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Arguments for a Co-production Approach to Community Flood Protection

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Abstract

With more intense rainfall and sea level rises predicted, increasing numbers of people across the UK are vulnerable to flood events. The government has pledged more funding for flood infrastructure planning, design and management. However schemes tend to focus on technical solutions, with the social impact, including needs and concerns of the local community, seen as secondary. Based on a detailed examination of three case studies in England, this paper identifies the mechanisms through which current processes restrict industry professionals from considering and incorporating the social perspective, often in spite of seemingly effective community engagement. The paper argues for an approach that incorporates social concerns alongside the technical. Rather than 'community engagement', it is argued that 'co-production', in which lay communities work alongside technical experts in the design of flood risk alleviation schemes, would enable both a more socially acceptable, and also a more technically successful, final outcome.

Keywords

Social Impact; Infrastructure Planning; Floods and Floodworks; Co-production; Participatory community engagement

Introduction

Climate change is a subject that is increasingly on public and political agendas (Chilvers et al., 2014; Jordan et al., 2010). The Intergovernmental Panel on Climate Change (IPCC) in their most recent assessment predict that annual rainfall in England, where this research is focused, will increase by 10% by 2100 compared to the period 1986-2005 (IPCC, 2014 p.12). Globally sea level rise will occur in over 95% of the ocean area (IPCC, 2014 p. 13). The inevitable consequence of both more rainfall and a rise in sea level is increased likelihood of flooding (Johannessen and Hahn, 2013; Tripathi et al., 2014).

In 2016 there were already 5 million people in England alone at risk of flooding (EFRAC, 2016), and more across the UK. The winter of 2015-16 broke rainfall records with significant storms Desmond, Eva and Frank causing chaos and disruption. This had a serious financial impact; Storm Desmond alone cost the UK an estimated £5 billion in damage, insurance claims and disruption (EFRAC, 2016). In response to the increasing vulnerability to flooding, the UK Government has continued to increase funding budgets for flood risk management, including the design and management of new flood alleviation schemes (EFRAC, 2016).

This paper uses case study research to investigate the process through which flood alleviation schemes are being designed and constructed within England, with a particular focus on which aspects are prioritised and whose concerns are included. The case studies demonstrate that economic and technical considerations are still paramount (Howgate and Kenyon, 2009; Meyer et al., 2009; Penning-Roswell and Pardow, 2012; Graham et al., 2013; Jeffers, 2013). Firstly, the economic considerations mean that funding is primarily allocated, and schemes justified, based on a Cost-Benefit Analysis (CBA) process (Hunt and Taylor, 2009). This process quantifies the benefits to society in simple economic terms usually based primarily around property values (Hansson, 2007); should the benefits costed in this way exceed the economic cost of the intervention, the scheme will proceed (Hansson, 2007; Vickerman, 2007). However adopting such an approach offers only limited inclusion of social impacts and concerns; aspects of community and personal social values which are important to individuals, but translate poorly into monetary value, are excluded from the CBA process (Fitton, 2015). Social values which are therefore often impossible to quantify are not considered (Steelman, 2002; Jeffers, 2013; Millar and Hall, 2013; Fitton et al. 2015; Clarke et al., 2016).

Secondly, the technical systems that are currently used often fail to provide accurate predictions of flooding patterns, since the multiple variables pose a near impossible task for technical modelling (Lopez Marrero and Yarnal, 2010; Jeffers, 2013). Local lay knowledge of the flooding patterns can offer additional information (Fitton, 2015). However the designs for flood alleviation schemes usually rely solely on the technical predictions, and therefore sometimes fail to protect

from damage and losses to property, infrastructure and life (Changnon, 2005; Lopez Marrero and Yarnal, 2010; Clarke et al. 2016).

This paper argues therefore that the current approach to the design and management of flood alleviation schemes is inadequate. A new approach is needed which can incorporate intangible social values as well as economic CBA, and includes community knowledge of flood risk into the technical modelling of watercourses. This requires the co-production of schemes by industry professionals and local communities, who together can design flood alleviation schemes that are more effective and fit for purpose (Lopez Marrero and Yarnal, 2010; Fitton, 2015; Clarke et al., 2016).

The next section provides further background to the research and a detailed literature review of the theoretical concepts. This is followed by an explanation of how the research was designed and conducted, and an overview of three flood alleviation schemes which were used as case studies. The following section presents the results and discussion. The final section provides the concluding remarks, and recommends that future flood alleviation design and management approaches should consider the effective co-production of schemes between local communities and professionals, in order to produce outcomes which are both technically successful and socially acceptable. A brief suggestion of future areas for research ends the paper.

Current Design and Management Approaches to Flood Alleviation

Within the academic fields of Large Technical Systems (LTS) and Science and Technology Studies (STS), infrastructure systems such as flood alleviation schemes are seen as both intertwined with, and constructed by, society (Hughes, 1986; Law and Callon, 1988). An understanding of society and its value systems is therefore critical in delivering an infrastructure scheme that meets the needs of those it is being designed and delivered for (Faehnle et al., 2014).

As for all communities, those who are impacted by flood infrastructure schemes have multiple and complex social values (Fitton, 2015), which include "... interests, pleasures, likes, preferences, moral obligations, desires, wants, goals, needs, aversions and attractions" (O'Brien and Wolf, 2010 p.233). These are constructed through personal experiences, and are continually evolving (Rokeach, 1979; Shillito and De Marle, 1992). They are therefore unique and subjective, making them difficult to incorporate in a techno-economic design process (Steelman, 2002; Millar and Hall, 2013; Fitton et al., 2015).

