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# **Integrating Vulnerability Analysis and Risk Assessment in Flood Loss Mitigation: An evaluation of barriers and challenges based on evidence from Ireland**

Despite well established critiques from hazards geographers, political ecologists and other social scientists, flood hazards policy and decision-making remain dominated by a technocratic approach to risk. Environmental hazards are understood through an ecological modernisation lens that emphasises quantifying biophysical risk and technological fixes. Flood induced losses are not distinguished from flood events with prevention becoming the overall goal of decision-making and policy. Risk is viewed as an egalitarian force impacting everyone equally and socio-economic vulnerability is rarely considered in local decision-making. Drawing on empirical research from three of Ireland's coastal cities this paper presents evidence for the persistence of the technocratic approach and examines several reasons for its perseverance. The results of qualitative research including semi-structured interviews with local decision-makers and content analyses of local and national policies illustrate that the persistence of the technocratic approach can be explained by several barriers and challenges to the integration of vulnerability research into public policy. The lack of an agreed methodology to present socio-economic vulnerability in applied and policy ready formats is a significant limitation. However the conceptual barriers to integrating perspectives on vulnerability into a decision-making and policy system that structurally and discursively frames flood risk almost exclusively in terms of physical exposure may represent an even greater challenge.

*Key Words:* risk, adaptation, vulnerability, hazards, flooding, Ireland

## ***1. Introduction***

Flood hazards and the disasters they all too frequently induce have long been a subject of concern to geographers. Since the seminal work of Gilbert White examined flood losses in the Mississippi Basin in the 1930s, this concern has included a persistent critique of the dominant approach to flood mitigation which traditionally focused on structural measures that aim to prevent losses by keeping flood waters away from exposed people and property (White, 1945). Despite these extensive critiques the 'tech fix' remains dominant and is frequently proposed as part of ecological modernisation based approaches to climate change adaptation (Byrne, et al. 2009). While some non-structural approaches such as an increased emphasis on land use planning in floodplains have gained increased traction, the 'tech fix' remains the preferred approach in many instances (Kelman and Rauken, 2012; Thomas, et al. 2011).

This paper seeks to evaluate some of the reasons for the continued dominance of the ‘tech fix’ and to examine why assessments of socio-economic vulnerabilities remain largely absent from the decision-making process, despite the ongoing development of vulnerability analysis among academic researchers. The research presented in this paper employs a mix of qualitative methods to examine policy and decision-making for both present flood hazards and future climate change adaptation in three of Ireland’s coastal cities. These cities have experienced coastal, river and pluvial flood events in recent years that have presented considerable challenges for local decision-makers (Jeffers, 2011). Each of these cities has also witnessed dramatic socio-economic changes associated with the growth and subsequent demise of the economic boom known as the ‘Celtic Tiger’ (Jeffers, *forthcoming*). Due to this combination of environmental and socio-economic change these cities represent useful cases for an examination of the roles of both physical exposure and socio-economic vulnerability in flood hazard mitigation.

The paper begins with a brief review of the critiques of quantitative risk assessment and structural engineering approaches to flood hazard mitigation that have emerged from geography and other social sciences. This is followed by a discussion of the research methods employed in this project and an outline of the three case study sites. The remainder of the paper is devoted to the presentation of results and an analysis of policy and practice. This examines several reasons for the continuing dominance of the ‘tech fix’ and the failure of vulnerability analysis to become a credible companion or alternative to the dominant strategy of flood risk management.

