Elsevier Editorial System(tm) for Applied Geography
Manuscript Draft

Manuscript Number:

Title: Combining participatory mapping with Q-methodology to map stakeholder perceptions of complex environmental problems

Article Type: Article

Keywords: GIS; flood management; wicked problems; mixed-methods; participation.

Corresponding Author: Dr. John Forrester,

Corresponding Author's Institution: University ofYork

First Author: John Forrester

Order of Authors: John Forrester; Brian R Cook; Louise Bracken; Steve Cinderby; Andrew Donaldson

Abstract: It is readily accepted that understanding socio-environmental challenges requires consideration of multiple stakeholder perspectives and knowledge claims. This paper looks at the development of one GIS-based methodology - and reports on the authors' using it - to understand and map stakeholder knowledge. Combining Q-methodology with participatory mapping helps to overcome a significant problem in social engagement: representing the unclear connection between what people say or do and their underlying attitudes, values or beliefs. The paper is based on reflexive research engagement with the topic of flood management and natural adaptive capacity in the Scottish-English Borderlands. This paper shows how such problems can be better understood through an appreciation of the wide range of stakeholders' positions, whether or not there are commonalities between positions, and a strategic and practical understanding of the beliefs informing those positions.

*2) Title Page (WITH author details)

Combining participatory mapping with Q-methodology to map stakeholder perceptions of complex environmental problems

John Forrester[a], Brian Cook[b], Louise Bracken[c], Steve Cinderby[d] and Andrew Donaldson[e]

a) Corresponding Author: Dr John Forrester, York Centre for Complex Systems Analysis (YCCSA), Ron Cook Hub, University of York, YO10 5DD, U.K. Telephone: + 44 (0)1904 673163, e-mail: john.forrester@york.ac.uk

b) Dr Brian R. Cook, Department of Resource Management and Geography, University of Melbourne, 207 Bouverie Street, Carlton, Melbourne, VIC 3010, Australia. E-mail: brian.cook@unimelb.edu.au

c) Dr Louise Bracken, Department of Geography, Durham University, Durham, DH1 3LE, UK. Telephone: +44 (0)191 33 41846, e-mail: l.j.bracken@durham.ac.uk

d) Mr Steve Cinderby, Stockholm Environment Institute, Grimston House, University of York, YO10 5DD, UK. E-mail: steve.cinderby@york.ac.uk

e) Dr Andrew Donaldson, School of Architecture, Planning and Landscape, Claremont Tower, Newcastle University, Newcastle, NE1 7RU, UK. E-mail: andrew.donaldson@newcastle.ac.uk

Combining participatory mapping with Q-methodology to map stakeholder perceptions of complex environmental problems

Abstract

It is readily accepted that understanding socio-environmental challenges requires consideration of multiple stakeholder perspectives and knowledge claims. This paper looks at the development of one GIS-based methodology – and reports on the authors' using it – to understand and map stakeholder knowledge. Combining Q-methodology with participatory mapping helps to overcome a significant problem in social engagement: representing the unclear connection between what people say or do and their underlying attitudes, values or beliefs. The paper is based on reflexive research engagement with the topic of flood management and natural adaptive capacity in the Scottish-English Borderlands. This paper shows how such problems can be better understood through an appreciation of the wide range of stakeholders' positions, whether or not there are commonalities between positions, and a strategic and practical understanding of the beliefs informing those positions.

Keywords: GIS; flood management; wicked problems; mixed-methods; participation.

1. Introduction

There is a growing trend encouraging researchers to approach complex environment and development issues from a systems perspective. This has led to recognition that inter- or trans-disciplinary methodologies are required (Horlick-Jones & Sime 2004; Petts et al 2008). Additionally, in the search for better understanding and application to problem resolution, openness towards different knowledge(s) has come to include knowledge and data drawn from diverse methods (Wynne 2003; Lidskog 2008; Collins & Weinel 2011; Bracken & Oughton,

2013). Specifically, part of this trend includes the use of GIS databases as more than simple repositories of spatial data but as ways of integrating competing knowledge claims and worldviews (*cf.* Debolini et al 2013; Henke & Petropolous 2013; Moghadam & Helbich 2013; Roig-Tierno et al 2013).

This paper recounts efforts to integrate diverse knowledge claims held by scientific officers, planners, and other local stakeholders relating to flood management in the Scottish-English Borders. The RELU-funded project "Managing Borderlands" (RES240250025) provided an applied case for observing the emergence and debate over concepts, all while the project actively engaged with the challenge of co-constructing and evaluating flood management options. We argue that a combination of Q-methodology and participatory GIS mapping can help to overcome one of the most significant critiques of social engagement with socio-environmental challenges: that is the unclear connection between what people say and the underlying feelings and values that guide action and behaviour. Further, combining Q with GIS overcomes having an apparently separate geographic method for representing attitudes, perceptions and beliefs (*cf.* Barnes, Islam & Toma 2013; Ernst & van Riemdijk 2013), which allows for the combination of spatial and social data (*cf.* Frazier et al 2013; Li & Griffin 2013). This allows inclusion and integration of the important social factors with their spatial context, providing an alternative method of *stakeholder analysis* (i.e. understanding stakeholder types (*cf.* Cuppen 2009)).

