The Cork City flood of November 2009: Lessons for flood risk management and climate change adaptation at the urban scale

James M. Jeffers

The Cork City flood of November 2009: Lessons for flood risk management and climate change adaptation at the urban scale

Flood hazards are a pressing challenge in several Irish and European cities and their impacts seem likely to intensify as climate change brings sea level rise, changes in storm patterns and increases in rainfall. Drawing on the example of Cork City and the November 2009 flood in particular this paper evaluates contemporary policy and decision-making responses to flood hazards to determine whether they are sufficient to address current and future flood risks and vulnerabilities. It is clear that current policy and practice remains heavily influenced by a risk management paradigm that emphasises physical exposure and largely ignores socio-economic vulnerability. Floods and the losses they induce are seen as identical while engineering and technological fixes are viewed as the optimal means of reducing future flood losses. This framing of flood hazards is shaped by several influences including the historic evolution of flood policy and current institutional structures. The November 2009 flood highlights the limits of current policy and practice. Recent changes in national and European policy may also prove to be ineffective in facilitating effective adaptation and further changes in policy and practice are likely to be required.

Keywords: climate change, adaptation, vulnerability, floods, risk, Cork

Introduction

Climate models indicate that increases in winter stream flow are likely in many parts of Ireland (Sweeney, *et al.* 2003, Charlton, *et al.* 2006, McGrath and Lynch, 2008, Steele-Dunne, *et al.* 2008), with the implication that more flooding is in store for riverine residents. Places like Cork City, which have a long history of human adjustment to floods, may be at particular risk. Although the unexpectedly destructive flood of November 20th 2009 was exacerbated by the decision to release water from the hard-pressed Inniscarra Dam, it provides a preview of the type of extreme event that is likely to become more common in the future. It also serves as a test of existing flood policies and offers clues to the climate change preparedness of Irish cities, contexts where multiple stakeholders share responsibilities for

anticipating and responding to flood hazards. In particular it provides an opportunity to review the adequacy of existing flood adaptation measures against the backdrop of Ireland's first Catchment Flood Risk Assessment and Management Study (CFRAM), a diagnostic planning tool that is becoming the centrepiece of Ireland's implementation of the European Union (EU) Floods Directive, part of efforts to improve the safety and security of flood threatened areas throughout the continent.

Climate change adaptation in cities

Climate change adaptation in cities has become an increasing focus of research by geographers and others (Fünfgeld, 2010, Carter, 2011, Hallegatte, *et al.* 2011, Hanson, *et al.* 2011, Hunt and Watkiss, 2011, Leichenko, 2011, Rosenzweig, *et al.* 2011). Adaptation research draws from and builds on an already extensive literature on natural hazards in urban contexts (Mitchell, 1999, Pelling 2003, Pelling and Wisner, 2009, Chatterjee, 2010). Flood hazards in particular have begun to receive increased attention from researchers across Europe (Mitchell, 2003, Johnson, *et al.* 2007, Parker, *et al.* 2007, Parvin, *et al.* 2008, Whittle, *et al.* 2010, Dawson, *et al.* 2011, Walker and Burningham, 2011) while the challenges associated with adaptation in Europe (Naess, *et al.* 2005, Amundesen, *et al.* 2010, Biesbroek, *et al.* 2010, Lugeri, *et al.* 2010, Mechler, *et al.* 2010,) and Ireland (Falaleela, *et al.* 2011, Kopke and O'Mahony, 2011) are also the subject of increasing scrutiny. Out of these different bodies of work has come a concern that the high adaptive capacity present in many developed countries may not automatically lead to successful adaptation (O'Brien, *et al.* 2004, Repetto, 2008, Moser, 2010).

The literature on climate change adaptation has highlighted several circumstances that enable or hinder effective decision-making in the face of hazards. Amundsen, *et al.* (2010) examine decision-making among municipal officials in Norway and conclude that direct

personal experience of hazards is the most important facilitator of adaptation but that this often leads to a highly reactive decision-making process. A lack of recent direct experience of hazards may attenuate concern and reduce the likelihood of adaptive or preparatory actions being taken (Harvatt, *et al.* 2011). It has also been suggested that reactive decision-making, particularly in response to surprise events may not bring about new or radical changes in policy but surprise events can act as a catalyst for changes that were already likely (Johnson, *et al.* 2005, Penning-Rowsell, *et al.* 2006).

The ways in which knowledge is shared and disseminated among officials and stakeholders and across different levels of governance also helps to shape decision-making and policy (Carmin, *et al.* 2009). Top down approaches that originate from national or international sources or other outside influences are often not the main drivers of local change (Anguelovski and Carmin, 2011) and top down policy can be ineffective due to slow rates of implementation at lower levels of governance (Tunstall, *et al.* 2009). Narratives that raise awareness and the actions they promote can also be heavily influenced by institutional structures or organisational cultures (Harries and Penning-Rowsell, 2011). These factors are important considerations in both an Irish and a European context. Flood hazards policy in Ireland is largely formulated at a national level although it has undergone some modification in recent years in response to policy changes at the European level. Cross-scale governance is increasingly important in European cities as the EU plays an increased role in both hazards and climate adaptation policy.

A mismatch between the operating requirements of institutions under "normal" conditions and during emergencies can play a central role in influencing the vulnerability and adaptation of local populations. Institutions that have been designed with clearly understood areas of responsibility, well defined geographical jurisdictions and appropriate types of expertise do not always perform effectively when faced with hazards that emerge quickly,

cross institutional borders, combine disparate causes, produce impacts in distant places, and require the application of cross-disciplinary knowledge (Robbins, *et al.* 2008). All of these challenges are present in Ireland, even though floods are not a new problem. Floods have complex human and non-human drivers that do not fit neatly within the skill sets of professionals in the agencies that are charged with their management. Governance structures that were perhaps suited to the circumstances that prevailed at the time they were created may not be well positioned to address contemporary issues (Dodds, *et al.* 2010).

Power relations both within and between institutions have been identified as an important influence on the decision-making process (Koch, *et al.* 2007). It is also likely that the power of formal state actors plays a particularly import role in defining approaches to the issue, influencing the behaviour of other state and non state institutions and actors. Koch, *et al.* (2007) have emphasised the role of institutional actors in South Africa in defining climate change and ranking it relative to other concerns such as economic growth, job creation or poverty reduction. How a problem is defined, whether it is considered a problem at all and how its importance is perceived relative to other issues are among the key factors influencing the types of decisions that are subsequently taken (O'Riordan and Jordan, 1999, Koch, *et. al.* 2007, O'Connor, 2001). It is clear that adaptation to urban climate change is influenced by a variety of situational contexts that set the boundary conditions for framing decisions and management strategies. The flood experience of Cork in 2009 offers an opportunity to study these contexts at close range.