## ***2. Critiquing the Dominant Paradigm of Flood Risk Management***

A range of critiques of the dominant technocratic approach to flood hazards are now well established. An over reliance on structural and technological solutions has been extensively

critiqued by geographers and other social scientists for a variety of reasons including the potential for engineering failures, increased losses when events in excess of their design capacity occur, the encouragement of risky behaviour as residents of protected areas assume flooding is unlikely, and their focus on addressing the immediate causes of flood hazards rather than the underlying drivers of loss (Changnon, 2005; López-Marrero and Yarnal, 2010; Ludy and Kondolf, 2012; Penning-Rowsell, et al. 1998; Penning-Rowsell, 2000; Wong and Zhao, 2001; Wisner, et al. 2004). A reliance on quantifying physical risk often promotes a unidirectional view of flood hazards in which an external event impacts society, but this fails to capture the range of social, cultural, economic and institutional factors that may shape the vulnerability of human populations to hazard events (see: Adger, 2006; Cutter, *et. al.*, 2000; Eakin, *et. al.*, 2010; Klinenberg, 2002; Pelling, 1999; Pelling, 2003; Wisner, *et. al.*, 2004). It also excludes the reality that all those who experience flood hazard events are not equal and that some people may be more vulnerable to the impacts of flood events than others. The idea that the burdens of environmental risks are shared equally by all exposed populations masks questions of equity, fairness and justice that inevitably arise in the context of an emphasis on engineering and technological fixes (Johnson, et al. 2007; Walker and Burningham, 2011). The agency of human populations to influence their own vulnerability or to frame and perceive risk and vulnerability in different ways and to respond accordingly is also largely excluded from risk assessments that focus exclusively on reducing physical exposure (Pidgeon, et al., 2003; Kasperson, et al. 1988; Kasperson and Kasperson, 1996; Renn, 2011). The uncertainties inherent in risk assessments are also rarely acknowledged, often leading to unrealistic expectations regarding the accuracy and applicability of statistical risk assessments (Brown and Damery, 2002). Recent research in Ireland has cautioned that historic data can no longer be relied upon in the context of climate change (Kiely, et al. 2010) while others have argued that current risk management practices attach a level of

manageability to risk that is likely to be unachievable in the context of global environmental change (Pidgeon and Butler, 2009).

### ***3. Methods and Field Sites***

Thirty-five semi-structured interviews with local executive officials (planners and engineers), elected decision-makers (city councillors) and other stakeholders (representatives of local business organisations, environmental groups and residents associations) were completed in the cities of Dublin, Cork and Galway during the summer of 2009. These examined a range of themes related to environmental hazards and climate change adaptation including the views of interviewees on current and future flood risks as well as strategies for their management and mitigation. In addition, a content analysis of the records of over three hundred and fifty City Council meetings across the three cities provided a record of at least four years of local government decision-making in each city. These covered the period January 2006 to January 2010 for all three cities but stretched back to January 2001 for Cork and January 2005 for Galway. A similar analysis of the records of Dáil Éireann<sup>1</sup> debates over the period 1985 to 2010 provided data on the evolution of national decision-making over an extended time period. Between December 1<sup>st</sup> 2009 and March 23<sup>rd</sup> 2010 the Joint Oireachtas Committee on the Environment<sup>2</sup> conducted an investigation into flooding and severe winter weather experienced in several parts of Ireland during November and December 2009. The hearings held during this investigation yielded over 160 pages of transcripts which were also analysed. Taken together these data sets provided a valuable picture of the ways in which flood risks are conceptualised and framed by local actors, the types of flood risks management practices that are employed, and the potential consequences of these for the exposure and vulnerability of local populations.

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<sup>1</sup> The lower house of the national parliament

<sup>2</sup> A committee composed of members of both houses of the national parliament

This research focused on three of the largest cities in the Republic of Ireland, Dublin, Cork and Galway. Each is a coastal city located at the mouth of at least one major river and has a history of flooding of both coastal and fluvial origin. In recent years each city has also experienced severe flash floods resulting from intense rainfall. Notable events include the coastal floods which struck Dublin in February 2002 and severe river flooding in Cork in November 2009. Pluvial flash floods were experienced in Dublin in 2004, 2008, 2009 and 2011, in Galway in 2003 and 2008, and in Cork in 2002 and 2012. The exposure of each of these cities to flooding is expected to increase as sea levels along much of the Irish coastline are already rising and are likely to continue to do so (Devoy, 1992; 2008; Olbert, et al. 2012). Increased rainfall and changing storm frequencies and intensities are also expected in the coming decades (Charlton et al. 2006; Lozano et al. 2004; McGrath et al. 2005; Semmler et al. 2008; Steele-Dunne et al. 2008; Sweeney et al. 2003). These cities have also experienced significant socio-economic changes that are likely to have had a profound impact on the vulnerabilities of local populations. All three cities exemplify the challenges facing cities that are experiencing both the impacts of environmental changes and the consequences of socio-economic change.