This paper is not written to simply present the empirical results of the "Borderlands" research of natural flood management, but is rather a reflexive engagement with the development and application of the Q+GIS methodology which involved engagement with scientists, professionals, and wider stakeholders including land owners, land managers, and residents, all concerning the issue of flood management in the Scottish-English borderlands. Conceptually, this case allows the analysis of the wider trend toward multi-stakeholder engagement. It represents our response to the relative paucity of suites of social science-inspired methodologies

applicable to socio-environmental issues planning and management, particularly with regard to the ability to accommodate stakeholder knowledge and perspectives in tandem with scientifically-informed expertise.

Given growing acceptance of the complexity of socio-environmental challenges, this analysis speaks to the role of stakeholder knowledge in evidence-informed policy and governance (Jasanoff 2003; Owens 2010; Campbell et al 2011; Ernst & van Riemsdijk 2013). We know that for beneficial outcomes, top-down, technical approaches must be balanced with bottom-up, participatory knowledge (Bracken & Oughton 2013; Cinderby et al. 2011), that communication is critical, and that knowledge production and knowledge communication are intertwined (Callon 1999). What presents problems is the application of these ideals in a world where experts and the public are growing more aware of the complexity of the "social-ecological" (e.g. see Carpenter et al 2009).

What follows is not a re-conceptualisation of the purposes or philosophy of stakeholder engagement, but a more applied analysis of one way to do it. Traditionally, stakeholder engagement in policy and management has been driven by the policy process: policymakers start with a problem, this problem needs more rigorous definition, solutions need to be identified and evaluated, these solutions then become policies that have to be implemented, the impact of the policy then needs to be evaluated, and the process is repeated (*cf.* Forrester et al 2008; Forrester et al 2011). Policymakers seek advice at various stages: often from the natural sciences at the stages of identifying viable responses and evaluation of policies; and from social sciences, and citizens, for economic and social evaluation. In such contexts, stakeholders are often perceived as anyone who holds a vested interest or who is affected by the process: in recent years stakeholders are also perceived as including anyone who has knowledge of or about any part of this process (*cf.* Forrester, Gerger Swartling & Lonsdale 2008). Nonetheless, stakeholders are still routinely involved only at different stages (Phillipson et al 2011; Bracken et al sub). The methods discussed in this paper differ in that they are based on the rationale that

end users of policy – i.e. the citizen – can become involved at any stage as a contributor of knowledge, whilst recognising that time and other practicalities do need to be considered.

The aim of this paper, then, is to document and evaluate one multi-level, multi-method, participatory approach in order to discern a range of different knowledge(s) and perspectives around a complex socio-environmental problem. The methodology emerged in response to the problem of flood management. This paper begins with a discussion of the context and theory of participation in that particular field, arguing that trends toward public participation result in significant tension when introduced to evidence-informed governance (Cook et al 2013a; Cook et al 2013b). We then comment on the wider methodology that determined our approach, and then introduce the Managing Borderlands project. We remind readers that the discussion of findings and evaluation of the mixed-method Q+GIS approach are also methodological in nature. We conclude that the first step in addressing complex problems is to appreciate that employing multi-method approaches is required to understand multiple knowledges and perspectives. We argue that this approach carries significance for policy and environmental management and for 'wicked', 'complex' or 'messy' problems more generally.

2. The Context of Water Management in the UK

Issues involving water are invariably complex: flooding, natural resource management, river restoration, and pollution each involve many specific, but often differing, local issues across different spatial levels. Further, these issues interact with other complicated (and sometimes also complex) issues such as economic development or human and societal wellbeing. Not only do levels of government add to complexity, but different organisational sectors often have incompatible governance structures which may themselves be organised across spatial scales. The European Water Framework Directive (WFD) guidance document for practitioners notes that "[k]ey to managing the scale issue in river basin management is communication and coordination across the scales and between units at the same scale" and that this "is very much

facilitated by building up formal and especially informal networks across scales and between units at the same scale" (European Commission 2003:23).

In the case of the WFD guidance, participation is defined as "allowing people to influence the outcome of plans and working processes", which should ideally lead to "shared decision-making and self determination". This puts an onus on practitioners to consult, though the guidance document wording uses vague terminology and caveats: stating that participation may "be considered best practice". Although conceived and implemented as top-down policy, the guidance makes clear why public participation should occur: to improve decision-making (i.e. to make better decisions). It is also clear who should be involved: "any person, group or organization with an interest or 'stake' in an issue either because they will be affected or may have some influence on its outcome" (*ibid*). Hence the desire for wide engagement with management and policy development is called for in legislation; though putting these ideals into practice is rarely nor clearly documented.

The particular reasons for stakeholder participation in water management include these, as well as ideas of ecosystems and their sustainability (UK National Ecosystem Assessment 2011), which mean that problem solving requires both social and natural sciences in order to account for the depth of socio-environmental problems. This presents significant methodological problems for scientist looking to integrate different types of knowledge (Eden & Tunstall 2006; Fish 2011), and for the application of that knowledge within management. In practice, achieving such 'evidence-informed governance' often remains idealistic. In simple terms, when called to implement policy in response to socio-environmental problems, practitioners often have a very difficult time reconciling the disparate knowledge and/or approaches that they may know are relevant.

Within debates involving participation and evidence-informed governance, there is a tendency for decision takers to seek solutions that rely on abstractions and which do not reflect the

complexity of the system, of the scientific knowledge, or of the diversity of local knowledge related to the problems (Funtowicz & Ravetz 1991; Fish et al 2010). This is an understandable tendency given the difficulties and constraints.

