Environmental knowledge and Human Experience: Using a historical analysis of flooding in Ireland to challenge contemporary risk narratives and develop creative policy alternatives

Focusing on three of the largest coastal cities in the Republic of Ireland this paper highlights the importance of a historical analysis of flood hazards in contextualising current events and potential future risks. Over the last decade the cities of Dublin, Cork and Galway have experience several major coastal, river and pluvial floods. In the aftermath of these floods two distinct but related narratives have dominated public discourse and official responses. The first narrative presents recent floods as unprecedented and as possible evidence of climate change. The second constructs floods primarily as natural events and assumes that the optimal means of reducing flood losses is to prevent flood events. In this paper I suggest that these narratives are not supported by a historical analysis of exposure and vulnerability to flood hazards in Irish cities. This paper draws primarily on newspaper archives to construct a record of past flooding that challenges these narratives in several ways and in doing so offers lessons for similar cities in other countries. I contend that these narratives are perpetuated by a narrow form of knowledge production (quantitative risk assessment) and a narrow range of data (numeric instrumental records). Incorporating a broader range of sources and data types into risk and vulnerability assessments may illuminate more creative strategies for reducing both contemporary and future flood losses.

Keywords: flooding, climate change, risk, adaptation, vulnerability, Ireland.

1. Introduction

Contemporary research and practice in the fields of global environmental change and natural hazards places a strong emphasis on the likely implications of future climatic changes for the exposure to environmental hazards. Researchers in fields such as physical geography and climatology have developed increasingly sophisticated techniques for modelling and predicting future climates (Solomon, et. al., 2007). At the same time research in human geography and similar social science disciplines continues to contribute to a rapidly growing literatures on the changing vulnerabilities of local communities in the face of both environmental and socio-economic changes (Eakin, Winkels, & Sendzimir, 2009; Frazier, Wood, Yarnal, & Bauer, 2010; Kleinosky, Yarnal & Fisher, 2006; Klinenberg, 2002; Leichenko & O'Brien 2008; Leichenko, O'Brien, & Solecki, 2010; O'Brien, et. al. 2004; Lopez-Marrero & Yarnal, 2011) and to the

challenges of adapting to those changes (Adger, et. al., 2009; Adger & Barnett, 2009; Moser and Boykoff, 2013; Moser & Ekstrom, 2010; Pelling, 2011). A particular emphasis has been placed on the contemporary and future challenges faced by cities in both developing and developed world contexts (Chan, Mitchell, Adekola, & McDonald, 2012; Chatterjee, 2010; Mitchell, 1999; Leichenko, 2011; Pelling, 2003; Solecki, Leichenko, & O'Brien, 2011). While this focus on the contemporary and future hazards facing cities is both admirable and necessary a growing number of researchers have also highlighted that there is much to be learned from historical analyses of both physical exposure and human vulnerability to past hazard events (Bankoff, Lübken, & Sand, 2012; Bankoff, 2013; Bankoff, 2003; Galloway, 2013; Hickey, 2011; Ludlow, et. al. 2013; Mauch & Pfister, 2009; Mitchell, 2011; Pfister, et. al. 1999; Rohr, 2013).

Focusing on three of Ireland's coastal cities this paper further highlights the importance of a historic analysis of flood hazards in contextualising current events and potential future risks. Contemporary narratives of large flood events experienced in Ireland within the last decade have presented recent floods as new and unprecedented while assuming that floods can and should be prevented through appropriate risk management. In this paper I contend that these narratives rely almost exclusively on one form of knowledge production (quantitative risk assessment) and one form of data (quantitative instrumental records and future modelling projections based on them). This reliance on one type of knowledge supports a narrow range of policy and decision making responses as quantitative risk management practices are assumed to be the optimal means of reducing loss. While non-structural alternatives to traditional engineering approaches now form part of national flood hazards management policy, they appear to have gained little traction. Assuming that their cities face an

unprecedented new challenge encourages officials, decision-makers and local communities to consider new and unprecedented solutions including large scale engineering fixes which may not be environmentally, socially or economically sustainable. It also neglects to consider the lessons that might be learned from an examination of how societies coped with floods in the past. I argue that historical evidence challenges the dominance of a risk management approach and illustrates the value of incorporating a wider range of data sources and types of knowledge into risk and vulnerability assessments. It demonstrates that large floods are a part of the historical experience of Ireland's coastal cities and that a historical analysis of these events may offer important lessons for contemporary policy and decision-making. The limited initial analysis presented in this paper draws primarily on newspaper archives but in doing so it highlights the need for further historical research based on additional archival and unwritten sources. This historic approach places the human experience of hazards at the centre of the analysis in contrast to impacts based approaches which have been accused of echoing environmental determinism and Darwinist principles (Ribot, 2011). A historic perspective can also illustrate the extent to which understandings of hazards shift over time allowing hazards to be framed in contrasting and sometimes contradictory ways with important implications for the types of decisions we make about them (Mitchell, 2006).

2. Ireland's Coastal Cities

This research focuses on three of Ireland's largest coastal cities, Cork, Dublin and Galway. Dublin is the capital of the Republic of Ireland and the largest city on the island. With a population of over 1.5 million people the Greater Dublin Area is home to almost 40% of the population of the Republic of Ireland and is the centre of economic and political activity in the country. Throughout the city's history, its proximity to water

has been essential to its development and growth (Gilligan, 1988). However the story of Dublin's development is not just about its proximity to water, it is a story of human-environment interactions including numerous attempts to manage and tame the waters that surround the city. The construction of quay walls, modification of river channels, and land reclamations have been a feature of the city's development for centuries (Moore, 2008). Dublin is situated on a low lying coastal plain at the confluence of three major rivers, the Liffey, Tolka and Dodder. The city is also traversed by numerous smaller streams and rivers, most of which have been culverted for some or all of their length. The larger rivers have also been modified. In the case of the Tolka this has been in the form of small weirs and flood defences which channelise the river. Three dams were built on the Liffey between 1937 and 1949. These were designed primarily for the production of hydroelectricity but have also been used to provide a reservoir for water supply and to regulate the discharge of flood waters (Fitzpatrick and Bree, 2001). Two earthen dams on the Dodder create water supply reservoirs for Dublin City Council. Concerns regarding the possible overtopping and failure of these dams during periods of heavy rainfall led to the construction of new spillways completed in 2006 (Dublin City Council, 2008a).

With a population of 119,000 within the city boundary, Cork is the second largest city in the Republic of Ireland. Due to its physical characteristics the city has a long history of flooding. Much of the city centre is built on what is now an island between two channels of the River Lee, both of which are tidal. The city was originally constructed on a series of islands in what was then a large swamp. Over several centuries neighbouring islands were included and the channels in between were filled or culverted over. Much of the modern city centre island lies at elevations that are just above the

level of the highest spring tides and is exposed to flooding of both river and tidal origin. Two upstream dams on the River Lee were completed during the 1950s and were built primarily for the production of hydroelectricity. While they have been operated to successfully control small floods in the past (Fitzpatrick and Bree, 2001), there have also been several occasions when large floods have exceeded the capacity of the dams to regulate them (Jeffers, 2011a).