Flooding in Cork

In many ways Cork City provides an ideal case study for an analysis of decision-making and policy responses to both contemporary flood hazards and the challenges likely to emerge from climate change. Due to its physical setting the city has a long history of exposure to

flood hazards. Much of the city centre is built on what is now a large island between two channels of the River Lee, both of which are tidal. These channels are the last vestiges of a more extensive surface drainage network. Much of the modern centre island lies at elevations just above the highest spring tides. As a result it is exposed to both fluvial and tidal flooding. On the western side of the city, lands on both river banks form part of the flood plain of the River Lee, an area of frequent inundation. On the eastern side, much of what is now the docklands area is situated on land reclaimed from the estuary of the Lee between 1774 and 1841 (Coughlan, 2009). This district remains liable to flooding due to its low elevation and poor drainage but despite its exposure, this portion of the city has been primed for extensive redevelopment. With the relocation of all of the city's port functions to locations further downstream, the long term plans for this area include the construction of large scale residential and commercial developments (Cork City Council 2001, Cork City Council, 2008, Cork City Council, 2009). The hydrology of the River Lee has also been modified by the construction of two upstream dams at Inniscarra and Carrigadrohid. These were completed during the 1950s and were built primarily for hydroelectric power, not flood control. However they have been used to reduce floods in the past (Fitzpatrick and Bree, 2001).

Published research reveals that two hundred and ninety floods were recorded in Cork between 1841 and 1988 (Tyrrell and Hickey 1991) while several additional floods occurred between 1988 and the present. There have been numerous relatively minor events but the city's history also includes large floods leading to loss of life and substantial economic costs. The earliest documented reports of flooding in Cork date from 1633 when several bridges are believed to have been swept away by the River Lee (Tuckey, 1837 cited Hickey, 2010). In 1789 a river flood described as being between 1.5m to 2m deep in some parts of the city killed at least one resident (Cawley, *et al.* 2005, Hickey, 2010). One of the most severe floods struck in November 1853 when 12 people were killed, with several of these deaths occurring

when St. Patrick's Bridge was partially swept away (Cawley, *et al.* 2005, Hickey, 2010). River floods in 1916 were among the worst experienced and were described as comparable to the 1853 event (Cawley, *et al.* 2005). It is worth noting that the 2009 flood was not the first time a release of water from the Inniscarra dam led to flooding in Cork City with similar but less severe floods having occurred in 1960 and 1988 (Hickey, 2010).

Methodology

The research on which this investigation of the Cork flood is based was part of a larger study of urban vulnerability to flooding in Ireland that examined, how available knowledge is used by local decision-makers in preparation for hazard events, how hazards are framed and conceptualised by those decision-makers for the purposes of policy-making and management, and whether current institutional structures and policies are sufficient to meet the challenges of contemporary hazards and future change. A content analysis of the minutes of 192 meetings of Cork City Council held between January 2001 and January 2010 provided an illustration of decision-making responses to floods over recent years. While the minutes provide a limited summary of the meetings they nevertheless present a clear indication of the types of policies formulated and illuminate some of the motivations behind particular decisions. A similar analysis of the records of Dáil Éireann debates over the period 1985 to 2010 provided data on the evolution of national decision-making over an extended time period. The investigation of the Joint Oireachtas Committee on the Environment into flooding and severe winter weather conducted over the course of seven meetings held between December 1st 2009 and March 23rd 2010 provided a unique opportunity to examine the views of numerous local stakeholders into the flooding experienced in Cork and other parts of Ireland in November 2009. The records of this investigation provide over 160 pages of transcripts which were analysed in conjunction with the final report published in the

aftermath of the investigation. Together these provided a valuable picture of the ways in which floods are conceptualised and framed by local actors and of the types of responses and adjustments to flood hazards they wished to see implemented. These content analyses were combined with a review of relevant policy documents. Finally semi-structured interviews with local executive officials, elected decision-makers and other stakeholders provided data on framings of hazards that were employed, likely future policies and the types of knowledge used in local decision-making. These interviews were completed less than three months before the November 2009 flood. This proved to be fortuitous because they provide insights into perceptions of flooding in advance of this event which can be contrasted with the discourses that have developed in its aftermath.

The November 2009 flood

The November 2009 flood was the most severe to affect Cork City in many years. It was triggered by heavy rain that led the Electricity Supply Board (ESB), owners and operators of the Inniscarra Dam, to release large volumes of water downstream in order to ensure its safety in the face of excessive inflows. At the peak of the flood it has been estimated that up to 535 tonnes of water per second was passing through the dam and the ESB has claimed that the event had a return period of 800 years (Hickey, 2010). Much of the city centre and the western suburbs experienced heavy flooding. Fortunately no fatalities occurred but economic losses and disruption to the life of the city was considerable. The municipal water treatment plant was damaged, leaving many of the city's residents without water for several days (Hickey, 2010). Classes at University College Cork were cancelled after a large portion of the campus was flooded. Flood waters also surrounded the Mercy University Hospital requiring key staff to travel to and from work by boat. It has been estimated that the total economic costs of the flood may exceed €100 million (Hickey, 2010).

Public attention has focused on two aspects of the event: (1) a perceived failure to give adequate warning to the population of the city and (2) a belief that the flood itself should have been prevented or more effectively managed. Both reactions have focused attention on the roles of several public agencies that have responsibilities for flood hazards preparedness and mitigation, most notably Cork City Council and the ESB. The post event discourses visible in media coverage and in the testimony of multiple witnesses before the Joint Oireachtas Committee on the Environment suggest that many stakeholders fail to distinguish between the physical event and the losses it induces. This misunderstanding of flood risk emphasizes physical exposure but does not consider other drivers of loss. This paper examines-reasons for the persistence of this view and the ways in which the 2009 event has highlighted some of its weaknesses. Despite recent changes of practice that may address some of the resulting problems, there are reasons for concern about continuing deficiencies in management of current and future flood hazards.

Prevention and control of flooding

The roles and responsibilities of various flood hazards managers in Ireland have evolved over a period of more than sixty years but the main public agencies with authority to act remain the Office of Public Works (OPW) and the local authorities (City and Council Councils). In the aftermath of the Report of the Flood Policy Review Group in 2004, the OPW was designated as the national lead agency for flood risk management for both river and coastal flooding. The local authorities remained responsible for storm water and road surface drainage, for some coastal protection works and for the regulation of planning and development in all areas including flood plains. This division of duty represented a realignment of responsibilities after widespread floods in 2002, particularly in Dublin. Previously, responsibility for flooding was more diffused with the OPW having some

responsibility for river flooding, although this had historically focused on the drainage of agricultural lands. Some powers to address river flooding were also vested in the local authorities while responsibility for coastal flooding lay with the Department of Communications, Marine and Natural Resources. As a result of the Flood Policy Review Group's work, Ireland acquired a somewhat more streamlined and centralised system of flood hazard management.

While the role of the OPW is now clearly described as one of flood risk management, historically it had as much to do with economic and agricultural policy as it did with environmental hazards. In particular, it had discharged many functions under the Arterial Drainage Acts 1945-1995. These laws were originally established not as flood hazards mitigation mechanisms but as a framework for the improvement of agricultural land. The focus on drainage of agricultural lands remained central to the mission of the OPW until the mid 1990s when increased emphasis was placed on urban flooding for the first time. The economic benefits that might accrue from the drainage of agricultural land were central to the passage of the Arterial Drainage Act in 1945 and this is evident in the records of parliamentary debates from the time. Hazards policy and decision-making rarely occurs in isolation from social and economic contexts that shape both the formation of policy and the vulnerabilities of human populations (Mitchell, *et al.* 1989, Watts, 1989, Mustafa 1998, Platt 1999, O'Neill 2006).