#### ***4. Framings of Risk in Policy and Practice***

Ireland's national flood hazards policies are outlined in the *Report of the Flood Policy Review Group* (Flood Policy Review Group, 2004) and in *The Planning System and Flood Risk Management: Guidelines for planning authorities* (Government of Ireland, 2009a). An initial analysis of these documents would suggest that national policy has shifted substantially from a previously reactive approach that emphasised only structural engineering to a more proactive strategy that favours a mix of structural and non structural responses. As one official interviewed described it "flooding is a fact of life and we have to manage that risk

rather than trying to eliminate it". However an examination of policy and practice at both local and national levels illustrates that change has been limited.

Risk remains understood almost exclusively as a physical phenomenon, external to human society but impacting upon it in various ways. While the definition of risk employed in national policies includes both the likelihood of flooding (probability and physical exposure) and the consequences of flooding (impacts and vulnerability) (Government of Ireland, 2009a), an analysis of local decision-making and interviews with local actors illustrates that risk is generally viewed as the physical exposure of human populations or their property to flooding, and that socio-economic vulnerability is either excluded completely from this analysis or included in simplistic ways that fail to capture its complexity.

The clearest expression of this conceptualisation of risk as an external threat lies in the 'Source-Pathways-Receptor' model of flood risk management that is now central to all national risk management strategies. In this model the 'sources' refer to the drivers of floods including increased sea levels or prolonged periods of rainfall. The term 'pathways' describes features such as flood plains and flood defences, while 'receptors' are people or property impacted by flooding. In this model human populations assume the role of largely passive receptors, a category which in addition to humans includes property and other things humans may value (see: Government of Ireland, 2009b). Within this framework risk is viewed largely as an egalitarian force, impacting all exposed people equally. When asked about different vulnerabilities among affected populations many interviewees admitted to never having considered this aspect of flood hazards while a small minority of respondents dismissed the usefulness of conceptualising hazards in this way, suggesting that everyone who experiences a flood is affected equally. Others saw vulnerability as a potentially

important consideration but placed a greater emphasis on quantifying physical exposure as they seemed unsure about how vulnerability might be considered within the decision-making process. One official commented “It’s an area that we will be looking at most likely, but it’s not at the top of our agenda at the moment”.

While the concept of vulnerability is discussed in national policy documents it is used inconsistently and imprecisely. Vulnerability is sometimes used to describe attributes of buildings or other physical infrastructure. When the term is used in reference to human populations, a relatively narrow definition is employed focusing mainly on discrete sectors of the population such as the elderly or the disabled who it is assumed will always be more vulnerable (see Government of Ireland, 2009a). However further confusion is evident in this definition as vulnerability is defined as a measure of the resilience of these populations but the definition of resilience employed in the same document focuses on the ability of buildings to withstand the physical impacts of flooding. The technical appendices to the national guidelines on flood risk and planning describe how a risk assessment should consider “the consequences to receptors such as people, properties and the environment” (Government of Ireland, 2009b p. 3) but provides no further details on how to do so. This broad approach may reduce the vulnerability of populations in new developments as all residential properties are placed within a category of highly vulnerable development that is not to be permitted in flood prone locations. However this does little to address the vulnerabilities present among existing populations in already developed cities as these aspects of vulnerability are almost completely absent from current policy. There is also no consideration of the ways in which vulnerability may vary across space and time, or how this may render two similar groups or individuals likely to experience radically different outcomes from the same event. The only aspect of vulnerability that is specifically acknowledged is the need to include provisions for

groups such as the elderly and the disabled within evacuation planning. Similar narrow interpretations of were also evident among the responses of interviewees (see Box 1)

Box 1 to be inserted approximately here.