A purely technical approach to flood management has long been critiqued in the social sciences, going as far back as Gilbert White's seminal 1945 paper 'Human adjustment to floods'

(White, 1945), and with many more recent publications (for example Wong and Shao, 2001, Changnon, 2005, Lopez-Marrero and Yarnal, 2010, Lundy and Kondolf, 2012).

Nevertheless, and as will be demonstrated later in this paper, the mechanisms that dictate how flood alleviation schemes are currently designed and managed remain heavily based on technical professional knowledge and focussed on mathematical modelling (Whatmore and Landstrom, 2011). Porter suggests that such quantification and mathematics have been commonly used to support claims of technical expertise because they are perceived to provide a degree of rigour, replication, transparency and validity (Porter, 1995); in other words, there is a belief that numbers cannot be wrong. While the 'lay' knowledge of the local can be seen to be subjective and even emotional (Simon-Vandenberg, 2007), the presentation of results based on quantification therefore generates trust in decision making (Hardy, 1967), and professional expertise, considered grounded in fact, is similarly seen as trustworthy (Kellens et al, 2011, Scott, 2001). Jasanoff (2004) further suggests that there is difficulty in arguing against the objectivity of maths with a non-quantified, subjective argument.

In response the past few years have seen the development of a field which seeks to quantify the social value and impact of projects, activities and organisations (Watson and Whitely, 2016), leading to a plethora of tools and methodologies which aim to provide a degree of 'mathematical logic and objectivity' to the subjective and intangible social perspective. One such example is Cost Benefit Analysis (CBA), the main method adopted by industry to justify and progress flood alleviation schemes. However, Porter (1995) also suggests that quantified methods can be manipulated to create the desired outcomes, and Lo (2014) considers the social perspective anyway to be incommensurable with quantification. Therefore many argue that quantification is not a suitable means by which to consider the social perspective, and tends to underestimate or misrepresent it (Hunt and Taylor, 2009; Nicholson-Cole and O'Riordan, 2009; O'Brien and Wolf, 2010).

The 'expert' knowledge of professionals meanwhile is socially constructed through training, and is also subjective (Pinch and Bijker, 1984). It may be narrow in scope, constraining the creativity required to solve problems (Henkel and Stirrat, 2001; Mosse, 2001). 'Lay' knowledge on the other hand is grounded in experience, and can contribute significantly to the development of a technically and socially successful scheme (Cooke et al., 2013). Milligan et al (2009) and McEwan (2011) therefore suggest that a combination of both 'expert' and 'lay' knowledge works best, 'co-producing' a design solution which integrates scientific and technical 'expert' knowledge with local experiences and values.

However challenges remain in changing industry's perception of the value of 'experienced based knowledge' (Landström et al 2011), and in enabling its effective collection (Warner, 2006). Currently, processes for interaction between the local community and the industry professionals, for flood alleviation and other infrastructure projects, are facilitated through

community engagement processes. These aim to gather the thoughts, opinions, knowledge and social values of the local community (O'Brien and Wolf, 2010; Graham et al, 2013; Ives and Kendal, 2014). The process of community engagement is a statutory part of the planning process for infrastructure; however, it can be seen by the industry professionals as a 'tick box' exercise, since it is not necessarily required to gain funding or justification for floodworks (Fitton et al. 2015; Begg et al., 2017; Moon et al., 2017).

Almost 50 years ago Arnstein (1969) described 'participation' as including a range of meanings of differing effectiveness, starting with the manipulation of communities, up to citizens having real power and influence over decisions. The variation in approaches to community engagement remains (Pretty, 2002; Few et al., 2007). Becker and Vanclay (2003) suggest a binary model which sees community engagement as either consultative or participatory. The consultative model merely informs the community; opinions are considered, but only incorporated where industry professionals decide they are relevant. In contrast, the participatory model engages with stakeholders at a deeper level allowing them real influence in decision-making. A participatory process is considered to be one that is inclusive of all aspects of the community, one in which all community members who wish to do so are able to influence decision-making, and one in which they are given equal access to the tools, education and attention of the professionals to do so (Arnstein, 1969; Fitton 2015; Begg et al., 2017; Moon et al., 2017).

The benefits of the participatory model include: identification of the needs and values of the community (Faehnle et al., 2014; Few et al., 2007; O'Riordan and Stoll-Kleeman, 2002); fostering a trusting partnership (Bickerstaff et al., 2010; Young et al., 2013); good future working relations (Orenstein et al., 2010); positive reputational benefits for industry (Wong et al., 2012); reduction of conflicts of interest (Fordham et al., 1991); and avoidance of planning delays (Ledoux et al., 2005). However a participatory process also poses many challenges for industry professionals, including: incorporating the plethora of values, interests, opinions and knowledge (Cleaver, 2001; Moon et al., 2017); financial, time and resource pressures (Correia et al., 1998); managing conflicts of interest between stakeholders (Fordham et al., 1991; Moon et al., 2017); and risking the technical success of a scheme (O'Brien, 2009). Fitton (2015) further showed that the nature of an effective participatory process, which necessitates that the power and control of the scheme design is shared between the professionals and the community (Gibbons et al., 1994; Jasanoff, 2006; Begg et al., 2017), is misaligned with the processes, attitudes and education of industry professionals.

However there is a further step still from the participatory model, which is that of 'co-production'. Co-production refers to the action of working together to produce the final outcome (Jasanoff, 2004; Boyle and Harris, 2009; Alford, 2014; Fitton 2015). Alford (2014) clarifies that co-production can be misconceived as one in which local communities have an input into design processes, while the professionals retain the final say in the design, construction and

management. Instead co-production brings both the local communities and the professionals to work on the design, and even construction (where applicable) and management (where applicable) of the solution (Jasanoff, 2004).