The Arterial Drainage Acts were the keystone of Ireland's flood hazard policy from 1945 until the mid 1990s when emphasis began to shift towards flood prevention in urban areas. Despite this change, the emphasis on drainage has continued to influence how flood hazards are conceptualised and understood, as well as the types of responses that are adopted. Institutional cultures formed when engineering and technological approaches were the norm can remain dominant even after alternative policies have become the favoured option (Harries

and Penning Rowsell, 2011). Floods continue to be viewed fundamentally as a problem of drainage and the reasons for addressing them in this way are seen primarily as economic, with little consideration given to future climate change.

An analysis of the City Council minutes in Cork, Dáil Éireann debates and interviews with local officials illustrates the dominance or a risk management paradigm that emphasises the control and prevention of physical exposure as the primary policy-making objective. Floods are viewed as controllable through the application of expert knowledge, usually that of engineers. When flooding occurs it is considered a failure of these professionals to properly apply their expertise to the challenge. All floods regardless of their size, origin or impact are often treated in the same way at local City Council meetings. Typically a City Councillor will ask that the City Manager direct the engineering or drainage department to conduct an investigation into a specific flooding problem and to find a solution that prevents the flood from reoccurring. The approach is similar regardless of whether the flood is simply an accumulation of water on an individual street that creates a traffic hazard, or a larger event that inundates multiple properties. In almost all cases floods are seen as preventable given the appropriate level of engineering expertise and the availability of sufficient funding. Discussions emphasise the "prevention" and "elimination" of floods and the "protection" of local residents. This appears to be largely supported by the City Managers whose replies often focus on the availability of funding and other resources to provide for engineering solutions rather than the wisdom of the engineering solutions themselves. When a flood occurs it is often seen as an indication that the City's artificial drainage network has failed to function adequately because it is assumed that it should be possible to virtually eliminate flooding in a modern city. This illustrates how local decision-making is the product of both a dominant discourse and related institutional structures at both local and national levels. The dominant discourse views floods as something that can be managed and controlled. This links

to the institutional structure of local government in Ireland which almost always assigns responsibility for flood hazards to the engineering or drainage department of the local authority. A loop is created where engineering is considered the optimal solution in part because engineers are given responsibility for floods, but that responsibility is given because floods are viewed as a problem engineers can fix. The historical focus on arterial drainage undoubtedly shaped these structures and institutional cultures formed when engineering was the preferred flood mitigation policy can continue to shape local practice. This focus on engineering excludes different perspectives (e.g. natural science) and knowledge (e.g. human ecological), among others, which might offer alternative strategies for flood loss mitigation.

A similar trend is visible in the discussion of flood hazards in the national parliament. An examination of the records of Dáil Éireann from 1985 through to 2009 shows that flooding is an issue that is raised with increasing frequency in parliament. Local TDs frequently raise questions regarding flooding in a particular location within their constituencies. The TD will typically request that the relevant Government Minister direct the attention of the OPW to the flooding in this location. The expectation is that the OPW will investigate flooding in this location and if funding is available provide an engineering solution in an attempt to ensure that flooding does not occur there again. In a similar manner to the discussions of flood at the level of local government, flood "elimination" and "anti-flooding" measures are viewed as the optimal means of ensuring that flood losses are reduced or eliminated.

The dominance of this tech-fix discourse was particularly evident in the recent inquiry of a parliamentary committee into the widespread floods of November 2009. Preventing the floods from reoccurring was seen as the only way of ensuring that losses and disruption experienced in Cork City and along the River Shannon were not repeated. As one TD observed during a meeting of the Committee on February 23rd 2010,

> "I welcome our visitors from the ESB, but with no disrespect, I have heard the same history and geography lessons in previous presentations relating to rainfall, etc. What the people in the midlands and people in Cork and throughout the country want is not history lessons but a solution to the problem".

Another commented "Much of this flooding could have been avoided and it caused unnecessary damage". These comments and many others made during the Committee's meetings illustrate the dominance of a conception of flood hazards that assumes that flooding can be prevented or at least dramatically reduced through a combination of dams, weirs and flood defences. This approach to flood risk management also creates a reactive decision-making process in which local policy and practice is heavily shaped by a retrospective analysis of past events. In the present era of concern about increasing future climate risks this approach may be fraught with difficulties.

A conception of flood hazards that sees floods as a risk largely external to society and views flood prevention as the centre piece of any flood hazards mitigation efforts was also evident in interview responses. Engineering interventions appeared to be viewed as the ideal option both for the management of current flood hazards and for any future hazards due to the impacts of climate change. Most respondents were confident that not only was engineering the preferred option for the future, but that it was providing protection against current flood risks. Several respondents were confident that the hydroelectric dams on the River Lee allowed for control and management of the river that would prevent flooding. They focused on coastal flooding as this was viewed as lacking the same control. An engineer commented,

> "there was a hydro electric scheme built on the Lee and obviously that has been beneficial in terms of controlling our river flooding. If there are heavy rainfall events or adverse conditions and we know about them in advance then the ESB can deal with the river water coming down".

He contrasted this perceived control over river flooding with the exposure to coastal flooding, commenting "but we've no control at the other end".

These comments were made less than three months before what was mistakenly perceived as reliable control failed in November 2009. Respondents saw flood defences for particularly exposed areas of the city as the solution to current exposure and large scale flood barriers as the solution to future coastal flood exposure due to sea level rise and any changes in storm patterns that may occur. Funding was seen as virtually the only limitation to these projects. As one City Councillor commented "The problem at the moment of course is funding. We can't afford to do something like that. It would be so expensive". However many respondents appeared to view the construction of such barriers as inevitable because they saw them as the only viable option, regardless of cost. It is worth noting that the recently published Draft Catchment Flood Risk Management Plan for the Lee Catchment concluded that such a coastal flood barrier for Cork currently fails to pass a cost benefit analysis but may do so in the future (Office of Public Works, *et al.* 2010).

The 2009 flood as a failure of current policy

The November 2009 flood in Cork highlights several weaknesses in contemporary flood hazards policy in Ireland and Europe. Engineering solutions and dams in particular often prevent smaller more frequent events but the false sense of security this can create often increases vulnerability to larger but less frequent floods (Wisner, *et al.* 2004, López-Marrero and Yarnal, 2010). Engineering solutions certainly work in some cases. During a flood in 1986 it is estimated that the attenuation provided by the two dams on the River Lee retained the water levels in Cork City at almost 1m lower than would have been the case had the dams not been present (Fitzpatrick and Bree, 2001). However this false sense of security may have helped to increase the vulnerability of Cork City to larger floods. Despite some forewarning of the potential for misplaced confidence (Fitzpatrick and Bree, 2001), Cork appears to have been largely unprepared for larger flooding events. While it was fortunate that no fatalities

occurred in November 2009 this appears to have been down to luck and a prompt response from the emergency services, rather than to the overall level of preparedness. Prior to 2009, the two dams to the west of Cork were seen as providing an effective means of preventing river flooding. While the City had an emergency plan for dealing with hazards of various kinds, no dedicated flood warning system was in place. Despite media coverage of the potential for flooding many of the city's residents were unprepared and awoke in the early hours of the morning to find their homes quickly filling with water. It is clear that the false sense of security highlighted by hazards researchers elsewhere (Wisner, *et. al.*, 2004, López and Yarnal, 2010) had well and truly set in.

