PROMOTING DOUBLE LOOP LEARNING IN FLOOD RISK MANAGEMENT IN THE SCOTTISH CONTEXT

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In Scotland, flood risk is predicted to double by 2100 due to climate change and land use changes within river basins. Flood Risk Management (FRM) has emerged as a strategic framework to encourage resilience through collaboration, risk assessment and flood plans designed to target investment for prevention and defence schemes. Learning in this context has often been criticised for being single loop, reactive, narrow, and fragmented and ignoring wider socio-technical issues. The Scottish Flood Risk Management Act (2009) has shifted focus from flood defence to a holistic prevention based approach which encourages the double loop learning (DLL) necessary to promote sustainability and greater resiliency within the social system. This research explores the extent FRM in Scotland has promoted DLL at both a strategic and project levels following the application of the 2009 Act. A literature review identifies that to promote DLL requires FRM to be proactive, seek new knowledge, be creative, question, and be holistic when making future based decisions. These characteristics were considered in two research phases, 1) a survey of Scottish local authorities (response from 22 of 32) in 2011, supplemented by stakeholder interviews focused on the strategic level and 2) follow up stakeholder interviews in 2014, and case study exploring operational implications at a project level. The research found that changes in FRM since 2009 have provided a framework where DLL can potentially flourish but this is a transitional phase with social-technical barriers restricting its delivery in practice at both strategic and project levels. Findings stress the importance of fostering a proactive and learning culture surrounding FRM which supports the management of explicit and tacit knowledge between strategic and project levels maximising opportunity for DLL during and post flood events, but also in identifying and managing individual projects.

Keywords: flood risk management, double loop learning, knowledge management, case study.

INTRODUCTION

The significant risk posed by flooding within the UK has been highlighted during the winter of 2013/4 by flood events in Humberside and across the South of England. Many argued that severe floods in 2007 and periodic floods in Cumbria in 2009 and 2012 had acted as a *"wake-up call"* to a naive British society (Pitt 2008). However, despite increased investment in flood defence schemes the resilience of the infrastructure remains incomplete and unable to cope with the frequency and severity of recent flood events. The cost to the wider economy, societal inconvenience, property damage, risk to life and animals, insurance concerns, coupled with a growing awareness of the link between river basin development patterns and flood risk is

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placing pressure on governments. The social system is unprepared, with the dominant approach focused on hazard management defending previously flooded locations through costly, disproportionate, heavily engineered reconstruction projects (Schmidt-Thome and Schmidt-Thome 2007).

Flood Risk Management (FRM) aspires to provide a proactive process based approach which examines the effects of flooding on the system by integrating stakeholders and considering their common problems and concerns, as well as learning from best practice and collective experience (McFadden *et al*. 2009). It intends to change the perception that flood events are extraordinary and reactively managed, but instead to be viewed as an ever present threat (Hillson 2007). This approach intends to be less responsive and instead planned, holistic, and proactive in identifying and then mitigating potential flood risk. Shaped around a classic risk management model of risk identification, risk analysis, risk assessment and risk reduction it is intended FRM will provide the basis for action plans which reflect the needs of the social system and enable targeted investment in a range of integrated measures based on adaptation and mitigation. Such an approach to risk aims to promote continual improvement and assessment of the system (economic, social and environmental) to proactively deal with risk (BS ISO 31000:2009). Under EU Floods Directive all member states must create and update flood maps and management plans to minimise the risk and create resiliency. Despite this rationale, many have questioned its current application in practice (Bosher *et al*. 2009); citing a retained inability to capture, acquire learned knowledge from past floods and to apply this effectively in flood mitigation management (Steinfuhrer 2009; McFadden *et al*. 2009). FRM principally aims to value knowledge and learning within its practice (Fleming 2001); however, the recent floods in the UK have promoted many to question the delivery of its basic principles in current practice and to call for prompt action from policy makers.