Research Design

This research used a qualitative inductive approach, following constructivist grounded theory (Glaser and Strauss, 1967; Charmaz, 2006). This approach iteratively develops theory from data, checks against further data, then refines the theory further (Charmaz, 2006; Urquhart, 2013). In common with other qualitative methodologies, the approach also recognises that the perspective, values and knowledge of the researcher will have an inevitable influence on the data collection process (Thornberg and Charmaz, 2014). A case study approach enabled the researcher to be immersed in a real world context, in order to study the research problem from within (Flyvberg, 2006).

The primary aim of the research was to investigate the process through which flood alleviation schemes are being designed and constructed within England, with a particular focus on which aspects are prioritised and whose concerns are included. Three flood alleviation schemes were selected for the study; each had been recently completed, and were significant schemes that had been identified by industry as a success. All three were within the north of England, chosen for practical reasons. Fitton (2015) describes in more detail the rationale for the choice of the schemes, and the details of each.

Publically available planning documents were used to describe the technical details of the schemes. However the primary source of data was semi-structured interviews with the professional team members delivering the schemes (including engineers, town planners, environmentalists, flood risk modellers and architects) and individuals from the communities affected by the schemes. This method allowed the researcher to direct the discussion while also allowing participants to identify topics of interest and importance to them (Creswell, 2009; Silverman, 2010). The interviews were used to identify differing perceptions and narratives of the schemes between the two groups.

Individuals who were closely embedded in the schemes both from the local community and from the professional team were initially identified as part of a theoretical sampling technique (Emmel, 2013; Urquhart, 2013). Snowball sampling (Bryman, 2012) was then used to identify additional suitable participants. Across the three schemes 71 participants were interviewed from April 2013 to April 2014, 25 from the professional teams associated with the schemes and 46 from within the local communities of the three case studies.

The data collected was analysed iteratively throughout the process (Glaser and Strauss, 1967; Hunter and Kelly, 2008). Interviews were recorded and transcribed, and then coded with the aid

of the Computer Aided Qualitative Data Analysis Software (CAQDAS), NVivo 10; this helped to manage the large sets of data (Bryman, 1988; King, 2008), while the researcher retained the role of analyst (Welsh, 2002; King, 2008). The coding process allowed the researcher to identify the relationships emerging from the data and develop theoretical explanation for the findings (Charmaz, 2006) which could then be tested as the work progressed. More information on this process is given in Fitton (2015).

The three case studies

The three flood infrastructure schemes chosen as case studies were; the Didsbury Flood Storage Basin Improvements Scheme; the Ripon Rivers Flood Alleviation Scheme; and the Todmorden Flood Alleviation Scheme. These schemes were chosen to be comparable in size, chronology and location, all being in the north of England (Fitton, 2015).

Didsbury Flood Storage Basin Improvements Scheme

Didsbury is in Greater Manchester. A 62ha flood storage basin, operational from 1979 and used to relieve peak flow from the River Mersey, is predominately used as a recreational area with allotments, a golf club, a rugby club and a park. The River Mersey is also a community attraction, with foot and cycle paths along the banks (Figure 1). There are a small number of residential properties situated within or in close proximity to the basin.

Figure 1. Public open space along the River Mersey. Source: Fitton (2015)

When the improvement scheme was first proposed, the basin had not been performing as required, with water unable to flow effectively to the western section and therefore exceeding its capacity in the eastern section. There was concern that the basin would not drain quickly enough if there were two flood events in quick succession. The proposed improvements included:

- Installation of new monitoring and telemetry equipment;
- Construction of a floodwall and floodgate to protect the residential properties;
- Installation of flood mitigation measures to the local amenities;
- Construction of a new outfall to the eastern section; and
- Creation of a maintenance strategy to ensure no obstructions impeded the flow of floodwater.

The improvement scheme was commissioned in 2009 by the Environment Agency, planning approved by Manchester City Council, and the scheme was completed in December 2011. The scheme was commended by the Institution of Civil Engineers in 2012 for its community work (Fitton, 2015).

Ripon Rivers Flood Alleviation Scheme

Ripon is a small market city in Yorkshire at the convergence of three rivers, the Ure, the Skell and the Laver. The city has been flooded on four separate occasions since 1980, and prior to the scheme over 500 properties were identified as at risk of flooding. The new scheme was commissioned by the Environment Agency and a planning application submitted to Harrogate Borough Council in 2006. Funding cuts led to a postponement, but a significant flood in 2007 reignited the scheme and secured the funding required. Work commenced on site in 2009, with scheme completion in 2011. The main component was the construction of an 8.6m high flood storage embankment located upstream to hold back the flow of the River Laver during heavy flow periods. The scheme also included:

- Floodwall construction around certain properties;
- Piled walls at certain points along the River Ure;
- Sympathetic redesign and construction of weirs (Figure 2); and
- ‘Soft’ engineering techniques such as vegetation planting on the banks of the rivers.

