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Institutions and disaster outcomes: successes, weaknesses and significant research needs

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Contents

Institutions and disaster outcomes: successes, weaknesses and significant research needs

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1. Introduction

The aim of this brief review is to examine the role of institutions in shaping disaster outcomes. Disasters are hazards that have caused significant damage to socio-ecological systems of value. Institutions are defined as rules and conventions which structure and constrain behaviours and which enable choice and action (North 1991; Hodgson, 2006) and are conceptualised here as having three components:

i) rules, regulations and/or laws;
ii) organisational structures; and
iii) behavioural norms.

In a report of this length it is not possible to determine unambiguously the causality between either the presence/absence of an institution, or the institutions' effectiveness on a disaster outcome. However we do consider the methodological challenges associated with determining causality and set these issues out in a section on limitations (Section 4).

Three types of natural hazards are considered in this report: tropical cyclones, earthquakes and floods. These hazards were selected as they are global in nature (i.e. they affect the developed as well as the developing world), and are significant in terms of their impacts and research needs. Within these three types of hazards, **nine** specific hazard events were identified that met the following criteria:

- **Availability of published data**: with data about the impacts of the event and the institutions involved before, during and after the event;
- **Hazards of approximately the same size**: in terms of either hazard magnitude, or the impact of the disasters, or relative impact on socio-economic systems;
- **Representing a variety of governance systems**: from small islands, to federal systems, with both centralised and decentralised institutions in place, and in both developed and developing countries.

The review starts with a brief description of the hazard events that we considered, and the impacts experienced (section 2). This will be followed (section 3) by an analysis of successes and weaknesses – and associated uncertainties and knowledge gaps – in relation to the three components of institutions listed above.

The results of this study have to be treated with caution owing to both the very rapid time scale for its development, and the lack of opportunity to assess fully the nature of the relationships

between the institutions and the disaster outcomes. As such we assess the limitations of this study, and the difficulties in exploring issues of causality (section 4). The report ends with recommendations for action, and also recommendations to improve the quality of scientific research in this area (section 5).

However, firstly, causality is highly problematic here, as indicated above. There is an issue therefore about the scale of any disaster, the response capacity of a country and how they both influence the outcome of that disaster. We hypothesise that the response capacity of a country can be related to its size (measured in a variety of ways), the remoteness and accessibility of the disaster-affected area, the country's gross national income, and its governance arrangements. However developing clear conclusions in this area would require a very substantial study that assesses the relationships between all these variables, and this is well beyond the scope of our analysis here.

Also no doubt of importance, secondly, is the type of government and the geographical characteristics of a country and their role in influencing institutions and hence the outcomes of a disaster. In term of the types of government (inactive/active; functional/dysfunctional; 'honest'/'corrupt'; stable/unstable) these will undoubtedly influence the extent and quality of disaster preparedness. However developing criteria by which to evaluate the relative quality of governance arrangements is not unproblematic and this was not attempted in the nine cases sides, and consequently assessments of the detail of governance arrangements were not undertaken. We believe both these two areas are ripe for future research.

This report draws heavily on three background reports on earthquakes, floods and tropical cyclones, produced respectively by: Cambridge Architectural Research Ltd (led by Emily So in collaboration with Robin Spence and Steve Platt), Middlesex Flood Hazard Research Centre (led by Sally Priest with Dennis Parker), and Emma Tompkins of Southampton University.