Another central tenant of current risk management practices lies in the assumption that risk can be managed and either significantly reduced or eliminated altogether. While national policy now draws a distinction between risk management and risk prevention, recognising the latter as an impossibility, this differentiation was rarely evident at the local level where almost all interviewees suggested that their goal was the reduction and elimination of flood risk through the prevention of flood events (see Box 2). No distinction was drawn between the physical event and the losses it may induce. Thus prevention was seen as the optimal, or even the only means of reducing flood losses. Similar viewpoints were clearly visible in City Council Minutes, Dáil Éireann debates and in the minutes of the investigation of the joint Oireachtas Committee on the Environment (see Boxes 3, 4 and 5). Local decision-makers frequently spoke of the need for “flood prevention” or the “protection” of local residents. Non structural solutions such as land use planning or programs that might identify and assist vulnerable populations were rarely mentioned and there is little evidence of such programmes being designed or implemented. While stricter planning guidelines have been implemented in recent years with the goal of reducing inappropriate development on flood plains (see Government of Ireland, 2009a) these were instigated too late for much of the development that took place during the ‘Celtic Tiger’ era. Extensive construction on flood plains has increased run off and placed additional populations in flood prone locations. There is no evidence that any strategies other than structural engineering are being considered to address these new exposures and vulnerabilities. As one city councillor observed “there have been

some very recent silly mistakes. Now that they are made, they are going to have to be protected”.

The dominance of a flood prevention approach based on quantitative risk assessment was visible even among interviewees who opposed structural solutions. One representative of an environmental NGO discussed his opposition to large flood control schemes, commenting “I can sympathise with those who have lived there for years and have had access to the beach and I can sympathise with the vulnerability they now feel, but I think the danger is [that] it’s looking at engineering solutions to systems and by and large those engineers are looking at it from a short term engineering point of view. I think the long term mechanism of hydrological systems means you tend to get some unexpected impacts and changes which are very difficult to model”. However despite these reservations he saw large flood prevention schemes as inevitable, adding “I don’t have an alternative to those types of interventions but I do have a reservation”. The belief that flooding must be prevented through engineering fixes remains so dominant that even those who are aware of its limitations have not considered alternative loss mitigation strategies.

Quantitative risk assessments and structural solutions form two key aspects of the policy and decision-making process. The final stage that determines whether a particular decision is implemented is a cost-benefit analysis. Funding was viewed by most interviewees as the only significant constraint on their ability to prevent floods from occurring and cost benefit analysis was seen as the means of determining which projects should be funded. Almost all interviewees saw cost-benefit analysis as the only means by which any flood hazards mitigation decisions could be made. Succulently expressing views similar to many other respondents, one local official in Cork commented “obviously cost benefit analysis will be

done and that will determine what will happen”. While several interviewees suggested that there was a need for alternative decision-making tools that would examine what one city councillor described as “broader benefits”, they lacked any clear vision of how such decision-making would be implemented, what factors would be included and what weight costs would carry within such an alternative decision-making model.

Boxes 2 3, 4 and 5 to be inserted approximately here.

### ***5. Challenges to Integrating Vulnerability Analysis and Risk Assessment***

Several factors may play an important role in the ongoing dominance of quantitative risk assessment and structural engineering fixes in contemporary flood hazards policy and decision-making, as well as in the apparent failure of vulnerability analysis and alternative loss mitigation strategies to gain significant traction. Decision-making with regard to environmental hazards is shaped by broader public policy concerns and is frequently subsumed into economic development objectives that play a powerful role in shaping the ways in which hazards events are framed and understood (Jeffers, forthcoming). However the evidence presented in this paper also indicates that there are issues directly related to the ways in which knowledge about flood hazards is produced and utilised within the decision-making process that play an important role in the continued dominance of the ‘tech fix’ and the ongoing neglect of alternative ‘social fixes’.