Figure 2. Redesigned Alma Weir. Source: Fitton (2015)

Todmorden Flood Alleviation Scheme

Todmorden is in West Yorkshire, at the bottom of the steep sided Calder Valley. Converging in the centre of Todmorden is the River Calder and its tributary, Walsden Water, and the Rochdale Canal also runs parallel to the Calder. The town has experienced five significant flood events since 1979 from the River Calder exceeding its capacity. The flood periods are usually relatively short due to the 'flashy' nature of the deep but short catchment. However, the flooding has been exacerbated due to inadequate drainage as well as increased surface water run off. In 2004 the Environment Agency gained planning permission for a three phase scheme, and Phases 1 and 2 were completed in 2006. A flood storage basin was created in Centre Vale Park (Figure 3), and a new playground, sports pitches and enhancements to the local environment were also delivered.

Due to funding constraints work halted on the scheme. However a significant flood event in 2008 may have precipitated the revision and redesign of phase 3 of the scheme, which was granted planning approval by Calderdale Council. These Phase 3 works consisted of;

- The construction of new flood defence walls in certain areas of the town;
- Repair of five culverts around the town; and
- The renovation of three listed buildings.

Figure 3. Centre Vale Park. Source: Fitton (2015)

Results and Discussion

Across the three flood alleviation schemes investigated, there was a general consensus from most industry participants about the importance of ensuring that the needs of the local communities were considered and, where possible, met (Fitton, 2015). As an industry participant from the Ripon scheme explained,

“I think it is definitely needed [social value]. It’s very important. ... We should be considering who is benefiting and what the impact is on their lives.”

However most industry participants also felt that the inability to *quantify* the social perspective made it difficult to include. One industry participant from the Todmorden scheme explained,

“... if you can’t put it in monetary terms then it doesn’t come into the Cost-Benefit Analysis.”

while another felt that,

“... if you’ve got a robust scheme then there is no point probing any further there to try and get anything different in terms of justification which may not be as easy to quantify.”

A further industry participant suggested that the process of funding (through CBA) was a restriction:

“The bottom line is cost and benefits and the way our projects get funded and at the end of the day we have very stringent rules on what goes ahead and what doesn’t.”

The industry professionals also considered local community knowledge as having a limited role in the schemes (Kellens et al., 2011; Whatmore and Landstrom, 2011; Begg et al., 2017; Moon et al., 2017). One industry participant from the Todmorden scheme explained

“...[the community were involved in] finishes and detail, but the actual technical scope – no. With the constraints of the valley there isn’t very many options we can go for, having done the feasibility [study] ... On a lot of the softer issues if you like, where there was practical, but no impact on the performance of the scheme, they [the local community] were very much included...”

Generally therefore the professionals suggested that they understood the importance of meeting the needs of the local community, but in reality the areas of the design that the communities were able to influence were limited to the ‘softer issues’. One industry participant from the Didsbury scheme explained that:

“... we are professional people; this is what we do for a day job. The person on the street does not do flood risk as a day job ... if they are paying me as an engineer to do that job then I shall do that job as an engineer.”

The participant’s expertise here is clearly tied up with the professional identity of an ‘engineer’, with the assumed ownership therefore of the ‘job’ of flood risk management (Begg et al., 2017; Moon et al., 2017).

However the perception of the community participants was noticeably different; they believed that lay knowledge could also help inform the technical perspective of the scheme (Cook et al., 2013; Fitton, 2015). A local community member from the Ripon scheme discussed how

“... they built a dam here [in the river] and they had these two big pipes coming down here to take away the water ... We said, when this river floods it is going to come straight over your dam because it is far too much water for your tubes, you are wasting your time. ... But what do we know? ... they said no, no!”

The water did indeed flood over the pipes as the local community participant predicted, setting the project schedule back (Figure 4), demonstrating both the value of empirical experience and also the problem of inadequate designs based on inaccurate data (Changnon, 2005; Lopez and Marrero and Yarnal, 2010; Jeffers, 2013; Clarke et al., 2016). If the knowledge of the community had been appreciated by the professionals it would have saved time and money (Fordham et al., 1991; Young et al., 2013).

Many of the local community participants understood and valued the potential of a co-production approach to the scheme design and maintenance (Gibbons et al., 1994; Jasanoff, 2006; Milligan et al., 2009; McEwan, 2011). The view of this local community participant from Todmorden was echoed by many across the three schemes:

“... people do have a lot of local knowledge, it’s very good you have the engineer and the modeller, but at the end of the day there is some local knowledge somebody will have that they [the industry professionals] really do need to listen to.”

Some local community participants also identified the limitations of 'expert' knowledge and reliance on quantification (Whatmore and Landstrom, 2011). A local community participant from Ripon explained:

"They [the design team] have done all this on computer graphics and everything, but it would be better if someone had actually seen the volume of water when it was at its worst. ..."

Figure 4. Construction works at Ripon. Source: Fitton (2015)

One of the primary methods of obtaining this 'lay' knowledge within all three schemes was through a community engagement process, although the process varied (Pretty, 2002; Few et al., 2007). An industry participant from the Didsbury scheme described their approach:

"... we had posters, we had maps, diagrams, and photographs so people could actually just walk round and ask a particular specialist what they wanted to know ... [we made] sure that there was a very clear and concise message about what we were doing and why we were doing it."

At Ripon in contrast, an industry participant explained:

"There was a full-time public liaison person ... who went along and spoke to them [the local community] and was there for them to ring up, any time day or night, to say we are not happy or we have got some concerns."

The third scheme at Todmorden employed a combination of both approaches, appointing a public liaison officer and also conducting open meetings for the local community to view plans and speak to the industry professionals.

Although the community engagement process differed, it was evident that the industry participants from all three schemes considered it to be a consultative rather than participative exercise. As an industry participant stated:

"[We] kept liaising with them and making sure that the option we selected was suitable for their arrangements as well."