This research focuses on the practice of FRM in the context of Scotland. Due to differences in topography, land use patterns and population densities when compared to the rest of UK, Scotland is argued to experience lower flood risk; however this is predicted to double by 2010 (Scottish Government 2014). Record investment has already been placed in flood defence schemes over the last decade and The Scottish Flood Risk Management Act (2009) (referred to as 'the Act') passed to guide future action and investment plans through its intended inclusive and proactive approach. At a strategic level, districts and sub-districts have been created with local authorities identified through legalisation to co-ordinate development of tailored flood plans with the Scottish Environmental Protection Agency (SEPA) guiding the process and developing flood risk maps. These maps aim to promote a better understanding of the nature of flood risks at a local level and to encourage co-ordination between agencies and service providers. As well as identifying hard engineering solutions in flood defence, the maps aim to promote the potential for natural flood management and to facilitate greater awareness amongst the various stakeholders and agencies of the nature of the risk highlighting interdependencies. The Act is phased in its introduction, with the Flood Risk Management Strategies to be developed by 2015, and Local Flood Risk Management Plans by 2016.

Since 2009, Scotland hasn’t been tested with the scale of flooding seen in other parts of the UK and a legitimate question remains over whether the Act has delivered the desired proactive inclusive approach in practice required to facilitate resilience or whether there are problems in the transition.

FRM Act and double loop learning

A change in culture is needed and whilst authors have challenged the nature of the learning approach within FRM, few have explored the type of learning required. In Scotland, the Act has sought to promote double loop learning (DLL) through a governance structure which encourages a questioning of the system, challenges the existing norms and permits a more sophisticated management response able to consider innovative solutions based on a wider evidence base. The Act outlines a process for developing flood risk strategies and plans at national and local levels which moves away from single loop learning (SLL) and its association with reactive approaches responding to the perception of risk (Argris and Schon 1978). To achieve this, a clear process with defined roles and responsibilities for stakeholders (including created role of FRM officer), stipulated requirements and mechanisms for stakeholder inclusion have been specified. Local Flood Risk Management Plans will be fully developed in 2016 with a review after 6 years as part of the FRM planning cycle, and the overall national FRM strategies spanning three of these cycles (i.e. 18 years). The process is structured to provide feedback and reflection aiming to promote DLL by enabling previous assumptions to be challenged through evidence and consideration of best practice. To support the process, the Act stipulates the need for an inclusive partnership of key stakeholders (local authorities, MET Office, SEPA and Scottish Water- SW) and to encourage active participation with the wider community in the development of the evidence base but also in formulation. A change in the way public bodies work together and gather evidence is recognised, with SEPA arguing that establishing knowledge and understanding collectively across administrative boundaries reflects the whole river catchment and is key to addressing wider causes and impacts of flooding. Whilst not fully applied till 2016, there is a need to consider how effective initial phases since 2009 have been in promoting DLL through structural and cultural changes at both a district level (strategic) and in its implications at an operational project level.

Requirements for promoting DLL

Despite its intentions and implementation, evidence from the winter floods of 2013/14 in England reveals high profile instances where authorities have been unable to predict accurately the flood risk and have been slow to respond in practice through mitigation and adaptation measures (Wedawatta *et al*. 2014). Voss and Wagner (2010) point to empirical evidence suggesting that FRM has often failed to achieve DLL due to limited participation of wider stakeholders thus restricting the potential to learn from previous flood events, incorporate alternate views and expertise, engage with socio-technical issues in the future infrastructure design and post flood reconstruction and response planning (a view supported by White *et al*. (2010)), with Frantzeskaki *et al*. (2014) calling for adoption of partnerships models to promote inclusion and learning

A key barrier identified within the literature relates to FRM's struggle to achieve its intended objectives due to a failure to move away from a traditional engineering mindset to the problem (Voss and Wagner, 2010; Steinfuhrer, 2009). In practice, FRM officers are emergency planners and/ or engineers who operate within a top-down structure and are often argued to restrict the opportunity for engagement with frontline stakeholders limiting their ability to contribute to future decisions (McFadden *et al*. 2009; Coaffe 2008). Many have experience of delivering flood defence schemes and display a preference through their training for a technocratic approach which can result in knowledge being considered in *"silos"*, narrow, hierarchical and exclusive by

manner with a preference for quantitative measures. Whilst their experience is valuable and plays a key role in decision making (Dawson *et al*. 2011), its retained dominance fails to reflect the intended wider socio-economic context, long- and short-term implications and variability of flood risk in FRM (Messner and Meyer 2005). In retaining a reliance on technocratic protocols and language, the potential exists for wider stakeholders to be excluded from decision making and learning processes (Steinfuhrer 2009). Such an approach retains SLL, and runs the danger of promoting apathy for FRM amongst decision makers during periods of limited flood events.