An emphasis on quantitative risk management and technological fixes has been extensively critiqued by geographers and other social scientists. Management approaches that view floods as a drainage problem that can be quantified, measured and assessed through natural science research methods assume that this approach will allow for the accurate calculation of return periods and the likelihood of future flood events. This assumption may prove to be inaccurate in the context of global climate change as the retrospective analysis of past events becomes a less reliable guide to the future. Recent research in Ireland has already expressed concern that analysis of past climate is no longer a reliable guide for future events (Kiely, *et al.* 2010). Probabilistic thinking which often dominates risk assessment (Wilkinson, 2010) focuses solely on the question of how often a particular event may occur. Such thinking alone may not be an effective means of preparing for future hazards as because it neglects to consider what may happen if a more extreme scenario unfolds (Jacob, *et al.* 2001). Not only are risk-based approaches imprisoned by past experience, they may encourage the selection of regulatory standards for flood prevention that are achievable by prevailing engineering technologies at acceptable cost, rather than more stringent safety margins that are more technically challenging and less cost effective. Risk based approaches often imply a

level of control and manageability that may be inappropriate in the context of the complex challenges presented by flood hazards particularly in the context of global climatic change (Pidgeon and Butler, 2009). This belief in control, combined with the probabilistic approach allows little scope for consideration of unusual or surprise events that do not fit within its predictions. Such surprises are often the source of greatest catastrophe precisely because the fall outside our expectations (Beck, 2009). Risk management approaches often assume that such control can be achieved through the application of appropriate technological or engineering innovations. Hazards geographers have extensively critiqued overreliance on the application of an engineering fix to flood hazards (White, 1945, Platt, 1982, Penning-Rowsell, *et al.* 1998, Penning-Rowsell, 2000, Wisner, *et al*, 2004, Changnon, 2005, Kahn and Mustafa, 2007, López-Marrero and Yarnal, 2010). These critiques have highlighted the potential for failure of engineering fixes and the likelihood of increased losses when events occur that exceed the design capacity of an engineering project (Wong and Zhao, 2001, Wisner, *et al.* 2004, Changnon, 2005; López-Marrero and Yarnal, 2010). Social theorists such as Ulrich Beck (1992, 1998, 1999, 2009) and Bruno Latour (1993, 2003) have offered even more sweeping critiques that question belief in the liner progression of modernity to a point where we can eliminate all of today's risks and hazards. Engineering and technological fixes also tend to focus on the immediate cause of hazards rather than addressing their underlying drivers (Penning-Rowsell, *et al.* 1998, Penning-Rowsell, 2000). Risk based approaches that focus solely on engineering solutions to particular flood problems often fail to consider the variety of factors and contexts which have been found to influence hazards losses (Mustafa, 1998, Pelling 1999, Cutter and Finch, 2008, Eakin, *et al.* 2010, López-Marrero and Yarnal, 2010, Whittle, *et al.* 2010, Wolf, *et al.* 2010). Risk management approaches also privilege certain types of knowledge and certain practices or responses over others (Beck, 1992, 2009). By placing responsibility for flood hazards in the hands of a small group of experts the range

of alternative responses to hazards (Mitchell, 2008) is limited. The role of expertise in environmental governance has been the subject of an extensive literature in geography and other social sciences with researchers increasingly recognising the complexity that the relationships between groups and individuals with varying degrees of expertise and knowledge brings to environmental decision-making (Birkenholtz, 2008, Prince, 2010).

An additional key feature of both the Cork event and flooding in the Shannon basin are worth noting. All of the state agencies involved in testimony before the Oireachtas Committee on the Environment appeared keen to avoid responsibility for the flooding and its consequences. This is evident in the blame game that has taken place between Cork City Council and the ESB regarding whose responsibility it was to warn the public of the impending flood threat. In the words of the Oireachtas Committee's report "Throughout our deliberations we repeatedly encountered a tendency on the part of various relevant State bodies to define their responsibilities more in terms of what they do not include rather than what they do" (Houses of the Oireachtas, 2010).

This tendency to avoid responsibility may be comparable to a phenomenon described as organised irresponsibility (Beck 2009). Focusing on national and international institutions Beck suggests that this organised irresponsibility can lead to the rationalisation and denial of the existence of particular risks. In the context of environmental hazards in local cities, organised irresponsibility may lead to acknowledgment that some risks exist (they are hard to deny after they have been realised as a flood disaster) but to a denial of responsibility for their occurrence or for the emergency management response to them. The notion of organised irresponsibility suggests a deliberate attempt to avoid responsibility for hazards management but it is more likely that emergencies require managerial skills different from normal operations and these have not yet been institutionalized. This has been shown by Robbins *et al.* (2008, p. 96) in a U. S. study of challenges presented by West Nile Virus that

demonstrated how government institutions and bureaucracies are constrained by "their specific geographic practices and boundary limits, as well as by the distinctive training, education, competences and governance capacities" available to them. In the same way flood hazards may fall between the cracks that separate agency jurisdictions. The intermittent nature of hazard events may add to this effect as they sit outside the day to day experience of most government organisations. Due to the long recurrence intervals of some hazards current managers may also have no direct experience of similar events. Strict adherence to the prescribed missions and responsibilities of different agencies is likely to create both overlaps and gaps in the decision-making structure that may explain the appearance of irresponsibility. Regardless of the exact cause of the irresponsibility it is clear that events such as the Cork floods create numerous challenges for contemporary institutional and decision-making structures and future flood hazards policies will need to take this into account if they are to successfully address both contemporary flood hazards and future climate change.

The November 2009 flood in Cork occurred just before the Draft Catchment Flood Risk Management Plan for the Lee Catchment was published in February 2010. The CFRAM model, part of Ireland's implementation of the EU Floods Directive represents a new catchment based framework for flood risk management. As this model is likely to form the basis of flood hazards policy in Ireland for the foreseeable future it is necessary to consider the extent to which it can address the shortcomings highlighted by the 2009 flood and its utility as a framework within which adaptation to future flood hazards brought about by climate change might occur. The remainder of this paper focuses on the CFRAM model, illustrating its strengths and weaknesses. While the catchment based model has many advantages and it represents an improvement on past practices, several shortcomings may limit its ability to successfully address both current and future flood risks.

Cross scale governance and the catchment model of flood risk management

In Ireland policy and decision-making about environmental hazards crosses three levels of governance with the EU, national government and local authorities all playing important roles. The role of the EU has increased significantly in recent years, particularly through the implementation of the EU Floods Directive, which requires the adoption of a catchment based approach to flood risk management. As local and national governments take steps to comply with the stipulations of the Directive there is an appearance of top-down decision-making. However this approach had already become part of the OPW's policies when it was recommended by the Report of the Flood Policy Review Group in 2004. Local interviewees sought to portray this as evidence that Ireland was leading the way in policy innovation. However, this is misleading because the river basin model was introduced by the EU in the Water Framework Directive of 2000. This model has several strengths but it was developed in response to transnational floods in large river basins such as those experienced across Europe in 2002 and its application to the Irish context may not be as smooth as-proponents would hope.

There are several advantages to the river basin model. First, it codifies the importance of natural systems criteria in environmental management by tying the analysis to a spatially defined ecosystem. Second, within these boundaries it encourages coordinated decision-making and holistic planning that minimizes negative spill over effects of separate decisions taken by different political jurisdictions. In Ireland this approach is being implemented through Catchment Flood Risk Assessment and Management Studies (CFRAMSs) that lead to Catchment Flood Risk Management Plans (CFRMPs). The first of these studies was piloted in the Lee Catchment in Cork with others now ongoing on the Dodder in Dublin, the Suir in the south west of the country and in the Fingal East Meath region. While the CFRAMS model has the advantages mentioned above, particularly when compared to past

approaches that were described by interviewees as “piecemeal” and “reactive”, it also has several shortcomings.