While engaging with the local community, by retaining ownership of the selection of options ('the option we selected') they were clearly not prepared to devolve power over decisions to the local communities (Fitton, 2015). Many industry participants also spoke about the challenges of the perceived cost of engagement, and of the difficulties of incorporating all views (Cleaver, 2001; Correia et al., 1998; Moon et al., 2017). Two industry participants explained the challenges they faced:

"...a lot of conflict and requirements ... the timescales and the budgets are always very restraining."

"... for managing expectations, not only of the public but from senior managers within the Environment Agency, you are into a lose-lose situation."

The local community participants' views on the processes varied. Some were pleased to be consulted, such as this man from Didsbury:

"You couldn't fault the consultation ... So, did I see drawings? Yes ... Did they produce any images to give me an idea of what it [a floodwall] would look like? Yes. So, there was no attempt to try and hoodwink me or assume that I couldn't read drawings."

However this response also reflects the presentation of information by industry as a fait accompli rather than allowing any input from the community affected, with professional expertise (through the professional language of drawings and images) used to define and explain the solutions (Cooke and Kothari, 2001). This reflects better the more common, negative, responses from the local communities, who were often aware of the merely consultative nature of the engagement. A local community participant explained:

"I wouldn't say it was consultation, it was informing us what was going to happen, so I wouldn't say it was consultation in the way I understand it, about what would you like to happen."

However the benefits of employing a more participatory process were demonstrated in the later phases of the Didsbury scheme. Inadequate engagement at the initial design stage led to protest from the local community against the scheme and its impact on the local area. As a result, the industry professionals had initially experienced hostility. An industry participant from the Didsbury schemes explained his experience:

“... so we won the job ... and turned up on site and that is when it really hit ... how major an issue this was. And then straight from the word go it was we need to re-think this ... We were conscious we didn’t want to end up in a battle with them, trying to force through some modifications ... that they were radically opposed to.”

The local community conversely were wary of the industry professionals because of their past experiences:

“...from an early stage it was clear that there was going to be a lack of trust because we were kept in the dark ...” (Didsbury community participant)

By not adopting a participatory approach initially, additional cost and time were incurred, as well as considerable conflict (Correia et al., 1998; Fordham et al., 1998; Moon et al., 2017). The extent of the protest led the Environment Agency to appoint a different consultant to work with the local community in order to produce a scheme that was more socially acceptable. Following a more participatory engagement process and a co-production approach led by the new consultant, the final implemented scheme was viewed by both industry and the local community as both a technical and social success (Gibbons et al., 1994; Jasanoff, 2004; Mc Ewan, 2011; Begg et al., 2017).

Conclusion

With more intense rainfall periods and sea level rises predicted for England, increasing numbers of people are at risk from flood events. The Government has pledged to increase budgets for flood alleviation measures. Through three detailed case studies of flood alleviation schemes this research has shown however that current industry practices do not facilitate the design and management of schemes that are socially acceptable to the local communities they are designed to protect, and nor do they utilise the local knowledge of flood risk. While the importance of schemes being suited to the local context and communities is understood by most individual industry professionals, design decisions are frequently embedded within and restricted by tools such as the commonly used Cost Benefit Analysis. Through quantification and numerical comparison of relative aspects of a design, CBA acts to exclude intangible and unquantifiable social aspects. This focus on quantification is founded in professional education and training, which concentrates on technical perspectives, and further fosters an attitude which expects technical expert knowledge to dominate decisions, considering lay knowledge to be of less or no relevance. The case studies presented here have demonstrated that lay knowledge and the empirical experiences on which it is founded can be just as important to the success of a scheme.

The community engagement process is the primary mechanism through which lay knowledge is gathered for infrastructure schemes. At its most effective the process should be participatory, forming the starting point for the multiple stakeholders to co-produce a scheme through their combined technical and social knowledge. In the case studies described however the engagement processes were consultative rather than participatory, allowing only very limited

input from local communities with power over decisions retained by the industry professionals and based on their technical models and the CBA analysis. This can result in a scheme which does not meet the social needs of the local community it is designed for, and can also lead to conflict between the community and professional team such as at Didsbury, with resultant financial loss. In some cases the lack of inclusion of local knowledge of flooding can further result in the technical failure of schemes such as at Ripon. All three cases of flood schemes received industry awards for their relationship with the local communities; however the realities experienced by the communities themselves, as identified through this research, were far from satisfactory.

The paper identifies three separate but related mechanisms currently working together to limit or exclude the consideration and incorporation of social values and lay knowledge into the design and management of flood alleviation schemes: 1) the use of quantitative decision-support tools such as CBA which exclude non-quantifiable issues, 2) common industry attitudes towards the hierarchy of 'expert' versus 'lay' knowledge, and 3) community engagement processes which are commonly consultative rather than participatory.

The findings clearly demonstrate that there is a need for radical change. Considered and effective participatory engagement with communities, which gives significant time and resources to understanding and incorporating local experiences and knowledge, is key. This can save time, costs and resources, and can alleviate the risk of local opposition, with clear reputational benefit for the industry parties. However for any process to work industry professionals must also appreciate the validity and importance of local knowledge. This requires a change in approach away from the current reliance on quantification tools such as CBA, and a simultaneous change in focus in initial education and training.

The ultimate goal should be for the co-production of flood risk alleviation schemes, which would allow for the incorporation of unquantifiable social values as well as economic costs, and which would include community knowledge of flood risk alongside the technical modelling of watercourses. This approach, it is proposed, would enable the creation of more socially acceptable, and more technically successful, flood alleviation schemes, providing optimum benefit to the local communities at risk of flood events and providing the best value for money for the Government.