Galway is a city of 72,000 located on the northern shore of Galway Bay, at the mouth of the River Corrib. Due to its location on Ireland's exposed west coast, Galway faces the greatest exposure to storms of the three research sites. River flooding has rarely been an issue in the city in modern times as the river is controlled by a weirs and canals. The city's exposure to coastal flooding has increased throughout its history as the city expanded westwards along the coastline eventually including the once separate village of Salthill. Parts of the city's docklands and other coastal districts are constructed on lands that were reclaimed from the sea. Further reclamations are likely as part of a plan to develop a new port in deeper water.

3. Dominant Narratives: Surprise and flood prevention

In recent years notable floods have occurred across all three cities leading to disruption, damage to infrastructure, substantial economic loss, and in a small number of cases, loss of life. Major river floods struck Dublin in 2002 and Cork in 2009. Coastal floods occurred in all three cities in 2002 but the most severe social and economic impacts were recorded in Dublin. All three cities have also experienced pluvial flash floods with notable events occurring in Dublin in 2004, 2008, 2009, and 2011, Cork in 2002 and 2012, and Galway in 2003 and 2008. Additional coastal flooding struck all three cities in January 2014. The aftermath of these floods has frequently been characterised by two

distinct but related reactions among those affected, the wider general public, and local officials. The first of these has been a narrative that presents these events as shocking, unusual, unprecedented and as evidence of climatic shifts. The second narrative presents floods as preventable and manageable through appropriate engineering interventions and assumes that the most effective means of reducing flood losses is to prevent the flood from occurring.

The narrative of surprise and shock was strongest in response to the coastal flooding experienced on February 1st 2002. On that afternoon, the city of Dublin and surrounding regions experienced the highest tide since recording began at Dublin Port in the early 1920s (Barry & Partners, 2002; Dublin City Council, 2002; O'Connell and Coe, 2003; Royal Haskoning, 2005). A tidal surge produced by a combination of gale force winds and low atmospheric pressure, coincided with an already high spring tide to produce sea levels over one metre higher than had originally been predicted (Dublin City Council, 2002; Royal Haskoning, 2005). While flooding was experienced in several parts of Ireland including Meath, Louth, Waterford, Kerry, Limerick, Cork, and Galway (Irish Red Cross, 2002; Office of Public Works, 2002), several neighbourhoods in Dublin city experienced the most severe impacts. Communities close to the lower tidal reaches of the River Dodder on the city's south side and along the banks of the Royal Canal on the north side were inundated by floodwaters ranging in depth from just a few centimetres to over one and a half metres (Barry & Partners, 2002; Dublin City Council, 2002; O'Connell and Coe, 2003; Royal Haskoning, 2005). Fortunately this flood did not result in any fatalities but economic losses were substantial. Almost eight hundred houses were flooded with many of these requiring expensive repairs and renovations (Dublin

City Council, 2002). It is estimated that as many as forty percent of these homes may not have had insurance coverage[1] (Dublin City Council, 2002).

The reaction to this flood and its aftermath among local officials and the general public was one of shock. In interviews completed in 2009 as part of the larger project of which this paper forms a part, local officials, residents and other stakeholders frequently spoke of their shock and distress at the extent of the 2002 flood, the fact that it was not predicted, its rapid onset, and its impacts on local communities (Jeffers, 2011b). This flood and subsequent river flooding in November of the same year prompted reviews of policy and practice at both local and national levels. Flood hazards were given a new priority at the local level in Dublin with the implementation of several flood defence projects and Dublin City Council's participation in international knowledge exchange projects including SAFER (Strategies and Actions for Flood Emergency Risk Management) and the FloodResilienCities project. A national review of flood hazards policy was completed in 2003 with the publication of the Report of the Flood Policy Review Group (Office of Public Works, 2004). This prompted a shift from a previously reactive flood risk policy to a more proactive flood risk management approach although there are doubts about the success of this change (Jeffers, 2013a, 2011a) and challenges to its implementation remain (Scott, el. al., 2013).

The second contemporary narrative of flood hazards suggests that flood events can be prevented through appropriate engineering interventions and that flood prevention is the optimal means of reducing flood losses. The influence of this narrative was most clearly manifested in the aftermath of river flooding experienced in Cork City in November

[1] Property insurance coverage in Ireland generally includes flood insurance.

2009. Although flooding is not unusual in Cork, the November 2009 flood was described by local officials and residents as the worst river flood to strike the city for many years (Jeffers, 2011a). It resulted from the release of large volumes of water from the Inniscarra Dam in the aftermath of heavy rainfall. The operators of the dam, the Electricity Supply Board (ESB, now known as Electric Ireland) claimed that the release was necessary to preserve the structural integrity of the dam during what they described as a one in eight hundred year event (Hickey, 2010). As a result of this discharge much of the city centre island and the city's western suburbs experienced heavy flooding. The impacts included widespread disruption to drinking water supplies due to damage to the city's water treatment plant. In the aftermath of the event public discourse was dominated by a narrative that suggested that the flood should have been preventable (or at the very least more accurately forecast) and that some agencies or organisations must be to blame for these failures. This narrative was clearly visible in the testimony of numerous witnesses before a parliamentary investigation into the event and its aftermath (Joint Committee on the Environment, Heritage & Local Government, 2010). The narrative of flood prevention and its influence on flood hazards policy was also clear in interviews with local officials and decision-makers across all three cities. Flood prevention through structural interventions was often seen as essential to economic prosperity due to the risk that flood events might be viewed negatively by potential investors (Jeffers, 2013b). Despite an official shift in policy that encourages a move away from reactive structural interventions in response to major flood events, prevention through an engineering fix remains the preferred means of managing flood risk (Jeffers, 2013a).

4. Historical Evidence for Large Floods

The research on which this paper is based formed part of a larger project which investigated vulnerability to flood hazards and climate change adaptation in Ireland's coastal cities (Jeffers, 2013a, 2013b, 2011a, 2011b). This wider project drew on a range of data collection methods including semi-structured interviews with local decision-makers and an analysis of records of decision-making such as the minutes of City Council meetings. In order to examine historic patterns of flood hazards exposure and vulnerability in each city several sources were used to establish a historical record of flood events. This included a search for any available academic literature, publications by public bodies such as Met Éireann (the Irish Meteorological Service), a search of the flood event database www.floodmaps.ie maintained by the Office of Public Works (OPW), and a search of the archives of *The Irish Times* newspaper. These archives which are available online (for a fee) provided complete access to the newspaper from 1859 to the present[2]. This Dublin based daily newspaper is recognised as Ireland's 'paper of record' and its online archive contains searchable digital records of its publications from 1859 to the present. The combination of *The Irish Times* archive and a range of other academic and policy publications has allowed for the compilation of a list of floods in each city stretching from the 1600s though to the present day.

It is recognised as inevitable that the record produced does not include every flood experienced in each city as some events may not have been reported, may not be included in the www.floodmaps.ie database or may not have been returned by the search function of *The Irish Times* database. There is also a wealth of other potential archival sources that could be used to add further detail to the record produced here

[2] The content of The Irish Times Archives is used and reproduced with the permission of the copyright owners, The Irish Times, Dublin, Ireland.