Since the mid 1990s, arguments for the inclusion of diverse perspectives into the governance of socio-environmental challenges have proliferated. More recently, the *Ecosystems Approach* (*cf.* UK NEA 2011) has become prominent. Such approaches show recognition that socio-environmental challenges are not simple scientific issues with simple scientific solutions, but complex issues that include social actors, each with decision making agency, and each – although autonomous agents – reacting to and affecting the social networks in which they exist.

3. Emerging Methods for Public Engagement

Rationalisation for the Managing Borderlands methodology (section 4) is based on previously undertaken research at the Stockholm Environment Institute (SEI). In particular, members of the SEI explored how local knowledge might be included more directly within policy making. This inclusion of local knowledge necessitated two steps: the first was to reframe local knowledge so that it could be interpreted by the technical officers who were advising decision makers, while the second step involved the validation of various types of locally grounded knowledge. Participatory approaches were used to gather local knowledge about air quality and to critique the information generated by predictive air quality models in three UK cities (Bailey et al 1999). However, the data generated was found to be un-interpretable to the policy community, who thought it either unwieldy – long transcripts of focus groups – or impenetrable because it was written in unfamiliar language. These problems led to SEI's adoption of participatory mapping using GIS to re-frame citizens' knowledge and present it to technical experts (Cinderby & Forrester 2005; Cinderby, Snell and Forrester 2008 – and leading to Forrester & Cinderby 2011). The boundary-crossing use of focus groups, community mapping and GIS also helped

address scale issues as well as disciplinary challenges, especially at the operational level (Wang et al 2008; Cinderby et al 2011).

Adding to wider trends toward stakeholder participation noted above, our methodology is designed to accommodate stakeholder knowledge and perspectives in tandem with scientifically-informed expertise and, thus, consider the wider factors affecting governance within a socio-environmental system. It also helps consider how those decisions are related to the production and use of knowledge amongst stakeholders.

4. The Managing Borderlands Project Methodology: Outline and evaluation

The aim of the Managing Borderlands project was to understand and contribute to knowledge exchange between organisations and individuals concerned with natural flood management in rural areas. We maintain that what the individuals shaping flood management know, but also how they perceive flooding, is central to such an objective. We focused our research on two sub-catchments of the River Tweed, which spans the border between Scotland and England. There is a strong need to increase the flood resilience of the region in response to expected climate change, which was underlined by severe flooding in the region in 2008 and 2009. The Tweed catchment is designated with the Solway as an area requiring a unified River Basin Management Plan (RBMP) under the Water Framework Directive. The title of the project thus reflects its position as located in politico-cultural-geographic borderlands as well as at the border of scientific and non-scientific stakeholder understanding.

Scottish devolution has led to an increasing divergence in policy within the Tweed catchment. There are different approaches to the complex issues of rural development and environmental protection, with designations administered by many different agencies on both sides of the border. The Tweed catchment provides an excellent case to illustrate the rapidly changing institutional environment that followed the floods of 2007 in England, the Pitt Review and

consequent recommendations, the introduction of the Scotland Flood Management Act 2009, and the England Water Management Act 2010. The approach to the research, and the qualitative and quantitative methods used, are outlined diagrammatically in Figure 1.

[insert Figure 1 near here]

In the Managing Borderlands project we used combined participatory mapping (using two different data collection approaches), interviewing, and performed a "Q-sort" with a range of stakeholders. These methods are illustrative of our belief that no one method is likely to capture and re-present the range of diverse and sometimes divergent views that produce the issue. While recognising diverse stakeholder perspectives, the project was not about non-specialist stakeholders manipulating 'official' data. Rather, it was designed to co-create flood management options anew, using co-created scientific and "situated knowledges" (*cf.* Irwin & Michael 2008). We applied a suite of approaches to better understand technical and popular – that is locally popular – implementation options for flood management.

First, we used participatory mapping to explore the views of three communities concerning perceived, optimal flood management measures. Two of the target communities were in Scotland and the third in England. We used the maps to provoke ideas, to help stakeholders clarify their views, and to emphasise the grounded realities in the catchments. Stakeholders were encouraged to draw their ideas, or putative plans, onto the maps.

Second, we used Q-methodology following Cuppen (2009) to "give a picture of the range of perspectives (the variety of perspectives) amongst the population, rather than analysing the level of support for those perspectives amongst the population (the balance of perspectives)". Q-methodology has been used to purposefully sample ranges of perspectives within stakeholder

groups (Cuppen 2009) and to impose a useful structure upon those 'subjectivities' (Eden et al 2005). Q-methodology, with its basis in factor analysis, is ideal in conjunction with methods that recognise socio-environmental complexity, which has been shown to be necessary within environmental governance.

Third, we extended the utility of the community-generated maps by digitizing them into a GIS and testing them with a wider stakeholder audience (using a rapid appraisal approach (Cinderby 2010)) alongside the outputs of the participatory Q-methodology. In this way we integrated spatial and social factors, such as societal norms and values.

In order to undertake Q-method, the research team collected over 2000 statements on the nature of flooding, drawing on documents such as the Pitt Review (Pitt 2008) and other research reports on flooding in England and Scotland. These were grouped and classified to produce 62 exclusive statements covering a wide range of opinions, which were used in the Q-sorts (see below). Examples include: "Traditional engineered flood defences are neither sustainable nor cost effective"; "Some lands need to be sacrificed in the national interest"; "Expert judgements of who is a flood victim are often hotly contested"; and "You're not going to win the war with the river".