Further research is now needed to investigate the effectiveness of flood risk management using a coproduction approach as advocated in this paper. This research should also assess the impact of new techniques and tools which claim to capture additional social aspects in comparison with CBA. As well as coproduction of the schemes between the communities and the professionals, future research into such a critical issue as flood risk management also

requires the continued coproduction of knowledge between industry and academia (Moncaster et al, 2010).

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References

- Alford, J. (2014) The Multiple Facets of Co-Production: Building on the work of Elinor Ostrom, *Public Management Review* 16 (3), 299-316
- Arnstein, S. R. (1969) A Ladder of Citizen Participation. *Journal of the American Institute of Planners*. 35, 216-224.
- Becker, H. A. & Vanclay, F. (2003) *The International Handbook of Social Impact Assessment*. Cheltenham: Edward Elgar Publishing.
- Begg, C, Callsen, I, Kuhlicke, C. & Kelman, I. (2017) The Role of Local Stakeholder Participation in Flood Defence Decisions in the United Kingdom and Germany. *Journal of Flood Risk Management*.
- Bickerstaff, K., Lorenzoni, I., Jones, M. & Pidgeon, N. F. (2010) Locating Scientific Citizenship: The Institutional Contexts and Cultures of public Engagement. *Science, Technology and Human Values*. 35, 474-500.
- Boyle, D. & Harris, M. (2009) *The Challenge of Co-production*. London: Nesta.
- Bryman, A. (1988) *Quantity and Quality in Social Research*. London: Unwin Hyman.
- Bryman, A. (2012) *Social Research Methods*. New York: Oxford University Press Inc.
- Changnon, S. A (2005) The 1993 Flood's Aftermath: Risks, Root Causes, and Lessons for the Future. *Journal of Contemporary Water Research and Education* 130, 70-74.
- Charmaz, K. (2006) *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis*. London: sage.
- Chilvers, J., Lorenzoni, I., Terry, G., Buckley, P., Pinnegar, J.K & Gelcich, S. (2014) Public Engagement with Marine Climate Change Issues: (Re)framings, Understandings and Responses. *Global Environmental Change*. 29, 165-179.
- Clarke, D, Murphy, C. & Lorenzoni, I. (2016) Barriers to Transformative Adaptation: Responses to Flood Risk in Ireland, *Journal of Extreme Events* 3 (2).
- Cleaver, F. (2001) Institutions, Agency and the Limitations of Participatory Approaches to Development. In: Cooke, B. & Kothari, U. (eds.) *Participation: The New Tyranny?* London: Zed Books Ltd.

- Cook, B. R., Kesby, M., Fazey, I. & Spray, C. (2013) The Persistence of 'Normal' Catchment Management Despite the Participatory Turn: Exploring the Power Effects of Competing Frames of References. *Social Studies of Science*. 43, 75-779.
- Cooke, B. & Kothari, U. (2001) The Case for Participation as Tyranny. In: Cooke, B. & Kothari, U. (eds.) *Participation: The New Tyranny?* London: Zed Books Ltd.
- Correia, F. N., Fordham, M., Saraiva, M. D. G. & Bernardo, F. (1998) Flood Hazard Assessment and Management: Interface with the Public. *Water Resources Management*. 12, 209-227.
- Creswell, J. W. (2009) *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. London: Sage.
- Department for Environment, Food and Rural Affairs (2007) *Ripon Land Management Project*.
- Emmel, N. (2013) *Sampling and Choosing Cases in Qualitative Research: A Realist Approach*. London: Sage.
- Environment, Food and Rural Affairs Committee. (2016) *Future Flood Prevention: Second Report of Sessions 2016-17*. London: House of Commons.
- Faehnle, M., Backlund, P., Tyrvaenen, L., Niemela, J. & Yli-Pelkonen, V. (2014) How can Residents' Experiences Inform Planning of Urban Green Infrastructure? Case Finland. *Landscape and Urban Planning*. 130, 171-183.
- Few, R., Brown, K. & Tompkins, E. L. (2007) Public participation and Climate change Adaptation: Avoiding the Illusion of Inclusion. *Climate policy*. 7, 46-59.
- Fitton, S.L., Moncaster, A. & Guthrie, P. (2015) Investigating the Social Value of the Ripon Rivers Flood Alleviation Scheme. *Journal of Flood Risk Management*.
- Fitton, S. L. (2015) *Social Value in Practice: A Case of Flood Alleviation Schemes*. PhD Thesis: University of Cambridge.
- Flyvbjerg, B. (2006) Five misunderstandings about Case-Study Research. *Qualitative Inquiry*. 12, 219-245.
- Fordham, M., Tunstall, S. & Penning-Roswell, E., C. (1991) Choice and Preference in the Thames Floodplain: The Beginnings of a Participatory Approach? *Landscape and Urban Planning*. 20, 183-187.
- Graham, S., Barnett, J., Fincher, R., Hurliman, A., Mortreux, C. & Waters, E. (2013) The Social Values at Risk from Sea- Level Rise. *Environmental Impact Assessment Review*. 41, 45-52.
- Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. & Trow, P. (1994) *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London: Sage.
- Glaser, B. & Strauss, A. (1967) *The Discovery of Grounded Theory: Strategies for Qualitative Research*. London: Weidenfeld and Nicolson.
- Hansson, S. O. (2007) Philosophical Problems in Cost-Benefit Analysis. *Economics and Philosophy*. 23, 163-183.
- Hardy, G. H. (1967) *A Mathematician's Apology*. Cambridge: Cambridge University Press.