(Mitchell, 2011) and the need for additional historic analysis is one of the main conclusions of this paper. Each of the sources used in this analysis are subject to clear limitations. Publications by Met Éireann and other public bodies tend to focus on events that were notable due to unusual physical characteristics or high impacts meaning that events that were less notable were unlikely to be included. The www.floodmaps.ie database is heavily reliant on reports produced by local authorities and tends to focus on recent decades. Newspaper archives are limited by editorial style and decision-making. Some events may have been deemed of insufficient significance for inclusion or may have occurred at times when other stories dominated the headlines. Editorial style may also have led to particular events being highlighted in ways that emphasise or minimise some of their impacts.

Despite its limitations the historical reconstruction produced here provides a new record of major floods. As I discuss in detail throughout the remainder of the paper, this analysis allows for an important critique of contemporary policy and practice, while also pointing to the pressing need for further historical analysis of urban flood hazards, not just in Ireland but also in flood prone cities in other countries where extensive archives and other source materials may be available but remain largely untapped. The listing of flood events generated for each city is included in Appendices 1, 2 and 3.

4.1 Floods in Dublin

River floods have been a frequent hazard throughout the history of the Dublin while coastal and pluvial flooding have also occurred periodically. Historical records dating from as early as the year 693 describe severe river flooding in eastern regions of Ireland but the first record specific to Dublin is of an event in 1385 when a bridge is believed to have collapsed during a flood (Dixon, 1953). Flooding from the Rivers Liffey, Poddle

and Dodder appear to have been most common during the 1700s and 1800s with numerous reports of bridges being damaged or destroyed as well as the flooding of homes and businesses (Cawley, *et. al.*, 2005; Dixon, 1953). While some of these bridge collapses are undoubtedly related to the nature of the bridges themselves which would have been neither as large nor as strong as their modern replacements, the city seems to have experienced some very large floods during its history. Despite the frequency and extent of flooding loss of life in flood events has generally been low. For example a flood on the Liffey, Dodder and Poddle in 1802 was described as one of the worst in the history of the city but only one death was recorded (Cawley, *et. al.*, 2005; Dixon, 1953). In contrast to the low death toll reported in this event a flood on the Liffey in 1807 resulted in at least nineteen deaths (Dixon, 1953) but such death rates appear to have been unusual.

The academic literature does not record any significant coastal flooding but beginning around 1870 *The Irish Times* contains several reports of coastal flooding ranging from apparently minor events where waves overtopped sea walls and no significant impacts are reported, to much more extensive flooding along of the city's coastline, with reports of widespread damage to property and disruption to transportation. During the late 1800s *The Irish Times Reports* coastal floods in 1877, 1880, 1884, 1893, 1898 and 1899. The 1877 flood appears to have been the most severe in terms of the range of impacts reported. The description of the flooding along the coastline and on the lower reaches of the Liffey, Dodder and Tolka rivers suggests that the flooding was associated with the passage of a storm system that brought a storm surge and high winds driving the tide far above average levels. This suggests that this event may be comparable to the coastal flooding experienced in February 2002. The 2002 event is framed as

unprecedented in part because it is the highest tide in the city's tide gauge record but this record extends less than one hundred years. An analysis of flood return periods based solely on the tide gauge record might lead to the conclusion that large coastal floods are a less frequent occurrence than is actually the case. Views of the 2002 flood may also be shaped by an apparent decrease in frequency of coastal flooding in the latter half of the twentieth century. The reporting of *The Irish Times* suggests that during the end of the nineteenth century and the first half of the twentieth century, coastal floods were a more frequent occurrence in Dublin than was the case during the second half of the twentieth century. However between 1945 and 2002 only one relatively minor coastal flood is recorded. An obvious explanation might be the construction of improved flood defences. However there is no evidence that new flood defences can account for this trend and some areas of the coastline remain unprotected. This gap is also covered by the tide gauge record for Dublin Port which would have recorded any unusually high tides even if they did not lead to significant flooding. The fact that 2002 event broke a tide record established in 1924 suggests that there were no similar events in the intervening period. Regardless of its cause it is clear that the city experienced several decades when coastal flooding became less frequent than previously, adding to the sense of shock when large coastal floods returned in 2002.

Throughout the Twentieth Century, the city continued to experience river flooding in the Liffey, Tolka, Dodder, Poddle and Camac basins. A decline in newspaper reports and other sources suggests that flooding on the Liffey appears to have become less frequent over this time period. This is likely to be a result of the construction of several hydroelectric dams upstream which have regulated the rivers flow (Fitzpatrick and Bree, 2001). Flooding on the Tolka and Dodder has remained a common feature of the

city's exposure to hazards throughout the Twentieth Century although the weather conditions required to produce flooding on each river are quite different. As a result it is unusual for flooding to be experienced in both basins at the same time. The Tolka tends to rise slowly with floods occurring when heavy rainfall is experienced over several days throughout its catchment. In contrast the Dodder is prone to rapid onset floods produced when heavy rainfall occurs in the upper portions of its catchment in the mountains south of the city. The river falls 751 metres in its 27km journey from its source to the sea resulting in floods that travel quickly down river. Prior to the 2002 coastal flood the most notable flood within living memory occurred in 1986 during the passage of a storm known erroneously as Hurricane Charlie.[3] This extra-tropical cyclone produced heavy rainfall across the southern half of Ireland shattering one day rainfall records. Flood waters were over 2.5m deep in some locations, affecting over 400 properties (Cawley, *et. al.*, 2005; Met Éireann, 1986). From 1986 until 2000 the city experienced few floods and all available reports suggest that those that did occur did not lead to any notable impacts. As mentioned earlier in 2002 the city experienced severe coastal and river flooding in separate events occurring in February and November. These events were followed by a less severe flood on the Dodder in 2003, a less serious coastal flood in 2004 and pluvial floods in 2004, 2008, 2009 and 2011.

4.2 Floods in Cork

Tyrrell and Hickey's (1991) flood chronology for Cork reveals that two hundred and ninety floods were recorded in the city between 1841 and 1988. My analysis indicates that at least eleven additional floods have occurred since 1988. There have been

[3] Two spellings for the storm name appear in media reports and academic literature. The storm is referred to as both Hurricane Charlie and Hurricane Charley.

numerous relatively minor events producing impacts such as street flooding but little or no property damage. However the city's record of flooding also includes a number of very large floods leading to loss of life and substantial economic losses. The earliest documented reports of flooding in Cork date from 1633 when several bridges were destroyed in a river flood (Tuckey, 1837 cited in Hickey, 2010). In 1789 a river flood described as being between 1.5m to 2.1m deep killed at least one resident (Hickey, 2010; Cawley, *et. al.*, 2005). In November 1853 another river flood produced water levels that are believed to have been between 2m and 3m deep and led to the deaths of 12 people (Hickey, 2010). Flooding continued to be a common feature of the life of the city throughout the Twentieth Century with further flooding in 1916 described by Cawley, *et. al.* (2005) as comparable to the 1853 event. However *The Irish Times* reported flood waters over 1.8m deep in areas to the west of the city centre and up to 1.5m closer the city centre, shallower depths than reported in 1853.