Widening participation during FRM is key to providing the potential for an exchange of knowledge both explicit (codified held, for example, in documents) and tacit (un-codified and held by individuals reflective of their role and experience) between stakeholders (Nonaka & Takeuchi 1995). DLL relies on both forms of knowledge to be effective but in retaining an engineering approach the potential exists to exclude the tacit knowledge stakeholders bring as professionals (expert knowledge) and as residents (local context and observed experience). Explicit forms of knowledge (e.g. quantitative data, best practice recommendations by government i.e. protocols) are important, but without tacit learnt experience of the local system (tacit knowledge) it is difficult to stimulate questions, be innovative and to foster tailored solutions reflective of the context and appropriateness of any intervention required from FRM.

In order to flourish, there is a need to provide a structure to the FRM process and to evolve the culture to: 1) be proactive, 2) provide new knowledge, 3) support creative thinking, 4) be questioning and 5) be holistic by nature. A limited number of successful examples highlighting that to deliver such a transition in practice leadership, guidance, and importantly enthusiasm need to be provided (Voss and Wanger 2010; White *et al*. 2014).

RESEARCH STRATEGY AND METHODS

A constructivist approach was followed in order to establish an understanding of current FRM practice and its promotion of DLL from the perspective of those involved. The high degree of change since 2009, and a lack of empirical studies in the Scottish context provide the basis for a study. Two research phases were undertaken: 1) in 2011 and 2) in 2014.

In 2011, a questionnaire survey was issued through email to the named FRM representative within the 32 Scottish local authorities as they were legally responsible for developing FRM strategy and plan in their district, establishing a base line of practice. 22 (69%) of the local authorities responded, representing a cross section in terms of size, rural/ urban split and geographical spread. Of the other 10, three failed to respond, and others cited reasons such as lack of time and newness to role. The survey was designed around attitudinal questions (using 5 point likert scale) to gauge views of established themes from the literature, with open questions to capture depth. The themes considered: background/ context, current flood plans and review process, nature of stakeholder involvement, learning styles (reactive/ proactive), knowledge (type, depth and creation), communication method (knowledge flow), and stimulus requirements for proactive learning (leadership, culture, resources). Five semi-structured interviews (each 30-40 minutes) with key stakeholders (FRM officers from two local authorities, SW and SEPA) were conducted to follow up findings from the survey with transcripts thematically analysed using Nvivo software.

A second phase was initiated in 2014 to explore further emerging themes but also to ensure the research reflected contemporary practice. Interviews were undertaken with a local authority Principle Flood Engineer (FRM Officer) and Flooding Project Engineer to explore practice at district and project levels. In order to consider the implications in practice, a case study project was considered which had been suggested by those interviewed as high profile and reflective of contemporary practice. The Bervie Braes slope stability project in Stonehaven (Aberdeenshire) is a complex project and represented an active flood risk threat.

RESEARCH ANALYSIS AND FINDINGS

This section explores themes emerging initially during the survey and interviews in 2011, but reflected on further in 2014.

Need to strengthen the role of a FRM officer

The survey revealed that FRM officer had emerged as a recognisable role with responsibility for overseeing the development of the flood risk strategy and plans. However, only five local authorities had created a full time position with the other 17 identifying this as a part time role held together with other positions commonly as emergency planners or civil engineers in roads and technical services. The interviews revealed a strong desire to elevate the position to a full time Senior FRM officer to raise the profile of flooding, but at the time, insufficient funds were available. The fragmentation of the role meant the ability and knowledge held by officers varied and had an impact on the delivery of FRM at a strategic and operation level. Indeed, 19 (of 22) either agreed or strongly agreed that the depth and desire for in FRM is dependent on the officer's motivation and ability to interpret knowledge. In 2014, outwith of some key authorities the situation had not changed.