2. The nine selected disaster events

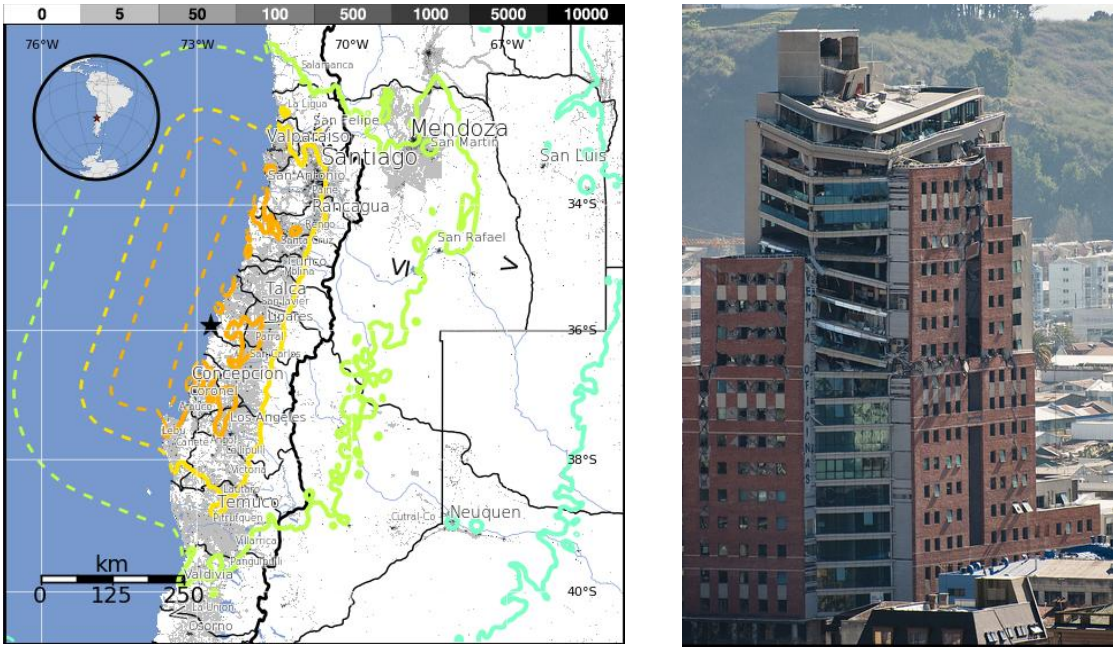
2.1 Three earthquake events: in Chile, New Zealand and Turkey

2.1.1 The Maule, Chile, Earthquake of 27th February, 2010

The Maule earthquake of 8.8Mw occurred at dawn (3.34am) on the 27 February 2010 at a depth of 35km. The epicentre was located 400km south of Santiago (see Figure 1). The earthquake generated a tsunami, affecting 500km of coastline, where a section of the earth's crust called the Nazca Plate subducted under the South American Plate.

The earthquake and successive tsunami caused hundreds of deaths and serious damage to homes and other infrastructure, primarily in the Maule and Bío Bío regions. Since the earthquake happened in the middle of the night and at a weekend, most people were asleep in their homes. In total, 521 people were killed with 56 still considered missing and 124 of the deaths were attributed to the ensuing tsunami. Nearly 370,000 buildings, equivalent to 11% of building stock in the affected area were destroyed or damaged.

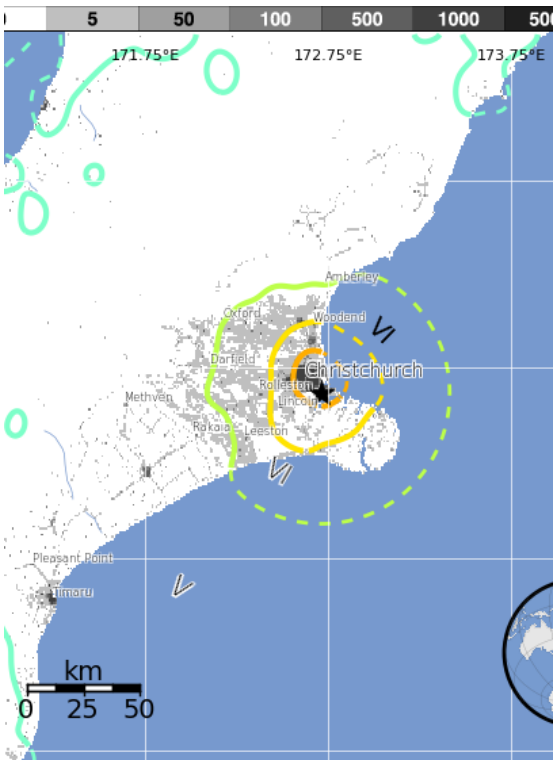
Figure 1: ShakeMap showing the level of ground shaking, population exposed and exposed cities (from USGS PAGER http://earthquake.usgs.gov/earthquakes/pager/events/us/2010tfan/index.html) for the Maule, Chile 2010 event. The maximum MMI was VII, as depicted by the orange contour (USGS); the right hand photo shows a recently completed 23-story Torre O'Higgins 241 office tower in Concepción suffered partial storey collapses (Source: EERI)



2.1.2 The Canterbury, New Zealand earthquake sequence from September 10, 2010

On September 4, 2010, a 7.1Mw earthquake struck the Canterbury Plain region in New Zealand's South Island but it caused no fatalities though many of the unreinforced masonry building in the Central Business District (CBD) suffered damage. The Canterbury Plain is a region of relatively low seismicity and the structure that ruptured was a previously unmapped fault (Gledhill *et al*., 2011). The aftershock sequence was relatively minor until February 22, 2011, when a Mw6.3 aftershock occurred 7 km northwest of the city of Christchurch, causing 185 deaths and over 7,000 injuries. Over 70% of the deaths are attributed to the collapse of two mid-rise reinforced concrete office buildings in the CBD. A ground shaking and exposure map from the USGS and a picture of the collapsed Canterbury Television building is shown below (Figure 2): three quarters of the occupants in this 6 storey building died.