The history of flooding in the city suggests that the largest flood depths and most significant socio-economic impacts were usually associated with river floods although tidal surges frequently left the city centre flooded to depths of up to 1 m. It is worth nothing that for some of these tidal flood events such as that experienced in February 1967, the residents and business owners of the city appear to have been well prepared. *The Irish Times* records that few losses were experienced as business owners had moved stock off ground floors. *The Irish Times* of May 3rd 1962 also reports that the city began tests on a flood warning system. It is not clear how the warnings were to be produced but they were to be disseminated to the population of the city by means of a loud speaker mounted on a van. These reports of a well prepared city contrast sharply with more recent events which appear to have struck a largely unprepared population. It is

not clear if the flood warning system being tested in 1960 was ever implemented but the city did not have a flood warning system or a clear means of disseminating such a warning to its population prior to the 2009 flood.

Cork has had several floods in recent years. In February 2002 the city experienced coastal flooding on the same day that Dublin and Galway were also affected by tidal surges. *The Irish Times* reports that floods several feet deep were experienced in many parts of the city centre, flooding numerous streets. However unlike in Dublin, this event was not perceived as being particularly unusual and seems to have had no impact on decision-making. In contrast to Dublin no new flood defences were constructed or policy initiatives undertaken in its aftermath. The tidal surge in February was not the only flooding to strike Cork in 2002 as a pluvial flood up to 1.5m deep struck the Blackrock area in November. As mentioned earlier the city experienced heavy flooding in November 2009 leading to large economic losses.

4.3 Floods in Galway

Despite its location on the banks of the Corrib my analysis did not find any reports of river flooding in Galway's recent history. This sits in contrast to coastal flooding which has occurred frequently. Reports on the 'Night of the Big Wind' in January 1839, reputed to be among the worst storms ever experienced in Ireland (Shields & Fitzgerald, 1989), describe Salthill has having been impacted by the storm but it is not clear if the damage was caused by the wind itself, coastal flooding or some combination of the two (Carr, 1993). The earliest flood reported by *The Irish Times* was in 1887 when the sea is described as having come up onto the land in the city. Further flooding is recorded by *The Irish Times* in 1883 when flooding impacted the fish market and the construction of the new docks. The report also notes a concern that the floods might "break in on the

town as happened on former occasions", indicating that significant floods had occurred in the past.

In January 1995 a storm brought flooding to Galway and other parts of the west coast (Met Éireann, 1995). At least 25 homes and businesses were flooded while numerous motorists abandoned their cars on flooded streets. In February 2002, Galway experienced coastal flooding on the same day that a storm surge also flooded Cork and Dublin. The Claddagh, Spanish Arch, the Docks and Salthill areas were all flooded. Galway appears to be similar to Cork in that this event has not acquired the same prominence as floods on the same day in Dublin. Like Dublin and Cork, Galway has also experienced pluvial flood events with notable floods occurring in July 2003, August 2006 and July 2008.

5. Challenging Narratives of Surprise

This historical record clearly demonstrates that rather than being unusual, flooding has been a consistent feature of life in Dublin, Cork and Galway for several hundred years. This raises the question of why a narrative of shock and surprise has been so prominent in reaction of local officials, decision-makers and residents to flood events that have occurred within the past decade, particularly in Dublin. Floods emerging from a variety of sources have clearly happened throughout the history of the city. However a careful analysis of the records produced in this analysis does illustrate a gap in recent decades where floods were less common. This gap has occurred at a time when increased media coverage and other recording of events might be expected. As mentioned earlier this gap is most obvious in the record of coastal flooding with only two notable coastal floods being recorded in Dublin between 1930 and 2002. This absence may help to

explain why the events of February 1st 2002 came as such a shock to both the local population and decision-makers.

However the available evidence of previous coastal floods also highlights the limitations and potential dangers inherent in contemporary narratives of flood risk and current practice based on them. The narrative of the 2002 floods as unprecedented has been reinforced and perpetuated by the use of a narrow process of knowledge production (quantitative risk assessments) and a narrow range of data (a relatively short instrumental record and future modelling projections based on it) (Jeffers, 2013a). Using this approach leads to the 2002 event in Dublin and the 2009 flood in Cork being presented as worst case scenarios and as evidence of climate change (Jeffers, 2011a; 2011b). Even a cursory analysis of the historical record indicates that a number of coastal floods impacted parts of Dublin during the 1800s producing a range of socio-economic impacts and disruptions to the life of the city. While the absence of an instrumental record makes direct quantitative comparisons with the 2002 event impossible, this evidence does suggest that the 2002 flood may be within current variability rather than evidence of change. The 2002 event may be an example of a remerging hazard (Mitchell 2003) rather than evidence of a new threat. This raises the possibility that the 2002 event is far from the worst case scenario and that bigger floods are possible or even likely under future sea level rise scenarios. This suggestion is also supported by studies which suggest substantial increases in both the size and frequency of coastal floods on Ireland's east coast in the years ahead (McElwain and Sweeney, 2006). The history of flooding in Cork also suggests that events producing impacts of the magnitude of those experienced in 2009 are not outside of past experience.

Under current policy and practice primacy is given to numeric quantifiable data in allowed flood risk assessments leading to the assumption that Ireland is "data poor" (Scott, et. al. 2013, p.137). However Ireland is only data poor when the types of data included in risk assessments is limited to numeric instrumental records. If a wider range of possible data sources is considered then Ireland is in fact data rich. A wide range of historical sources provides the potential to create long term historic databases for floods and other hazards drawing on sources ranging from newspaper archives to diaries and letters (Mitchell, 2011). Tyrrell and Hickey's (1991) examination of flooding in Cork based on local newspaper archives illustrates how a much more detailed record than the one provided in this paper might be constructed through more extensive archival research than was possible for this paper.

The narrow focus on quantitative risk assessment is understandable given the institutional structures within which flood hazards are managed. These place responsibility in the hands of a limited range of experts (usually engineers) who deploy the range of skills available to them to address the challenges they face (Jeffers, 2013a). They also operate within an institutional structure which assumes that floods can be prevented and managed through engineering fixes (Jeffers, 2013a). Some attempts have been made to implement a paradigm shift away from a reactive flood prevention based approach to a more proactive flood risk management approach that emphasises the importance of land use planning and regulating new development in flood prone locations (Scott et. al., 2013, Jeffers, 2013a). While this is a welcome step it is limited by the narrow focus on quantifiable data, and the validity of the outputs of quantitative risk assessments are often questioned by local stakeholders and elected representations (Scott, et. al., 2013). The historical analysis demonstrates that more effective risk and

vulnerability assessments could be conducted by including a wider range of data sources and expertise. My aim here is not to critique the important work of engineers but to suggest that their work could be supported by historians, geographers and other researchers from across the social sciences and the humanities. This could lead to a broader understanding of hazards and a wider range of policy options for addressing them.

The integration of such a broader coalition of research expertise and data sources into the decision-making process is of course limited by a range of challenges and barriers. These include the ways in which a quantitative risk management approach that focuses almost exclusively on physical exposure to the exclusion of socio-economic vulnerability is structurally and discursively embedded in the decision-making process (Jeffers, 2013a). The inclusion of a wider range of data can only occur with the acceptance of engineers who are likely to remain the key experts in decision-making positions in local authorities and other agencies charged with flood hazards management. Such acceptance might be enhanced through the training of engineers and other officials specialising in flood risk management or through specific policy requirements that require the inclusion of social and historical data.