The next phase asked policy-makers to sort the final set of statements into a pre-determined grid, following a quasi-normal distribution and with positively and negatively numbered columns. In practice, this forced participants to prioritise statements with a fine level of discrimination. The instructions were to sort the statements according to the extent to which the sorter agreed or disagreed, although we phrased this as "most or least like how I think". The process of highly discriminatory sorting provided an invaluable tool for engaging stakeholders, and the Q-sort experience has since generated supplementary material and insight into relationships between participants and amongst stakeholders. For example, during the exercise,

many participants noted the difficulty of having to consider how they "really understood" the issues.

The results of the sorts were analysed following best practices, producing a number of ideal sort positions around which participants' views cluster (for a more extensive methodological review see Eden et al 2005). The ideal sorts were converted back into text using the significant Q-statements from each as a basis. This helped the research team interpret key messages, both by examining trends and exploring outliers.

The Q-methodology produced findings that were then taken back to participants and presented to a wider constituency for validation. Thus, although Q methodology was not originally intended as a participatory technique, the phases and the various structuring techniques meant that this combination of methods suited participatory research involving a wide range of public and disciplinary perspectives. This approach, then, helped us explore the knowledge of a wide range of stakeholders and identify trends amongst the complex assemblage of positions and issues that populate the debate over flood management in the Scottish-English borderlands. The end result of the Q-methodology were three options (hereafter called "Q-options"), which summarised positions concerning the issue of flood management amongst our participants.

5. Combining Maps and Models: the role of multiple methods

While Q-methodology is time consuming in its early stages, once a set of statements exists it can be used repeatedly and speedily to generate data. But the gathering and grouping activity used to generate the statements provided a focus for the research team to discuss the issues under investigation and was a valuable exercise. Hence this process can be viewed as a form of analysis, wherein different theoretical positions guide the selection. An open process was adopted for the Managing Borderlands project which divided the statements into thematic categories, which were then whittled down. Our approach prompted debate amongst the

different members of the multi-disciplinary research team, requiring detailed discussion of the issues under investigation. This proved a valuable exercise that highlighted the positions of team members and generated discussion about possible avenues of analysis. The quantitative phase in the middle of the Q-methodology raised issues in ways that were unexpected. It also provided a way of taking a rapid assessment of primary qualitative data, as well as questioning preconceived notions of stakeholder types.

The utility of a quasi-quantitative methodology – that is one with concise structured outputs rather than wordy reports – also has the great benefit that the output, like the community mapping, is apparently simple. Thus, it had an immediate utility not normally associated with purely qualitative mixed methods. The further utility of blending Q-methodology with another methodology is that the understanding produced could be used to open up and/or close down discussions as apposite. For example, in the wider validation of initial Q outputs we used agreement with one of the three alternative approaches to flood management – the Q-options – to categorise stakeholders into 'types': attendees at the agricultural shows had no difficulty in agreeing quickly, unambiguously, and definitely with one or other Q-option. We recorded demographic details, including postcodes, so could correlate 'beliefs about flood management' with residency location.

In tandem with the Q-options, we used citizen-generated participatory maps turned into GIS-database maps as a heuristic device (the methodology used in the project is explained in detail in Forrester & Cinderby 2011). In previous research where GIS maps have been used, they have been used as both a "dialectic" – that is a communication tool – and as a "heuristic device" that is as an aid to discussion (Cinderby & Forrester 2005; Wang et al 2008; Forrester et al 2011; Knol 2011). However, maps lack the ready inclusion of social values and beliefs that are necessary for understanding socio-environmental, and therefore socio-political, elements. The combination of Q+GIS addressed this challenge. In combination, supported by interviews and

discussions with stakeholders, the methods provided a basis to analyse management as it is perceived. Together, the two methodologies functioned to provide:

- a better understanding of the rationale(s) behind the strategic decisions of stakeholders (their standpoints having been identified by the Q-sort);
- a series of co-created and scheme-level plans of the possible and potential management options in real, local areas (using the participatory GIS-based mapping).

By using both methods concurrently we investigated the relationship between strategic and operational standpoints. Understanding that data is not only an output but a tool, we were able to begin exploring how people used knowledge through the process of gathering it and sharing it. Our experience is that the process of co-authoring maps was educative to both the research team and to those involved in our participatory mapping sessions. The process also produced an output in the form of a map which could be digitised, and compared with other forms of officially mapped spatial data.

The process of modelling – note that we are talking of descriptive models, not computer simulation models – can be described very simply: first, we explored stakeholders' values, including the knowledge and beliefs that inform those values (de Vries & Peterson 2009); we did this using the Q-sort and the Q-options. Second, we translated the stakeholders' worldviews into scenarios; we generated these scenarios separately using participatory mapping sessions. Third, we analysed the findings within the context of existing governance; we did this within the GIS database.

In the Managing Borderlands project we carried out community mapping sessions to generate maps of flood management options. We produced base maps (printed at A0 size, 84cm by 119cm) for each community at 1:10,000 scale and the whole catchment at 1:25,000 scale. The maps were a homogenization of aerial photography and cartographic data. Community stakeholders and representatives of key local organisations attended the different meetings in

which the maps were discussed. Stakeholders first drew where flood issues had occurred in the past on the map. We then asked participants to highlight their personal interpretations of where they thought new flood protection or land use changes could reduce flooding or flood impacts. We noted where they made responses on the maps and linked these map references to their comments on audio recordings of the group discussion during the mapping exercise. The mapping exercise itself took approximately two hours of the stakeholders' time, including introductions and refreshments.