By defining its unit of analysis as a river basin, the CFRAMSs model may unintentionally divert attention away from human drivers of flooding that transcend this unit (e.g. worldwide anthropogenic climate change as well as institutional biases towards technological fix adjustments and the primacy of economic investment criteria as guides for action). This is evident in the Draft CFRMP for the Lee Catchment. As the first of its kind this draft plan provides an early indication of how the CFRAMSs model will influence future flood hazards mitigation strategies in Ireland. The draft report focuses heavily on modelling physical exposure to flooding but the social drivers of vulnerability are not a significant portion of the analysis. While it emphasises that national policy now promotes the increased use of non-structural solutions to flooding (Office of Public Works, *et al.* 2010) and flood warnings are mentioned, the Lee CFRMP focuses on structural flood defences and alternatives are accorded little weight. Floods are conceptualised within a Source-Pathway-Receptor model which focuses on the physical drivers of flood events. The draft CFRMP for the Lee Catchment does contain a short section on what is described as “social flood risk”. However this aspect of the analysis merely quantifies the numbers of properties within flood risk zones. Higher population density is equated with higher vulnerability and the analysis does not attempt to differentiate between residents within flood prone areas. Vulnerability is defined solely as a unit of exposure. This conception of vulnerability contrasts sharply with the extensive geographic literature on the socioeconomic factors that shape hazard losses (Kleinosky, *et al.* 2006, Cutter and Finch, 2008, Eakin, *et al.* 2009, Mustafa, *et al.* 2010, Wolf *et al.* 2010). Whether it is possible to present information on vulnerability in formats that are easily applicable to policy-making is the subject of ongoing debate among vulnerability researchers (Mustafa, *et al.* 2010) but its exclusion from current policy in Ireland appears to

be a conceptual rather than a methodological issue. The absence of a more expansive conceptualisation of vulnerability may prove to be a critical flaw in the design of CFRMPs that may only become clear during future disasters when some groups suffer greater losses than others.

While economic losses receive some consideration in the analysis of flood hazards, they are narrowly defined. The draft CFRMP states that economic loss occurs when "floodwater gets above the threshold level of a building, for example an entrance door to a building" (Office of Public Works, *et. al.*, 2010, p. 40). This interpretation neglects situations where buildings are isolated but not physically inundated or where the infrastructure on which they depend is damaged or disrupted without impairment of a building's integrity. It also excludes the costs of business interruption and loss of customers for commercial enterprises as well as service denial for public sector facilities. Economic loss is tied to the ownership of fixed property and only where water enters regularly occupied structures. Damage to moveable property (e.g. vehicles), ancillary features (e.g. gardens), access routes (e.g. driveways) and external fittings is apparently not considered. This definition of economic loss also assumes that it is easy to identify which properties have been flooded and which have not. However studies of damage inflicted by a 2007 flood in Hull (U.K.) reveal that costly, unforeseen and delayed "secondary flooding" effects are common (Whittle, *et. al*., 2010). In this case, water entered homes beneath the level of the floorboards. Homeowners initially assumed they have been spared but rising dampness and condensation emerged later to cause the same level of damage as if visible flooding had occurred. In such cases the expert judgment of insurance assessors becomes the criterion for aid, not the standards adopted in flood management regulations (Whittle, *et. al*., 2010). The apparently straightforward question of the spatial extent of a flood becomes increasingly complex and contested. If the narrow definition of flood losses employed in the draft Lee CFRMP

becomes the standard for adjudicating insurance claims real victims may be officially declared to not have experienced flooding at all. Who decides when loss has been suffered and on what basis they do so may become a crucial matter in determining the course of recovery after flooding and the value of the CFRMP planning guidelines may be undercut.

The EU Floods Directive was also criticised by some interviewees for its emphasis on river flooding to the exclusion of other types. The catchment based approach assumes that it is possible to quantify flood risk and to clearly identify different exposure units. This is potentially achievable for river and coastal flooding but unlikely for rainfall-driven flash floods. These deficiencies reflect the Flood Directive's origins on the European mainland. There flooding typically covers very large areas in even larger river basins, and lasts for weeks or even months. With the notable exception of the Shannon, almost all other Irish rivers are relatively short and floods rarely last more than a few days (though their effects may be felt for much longer). Coastal floods also tend to be of shorter duration, usually a matter of hours coinciding with the peaks of tidal cycles. In estuarine locations like Cork City the most severe floods often result from a combination of fluvial and tidal drivers. These characteristics are fundamentally different from the continental European flood experience that has helped to shape the Floods Directive. While pan European flood strategies may encourage action at the local level and the catchment model has the potential to facilitate effective partnerships between local stakeholders, the ultimate success of EU policies may depend on their ability to leave space for the uniqueness of local places and contexts.

Another influential aspect of governance structures in the Republic of Ireland, that contrasts with much of mainland Europe, is the relationship between local and national government and the role that each plays in policy that pertains to hazards and climate impacts. Compared to other countries, local government in Ireland often appears to have a "lesser status" (Callanan, 2003, p.475). Irish local authorities have significantly fewer areas

of responsibility than European counterparts (Tierney, 2003). Despite this, local governments in Ireland do have responsibility for several functions that are of particular relevance to hazards mitigation and climate adaptation. City and County Councils are the primary regulators of planning and development within their territories (Grist, 2003). Local authorities are also responsible for emergency management because they usually provide local fire services and they are designated as lead agencies for managing weather emergencies (including flooding) under the National Framework for Emergency Management (Department of the Environment, Heritage and Local Government, 2006).

Local authorities retain these functions but their decision-making power is often curtailed by their limited ability to raise local revenue. While tax raising authority might seem essential to the autonomy of local government, since the abolition of domestic rates in 1978 Irish local authorities have had a very limited ability to raise funds locally and are heavily dependent on grants from the national government. In 2002 almost 50% of local government funding came directly from central government with the remainder split almost evenly between commercial rates and other sources such as service charges (Dollard, 2003). This leaves local government particularly dependent on businesses whose commercial tax payments (rates) are the chief source of locally generated revenue. Such dependence may play an important role in shaping policy decisions as local authorities are keen to protect this revenue stream.

Recently, there has been increased emphasis on land use planning and the regulation of development as a flood risk management tool. This is highlighted by the 2009 publication of a set of guidelines - The Planning System and Flood Risk Management: Guidelines for Planning Authorities - that places local government in a key position to effect reductions in future flood losses. This new initiative is undoubtedly a major step forward from past practice. However as experience from other countries including the US illustrates, the shift

from engineering to planning may not be enough to substantially reduce losses (Changnon, 2000). Many of the most significant floods experienced in Ireland in recent years have occurred in already developed city centres and towns. Substantial building (including on flood plains) took place during the years of economic growth and tailed off before the 2009 guidelines were published. Additional new development is likely to be much less for the foreseeable future due to the state of the national economy. As a result the impact of land use planning on flood losses may be limited to avoiding additional increases in runoff from impermeable surfaces. When permission for new developments are sought there are also no guarantees that the flood risk guidelines will prevent inappropriate development on flood plains.