Any broader coalition of expertise and data sources would need to recognise the strengths and limitations inherent in all data sources, and that different types of data will serve different purposes within an overall assessment of risk and vulnerability. There are obvious limitations to the use of non numeric historic data as it cannot be easily integrated into quantitative models of risk. However it can clearly illustrate that large floods have occurred in the past and if sufficient data is available it can be used to

construct more accurate estimates of return periods (de Kraker, 2013). This data should not be ignored as it illustrates the limitations of quantitative risk assessment. It demonstrates that risk assessments based on relatively short instrumental records may not be able to deliver what they promise, that is they may not be able to accurately predict return periods. The more qualitative data available from other sources can be used to help address these limitations by potentially extending the database of known flood events by hundreds of years or more. While details such as the depth and extent of any individual flood may not be easily quantifiable with the degree of accuracy provided by the instrumental record, the overall picture of flood risk that could be created would be a more complete one that could better support sustainable hazards management.

6. Challenging Narratives of Prevention

While the data provided by a historical analysis suffers from the limitations discussed above, one of its greatest strengths lies in its ability to provide insights that the quantitative instrumental record cannot, that is, insights into the human and social dimensions of flood hazards over time. Such data can provide information on the ways in which floods have been framed and understood and the ways in which they have been experienced and responded to. These insights can directly challenge the second narrative that has often dominated reactions to recent flood events. This second narrative has focused on the idea that floods can and should be prevented and that such prevention provides the optimal means of reducing flood losses. This narrative is closely linked to the narrative of surprise and shock discussed above. As a narrow range of knowledge is used in the study of flood risk, floods continue to be viewed as external events impacting on an often largely passive human society (Jeffers, 2013a). This view persists despite an official attempt to shift national flood policy to less structural

approaches (Scott, et. al.,2013; Jeffers, 2013a). A conceptualisation of floods as external events impacting a passive human population is perpetuated through devices such as the source-pathway-receptor model of flood risk which features prominently in the new planning based policies (Jeffers, 2013a). Little or no consideration is given to what have been described as "the societal issues associated with flood risk" (Scott et. al., 2013, p.135). This narrow understanding of flood hazards encourages a narrow range of potential responses to flood hazards, those that claim to be able to eliminate flood events themselves through engineering fixes, an approach that has been extensively critiqued by geographers and other social scientists (Changnon, 2005; Ludy & Kondolf, 2012; López-Marrero & Yarnal, 2010; Penning-Rowsell, 2000; Penning-Rowsell, Winchester, & Gardiner, 1998; Wisner, Blaikie, Cannon, & Davis, 2004; Wong & Zhao, 2001).

The historical analysis presented in this paper challenges the narrative that flood prevention is the optimal means of reducing loss. It demonstrates that although many of their current residents may not be aware of it, the occupants of each of Ireland's coastal cities have amassed hundreds of years of experience of living with flood hazards. The available evidence suggests that each city was historically well adjusted to flood hazards. While disruption and economic loss have been significant, fatalities have been rare and when they have occurred the numbers involved have generally been low. Some of the records of flood events in Cork discussed earlier indicate that the local population was well prepared for flooding and that warnings were given. This contrasts sharply with more recent events where ineffective warnings were given and the local population appeared largely unprepared. In this regard historical analysis can illuminate flaws in contemporary hazards preparedness and suggest possible alternatives that have been

used successfully in the past. Historic analyses focusing on flood hazards in other parts of Europe and examining longer time periods have found evidence of city populations that were both well aware of and well adjusted to ongoing flood hazards (Rohr, 2013). They have also emphasised the need to view flood hazards as complex interactions between socio-economic, political, cultural and environmental processes in order to fully understand their impacts (Bankoff, 2013; Galloway, 2013).

These reports of greater preparedness in earlier decades of the twentieth century may also suggest that the contemporary narrative of flood prevention is part of a shift in the expectations of local populations regarding the rights and responsibilities of the State in the field of flood hazards management. It may be the case that local populations assumed a greater degree of personal responsibility in the past but that there is now an increased expectation that the burden of flood hazards preparedness, management, and loss should be borne by the State or by other stakeholders such as insurance companies. Possible shifts in the social contract between citizens, the State and other actors have been the focus of recent research which suggests a significant level of reliance on the State among populations experiencing flooding in Ireland (Adger, Quinn, Lorenzoni, Murphy, & Sweeney, 2012). Encouraging individual home and business owners to take an increased responsibility for flood preparedness as they seem to have done in the past could constitute one means of improving preparedness and reducing vulnerability. This is not an argument for allowing the State to divest itself of responsibility but for a discussion on the rights and responsibilities of all stakeholders, and the most appropriate scale at which to address flood hazards. Longer term historical studies in other parts of Europe have revealed that a variety of institutional structures and cultural practices had emerged in response to ongoing flood hazards. In medieval England a system of marsh

law enshrined the principle that those who benefited from flood defences ought to contribute to their maintenance (Galloway, 2013), while in fourteenth and fifteenth century Austria, municipal regulations and charters helped to create a culture of flood management (Rohr, 2013).

An attempt to institute a change in the roles and responsibilities and actors by shifting more responsibility on to home and business owners in Ireland appears to have been made through initiatives such as the www.flooding.ie website which provided advice to home and business owners on flood preparedness. However events such as the flooding experienced in Cork in 2009 suggest this initiative has not been successful in creating any significant reduction in vulnerability through increased preparedness. A culture of reliance on the State, faith in technological and engineering fixes, and socio-economic changes that increase vulnerability are likely to have contributed to its ineffectiveness. However the attempt to shift the roles and responsibilities of stakeholders without a full debate on the social contract is also likely to be a key reason for its ineffectiveness. The initial historic analysis presented in this paper clearly illustrates that society may have been more prepared and consequently less vulnerable in the past. The reasons why this is was the case and how it might be replicated today could be illuminated by a more in-depth historical analysis. Effectively managing future flood risks and vulnerabilities will require a wider range of innovative and creative approaches than is currently employed. It will also require a shift from assuming that flooding will not happen to learning to live with flood risk (Bankoff, 2013; Lewis and Kelman, 2009). A historical perspective that looks to both the recent and more distant past for inspiration has much to offer in helping to develop alternative strategies.

The historical analysis presented here also challenges the narrative of flood prevention by illustrating that floods are just one aspect of the relationship between urban and the waters they live beside. It also illustrates that cities themselves are dynamic entities whose growth and change is constantly reshaping vulnerability and exposure. Changes in the size, extent, architecture and built environment of any city combine with shifting socio-economic conditions to create a complex mix of vulnerabilities (Bankoff, 2003). As mentioned earlier changes such as modification of river channels and the construction of dams often reduced flood risk. However these may also have increased longer term vulnerability by creating a false sense of security, while urban expansion increased exposure through development on flood plains and runoff from paved surfaces (Jeffers, 2013b). These changes have led to the re-emergence of past hazards (Jeffers, 2013b; Mitchell, 2003). Docklands regeneration projects across all three cities are also likely to increase the number of people living and working in exposed locations (Jeffers, 2013b).