#### **5.1 Methodological challenges**

It is clear from the evidence presented earlier that local officials and decision-makers are confident in their ability to quantify physical exposure to hazards through the techniques of risk assessment and to make policy decisions based on the results obtained from those analyses. Despite the critiques of quantitative risk assessment reviewed earlier in this paper it

is nevertheless the case that it remains an accepted practice with a clearly established set of methods through which it is implemented. These practices and methods retain the confidence of both local and national decision-makers. This is evident from their prominent position in national flood hazards policies and from the confidence with which local decision-makers discussed their use and their reliance upon them. This sits in sharp contrast to vulnerability analysis. When asked about vulnerability analysis and how it might be incorporated into flood hazards policy, officials and decision-makers were generally (with some exceptions) willing to acknowledge that it should probably form part of a full analysis of flood hazards. However as the data presented earlier illustrates they seemed unsure of how this might be accomplished, what methods might be used to do so, and what policy outputs might result from such an analysis. In other words they are comfortable and confident with relatively well understood physical processes but not with what they perceive as less well understood social processes and their implications. This suggests that the ongoing exclusion of vulnerability analysis from decision-making is partly explained by the lack of a clearly accepted methodology that can generate applied outcomes.

While vulnerability has often been easier to capture and explain through narratives, this has also limited its applicability to public policy (Mustafa, et al. 2010). Narratives of vulnerability have helped to develop theoretical understandings of the concept but they have often suited the needs of academics rather than those of decision-makers (Mustafa, et al. 2010). Despite the focus on narratives, attempts at quantification have also been evident throughout the evolution of vulnerability research (Boruff, et al. 2005; Cutter, et al. 2000; Cutter, et al. 2003; Rygel et al. 2006). This has include attempts to quantify and map vulnerabilities to multiple hazards (Cutter, et al. 2000), to integrate measures of physical exposure and socio-economic vulnerability (Boruff, et al. 2005), and to map the combined

impacts of environmental change and socio-economic change (O'Brien, et al. 2004, Leichenowicz and O'Brien, 2008). However these attempts at quantification have also revealed disagreements about appropriate methodologies and statistical techniques and highlighted the lack of a consensus regarding which indicators of vulnerability are the most relevant. Vulnerability assessments have also frequently been limited by data availability and the spatial scales at which it can be quantified, with studies often based on the accessibility of data at the appropriate scale rather than on the data that might be most pertinent to determining the potential for loss. Attempts to develop methodologies for the quantification of vulnerability have continued (Kahn, 2012; Mustafa, et al. 2010; Noriega and Ludwig, 2012) with an increasing emphasis on the need to present vulnerability in applied formats that might be used by decision-makers. These efforts are welcome and are an area where ongoing research is likely to be needed. However the results of the research presented in this paper also illustrate that improved methodologies alone are unlikely to lead to an increased role for vulnerability analysis in hazards policy or to any reduction in the dominance of the 'tech fix'.

## **5.2 Structural, discursive, and conceptual challenges**

While new methods for vulnerability analysis that could be used to create applied policy relevant data on socio-economic vulnerabilities would be a welcome improvement from current practices, on their own they appear unlikely to serve as a catalyst for substantial changes. The results of the research presented earlier demonstrate that the dominance of quantitative risk assessment and structural engineering solutions cannot be accounted for simply by the lack of an agreed methodology for vulnerability analysis. Quantitative risk assessment and engineering fixes are structural and discursively embedded in the decision-making process in ways that promote a particular conceptualisation of flood hazards and their causes.

The decision-making process and the actors within it operate from the starting point of a particular understanding of flood hazards and their causes. In policy documents floods are understood largely as exogenous physical events impacting on human society. This viewpoint is articulated most clearly in the “Source-Pathway-Receptor model but permeates throughout both written policy documents and the decisions that result from them. As floods are viewed as events that are largely external to society no distinction is drawn between flood events themselves and the losses that they induce. This conceptualisation of flood hazards leads to the conclusion that they should be assessed through quantifying physical exposure and that loss should be eliminated by preventing the event itself from occurring, in so far as it is practical to achieve this. The pervasiveness of this viewpoint is illustrated in the interview data presented earlier where even interviewees who were opposed to quantitative risk assessments and structural engineering solutions saw them as unavoidable.