Retained technocratic bias in decision making

The Act, has stipulated a rounded role for a FRM officer with structured duties designed to mitigate reliance on an individual's own perspective and attributes. Despite this, legalisation was felt to be vague on non-engineering factors and with FRM officers being predominantly engineers this has restricted the degree of questioning and creative thought around socio-technical issues. A FRM officer felt that whilst engagement with local residents and stakeholders had increased, it remained in response to historic and visible flood risk retaining the dominance of SLL and limiting the ability to think proactively and holistically. SEPA and SW representatives argued that when placed in a culture of budget cuts, this mindset limits stakeholder engagement as a minimum requirement, a view encountered also in 2014.

Development of dictated flood maps, plans and procedures

FRM officers argued the Act has outlined a structure which will create an environment where plans are created and periodically reviewed in depth, thus promoting learning by the set approach to evaluating flood risk data. Prior to the Act, councils produced bi-annual reports where projects are added to by members only promoting major changes should a flood event occur; embodying SLL. In 2011 it was too early to observe the full impact of the Act in practice with 13 (out of 22) councils still having no flood plan and with 18 indicating they had no procedure underpinning the identification of risk. In 2014, delays in district level flood risk maps were observed to be retaining a reactive approach identifying future projects.

Knowledge gaps in reporting

17 (of 22) respondents concluded that there remained knowledge gaps within FRM both in terms of its delivery as a process and in terms of its analysis. Prior to the Act,

knowledge needed to be explicit, factual and evidence based with risk assessed largely on past events. The Act aims to promote stakeholder engagement and brainstorming in order to capture tacit knowledge and promote learning around the development of the bi-annual report. Several FRM officers observed that these reports cannot realistically deal with all of the issues surrounding flooding and there was a tendency for those involved to primarily focus on the physical damage caused, the environment that caused it and the council's response to it. However, the SEPA representative stated that guidance is provided for methods of data gathering and storage of flood data and knowledge. Local authorities widely reported a shortfall in the reflection of tacit knowledge in these reports, and from a project perspective a need exists to capture lessons learnt to inform future FRM strategy and other projects essential for DLL, and no change was observed in 2014.

Moves towards proactive learning

20 (of 22) observed that learning takes place largely due to new knowledge gained after a flood event; however 19 felt that in retrospect much of this could be learned prior to the actual flood. In-spite of the Act, nine respondents felt that learning remains reactive, relying heavily on flood events for evidence. However, the potential exists through the Act for a proactive approach but the wider view was its implementation needs better support. A strong barrier observed to promoting a proactive approach was the potential reaction of unaware residents that their properties were now at risk.

Sub-district Advisory Groups

The introduction of the Bi-annual Sub-district Advisory Group was bringing greater creativity through its increased membership and diversity but it was observed to be confined to engineering aspects and limited concern for socio-technical issues. Although chaired by SEPA, its success depends on the local FRM officer to facilitate an environment where local stakeholders provide this knowledge. However, involving and documenting the views of large numbers of stakeholders will present resource pressures which could limit potential for inclusion and ultimately DLL.

Guarding against apathy

A culture of budget cuts forcing mergers of roles and increased workload was argued to present the potential for complacency and apathy to flood risk especially with long periods between major flood events. Respondents revealed that successful FRM takes place when politicians recognise the severity of the problem, and when a proactive FRM officer drives the process to foster DLL. Highlighted in both 2011 and 2014 the desire to engage with wider stakeholders and develop a high level of collective knowledge is difficult in a culture of apathy.

Significance of tacit knowledge and its management

The survey identified reliance during FRM on explicit sources of knowledge such as best practice guidelines, statistical data and records, stakeholder reports. An awareness of the value of advice from experts, locals, and stakeholders was presented but such tacit sources remained low in priority. The value of tacit knowledge was highlighted where local knowledge of coastal conditions greatly informed the development of flood maps resulting in significant cost saving through design changes on a flood defence project. The challenge of managing and retaining access to this resource during the planning cycle was revealed as the individual (local authority employee) was retiring.