Having gathered this stakeholder data, digitised it into a GIS database, and validated it with the stakeholders who gave us their information, we then presented digitised copies of the stakeholder maps at day-long agricultural shows in Scotland (the Peebles Show) and in England (the Glendale Show, Wooler). This allowed wider public engagement. By combining the Q-outputs with the GIS outputs, we were able to design a process in which those (admittedly self selecting) participants at the shows were questioned not only on the mapped schemes but on the more strategic Q-options. Show attendees could also add comments and make additional suggestions through a continuation of the community mapping, using flags to mark locations where they agreed or disagreed with the findings of the earlier stages of the project. By collecting demographic information on who the participants were – data such as occupation, postcode, age, gender – we were also able to identify which opinions were most popular and with which groups. Further, we were able to identify whether certain opinions on flood management were common to particular groups, and to correlate this data with stated favoured strategic Q-options. The results of the wider feedback at the shows were then fed back into the GIS to add another layer of community mapping into our understanding of flood management alternatives as perceived by local residents.

6. Using Q+GIS: Discussion and implications

Through the detailed understanding garnered from the mapping process, combined with the identification of idealised standpoints from the Q-sort, we developed a procedure for understanding the inclusion of social factors such as an actor's worldview, values, beliefs, and attitudes, to more technical understandings of the practical aspects of flood management. We believe that this is a real contribution to current practice.

The specific task of creating a model is to identify the critical points of the human social system that influence what is under investigation in the same way that the map did for the physical system whereby "mapping can provide solutions to issues at stake in the regulation of human activities in contested geographic and moral space" (Knol 2011). Models can do this for non-spatial data as well. In order to do this, it is argued, any model needs to "combine qualitative inputs in terms of [stakeholder and expert] preferences with quantitative modelling" (Vejre et al 2011). Q+GIS starts to address this. We did not produce a single output, but a combination of accessible and linked outputs. Throughout, the GIS acted as a search-friendly repository for all our project outputs.

We also tested whether stakeholder alliance with different Q-options could be taken as being indicative of different understandings of how the system – that is the socio-environmental system around flooding and flood management – worked. We explored whether the Q-options describe the stakeholders' perceptions of relations between social entities and between those social entities and the natural world. We used the Q-sort to elucidate whether or not we can have, or actually have, a single understanding of the system or whether there are competing worldviews. Through data collection and multiple-methods, we have shown a way to overcome the caveat that when "complex systems theory ... [is] applied to economic, ecological, and social systems, the operationalization or actor tends to be abstract with few concrete sociological characteristics" (Geels 2010).

[table 1 here]

The analysis undertaken in the Managing Borderlands project aimed to both spatially and conceptually map the knowledge that members of local communities and environmental professionals apply to flood management issues. We not only worked with different publics, but engaged with the scientific and policy community so that the information produced by citizen maps (from the GIS) and citizen models (from the Q+GIS, see Table 1) are not just critiques of top-down governance but are contributors to new, more inclusive knowledge about local environmental issues. Further, because of the attention to clear quantitative and mapped outputs, this "new" knowledge is easily utilizable by agency staff and other technical professionals involved – as well as other local citizens.

Furthermore, using the Managing Borderlands project as an example, we argue that talk of science or policy "experts" communicating effectively to "lay" and "non-experts" becomes a misrepresentation of the complex realities involved. Knowledge is used politically by all actors and is influenced as much by the actor's own values (as represented by the Q-option) as it is by other factors. We do not argue that the technological reframing using a GIS database or Q-methodology of itself makes it "new" knowledge, but it does create the common heuristic or basis for understanding that allows such a shared knowledge to develop (i.e. co-production). We argue that no one method would have produced such a deep, detailed, and useful understanding of the issues of flooding in the Borderlands.

7. Conclusion

For nearly 30 years, sociologists of science, practitioners, theoreticians, and some scientists have advocated greater public engagement in the governance of science and greater communication between scientists and public(s). Phrases such as "socially robust knowledge" are now routinely taken alongside "reliable knowledge" and "evidence-informed policy" as

indicators of acceptable environmental management. However, in the empirics of reality – such as in the practicalities of dealing with local-level and catchment-level flood management, especially where this catchment involves a multiplicity of local-level stakeholders and a duality of statutory agencies, knowledge generation is complicated and its use is complex.

While strands of the social geography of environmental governance have sought to be inclusive in the creation of new knowledge and lead us to see members of the public as providers of high quality locally-specific knowledge, inclusion and application of that knowledge within policy remains a glaring impediment.

The first step in addressing complex (a.k.a. "messy" or "wicked") problems is to – try to – appreciate the mess (Donaldson et al. 2010). The multi-method, multi-level approach adopted by Managing Borderlands – using Q-methodology, community mapping, focus groups, and participatory GIS – has enabled the co-production of knowledge around interventions into flooding, thereby contributing to the literature on 'spatial+' methods. However, each method retains an internal truth to the original data: maps are a good way to understand ideas for schemes; Q-methodology is a good way to understand attitudes and values. The lesson of this experience is that no one method will suffice to unpick the mess and to engender better management across the strategic, decision-taking, and practical implementation stages. The implications for stakeholder engagement in knowledge co-creation are high and the use of mixed methods – such as Q+GIS – to characterise stakeholder knowledge contributes to this process.