This conceptualisation of flood hazards is embedded within the decision-making process in several ways that can be explained at least in part by the historical evolution of flood hazards policy in Ireland. As in many other countries, flood hazards policies and the institutions responsible for them have evolved over time based on shifting public policy priorities and the interests of influential groups (see O’Neill (2006) for a discussion of the evolution of flood hazards policy in the US). Throughout much of the history of the Irish State flood hazards were viewed largely as a threat to the productivity of agricultural land rather than as a risk for urban populations. National flood hazards policy was enshrined in the Arterial Drainage Acts 1945-1995. These focused on the drainage and improvement of agricultural lands and designated the Office of Public Works as the national agency responsible for implementing drainage and improvement schemes. This focus on agricultural drainage remained central to

flood hazards policy until the 1990s when the emphasis began to shift to the exposure of urban populations to flood events.

This history continues to shape the decision-making and policy process in several ways. The economic benefits of draining and improving agricultural land were a key factor in the passage of the Arterial Drainage Acts (Jeffers, 2011) and an economic framing of hazards continues to shape policy and decision-making today (Jeffers, forthcoming). The historical evolution of flood hazards policy also continues to shape who the key actors in the decision-making process are. A relatively narrow range of expertise centred around engineers and professional planners dominates the decision-making process. Consequently floods are viewed largely as drainage problems that may hinder the economic development of a city (Jeffers, forthcoming). It is not that decision-makers are completely unaware of or unwilling to engage with alternative perspectives but their training, experience and expertise are all shaped by a discourse that emphasises the role of physical exposure as the primary driver of loss or damage during floods.

The influence of this conceptualisation of flood hazards was also clearly evident among elected decision-makers who are not trained in areas of expertise such as engineering. Their support for the continued dominance of the ‘tech fix’ may also result from a lack of awareness of alternatives as well as from other factors related to the decision-making process such as the distribution of costs and benefits and their implications for local government. Flood hazards policy is heavily influenced by the cost-benefit model that permeates most areas of decision-making. The cost-benefit approach, and in particular the ways in which costs and benefits are distributed within it, plays a key role in shaping the outcomes that emerge. Under current arrangements most funding for local government in Ireland is

provided by the national exchequer with local authorities having a limited ability to generate their own revenue. In contemporary flood hazards policy almost all major flood prevention schemes are funded by the national government. Local authorities receive several direct and indirect benefits as a result. Local businesses that are protected from flooding are likely to be more able and willing to pay commercial rates, the chief source of locally generate revenue for local government in Ireland, than would be the case if they were experiencing flood induced losses. The prevention of floods also fits within the dominant discourse of local and national policy in Ireland which sees the chief responsibility of governments as the promotion of a particular vision of economic development and the creation of conditions conducive to external investment (Jeffers, forthcoming).

Flood prevention schemes also provide clear benefits for elected representatives. Flood defences are typically large structures. Both during their construction and through their subsequent presence they are a visible reminder that action has been taken to address an issue that was perceived as a problem. This sits in sharp contrast to the range of alternative strategies for flood loss mitigation which are often less visible and may take longer to implement. Their results may also be less visible as even though they may reduce loss they may not prevent the flood event itself. Funding and where it should be sourced would also likely become an increasingly complex issue under any policies that emphasise reducing vulnerability. At both local and national levels the agencies and institutions that are responsible for addressing aspects of socio-economic vulnerability are generally rather different from those that address flood hazards. Decision-making and policy is compartmentalised into discrete areas whereas balancing the emphasis on physical exposure with an increased awareness of socio-economic vulnerability would require a new integrated approach to the issue.