Cities develop in the locations they occupy for reasons that are closely associated with their proximity to water. Dublin, Cork and Galway mirror many cities around the world in developing in their current locations for defensive and trading purposes. While the defensive importance of the sites has long passed, the economic importance of the port functions remains although these have moved further from the city centre over time. The historic development of each city illustrates that proximity to water is both a resource and a hazard, and that living in these cities involves some balance between these elements. This balance was illustrated during a dispute that emerged between local residents and Dublin City Council officials over plans for new flood defences in the Clontarf area of the city. In 2011 local residents and businesses vigorously opposed

plans to erect large flood defences along the sea front citing negative impacts on their views of the sea and limitations on access to the shoreline. While it could be suggested that some residents were seeking to have their cake and eat it, in arguing for both flood defences and the preservation of recreational use, it could also be argued that their campaign for smaller flood defences was a recognition of the need for balance between the resources and the hazards of living in a coastal location. A historic analysis illustrates how this balance has been recognised in the past and therefore further challenges the narrative that flood prevention is the optimal means of reducing loss. This is not to suggest that engineering solutions will not play some part in effectively addressing flood hazards as in some cases they clearly will. However in order to determine the most appropriate means of addressing flood hazards, a wider discussion that recognises a broader understanding of human-environment interaction is necessary. It may be more beneficial to focus on flood loss which geographers have long declared to be a social phenomenon (White 1945,) rather than floods themselves which are often viewed as natural events with social consequences. A historic analysis helps to illuminate this social character of flood losses.

7. Conclusions

This paper has employed a limited historic analysis of flood events in three of Ireland's coastal cities to challenge contemporary narratives of flood risk and the decision-making and policy responses that have emerged from them. In doing so it demonstrates the value of such a historic perspective, not just for understanding hazards in Irish cities but for similar cities in other counties. In critiquing these narratives and current flood hazards policy my aim has been not simply to wield what Paul Robbins would describe as the hatchet of critique (Robbins, 2004), but to attempt to sow the seeds of a creative and innovative alternative. There are clear deficiencies in current policy and practice in

Ireland, despite well intentioned attempts to implement a paradigm shift in flood hazards management. Similar deficiencies are evident in wider approaches to climate change adaptation in many countries which has focused on quantifying physical exposure and attempting to model future risk with the social dimensions of climate hazards often limited to an impacts based approach (Ribot, 2011; Bassett and Fogelman, 2013). This paper proposes that a more extensive historical analysis of both physical exposure and socio-economic vulnerability that draws on the expertise of a range of researchers including geographers and historians can provide a broader understanding of current and future hazards. This in turn can open the possibilities for a genuine paradigm shift in policy and practice, leading to more effective vulnerability reduction strategies that recognise environmental hazards as a complex social phenomenon, and decreasing the reliance on costly and environmentally harmful engineering solutions.

References

Adger, W., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D., . . . Wreford, A. (2009). Are there social limits to adaptation to climate change? *Climatic Change, 93,* 335-354. doi:10.1007/s10584-008-9520-z

Adger, W. N., & Barnett, J. (2009). Four reasons for concern about adaptation to climate change. *Environment & Planning A, 41,* 2800-2805. doi:10.1068/a42244

Bakoff, G. (2013) The 'English Lowlands' and the North Sea Basin System: A History of Shared Risk. *Environment and History, 19,* 3-37. doi: 10.3197/096734013X13528328438992

Bankoff, G., Lübken, U., & Sand, J., (Eds.). (2012). Flammable cities urban conflagration and the making of the modern world. The University of Wisconsin Press, Madison.

Bankoff, G. (2003). Constructing Vulnerability: The Historical, Natural and Social Generation of Flooding in Metropolitan Manila. *Disasters, 27,* 224-238. doi: 10.1111/1467-7717.00230

Barry and Partners. (2002). *Ringsend flood study: Interim report.* Dublin: Dublin City Council.

Bassett, T. J., & Fogelman, C. (2013). Déjà vu or something new? the adaptation concept in the climate change literature. *Geoforum, 48*, 42-53. doi:http://dx.doi.org/10.1016/j.geoforum.2013.04.010

Carr, P. (1993). *The Big Wind: The Story of the Legendary Big Wind of 1839 Ireland's Greatest Natural Disaster.* Belfast: The White Row Press.

Cawley, A. M., Fitzpatrick, J., Cunnane, C., & Sheridan, T. (2005). A selection of extreme flood events: The Irish experience. *National Hydrology Seminar 2005: Understanding & Managing Hydrological Extremes,* 14.

Chan, F. K. S., Mitchell, G., Adekola, O., & McDonald, A. (2012). Flood risk in Asia's urban mega-deltas: Drivers, impacts and response. *Environment and Urbanization Asia, 3*, 41-61. doi:10.1177/097542531200300103

Changnon, S., A. (2005). The 1993 flood's aftermath: Risks, root causes and lessons for the future. *Journal of Contemporary Water Research & Education, 103*, 70-74. doi:10.1111/j.1936-704X.2005.mp130001012.x

Chatterjee, M. (2010). Slum dwellers response to flooding events in the megacities of India. *Mitigation and Adaptation Strategies for Global Change, 15*, 337-353. Retrieved from http://dx.doi.org/10.1007/s11027-010-9221-6

Cutter, S. L., Mitchell, J. T., & Scott, M. S. (2000). Revealing the vulnerability of people and places: A case study of Georgetown County, South Carolina. *Annals of the Association of American Geographers, 90*, 713-737. doi: 10.1111/0004-5608.00219

de Kraker, A. (2013). Storminess in the Low Countries, 1390-1725. *Environment and History, 19,* 149-171. doi: 10.3197/096734013X13642082568570

Dixon, F. E. (1953). Weather in old Dublin. *Dublin Historical Record, 13*, 94-107.

Dublin City Council. (2002). *Interim assessment report flood 2002.* Dublin: Dublin City Council.

Flood emergency management in Dublin City: Behind the paradigm. Dublin City Council (Director). (2008). [DVD] Dublin: Access Media Productions.

Dublin Docklands Development Authority. (2008). *Draft Poolbeg planning scheme* Dublin: Dublin Docklands Development Authority.

Eakin, H., Winkels, A., & Sendzimir, J. (2009). Nested vulnerability: Exploring cross-scale linkages and vulnerability teleconnections in Mexican and Vietnamese coffee systems. *Environmental Science & Policy, 12*, 398-412. Doi:10.1016/j.envsci.2008.09.003

Fitzpatrick, J., & Bree, T. (2001). Flood risk management through reservoir storage and flow control. *National Hydrology Seminar 2001*

Frazier, T. G., Wood, N., Yarnal, B., & Bauer, D. H. (2010). Influence of potential sea level rise on societal vulnerability to hurricane storm-surge hazards, Sarasota County,

Florida. *Applied Geography, 30*, 490-505. doi:http://dx.doi.org/10.1016/j.apgeog.2010.05.005

Galloway, J. A. (2013). Coastal Flooding and Socioeconomic Change in Eastern England in the Later Middle Ages. *Environment and History, 19,* 173-207. doi: 10.3197/096734013X13642082568615

Gilligan, H. A. (1988). *A history of the Port of Dublin*. Goldenbridge, Dublin; New York: Gill and Macmillan.