Acknowledgements

The Authors would like to acknowledge Liz Oughton at the Centre for Rural Economy, Newcastle University, UK, who was PI of the *Managing Borderlands* project and Chris Spray of the UNESCO Centre for Water Law, Policy and Science, University of Dundee, Scotland,

who facilitated Brian Cook's involvement in this work through funding from the Scottish Government.

References

Bailey, P., Yearley, S. and Forrester, J. 1999. "Involving the public in local air pollution assessment: a citizen participation case study" *International Journal of Environment and Pollution* 11(3): 290-303.

Barnes, A., Islam, M., and Toma, L. 2013. "Heterogeneity in climate change risk perception amongst dairy farmers: A latent class clustering analysis" *Applied Geography*, 40: 105-115.

Bracken, L. and Oughton, E., 2013. "Making sense of policy implementation: The construction and uses of expertise and evidence in managing freshwater environments" *Environmental Science & Policy*, 30:10-18.

Bracken, L, Bulkeley, H. and Whitman G, sub. Transdiscplinary research: understanding the stakeholder perspective. *Journal of Environmental Planning and Management.*

Callon M, 1999. The role of lay people in the production and dissemination of scientific knowledge. *Science Technology and Human Values*, Vol.4, 81-94.

Campbell, D., Donald, B., Moore, G. and Frew, D. 2011. Evidence Check: knowledge brokering to commission research reviews for policy. *Evidence & Policy* 7(1): 97-107.

Carpenter, S., Folke, C., Scheffer, M. and Westley, F., 2009. Resilience: Accounting for the Noncomputables. *Ecology and Society*, 14(1), article 13 [online - accessed 07 April 2012].

Cinderby, S., 2010. How to reach the "hard-to-reach": the development of Participatory Geographic Information Systems (P-GIS) for inclusive urban design in UK cities. *Area*, *42*(2), 239–251.

Cinderby, S. and Forrester, J., 2005. Facilitating the Local Governance of Air Pollution using GIS for Participation. *Applied Geography,* Vol.25, 143–158.

Cinderby, S. Snell, C. and Forrester, J., 2008. Participatory GIS and its application in governance: the example of air quality and the implications for noise pollution. *Local Environment,* Vol.13 (4), 309-320.

Cinderby, S., De Bruin, A. Mbilinyi, B., Kongo, V., & Barron, J., 2011. Participatory geographic information systems for agricultural water management scenario development: A Tanzanian case study. Physics and Chemistry of the Earth, Parts A/B/C, 36(14-15), 1093–1102.

Collins, H.M. and Weinel, M. 2011. Transmuted expertise: how technical non-experts can assess experts and expertise. *Argumentation* 25: 401-413.

Cook, B. R., Atkinson, M., Chalmers, H., Comins, L., Cooksley, S., Deans, N., Fazey, I., Fenemor, A., Kesby, M. and Litke, S. 2013a. Interrogating participatory catchment organisations: cases from Canada, New Zealand, Scotland and the Scottish–English Borderlands. *The Geographical Journal*.

Cook, B. R., Kesby, M., Fazey, I., and Spray, C. 2013b The persistence of 'normal' catchment management despite the participatory turn: Exploring the power effects of competing frames of reference. *Social Studies of Science*, doi:10.1177/0306312713478670.

Cuppen, E., 2009. *Putting Perspective into Participation: Constructive Conflict Methodology for problem structuring in Stakeholder Dialogues.* Rotterdam: Uitgeverij BOXPress, Oisterwijk.

Debolini, N., Marraccini, E., Rizzo, D., Galli, M., and Bonari, E. 2013 "Mapping local spatial knowledge in the assessment of agricultural systems: A case study on the provision of agricultural services" *Applied Geography*, 42: 23-33.

de Vries, B. and Petersen, A., 2009. Conceptualizing sustainable development: an assessment methodology connecting values, knowledge, worldviews and scenarios. *Ecological Economics,* Vol.68, 1006-1019.

Donaldson, A., Ward, N. and Bradley, S. 2010. Mess among disciplines: Interdisciplinarity in environmental research. *Environment and Planning A* 42(7): 1521-1536.

Eden, S., Donaldson, A. and Walker, G., 2005. Structuring Subjectivities? Using Q methodology in human geography. *Area,* Vol. 37(4), 413-422.

Eden, S. and Tunstall, S., 2006. Ecological versus social restoration? How urban river restoration challenges but also fails to challenge the science-policy nexus in the United Kingdom. *Environment and Planning C: Government and Policy,* Vol. 24, 661-680.

Ernst, K., & van Riemsdijk, M. 2013. "Climate change scenario planning in Alaska's National Parks: Stakeholder involvement in the decision-making process" *Applied Geography* 45: 22-28.

European Commission, 2003. *Common Implementation Strategy for the Water Framework Directive (2000/60/EC) Guidence document no.8: Public participation in relation to the water Framework Directive.* Luxembourg: EC.

Fish, R., Ioris, A. and Watson, N., 2010. Integrating Water and Agricultural Management: Collaborative Governance for a Complex Policy Problem. *Science of the Total Environment,* Vol.408, 5623-5630.