Overcoming these challenges and integrating vulnerability research into policy is likely to require partnerships and engagement between social science researchers and local stakeholders (Mitchell, 2006). However the success of such partnerships would depend on a genuine willingness to engage with multiple perspectives and an openness to having previously held assumptions challenged by alternative viewpoints. Such partnerships may be difficult to create and even more difficult to sustain as they are likely to require dramatic changes in their framings and conceptualisations of flood risk among local stakeholders, a reassessment of the types of losses they are willing to accept, and substantial changes to the decision-making process.

## **6.0 Conclusions**

It is clear that quantitative risk assessments and structural engineering fixes continue to dominate flood hazards policy and decision-making despite sustained critiques of both by geographers and other social scientists. It is also clear that vulnerability analysis has largely failed to emerge as a complementary decision-making tool which could promote a wider range of strategies for flood loss mitigation. The empirical research presented in this paper shows that there are several factors that help to explain the ongoing dominance of the 'tech fix' and that provide obstacles to any attempts to promote alternatives. The absence of an agreed methodology for vulnerability analysis is certainly a significant limitation. Physical exposure is a relatively well understood phenomenon and despite critiques by social-scientists the methods for its assessment are also well understood and widely accepted. Decision-makers are comfortable with the metrics, concepts, tools and outcomes involved in quantifying physical exposure. This sits in contrast to socio-economic drivers of vulnerability

which are viewed as less well understood and much more uncertain. Improved methods for vulnerability analysis can certainly help to overcome this challenge.

However there are also more fundamental obstacles to change. A particular conception of flooding that emphasises physical exposure and neglects other drivers of loss is structurally and discursively ingrained in the decision-making process. While this is to a large extent the product of historical circumstances it is nonetheless difficult to change. Promoting alternative strategies for the assessment of flood hazards losses and decision-making responses to them requires a substantial shift in the ways in which flood hazards are conceptualised by decision-makers. It requires creating a distinction between flood events and the losses that they induce. It also requires radical changes in the ways in which decisions regarding flood hazards are made, and in the distribution of costs and benefits associated with them. In this regard contemporary environmental and socio-economic changes may represent an opportunity for such a transformation. The experience of Ireland's cities mirrors global trends with environmental change leading to increased exposure, and socio-economic change potentially leading to increased vulnerabilities. Contemporary economic crises also present a fundamental challenge for the 'tech fix' as the constraints on available government funding may limit the scale of engineering interventions that are possible. This context provides a new opportunity for geographers to engage once again with decision-making and policy in an attempt to promote a broader range of alternative flood loss mitigation strategies that may prove to be more economically, socially and environmentally sustainable. Quantitative risk assessment and structural engineering are always likely to form an important part of flood loss mitigation strategies. However their dominance is likely to be increasingly challenged by both environmental and socio-economic change and this presents a new opportunity to promote positive alternatives.

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### **Box 1. Interviewee's views on socio-economic vulnerabilities**

*Obviously there should be a plan there [to address social vulnerabilities] but I can't see it being a huge issue. (City Councillor – Galway)*

*That would be part of our emergency plan to deal with that, with vulnerable places or if you have homes where there are elderly people or those who didn't have their own means of getting out of the flooded areas. (Engineer – Cork)*

*I have mentioned previously in terms of schools, crèches, hospitals, institutions, anything like that, and particularly as it relates to the weaker in our society there must be [a plan to address their vulnerabilities]. (City Councillor – Galway)*

*We have put quite an amount of effort into that [vulnerability] to the point where within each one of the localised areas we have local population distributions, we have age profiles in those areas, we have identified evacuation routes, locations for evacuation, we have identified complementary facilities so we have probably done more in terms of the pre planning for evacuation than people might give us credit for at the moment. (Engineer – Dublin)*

*Our less mobile population like the elderly or people who are dependent on carers and that type of stuff. There should be some sort of a plan put in place. Whether or not it will ever have to be activated is up to the elements. That's something that should be considered. I didn't think of that before now to be honest. (City Councillor – Cork)*