- Henkel, H & Stirrat, R. (2001) Participation as Spiritual Duty: Empowerment as Secular Subjection. *In: Cook, B. & Kothari, U. (eds.) Participation: The New Tyranny?* London: Zed Books.
- Howgate, O. R. & Kenyon, W. (2009) Community Cooperation with Natural Flood Management: A Case Study in the Scottish Borders. *Area*. 41, 329-340.
- Hughes, T., P. (1986) The Seamless Web: Technology, Science, Etcetera, Etcetera. *Social Studies of Science*. 16, 281-292.
- Hunt, A. & Taylor, T. (2009) Values and Cost-Benefit Analysis: Economic Efficiency Criteria in Adaption. *In: Adger, W., N., Lorenzoni, I. & O'Brien, K. L. (eds.) Adapting to climate Change: Thresholds, Values and Governance*. Cambridge: Cambridge University Press.
- Hunter, K. & Kelly, J. (2008) Grounded Theory. *In: Knight, A.. & Ruddock, L. (eds.) Advanced Research Methods in the Built Environment*. Chichester: John Wiley and Sons.
- IPCC. (2014) *Climate Change 2014 Synthesis Report: Summary for Policymakers* [Online]. Available: <http://www.ipcc.ch/report/ar5/syr/>.
- Ives, C., D. & Kendal, D. (2014) The Role of Social Values in the Management of Ecological Systems. *Journal of Environmental Management*. 144, 67-72.
- Jasanoff, S. (2004) Heaven and Earth: The Politics of Environmental Images. *In: Jasanoff, S. & Martello, M. L. (eds.) Earthly Politics: Local and Global in Environmental Governance*. Cambridge: The MIT Press.
- Jasanoff, S. (2006) The Idiom of Co-production. *In: Jasanoff, S. (ed) States of Knowledge: The Co-production of Science and the Social Order*: London: Routledge.
- Jeffers, J.M. (2013) Integrating Vulnerability Analysis and Risk Assessment in Flood Loss Mitigation: An Evaluation of Barriers and Challenges Based on Evidence from Ireland, *Applied Geography*, 37: 44-51.
- Johannessen, A. & Hahn, T. (2013) Social Learning Towards a More Adaptive Paradigm? Reducing Flood Risk in Kristianstad Municipality, Sweden. *Global Environmental Change*. 23, 372-381.
- Jordan, A., Huitema, D., Van Asselt, H., Rayner, T. & Berkhout, F. (2010) *Climate Change Policy in the European Union: Confronting the Dilemmas of Mitigation and Adaption?* Cambridge: Cambridge University Press.
- Kellens, W., Zaalberg, R., Neutens, T., Vanneuville., W. & De Maeyer, P. (2011) An Analysis of the Public Perception of Flood Risk on the Belgian Coast. *Risk Analysis*. 31, 1055-1068.
- King, A. (2008) Using Software to Analyse Qualitative Data. *In: Knight, A.. & Ruddock, L. (eds.) Advanced Research Methods in the Built Environment*. Chichester: John Wiley and Sons.
- Landström, C., Whatmore, S.J., Lane, S.N., Odoni, N.A, Ward, N. & Bradley, S. (2011) Coproducing Flood Risk Knowledge: Redistributing Expertise in Critical 'Participatory Modelling' *Environment and Planning A: Economy and Space* 43 (7), 1617 - 1633
- Law, J. & Callon, M. (1988) Engineering and Sociology in a Military Aircraft Project: A Network Analysis of Technological Change. *Social Problems*. 35, 284-297.

- Ledoux, L., Cornell, S., O’Riordan, T., Harvey, R. & Banyard, L. (2005) Towards Sustainable Flood and Coastal Management: Identifying Drivers of, and Obstacle to, Managed Realignment. *Land Use Policy*. 22, 129-144.
- Lo, A. Y. (2014) More or Less Pluralistic? A Typology of Remedial and Alternative Perspectives on the Monetary Valuation of the Environment. *Environmental Values*. 23, 253-274.
- Lopez-Marrero, T. & Yarnal, B. (2010) Putting Adaptive Capacity into the Context of People’s Lives: A Case Study of Two Flood-Prone Communities in Puerto Rico, *Natural Hazards* 52: 277–297.
- McEwen, L. (2011) Approaches to Community Flood Science Engagement: The River Severn Catchment, UK as Case-Study. *International Journal of Science in Society*. 2, 160-179.
- Meyer, V., Scheuer, S. & Haase, D. (2009) A Multi-criteria Approach for Flood Risk Mapping Exemplified at the Mulde River, Germany. *Natural Hazards*. 48, 17.
- Millar, R. & Hall, K. (2013) Social Return on Investment (SROI) and Performance Measurement. *Public Management Review*. 15, 923-941.
- Milligan, J., O’Riordan, T., Nicholson-Cole, S. A. & Watkinson, A. R. (2009) Nature Conservation for Future Sustainable Shorelines: Lessons from Seeking to Involve the Public. *Land Use Policy*. 26, 203-213.
- Moncaster A.M., Hinds D, Cruickshank H, Guthrie PM, Crishna N, Baker K, Beckmann K and Jowitt PW (2010) Knowledge exchange between academia and industry, Proceedings of the Institution of Civil Engineers, Engineering Sustainability, 163 (3), pp 167 –174
- Moon, J, Flannery, W. & Revez, A. (2017) Discourse and Practice of Participatory Flood Risk Management In Belfast, UK, *Land Use Policy* 63: 408–417.
- Mosse, D. (2001) ‘People’s Knowledge’, Participation and Patronage: Operations and Representations in Rural Development. In: Cook, B. & Kothari, U. (eds.) *Participation: The New Tyranny?* London: Zed Books.
- Nicholson-Cole, S. A. & O’Riordan, T. (2009) Adaptive Governance for a Changing Coastline: Science, Policy and Publics in Research in Search of a Sustainable Future. In: Adger, W., N., Lorenzoni, I. & O’Brien, K. L. (eds.) *Adapting to climate Change: Thresholds, Values and Governance*. Cambridge: Cambridge University Press.
- O’Brien, K. L. (2009) Do values Subjectively Define the limits to Climate change Adaptation? In: Adger, W., N., Lorenzoni, I. & O’Brien, K. L. (eds.) *Adapting to climate Change: Thresholds, Values and Governance*. Cambridge: Cambridge University Press.
- O’Brien, K. L. & Wolf, J. (2010) A Values-Based Approach to Vulnerability and Adaptation to Climate Change. *Climate Change*. 1, 232-242.
- O’Riordan, T. & Stoll-Kleeman, S. (2002) Deliberative Democracy and Participatory Biodiversity. In: O’Riordan, T. & Stoll-Kleeman, S. (eds.) *Biodiversity, Sustainability and Human Communities: Protecting Beyond the Protected*. Cambridge: Cambridge University Press.
- Orenstein, M., Fossgard-Moser, T., Hindmarch, T., Dowse, S., Kuschminder, J., McCloskey, P. & Mugo, R. K., (2010) Case Study of an Integrated Assessment: Shell’s North Field Test in Alberta, Canada. *Impact Assessment and Project Appraisal*. 28, 147-157.