SW argued that the Act should result in a greater volume of learning, however the depth and quality of learning is dependent on the willingness of the parties to

cooperate and it is this interaction which creates new knowledge and facilitates DLL. The Act creates the structural conditions; however the FRM officer was identified as playing a key role in the delivery of more tacit knowledge and aiding the transition from SLL to DLL. Despite this, interviews in 2011 and 2014 questioned the ability of the FRM officer to capture the vast amounts of knowledge held by frontline staff and local stakeholders relating to flood risk. The interviews revealed concern that through the absence of techniques such as lessons learnt at the project level, only the most important tacit knowledge is captured by the FRM officer, often in a general way thus restricting DLL.

Communication pathways

At a strategic level, a traditional focus on meetings and reports was slowly evolving to include more informal communication pathways between stakeholders. The Bi-annual Sub-district Advisory Group was seen as encouraging wider inclusion, but many felt that the frequency should be limited as too much knowledge exchange could prove counterproductive and result in a 'talking shop'. The FRM officer is key to ensuring a meaningful transfer of knowledge between FRM at a district level into individual projects. Their organisational skills and enthusiasm for the Act were identified as crucial to its success as they set the strategic context and provide guidance to project teams providing legitimacy for decisions which may not seem intuitive within the context of an individual project. As the knowledge 'broker', an apathetic officer has the potential to restrict the process and fail to create the opportunity to learn. However, a lack of formal guidance was observed in 2011 and 2014 as causing problems at an operational level.

Skills gap in those delivering FRM

An inability for local authorities to build capacity due to budget restrictions was been identified to have led to a reliance on consultants who provide a specialist service such as flood modelling. However, a consultant is often removed from the local context, and therefore isolated from the knowledge exchange necessary for DLL. This approach may further reduce the skill levels in local authorities, as they rely on this expertise without being able to learn from it. In this position, the officers need to learn to ask the right questions, with a clear need to provide integration between strategic and project levels

Integration of FRM between strategic and project levels

Emerging across both research phases was the need for better integration between the national, district and project levels in delivering FRM something which the increased availability of flood risk maps over the next year or so will promote aiding a shift towards a proactive approach. Until then, many districts will still identify future projects based on budget and perceived need, but the potential exists for the maps to transform how local authorities approach FRM within their district towards a proactive standpoint. Whilst a transition is emerging in project identification, by 2014 evidence suggested that DLL was further promoted by FRM being tied to developing the local plan and therefore shaping planning requirements. At a project level, to enable DLL increased focus is required to ensure that lessons learnt from previous projects are established but the interviews revealed that there were no specific measures in place to enable the capture, storage and retrieval of key lessons. Explicit knowledge held in project documents can be stored and shared, but it is apparent that more needs to be done to ensure the learned experience of the project team is captured and accessible to help shape future decisions.

BERVIE BRAES SLOPE STABILITY PROJECT, STONEHAVEN

The Bervie Braes comprises a 850m long coastal slope bisected by a former trunk road which has suffered from instability for a number of years. The project's initial focus was to stabilise the road posing a potential flood risk highlighted following significant flood events in 2009 and 2012, enabling political recognition and resources to be available to support the stabilisation project. Owned by a private trust (although Aberdeenshire Council retain responsibility for the road and its footprint) the future of the slope achieved wide spread engagement from stakeholders. Investigations revealed that the instability is caused by shallow groundwater which promotes increased pore water pressures at times of heavy rainfall which, in turn triggers slope instability especially in the steeper areas of the Braes (Mickovski *et al*. 2013). Stabilisation was proposed involving a design focused on soil nailing and a range of drainage measures to control surface water and ground water levels.