Fish, R., 2011. Environmental decision making and an ecosystems approach: Some challenges from the perspective of social science. *Progress in Physical Geography,* Vol.35(5), 671-680.

Forrester, J., Gerger Swartling Å. and Lonsdale, K, 2008. Stakeholder Engagement and the Work of SEI: An Empirical Study. Stockholm: SEI: IPS working paper. http://sei-

international.org/mediamanager/documents/Publications/Policy-institutions/stakeholder_engagement_workof_sei.pdf

Forrester, J., Nilsson, M., Lee, C., Moora, H., Persson, L., Persson, Å., Peterson, K., Simon J. and Tuhkanen H., 2008. *Getting to Policy Impact: some lessons from 20 years of bridging science and policy with sustainability knowledge* Stockholm: SEI.

Forrester, J., Hicks, K., Kuylenstierna, J., Simon, J., Snell, C., Chadwick, M.J., Schwela, D. and Emberson, L., 2011. Governance of Air Quality and Stakeholder Engagement. Lessons and Experience from International Cases. *In:* R. Lidskog and G. Sundqvist, eds. *Governing the Air: Science-Policy-Citizens Dynamics in International Environmental Governance.* Cambridge, MA: MIT Press, 558-607.

Forrester, J. and Cinderby, S. 2011. A Guide to using Community Mapping and Participatory-GIS. SEI and Tweed Forum: http://www.tweedforum.org/research/Borderlands_Community_Mapping_Guide_.pdf

Frazier, T., Thompson, C., Dezzani, R., and Butsick, D. 2013. "Spatial and temporal quantification of resilience at the community scale" Applied Geography, 42: 95-107.

Funtowicz, S. and Ravetz, J., 1991. A new scientific methodology for global environmental issues. *In: Ecological Economics, the science and management of sustainability*. R. Costanza, ed. New York: Columbia University Press, 137-152.

Geels, F., 2010. Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. *Research Policy,* Vol.39, 495-510.

Henke, J. & Petropoulos, G. 2013. "A GIS-based exploration of the relationships between human health, social deprivation and ecosystem services: The case of Wales, UK" *Applied Geography*, 45: 77-88.

Horlick-Jones, T. and Sime, J. 2004. Living on the border: knowledge, risk and transdisciplinarity. *Futures 36*(4): 441-456.

Irwin, A. and Michael, M. 2008. Eliciting situated knowledges about new technologies *Public Understanding of Science*, Vol. 17: 105-119.

Jasanoff, S. 2003. Breaking the waves in science studies: Comment on H.M. Collins and Robert Evans, 'The Third Wave of science studies'. *Social Studies of Science* 33(3): 389-400.

Knol, M., 2011. Mapping ocean governance: from ecological values to policy instrumentation. *Journal of Environmental Planning and Management*, Vol.54(7), 979-995.

Li,, X. & Griffin, W. 2013. "Using ESDA with social weights to analyze spatial and social patterns of preschool children's behaviour" *Applied Geography*, 43: 67-80.

Lidskog, R. 2008. Scientised citizens and democratise science. Re-assessing the expert-lay divide. *Journal of Risk Research* 11: 69-86.

Moghadam, H. & Helbich, M., 2013. "Spatiotemporal urbanization processes in the megacity of Mumbai, India: A Markov chains-cellular automata urban growth model" *Applied Geography*, 40: 140-149.

Owens, S.E. 2000. Engaging the public: information and deliberation in environmental policy. *Environment and Planning A* 32: 1141- 1148.

Pain, R., Kesby, M. and Askins, K., 2011. Geographies of impact: power, participation and potential. *Area*, Vol.43, 183-188.

Petts, J., Owens, S. and Bulkeley, H. 2008. Crossing boundaries: Interdisciplinarity in the context of urban environments. *Geoforum 39*(2): 593-601.

Phillipson J., Lowe P., Proctor, A. and Ruto, E. 2011. Stakeholder engagement and knowledge exchange in environmental research. *Journal of Environmental Management* 95 (1): 56-65.

Roig-Tierno, N., Baviera-Puig, A., Buitrago-Vera, J. & Mas-Verdu, F. 2013. "The retail site location decision process using GIS and the analytical hierarchy process" *Applied Geography*, 40: 191-198.

UK National Ecosystem Assessment (2011) *Understanding Nature's Value to Society: Technical Report*. UNEP-WCMC: Cambridge.

Vejre, H., Vesterager, J., Kristensen, L. and Primdahl, J., 2011. Stakeholder and expert-guided scenarios for agriculture and landscape development in a groundwater protection area. *Journal of Environmental Planning and Management*, Vol.54(9), 1169-1187.

Wang, X., Yu, Z., Cinderby, S. and Forrester, J., 2008. Enhancing participation: Experiences of participatory geographic information systems in Shanzi province, China. *Applied Geography*, Vol.28, 96-109.

Wynne, B. 2003. Seasick on the Third Wave? Subverting the hegemony of propositionalism: response to Collins and Evans (2002). *Social Studies of Science* 33: 401-417.

