making. These ethical concerns should be a consideration in any form of PGIS engagement but may need particular attention in relation to vignettes and mapping (Gutmann and Stern, 2006). Whilst the use of vignettes may have stimulated negative feelings about particular places for participants feedback from the group meetings indicated that most people had valued the opportunity to talk about the issue of inequality and fairness. The very fact that participants were all living in rural England indicated that they had chosen to live and stay in these communities despite any difficulties.

CONCLUSIONS

The use of a mixed methods approach incorporating a rapid scoping of local conditions and PGIS combined with vignette techniques proved insightful for understanding how inequalities were perceived by rural English residents. The high participation levels of the RAP-GIS mapping demonstrated its potential as a scoping method for engaging with a wide cross-section of a community. The possible limitations of the approach for recruitment were highlighted by the low uptake of participation in the group meetings.

The methodological development of linking vignettes from qualitative research to participatory mapping and GIS holds great potential. Vignettes are a useful tool for stimulating discussions on sensitive or contentious topics allowing researchers to gain insight into participants understanding and normative framing around difficult issues. Linking this to PGIS adds the spatial dimension which relates responses to the *actual* rather than the *abstract*. For topics such as inequalities, inequity, unfairness and justice this spatial framing allows both participants and facilitators to generate significant insight into the current distribution of resources and consequent effects on the choices and options available to real residents and communities. Particular ethical care needs to be given to applying spatial vignettes to ensure that the participants and also the places identified are not stigmatised by the findings, particularly in relation to contentious issues such as inequality. The information generated from this hybrid method can be analysed spatially in comparison to other data, including official viewpoints on the same topic, one of the longstanding benefits of a PGIS approach. The use of mapping also seems to help participants understand and focus their responses to the fictional descriptions grounding them in the real world and leading to qualitative spatial insights that may not be generated from vignettes alone.

The tentative findings of the comparison between qualitative understandings of inequalities and their distribution with that generated on higher geographies indicates that policy makers need to consider their responses to such issues carefully. Understandings generated from official data may be operating on different a scale to the underlying inequalities. This may mask the actual distribution of effects and consequent problems. The use of participatory methods such as those described here can highlight these fine-grained differences and concerns at the geography experienced by real residents. This could be used to generate useful finding to guide policy interventions and changes on the ground.

Using a mixture of methods stimulated participation and interest in this important and challenging topic. By employing a combination of approaches to investigate the distribution of resources, social, environmental and economic in rural England and examine the consequences of these differences a more insightful, rounded and useful understanding was generated for the research team, policy makers and rural participants.

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