There are several other aspects of the relationship between local and national governance in Ireland that may help to shape hazards policy. Local governments in Ireland have limited responsibilities for the provision of social services, with the exception of housing where they play an important role (Tierney, 2003). As a result almost none of the agencies responsible for flood hazards have any substantial role in the provision of social services. This institutional structure may help to exclude social drivers of loss from hazards policy because the decision-makers who are most likely to be aware of the social drivers of vulnerability are not included in the hazards decision-making process. The weakness of local government in Ireland may also limit the potential for partnerships across all levels of government to address environmental hazards. The weakness of Irish local government sits in contrast to other countries where partnerships across levels of government and between stakeholders have been most successful.

The local emphasis of national politics in Ireland also plays a role in shaping many aspects of policy and this is no doubt true of hazards and climate policy. One of the criticisms of national politicians in Ireland is that they focus on local issues and neglect national

priorities (Gallagher and Komito, 1999). This is underlined in records of Dáil Éireann that show how local requests for flood relief are typical and national perspectives rarely get aired in debates or other parliamentary proceedings. This local emphasis in national policy is difficult to change because it may enhance the prospects of re-election for some representatives. Flood defences are a visual manifestation of action even if they are not always the optimal solution. Their physical presence and their ability to make flood waters disappear at least in the short term, ensures they remain the central focus of flood hazards policies.

Conclusions

It is clear that current exposures and vulnerabilities to flood hazards present numerous challenges for Cork and other Irish cities. These challenges are likely to intensify in the future as climate change brings increases in stream flow, sea level rise and changing storm patterns. Available evidence shows that current policy, decision-making and institutional structures may be ill suited to the dynamic challenges these changes will present. Current policy and practice at both local and national levels of governance remains heavily influenced by a largely reactive decision-making process based on the retrospective analysis of past events. Reactive experiential based responses are unlikely to facilitate effective adaptation because past experience may prove to be an unreliable guide to future hazards.

Contemporary decision-making is also strongly influenced by a conceptualisation of flooding that fails to distinguish between the physical floods and the losses they induce, as well as an emphasis on large scale engineering and technological fixes as preferred responses. These perspectives reflect several influences including the often unique historical circumstances under which flood policies developed and the compromises made to

accommodate established institutional structures. Experiences from the Lee floods of 2009 and elsewhere highlight some of the potential pitfalls of this approach.

Despite recent changes in both national and EU policy there remain several reasons for concern that current policies and institutional arrangements may prove insufficient to meet future challenges. Floods continue to be conceptualised largely as physical events and socio-economic influences on flood losses are not considered. Desirable modifications to the CFRAM model may include a wider conceptualisation of flood losses and their causes, and a broader range of alternative policy responses. The CFRAM model itself may also need to be modified to incorporate differences in the biophysical, socio-economic, cultural and institutional contexts of local places. A continuation of existing policies and practices may lead to similar losses like those experienced in Cork and other parts of Ireland in November 2009. The CFRAM model undoubtedly represents a positive attempt to reorient policy and practice towards a more pro-active flood hazards management strategy but further reconceptualisation of policy and reorganisation of institutional structures may be required to successfully address contemporary and future challenges.

Acknowledgements: This paper is part of a larger project completed for the author's doctoral dissertation. The author would like to acknowledge James. K. Mitchell, Robin Leichenko, Trevor Birkenholtz and John Sweeney for their comments on the dissertation and James K. Mitchell, John Sweeney and an anonymous reviewer for additional comments on a previous draft of this paper.

Bibliography

Amundsen, H., Berglund, F. and Wetskog, H., 2010. Overcoming barriers to climate change adaptation - a question of muiltilevel governance? *Environment and Planning C: Government and Policy,* 28(2), 276-289.

Anguelovski, I. and Carmin, J., 2011. Something borrowed, everything new: Innovation and institutionalization in urban climate governance. *Current Opinion in Environmental Sustainability,* 3(3), 169-175.

Beck, U., 2009. *World at risk.* Malden, MA. Polity Press.

Beck, U., 1999. *World risk society.* Malden, MA. Polity Press.

Beck, U., 1998. Politics of risk society *In:* J. Franklin, eds. *The politics of risk society.* Malden, MA: Polity Press, 9-22.

Beck, U., 1992. *Risk society: Towards a new modernity.* London; Sage.

Biesbroek, G.R., Swart, R.J., Carter, T.R., Cowan, C., Henrichs, T., Mela, H., Morecroft, M.D. and Rey, D., 2010. Europe adapts to climate change: Comparing national adaptation strategies. *Global Environmental Change,* 20(3), 440-450.

Birkenholtz, T., 2008. Contesting expertise: The politics of environmental knowledge in northern indian groundwater practices. *Geoforum,* 39(1), 466-482.

Callanan, M., 2003. Where stands local government? *In:* M. Callanan and J.F. Keogan, eds. *Local government in Ireland: Inside out.* Dublin: Institute of Public Administration, 475-501.

Carmin, J., Roberts, D. and Anguelovski, L., 2009. Planning Climate Resilient Cities: Early lessons from early adapters. *In: World Bank Fifth Urban Research Symposium, Cities and Climate Change.* The World Bank, Marseille.

Carter, J.G., 2011. Climate change adaptation in European cities. *Current Opinion in Environmental Sustainability,* 3(3) 193-198.

Cawley, A.M., Fitzpatrick, J., Cunnane, C. and Sheridan, T., 2005. A Selection of Extreme Flood Events: The Irish Experience. *In: National Hydrology Seminar 2005: Understanding & Managing Hydrological Extremes.* Irish National Committees of the IHP and ICID National Hydrology Seminar 2005,14-25.

Changnon, S.A., 2005. The 1993 flood's aftermath: Risks, root causes and lessons for the future. *Journal of Contemporary Water Research & Education,* 103(1), 70-74.

Changnon, S.A., 2000. The record 1993 Mississippi river flood: A defining event for flood mitigation policy in the united states *In:* D.J. Parker, ed. *Floods.* London: Routledge, 288-301.

Charlton, R., Fealy, R., Moore, S., Sweeney, J. and Murphy, C., 2006. Assessing the impact of climate change on water supply and flood hazard in Ireland using statistical downscaling and hydrological modelling techniques. *Climatic Change,* 74(4), 475-491.

Chatterjee, M., 2010. Slum dwellers response to flooding events in the megacities of India. *Mitigation and Adaptation Strategies for Global Change,* 15(4), 337-353.

Cork City Council, 2009. *Cork City Development Plan 2009-2015.* Cork: Cork City Council.

Cork City Council, 2008. *South Docks Local Area Plan 2008.* Cork: Cork City Council.

Cork City Council, 2001. *Cork Docklands Development Strategy 2001.* Cork: Cork City Council.

Coughlan, S. 2009, *Lee Catchment Flood Risk Assessment and Management (CFRAMS) - A Case Study: Presentation to the Irish Planning Institute* [Online]. Available from: http://www.corkdocklands.ie/publications/ [Accessed 7 June 2010].

Cutter, S.L. and Finch, C., 2008. Temporal and spatial changes in social vulnerability to natural hazards. *Proceedings of the National Academy of Sciences,* 105(7), 2301-2306.

Dawson, R.J., Ball, T., Werritty, J., Werritty, A., Hall, J.W. and Roche, N., 2011. Assessing the effectiveness of non-structural flood management measures in the Thames estuary under conditions of socio-economic and environmental change. *Global Environmental Change,* 21(2) 628-646.