	Participatory Mapping	Q-Methodology	Q+GIS
Main Benefits	Clear policy-friendly output of ideas for spatially-validated options	Access to statistically-validated understandings of the range of beliefs amongst stakeholders	Is able to represent statistically and spatially the underlying support for different options
Main Disadvantage	Not easy to gather – and record – beliefs about different options	No particular idea of the level of support for different beliefs across different demographics	Time-consuming

Table 1: benefits of using Q+GIS

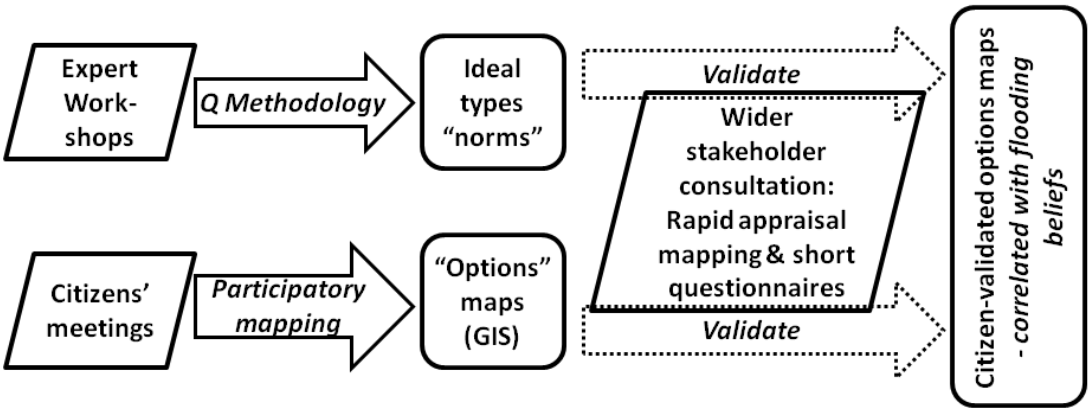
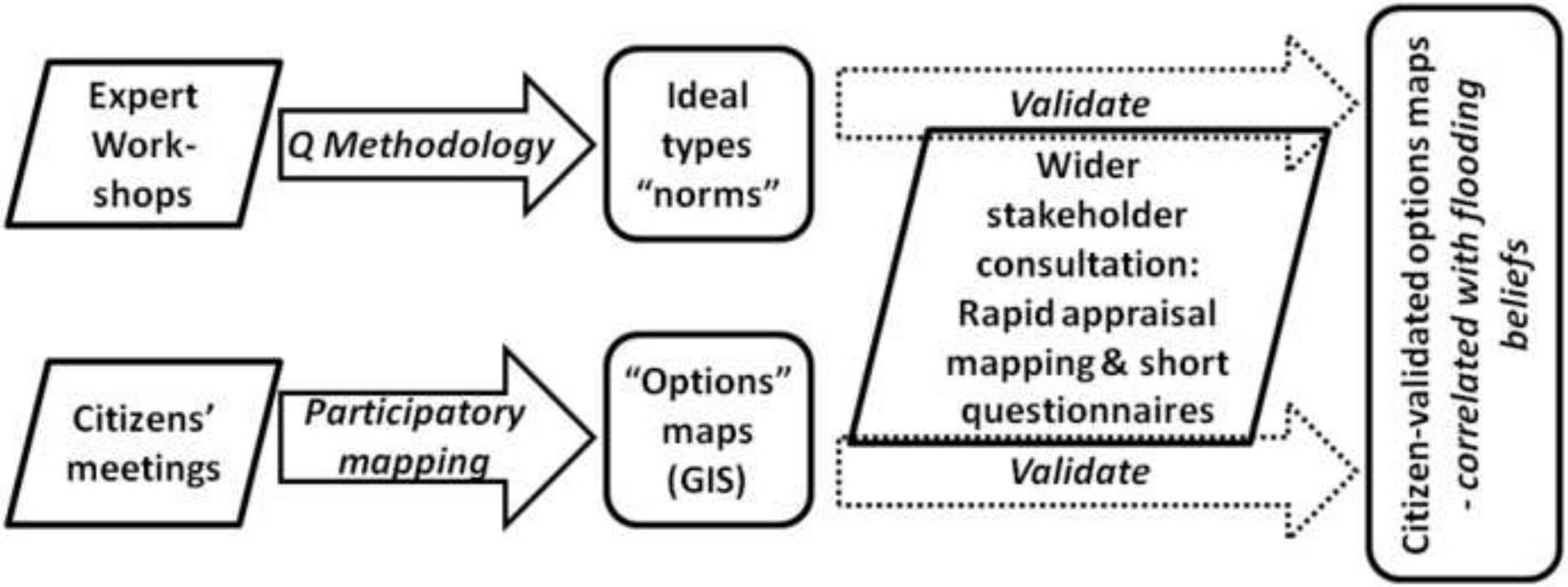


Figure 1: "Borderlands" project design for progressing qualitative and structured data

***Highlights (for review)**

- participatory mapping produces clear output of ideas for spatially-validated management options
- Q-Method allows statistically-valid understandings of ranges of beliefs amongst stakeholders
- Q plus mapping (Q+GIS) allows statistical and spatial underlying of support for different options
- this allows linking what people say or do and their underlying attitudes, values or beliefs

Figure
Click here to download high resolution image



Table

	Participatory Mapping	**Q-Methodology**	**Q+GIS**
Main Benefits	Clear policy-friendly output of ideas for spatially-validated options	Access to statistically-validated understandings of the range of beliefs amongst stakeholders	Is able to represent statistically and spatially the underlying support for different options
Main Disadvantage	Not easy to gather – and record – beliefs about different options	No particular idea of the level of support for different beliefs across different demographics	Time-consuming

Table 1: benefits of using Q+GIS