### **Box 2. A selection of interviewees' views on flood prevention**

*It's all about prevention. It's fine to say with developments like the docklands that it needs to engineer out the potential problems but the real solution possibly is having some form of barrages or something like that in the outer harbour. (Business Representative – Cork)*

*I think prevention has to be emphasised more, we would hope that it would not come to a situation where people would need to be evacuated or that emergency services would find themselves ill equipped to deal with the situation so if you are going to prioritise funding for example well then I would have thought prevention in terms of flood defences and land use for the future, they would be the two that should be prioritised. (City Councillor – Dublin).*

*I think the idea of protecting that by way of barrage into the future is something that you can't ignore if sea levels are going to rise if this continues to be a trend then you have to look at protecting the city. (Planner – Dublin)*

### **Box 3. Discussions of Flood Risk in the Minutes of City Council Meetings**

*The bad weather and flooding in the South and West has highlighted the need for the fast tracking of urgently required flood prevention measures. Ringsend and Sandymount have been flooded recently and residents, many of whom are elderly, are living in fear that their homes will be flooded once again unless Dublin City Council speeds the process up. There is no point in waiting until their homes are flooded again. (Dublin City Council meeting, February 2007)*

*In light of recent flooding around Dublin such as Donnycarney and the Council's mention of flood management on page 59 [of the city development plan], can the Council outline the methods by which they will ensure that flooding in the very prone areas will be drastically reduced or eliminated altogether. (Dublin City Council meeting, October 2009)*

*To ask the [City] Manager to outline the status and timetable of plans to protect the residents on Beach Road, Newgrove Avenue and Gilford Road from any future flooding. (Dublin City Council meeting, September 2009)*

*Could the [City] Manager advise if Cork City Council intends to construct a storm barrage to protect inland areas from surges at sea. And if not, what he expects will protect the city from flooding. (Cork City Council, March 2009)*

### **Box 4. Comments on Flood Risk During Dáil Éireann Debates.**

*I draw the House's attention to the East Wall-North Strand area, which lies between the mouth of the River Tolka and the point at which the Royal Canal enters the Liffey. It has been flooded from both sides in the past and has a history of flooding, yet no actual work has been carried out adjacent to this area. The issue is not being taken half seriously, if it is at all. (February 1<sup>st</sup> 2005)*

*Deputy Joe Costello asked the Minister for Finance his plans for dealing with the threat of flooding on the north side of Dublin; if the anti-flooding measures for the final stretch of the River Tolka at Distillery Road will be put in place. (September 24<sup>th</sup> 2008)*

*Something must be done. In the first instance, families whose homes were damaged must receive some assistance. The most important action is the raising of regional roads. The fifty vulnerable spots identified by Mayo County Council must be dealt with immediately. A situation such as that at Christmas, where people were unable to access their homes, cannot be allowed to recur. (February 14<sup>th</sup> 2007)*

*I wish to ask the Minister for Finance if he is satisfied with the measures taken to avoid flooding following the latest incidents in Dublin and along the south and east coast yesterday. (October 28<sup>th</sup> 2004)*

**Box 5. A selection of quotes from the records of the Committee on the Environment, Heritage and Local Government.**

*Something caused the flooding in Cork to happen and it cannot simply be rainfall. (Elected Representative, March 2<sup>nd</sup> 2010)*

*In Athenry in south Galway people have not been able to get back into their houses. If they do get back, will work be carried out by the OPW [Office of Public Works] to ensure that flooding does not occur again? (Elected Representative, March 9<sup>th</sup> 2010)*

*I hope flooding that occurred all over the country will become a thing of the past. (Elected Representative, February 23<sup>rd</sup> 2010)*

*We have invested in flood prevention measures. Senator Buttimer may dispute this but it is a fact. That budget has been increased and is set to increase even further despite the cutbacks. We are determined to make that investment because it is not acceptable that certain areas continue to be flooded. (Minister for the Environment, Heritage and Local Government, March 2<sup>nd</sup> 2010)*