Department of the Environment, Heritage and Local Government, 2006. *A framework for major emergency management: Working draft, guidance document 11, a guide to flood emergencies* Dublin: Department of the Environment, Heritage and Local Government.

Dodds, W., Cooper, J.A.G. and McKenna, J., 2010. Flood and coastal erosion risk management policy evolution in Northern Ireland: "Incremental or leapfrogging? *Ocean & Coastal Management,* 53(12), 779-786.

Dollard, G., 2003. Local government finance: The policy context *In:* M. Callanan and J.F. Keogan, eds. *Local government in Ireland: Inside out.* Dublin: Institute of Public Administration (Ireland), 325-340.

Eakin, H., Lerner, A.M. and Murtinho, F., 2010. Adaptive capacity in evolving peri-urban spaces: Responses to flood risk in the upper Lerma river valley, Mexico. *Global Environmental Change,* 20(1), 14-22.

Eakin, H., Winkels, A. and Sendzimir, J., 2009. Nested vulnerability: Exploring cross-scale linkages and vulnerability teleconnections in Mexican and Vietnamese coffee systems. *Environmental Science & Policy,* 12(4), 398-412.

Falaleeva, M., O'Mahony, C., Gray, S., Desmond, M., Gault, J. and Cummins, V., 2011. Towards climate adaptation and coastal governance in Ireland: Integrated architecture for effective management? *Marine Policy,* 35(6), 784-793.

Fitzpatrick, J. and Bree, T., 2001. Flood Risk Management Through Reservoir Storage and Flow Control. *In: National Hydrology Seminar 2001,* 87-96.

Fünfgeld, H., 2010. Institutional challenges to climate risk management in cities. *Current Opinion in Environmental Sustainability,* 2(3), 156-160.

Gallagher, M. and Komito, L., 1999. The constituency role of Dáil deputies *In:* J. Coakley and M. Gallagher, eds. *Politics in the Republic of Ireland. ,* 3rd ed. New York: Routledge, 242-271.

Grist, B., 2003. Planning *In:* M. Callanan and J.F. Keogan, eds. *Local government in Ireland: Inside out.* Dublin: Institute of Public Administration (Ireland), 221-252.

Hallegatte, S., Ranger, N., Mestre, O., Dumas, P., Corfee-Morlot, J., Herweijer, C.and Wood, R. 2011, Assessing climate change impacts, sea level rise and storm surge risk in port cities: A case study on Copenhagen. *Climatic Change,* 104(1), 113-137.

Hanson, S., Nicholls, R., Ranger, N., Hallegatte, S., Corfee-Morlot, J., Herweijer, C.and Chateau, J. 2011. A global ranking of port cities with high exposure to climate extremes. *Climatic Change,* 104(1), 89-111.

Harries, T. and Penning-Rowsell, E., 2011. Victim pressure, institutional inertia and climate change adaptation: The case of flood risk. *Global Environmental Change,* 21(1), 188-197.

Harvatt, J., Petts, J. and Chilvers, J., 2011. Understanding householder responses to natural hazards: Flooding and sea-level rise comparisons. *Journal of Risk Research,* 14(1), 63-83.

Hickey, K., 2010. *Deluge: Ireland's weather disasters 2009-2010.* Dublin. Four Courts Press.

Hunt, A.and Watkiss, P. 2011. Climate change impacts and adaptation in cities: A review of the literature. *Climatic Change,* 104(1), 13-49.

Jacob, K., Edelblum, N. and Arnold, J., 2001. Risk increase to infrastructure due to sea level rise *In:* C. Rosenzweig and W.D. Solecki, eds. *Climate change and a global city: The potential consequences of climate variability and change - metro east coast. report for the U.S. global change research program, national assessment of the potential consequences of climate variability and change for the united states.* New York: Columbia Earth Institute.

Johnson, C. and Penning-Rowsell, E., 2010. What really determines policy? An evaluation of outcome measures for prioritising flood and coastal risk management investment in England. *Journal of Flood Risk Management,* 3, 25-32.

Johnson, C., Penning-Rowsell, E. and Parker, D., 2007. Natural and imposed injustices: The challenges in implementing "fair" flood risk management policy in England. *The Geographical Journal,* 173(4), 374-390.

Johnson, C.L., Tunstall, S.M. and Penning-Rowsell, E., 2005. Floods as catalysts for policy change: Historical lessons from England and Wales. *International Journal of Water Resources Development,* 21(4), 561-575.

Joint Committee on the Environment, Heritage and Local Government, 2010. *The Management of Severe Weather Events in Ireland and Related Matters.* Dublin: Houses of the Oireachtas.

Kahn, F.M. and Mustafa, D., 2007. Navigating the contours of Pakistani hazardscapes; disaster experience versus policy *In:* M. Moench and A. Dixit, eds. *Working with the winds of change: Towards strategies for responding to the risks associated with climate change and other hazards.* 2nd ed. Kathmandu, Nepal: ISET-Nepal, 193-234.

Kiely, G., Leahy, P., Ludlow, F., Stefanini, B., Reilly, E., Monk, M. and Harris, J. 2010. *Extreme Weather, Climate and Natural Disasters in Ireland* Wexford: Environmental Protection Agency.

Kleinosky, L.R., Yarnal, B. and Fisher, A., 2006. Vulnerability of Hampton Roads, Virginia to storm-surge flooding and sea-level rise. *Natural Hazards,* 40(1), 43-70.

Koch, I.C., Vogel, C. and Patel, Z., 2007. Institutional dynamics and climate change adaptation in South Africa. *Mitigation and Adaptation Strategies for Global Change,* 12, 1323-1339.

Kopke, K. and O'Mahony, C., 2011. Preparedness of key coastal and marine sectors in ireland to adapt to climate change. *Marine Policy,* 35(6), 800-809.

Latour, B., 2003. Is re-modernization occurring — and if so, how to prove it? *Theory, Culture & Society,* 20(2), 35-48.

Latour, B., 1993. *We have never been modern.* Cambridge, MA. Harvard University Press.

Leichenko, R., 2011. Climate change and urban resilience. *Current Opinion in Environmental Sustainability,* 3(3) 164-168.

López-Marrero, T., 2010. An integrative approach to study and promote natural hazards adaptive capacity: A case study of two flood-prone communities in Puerto Rico. *Geographical Journal,* 176(2), 150-163.

López-Marrero, T. and 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(2), 277-297.

Lugeri, N., Kundzewicz, Z., Genovese, E., Hochrainer, S.and Radziejewski, M. 2010. River flood risk and adaptation in Europe—assessment of the present status. *Mitigation and Adaptation Strategies for Global Change,* 15(7), 621-639.

McGrath, R. and Lynch, P. eds. 2008. *Ireland in a warmer world: Scientific predictions for the Irish climate in the twenty first century.* Maynooth: Climate Change Consortium for Ireland.

Mechler, R., Hochrainer, S., Aaheim, A., Salen, H.and Wreford, A. 2010. Modelling economic impacts and adaptation to extreme events: Insights from European case studies. *Mitigation and Adaptation Strategies for Global Change,* 15(7), 737-762.

Mitchell, J.K., 2003. European river floods in a changing world. *Risk Analysis,* 23(3), 567-574.

Mitchell, J.K., 2008. Perspectives on alternatives: Differentiation and integration in pursuit of a better fit between society and nature. *Progress in Human Geography,* 32(3), 451-458.