Aberdeenshire Council's flood team (principal engineer for flooding i.e. FRM officer and a project engineer) were interviewed and reported that the project was reactive by nature to a long term problem but, given local interest and political support for a solution, the design was able to consider the long term sustainability of the slope. The planning phase involved preliminary discussions between stakeholders regarding specifics of flood risk, legalisation, budget, timescales and disruption. Engagement with locals and wider stakeholders was reported to be significant compared to comparable projects within the same district due mainly to self-organisation, interest and willingness to be involved amongst the local community. Regular formal and informal meetings during planning (but continuing through the project) helped designers to reflect local knowledge but also facilitated community understanding and acceptance of proposals and eventual disruption. It was stressed that this wasn't initiated by the changes in the Act but was driven in response to local interest, but shares many of the principles encouraged and aids DLL. The planning application was positive, but some design changes were made following hydrological and hydrogeological studies (Mickovski *et al*. 2013), with a decision taken to discharge road drainage directly into the watercourse which was more distant but had higher attenuation capacity. A number of options were presented, and considered by stakeholders in a range of formal (Sub-district Advisory Group, project meetings) and informal (one to one discussions) mechanisms. Implications were explored, and through consultation, and assessment of flood risk a design was agreed. The design changes were costly (time and monetary), however through consultation and an effective flow of communication and local knowledge between designer and stakeholders, the proposals were deemed acceptable and the end cost was reduced. The solution reduced potential of flood risk from the source of very high drainage volumes making this cost minor in comparison to the potential damage from a flood event. To aid engagement with the community, a video fly through was developed to facilitate acceptance and engagement with the project.

Reflecting the transition in practice since 2009, it has lacked district flood risk maps, but has embraced stakeholder engagement in line with the principles outlined in the Act. Political acceptance and a proactive FRM officer have helped provide an environment where the holistic picture can help shape project decisions. Enabling the designer to suggest innovative long term solutions and by promoting these through community engagement facilitate acceptance but benefit the design through local knowledge. In contrast, the same team were presented with another project in the district with less profile, high levels of apathy and a disengaged community resulting

in a less creative design process. This illustrates the importance of a proactive project culture to promoting a dynamic learning environment, and this can't be left to chance.

Three additional issues emerged reflecting a need for integration between strategic and project levels: 1) the project team felt isolated from the flow of the knowledge surrounding FRM as this was held by the officer or SEPA; 2) the process relied heavily on the FRM officer to manage the flow of knowledge and interpret SEPA guidance for individual project teams; and 3) with legalisation interpretation being left to individual councils this presents contrasting experiences.

A key observation in terms of promoting DLL was a gap existing in the flow of knowledge between this and other projects. Projects identified in a district FRM plan tend to operate in parallel, but managed by different teams. FRM officer stated that greater communication is being encouraged between teams to share their experiences but this remains at a high level and not on detail or technical issues which could have highest impact. This aligns with findings from earlier interviews where establishing lessons learnt has potential to support the transfer of knowledge between strategic and project levels, but also individual projects and thus enhances DLL.

CONCLUSIONS

The research revealed that since the Act 2009 the application of FRM in Scotland is in a period of transition, with full implementation not due to 2016. The Act intended to foster a holistic and proactive approach to FRM through a structured process designed to promote evidence based decisions within an inclusive stakeholder centred environment aiming to promote DLL. FRM officers broadly supported the principles advocated through the Act and recognised the intention of the structural process outlined and its potential to promote DLL. A recent delay in the production of complete flood risk maps across Scotland is making it difficult to fully implement the desired proactive approach to FRM. However even in its transition, stakeholder engagement has emerged as a recognised part of the process at both strategic and project levels responding to structural requirements but importantly a growing cultural awareness is emerging amongst decision makers of its value for DLL. Evidence suggested that enabling a wide range of stakeholders to participate allowed tacit knowledge from communities to contribute towards decision making but also aided acceptance. Despite this, a number of social-technical barriers were identified which currently impede the ability of FRM to promote DLL: the fragmented role of FRM officer, retained engineering mindset, skills gap in those delivering FRM at district level, resource limitations, apathy, knowledge gaps in reporting, absence of flood risk maps, challenge of managing tacit knowledge, and a lack of inter and intra project learning. The case study reveals a positive picture, highlighting the value of local knowledge and stakeholder collaboration to ensure the strategic and local flood risk considerations are incorporated at a project level. This project displayed many of the proactive and questioning characteristics associated with DLL, but instilling these characteristics in other projects is largely dependent on removing the socio-technical barriers and recognition of the value of knowledge for stimulating learning. Finally, interviews in 2014 highlighted the need to strengthen opportunities to learn from flood events in different contexts and between projects, with research needed to support the capture, storage and retrieval of knowledge.

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