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

Hickey, K. (2011). The historic record of cold spells in Ireland. *Irish Geography, 44,* 303-321. doi:10.1080/00750778.2011.669348

Jeffers, J. M. (2011a). The cork city flood of November 2009: Lessons for flood risk management and climate change adaptation at the urban scale. Irish Geography, 44, 61–80. doi:10.1080/00750778.2011.615283

Jeffers, J. M. (2011b) Confronting climate: Linking knowledge, values and decision-making to vulnerability and adaptation in Ireland's coastal cities (Unpublished thesis). Rutgers University, New Brunswick.

Jeffers, J. M. (2013a). Integrating vulnerability analysis and risk assessment in flood loss mitigation: An evaluation of barriers and challenges based on evidence from Ireland. Applied Geography, 37, 44–51. http://dx.doi.org/10.1016/j.apgeog.2012.10.011

Jeffers, J. M. (2013b). Double exposures and decision-making: Adaptation policy and planning in Ireland's coastal cities during a boom-bust cycle. Environment and Planning A, 45, 1436–1454. doi:10.1068/a45386

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.

Kleinosky, L. R., Yarnal, B., & Fisher, A. (2006). Vulnerability of Hampton Roads, Virginia to storm-surge flooding and sea-level rise. *Natural Hazards, 40,* 43-70. doi: 10.1007/s11069-006-0004-z

Klinenberg, E. (2002). *Heat Wave: A social autopsy of disaster in Chicago*. Chicago: University of Chicago Press.

Leichenko, R. (2011). Climate change and urban resilience. *Current Opinion in Environmental Sustainability, 3,* 164-168. doi:DOI: 10.1016/j.cosust.2010.12.014

Leichenko, R. M., & O'Brien, K. (2008). *Environmental change and globalization: Double exposures*. Oxford: Oxford University Press.

Leichenko, R., O'Brien, K., & Solecki, W. D. (2010). Climate change and the global financial crisis: A case of double exposure. *Annals of the Association of American Geographers, 100*, 963-972. doi:10.1080/00045608.2010.497340

Lewis, J. & Kelma, I. (2009). Housing, Flooding and Risk-Ecology: Thames Estuary South-Shoreland and North Kent. *Journal of Architectural and Planning Research, 26,* 14-29.

López-Marrero, T., & Yarnal, B. (2010). Putting adaptive capacity into the context of people's lives: A case study of two flood-prone communities in Puerto Rico. *Natural Hazards, 52*, 277-297. Retrieved from http://dx.doi.org/10.1007/s11069-009-9370-7

Ludlow, F., Stine, A., Leahy, P., Murphy, E., Mayewski, P., Taylor, D., Killen, J., … & Kiely, J. (2013). Medieval Irish chronicles reveal persistent volcanic forcing of severe winter cold events, 431–1649 CE. *Environmental Research Letters, 8*, 024035. doi: 10.1088/1748-9326/8/2/024035

Ludy, J., & Kondolf, G. M. (2012). Flood risk perception in lands "protected" by 100-year levees. *Natural Hazards, 61*, 829-842. doi:10.1007/s11069-011-0072-6

Mauch, Christof., Pfister, Christian., (Eds.). (2009). *Natural disasters, cultural responses: Case studies toward a global environmental history*. Lanham, MD: Lexington Books.

McElwain, L., & Sweeney, J. (2006). *Implications of the EU climate projection target for Ireland.* Johnstown Castle, Co. Wexford, Ireland: Environmental Protection Agency Ireland.

Met Éireann. (1986). *Monthly weather bulletin supplement: August storms.* Dublin: Met Éireann.

Met Éireann. (1995). *Monthly weather bulletin: January 1995.* Dublin: Met Éireann.

Mitchell, J. K. (2006). Empowering knowledge: A modest proposal for a broader social science research agenda in the wake of katrina in: 'Understanding Katrina: Perspectives from the social sciences. Retrieved from http://understandingkatrina.ssrc.org/Mitchell/

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

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

Mitchell, J. K. (2011). Looking backward to see forward: Historical changes of public knowledge about climate hazards in Ireland. *Irish Geography, 44*, 7-26. doi:10.1080/00750778.2011.615492

Moore, N. (2008). *Dublin docklands reinvented: The post-industrial regeneration of a European city quarter.* Dublin: Four Courts Press.

Moser, Susanne C., Boykoff, Maxwell T., (Eds.). (2013). *Successful adaptation to climate change: Linking science and policy in a rapidly changing world*. Abingdon, Routledge.

Moser, S. C., & Ekstrom, J. A. (2010). A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences, 107*, 22026-22031. doi:10.1073/pnas.1007887107

O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., . . . West, J. (2004). Mapping vulnerability to multiple stressors: Climate change and globalization in india. *Global Environmental Change Part A, 14*, 303-313. doi:10.1016/j.gloenvcha.2004.01.001

O'Brien, K. L., & Leichenko, R. M. (2000). Double exposure: Assessing the impacts of climate change within the context of economic globalization. *Global Environmental Change, 10*, 221-232. doi:10.1016/S0959-3780(00)00021-2

O'Connell, G., & Coe, V. (2003). *Tidal flooding of 1st February 2002.* Dublin: Dublin City Council.

Office of Public Works. (2002). *Memo on flood levels February 2002.* Dublin: Office of Public Works.

Office of Public Works. (2004). *Report of the flood policy review group.*Dublin: Office of Public Works.

Pelling, Mark. (2011). *Adaptation to climate change: From resilience to transformation*. London; New York: Routledge.

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

Penning-Rowsell, E. (2000). Has Venice crossed the rubicon? In D. J. Parker (Ed.), *Floods* (pp. 277-287). London: Routledge.

Penning-Rowsell, E., Winchester, P., & Gardiner, J. (1998). New approaches to sustainable hazard management for Venice. *The Geographical Journal, 164*,1-18. Retrieved from http://www.jstor.org/stable/3060541

Pfister, C., Brazdil, R., Glaser, R., Barriendos, M., Camuffo, D., Deutsch, M., . . . Rodrigo, F. (1999). Documentary evidence on climate in sixteenth-century Europe. *Climatic Change, 43*, 55-110. doi:10.1023/A:1005540707792

Ribot, J. (2011). Vulnerability before adaptation: Toward transformative climate action. *Global Environmental Change, 21*, 1160-1162. doi:http://dx.doi.org/10.1016/j.gloenvcha.2011.07.008

Robbins, P. (2004). *Political ecology: A critical introduction*. Malden, MA: Blackwell.

Rohr, C. (2013) Floods of the Upper Danube River and Its Tributaries and Their Impact on Urban Economies (c. 1350-1600): The Examples of the Towns of Krems/Stein and Wels (Austria). *Environment and History, 19,* 133-148.

doi: 10.3197/096734013X13642082568534

Royal Haskoning. (2005). *Dublin coastal flooding protection project final report.* Dublin: Dublin City Council.