- Penning-Roswell, E., C. & Pardow, J. (2012) Who Benefits and Who Loses from Flood Risk Reduction? *Environment and Planning C: Government and Policy*. 30, 448-466.
- Pinch, T. J. & Bijker, W. E. (1984) The Social Construction of Facts and Artefacts: or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other. *Social Studies of Science*. 14, 399-441.
- Porter, T., M. (1995) *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*. New Jersey: Princeton University Press.
- Posthumus, H., Hewett, C. J. M., Morris, J. & Quinn, P. F. (2008) Agricultural Land Use and Flood Risk Management: Engaging with Stakeholders in North Yorkshire. *Agricultural Water Management*. 95, 787-798.
- Pretty, J. (2002) People, Livelihoods and Collective Action in Biodiversity Management. In: Adger, W., N., Lorenzoni, I. & O'Brien, K. L. (eds.) *Adapting to climate Change: Thresholds, Values and Governance*. Cambridge: Cambridge University Press.
- Reservoirs Act (1975) [C.23] London: The Stationary Office.
- Rokeach, M. (1979) *Understanding Human Values: Individual and Societal*. London: collier Macmillan Publishers.
- Scott, J. (2001) *Power*. Oxford: Blackwell.
- Shillito, M. L. & De Marle, D. J. (1992) *Value: Its measurement, Design and Management*. New York: John Wiley & Sons, Inc.
- Silverman, D. (2010) *Doing Qualitative Research*. London: Sage.
- Simon-Vandenberg, A. M. (2007) Lay and Expert Voices in Public Participation Programmes: A Case of Generic Heterogeneity. *Journal of Pragmatics*. 39, 1420-1435.
- Steelman, T., A. (2002) Community-Based Involvement in Biodiversity Protection in the United States. In: O'Riordan, T. & Stoll-Kleeman, S. (eds.) *Biodiversity, Sustainability and Human Communities*. Cambridge: Cambridge University Press.
- Thornberg, R. & Charmaz, K. (2014) Grounded Theory and Theoretical Coding. In: Flick, U. (ed) *The SAGE Handbook of Qualitative Data Analysis*. London: Sage.
- Tripathi, R., Sengupta, S. K., Patra, A., Chang, H. & Wong, I. W. (2014) Climate Change, Urban Development, and Community Perception of an Extreme Flood: A Case Study of Vernonia, Oregon, USA. *Applied Geography*. 46, 137-146.
- Urquhart, C. (2013) *Grounded Theory for Qualitative Research: A Practical Guide*. London: Sage.
- Vickerman, R. (2007) Cost-Benefit Analysis and large-Scale Infrastructure Projects: State of the Art and Challenges. *Environment and Planning B: Planning and Design*. 34, 598-610.
- Warner, J. F. (2006) More Sustainable Participation? Multi-Stakeholder Platforms for Integrated Catchment Management. *International Journal of Water Resources Development*. 22, 15-35.
- Watson K. J. & Whitley, T. (2016) Applying Social Return on Investment (SROI) to the built environment. *Building Research & Information*.
- Welsh, E. (2002) Dealing with Data: Using NVivo in the Qualitative Data Analysis Process. *Forum: Qualitative Social Research*.

- Whatmore, S. & Landstrom, C. (2011) Flood Apprentices: An Exercise in Making Things Public. *Economy and Society*. 40, 582-610.
- Wong, K. K. W., Kumaraswamy, G. M. & Ng, S. T. (2012) Utilising Societal Engagement as a Vehicle for Enhancing the Image and Sustainability of the Construction Industry. *Sustainable Development*. 20, 222-229.
- Young, J. C., Jordan, A., Searle, K. R., Butler, A., Chapman, D. S., Simmons, P. & Watt, A. D. (2013) Does Stakeholder Involvement Really Benefit Biodiversity Conservation? *Biological Conservation*. 158, 359-370.