Mitchell, J.K., 1999. *Crucibles of hazard: Mega-cities and disasters in transition.* New York: United Nations University Press.

Mitchell, J.K., Devine, N. and Jagger, K., 1989. A contextual model of natural hazard. *Geographical Review,* 79(4), 391-409.

Moser, S.C., 2010. Now more than ever: The need for more societally relevant research on vulnerability and adaptation to climate change. *Applied Geography,* 30(4), 464-474.

Mustafa, D., Ahmed, S., Saroch, E. and Bell, H., 2010. Pinning down vulnerability: From narratives to numbers. *Disasters,* 35(1), 62-86.

Mustafa, D., 1998. Structural causes of vulnerability to flood hazard in Pakistan. *Economic Geography,* 74(3), 289-305.

Næss, L.O., Bang, G., Eriksen, S. and Vevatne, J., 2005. Institutional adaptation to climate change: Flood responses at the municipal level in Norway. *Global Environmental Change,* 15(2), 125-138.

Neumann, J., Hudgens, D., Herter, J. and Martinich, J., 2011. The economics of adaptation along developed coastlines. *Wiley Interdisciplinary Reviews: Climate Change,* 2(1), 89-98.

O'Brien, K., Eriksen, S., Sygna, L. and Naess, L.O., 2004. Questioning complacency: Climate change impacts, vulnerability and adaptation in Norway. *AMBIO,* 35(2), 50-56.

O'Connor, A., 2001. *Poverty knowledge : Social science, social policy, and the poor in twentieth-century U.S. history.* Princeton University Press.

Office of Public Works, Cork City Council and Cork County Council, 2010. *Lee Catchment Flood Risk Assessment and Management Study: Draft Catchment Flood Risk Management Plan* Cork: Office of Public Works.

O'Neill, K.M., 2006. *Rivers by design: State power and the origins of U.S. flood control.* Durham, NC. Duke University Press.

O'Riordan, T. and Jordan, A., 1999. Institutions, climate change and cultural theory: Towards a common analytical framework. *Global Environmental Change,* 9(2), 81-93.

Parker, D.J., Tunstall, S.M. and McCarthy, S., 2007. New insights into the benefits of flood warnings: Results from a household survey in England and Wales. *Environmental Hazards,* 7(3), 193-210.

Parvin, S., Thompson, P. and Green, C. 2008. Can England learn lessons from Bangladesh in introducing participatory floodplain management? *Water Resources Management,* 22(3), 357-376.

Pelling, M., 2003. *The vulnerability of cities: Natural disasters and social resilience.* London; Sterling, VA. Earthscan.

Pelling, M., 1999. The political ecology of flood hazard in urban Guyana. *Geoforum,* 30(3), 249-261.

Pelling, M., and Wisner, B. , 2009. *Disaster risk reduction: Cases from urban Africa.* London: Earthscan.

Penning-Rowsell, E., 2000. Has Venice crossed the Rubicon? *In:* D.J. Parker, eds. *Floods.* London: Routledge, 277-287.

Penning-Rowsell, E., Johnson, C. and Tunstall, S., 2006. 'Signals' from pre-crisis discourse: Lessons from UK flooding for global environmental policy change? *Global Environmental Change,* 16(4), 323-339.

Penning-Rowsell, E., Winchester, P. and Gardiner, J., 1998. New approaches to sustainable hazard management for Venice. *The Geographical Journal,* 164(1), 1-18.

Pidgeon, N. and Butler, C., 2009. Risk analysis and climate change. *Environmental Politics,* 18(5), 670-688.

Platt, R.H., 1982. The Jackson flood of 1979: A public policy disaster. *Journal of the American Planning Association,* 48(2), 219-231.

Prince, R., 2010. Fleshing out expertise: The making of creative industries experts in the United Kingdom. *Geoforum,* 41(6), 875-884.

Repetto, R. 2008. *The Climate Crisis and the Adaptation Myth.*Yale School of Forestry.

Robbins, P., Farnsworth, R. and Jones, J.P.I., 2008. Insects and institutions: Managing emergent hazards in the US southwest. *Journal of Environmental Policy and Planning,* 10(1), 95-112.

Rosenzweig, C., Solecki, W., Blake, R., Bowman, M., Faris, C., Gornitz, V., Horton, R., Jacob, K., LeBlanc, A., Leichenko, R., Linkin, M., Major, D., O'Grady, M., Patrick, L., Sussman, E., Yohe, G.andZimmerman, R. 2011. Developing coastal adaptation to climate change in the New York City infrastructure-shed: Process, approach, tools, and strategies. *Climatic Change,* 106(1), 93-127.

Steele-Dunne, S., Lynch, P., McGrath, R., Semmler, T., Wang, S., Hanafin, J. and Nolan, P., 2008. The impacts of climate change on hydrology in Ireland. *Journal of Hydrology,* 356(1-2), 28-45.

Sweeney, J., Brereton, T., Byrne, C., Charlton, R., Emblow, C., Fealy, R., Holden, N., Jones, M., Donnelly, A., Moore, S., Purser, P., Byrne, K., Farrell, E., Mayes, E., Minchin, D.,

Wilson, J. and Wilson, J. 2003. *Climate Change Scenarios and Impacts for Ireland* Wexford: Environmental Protection Agency.

Tierney, J., 2003. Process: How the system operates *In:* M. Callanan and J.F. Keogan, eds. *Local government in Ireland: Inside out.* Dublin: Institute of Public Administration , 143-164.

Tunstall, S., McCarthy, S. and Faulkner, H., 2009. Flood risk management and planning policy in a time of policy transition: The case of the Wapshott Road planning inquiry, Surry, England. *Journal of Flood Risk Management,* 2,159-169.

Tyrrell, J. and Hickey, K.R., 1991. A flood chronology for Cork City and its climatological background. *Irish Geography,* 24(2), 81-90.

Walker, G. and Burningham, K., 2011. Flood risk, vulnerability and environmental justice: Evidence and evaluation of inequality in a UK context. *Critical Social Policy,* 31(2), 216-240.

Watts, M., 1983. On the poverty of theory: Natural hazards research in context *In:* K. Hewitt, eds. *Interpretations of calamity from the viewpoint of human ecology.* Boston: Allen & Unwin, 229-262.

White, G.F., 1945. *Human adjustment to floods: A geographical approach to the flood problem in the united states Department of geography research paper, 29.* University of Chicago Press.

Whittle, R., Medd, W., Demming, H., Kashefi, E., Mort, M., Twigger Ross, C., Walker, G. and Watson, N. 2010. *After the Rain - Learning the lessons from flood recovery in Hull, final project report for Flood, Vulnerability and Urban Resilience: a real time study of local recovery following the floods of June 2007 in Hull*. Lancaster University.

Wilkinson, I., 2010. *Risk, vulnerability and everyday life.* London: Routledge.

Wisner, B., Blaikie, P., Cannon, T. and Davis, I., 2004. *At risk: Natural hazards, people's vulnerability, and disasters.* 2nd ed. London: Routledge.

Wolf, J., Adger, W.N., Lorenzoni, I., Abrahamson, V. and Raine, R., 2010. Social capital, individual responses to heat waves and climate change adaptation: An empirical study of two UK cities. *Global Environmental Change,* 20(1), 44-52.

Wong, K. and Zhao, X., 2001. Living with floods: Victims' perceptions in Beijiang, Guangdong, China. *Area,* 33(2), 190-201.