Shields, L. & Fitzgerald, D. (1989). The 'Night of the Big Wind' in Ireland, 6-7 Jamuary 1839. *Irish Geography, 22,* 31-43. doi:10.1080/00750778909478784

Scott, M., White, I., Kuhlicke, C., Steinführer, A., Sultana, P., Thompson, P., . . . Russell, E. (2013). Living with flood risk/The more we know, the more we know we don't know: Reflections on a decade of planning, flood risk management and false precision/Searching for resilience or building social capacities for flood risks?/Participatory floodplain management: Lessons from Bangladesh/Planning and retrofitting for floods: Insights from Australia/Neighbourhood design considerations in flood risk management/Flood risk management – challenges to the effective implementation of a paradigm shift. *Planning Theory & Practice, 14,* 103-140. doi:10.1080/14649357.2012.761904

Solecki, W., Leichenko, R., & O'Brien, K. (2011). Climate change adaptation strategies and disaster risk reduction in cities: Connections, contentions, and synergies. *Current Opinion in Environmental Sustainability, 3,* 135-141. doi: 10.1016/j.cosust.2011.03.001

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K. B., . . . (Eds.). (2007). *Climate change 2007: The physical science basis: Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change*. Cambridge; New York: Cambridge University Press.

The Irish Red Cross. (2002). *Report to the Minister for Finance: Government humanitarian aid flood relief scheme February 2002.* Dublin: The Irish Red Cross.

Tyrrell, J., & Hickey, K., R. (1991). A flood chronology for cork city and its climatological background. *Irish Geography, 24,* 81-90. doi: 10.1080/00750779109555764

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*. Chicago: University of Chicago Press.

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

Wong, K., & Zhao, X. (2001). Living with floods: Victims' perceptions in Beijiang, Guangdong, China. *Area, 33,* 190-201. doi:10.1111/1475-4762.00022

Appendix 1: Flood Events in Dublin

Year	Date	Type
2011	24th Oct	Pluvial
2009	2nd July	Pluvial

2008	9th July	Pluvial
2004	27th Nov	Coastal
2004	23rd Aug	Pluvial
2003	2nd Dec	River (Dodder)
2002	14th Nov	River (Tolka) &Pluvial
2002	1st Feb	Coastal
2000	6th Nov	River (Tolka)
2000	5th Nov	River (Dodder)
2000	4th Nov	River (Poddle)
2000	4th Nov	River (Liffey)
1996	24th Oct	Pluvial
1993	11th June	River (Dodder)
1986	26th Aug	River (Tolka, Dodder, Poddle & Camac)
1978	8th Dec	River (Dodder & Poddle)
1969	17th Jan	Coastal
1968	2nd Nov	River (Dodder)
1965	17th Nov	River (Dodder)
1963	11th June	Pluvial
1960	2nd Oct	Pluvial and River
1958	19th Dec	River (Dodder)
1957	25th Sept	River (Dodder)
1956	29th Sept	River (Dodder)
1954	December, date unknown	River (Naniken)
1954	8th Dec	River (Grange Stream, Liffey & Tolka)
1948	3rd Jan	River (Tolka)
1946	20th Sept	River (Tolka)
1946	5th Feb	River (Tolka)
1946	12th Aug	River (Dodder)
1945	18th Dec	Coastal
1932	19th Dec	River (Tolka)
1931	1st Sept	River (Tolka)
1931	September, date unknown	River (Poddle)
1931	3rd Sept	River (Dodder)
1930	7th Feb	Coastal
1930	15th Mar	Coastal
1924	27th Dec	Coastal
1924	25th Feb	Coastal
1916	29th Dec	River (Liffey)
1916	27th Oct	Coastal
1916	17th Nov	River (Tolka)
1915	12th Nov	River (Tolka)
1912	26th Aug	River (Dodder)
1909	3rd April	River (Tolka)

1905	24th Aug	River (Dodder)
1901	12th Nov	River (Tolka)
1899	12th Feb	Coastal
1898	23rd Nov	River (Tolka)
1898	15th Oct	Coastal
1893	10th Dec	Coastal
1891	19th Oct	River (Dodder)
1884	12th Feb	Coastal
1883	16th Nov	River (Dodder)
1880	29th Oct	River (Liffey)
1880	27th Oct	Coastal
1880	22nd Oct	River (Tolka)
1880	4th Oct	River (Liffey)
1880	September, date unknown	River (Dodder)
1877	2nd Jan	Coastal
1851	Jan, date unknown	River (Dodder)
1839	6th Jan	Coastal
1807	September, date unknown	River (Liffey)
1807	September, date unknown	River (Dodder)
1802	2nd Dec	River (Liffey & Dodder)
1794	November, date unknown	River (Poddle)
1794	November, date unknown	River (Dodder)
1787	September, date unknown	River (Dodder)
1750	Date unknown	Pluvial
1749	March, date unknown	River (Poddle)
1739	Date unknown	River (Dodder)
1728	Date unknown	River (Poddle)
1726	Date unknown	River (Poddle)
1687	Date unknown	River (Liffey)
1646	Date unknown	River (Liffey)
1358	Date unknown	River (Liffey)

Appendix 2: Flood Events in Cork

Year	Date	Type
2012	17th Oct	Coastal
2012	28th June	Pluvial
2009	20th Nov	River

2004	27th Oct	Coastal
2002	27th Nov	Coastal & Pluvial
2002	1st Feb	Coastal
1998	29th Dec	River
1996	24th Oct	Coastal
1994	3rd Nov	Coastal
1989	13 Dec	Coastal & River
1989	17th Dec	Coastal
1988	12th Jan	Coastal & River
1988	11th Oct	Pluvial
1986	5th Aug	River
1983	18th July	Pluvial
1974	11th Jan	Coastal and River
1974	8th Feb	Coastal
1969	17th Jan	River
1969	18th Feb	Not clear
1968	23rd Oct	Coastal
1967	15th Feb	Coastal
1967	27th Feb	Coastal
1967	5th Oct	Coastal
1966	10th Jan	Coastal & River
1966	15th Feb	River
1966	17th Oct	Coastal
1963	1st Nov	Coastal
1963	30th Oct	Coastal
1962	9th March	Coastal
1961	22nd Oct	Coastal
1960	4th Dec	River
1960	5th Oct	Coastal
1958	25th March	River
1954	12th Nov	Coastal
1948	6th Dec	River
1945	19th Dec	Coastal
1941	10th Nov	River
1937	20th March	Coastal & River
1928	27th Dec	Pluvial
1924	25th Feb	Coastal
1921	2nd Oct	Coastal
1916	27th Nov	River
1907	26th Dec	River
1892	21st Nov	River
1881	3rd March	Coastal & River
1877	3rd Jan	Coastal
1875	26th Dec	Coastal & River
1853	2nd Nov	River
1789	17th Jan	River

1633	date unknown	River

Appendix 3: Flood Events in Galway

Year	Date	Type
2008	21st July	Pluvial
2006	26th Nov	Pluvial & Coastal
2006	3rd Dec	Coastal
2005	9th Jan	Coastal
2003	20th July	Pluvial
2002	1st Feb	Coastal
1995	17th Jan	Coastal
1977	11th Nov	Coastal
1974	10th Jan	Coastal
1963	18th Nov	Coastal
1930	Date unknown	Coastal
1912	24th Dec	Coastal
1883	18th Oct	Coastal
1877	7th Jan	Coastal
1839	6th Jan	Coastal