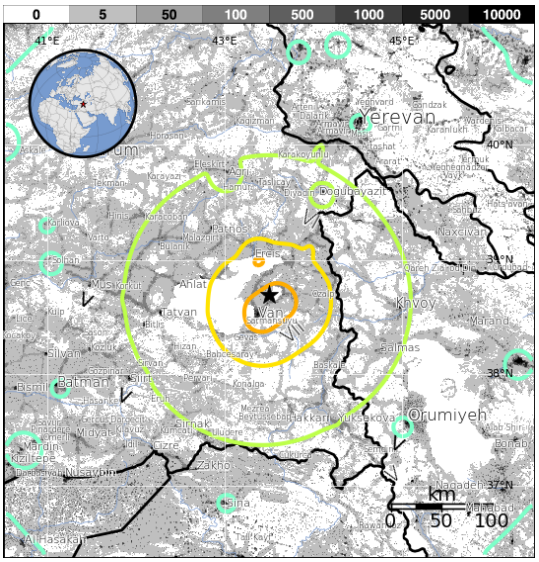
Figure 2: ShakeMap showing the level of ground shaking, population exposed and exposed cities (from USGS PAGER) for the Christchurch, NZ earthquake in 2011. Source: NZ Herald. The maximum MMI was VII, as depicted by the orange contour.



2.1.3 The Van, Turkey, earthquake of 23rd October 2011

A 7.1 Mw earthquake struck eastern Turkey near the city of Van on Sunday, 23 October 2011 at 13:41 local time. This was followed by a 5.6Mw earthquake on the November 9th, which brought down a hotel housing international relief workers (Figure 3). The 23 October earthquake killed 604 people, wounded more than 4000, and left tens of thousands homeless. The second earthquake killed 40 people. In total, 14,000 buildings were deemed uninhabitable from the two earthquakes.

Figure 3: ShakeMap showing the level of ground shaking, population exposed and exposed cities (from USGS PAGER) for the Van, Turkey earthquake in 2011. The maximum MMI was VII, as depicted by the orange contour. Right hand photo shows soft-storey collapses of typical mid-rise reinforced concrete frame buildings (Source: KOERI)



2.2. Three hurricane/cyclone events: in the Cayman Islands, the US and in Bangladesh

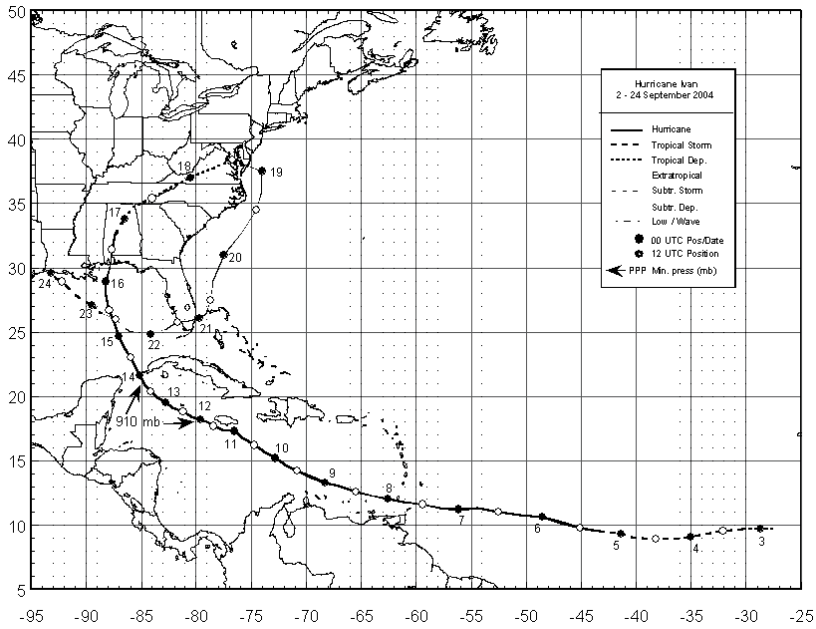
2.2.1 Hurricane Ivan, Cayman Islands, September 11-12 2004

Hurricane Ivan started as a classical 'Cape Verde' depression (Stewart, 2004). It passed Jamaica as a Category 5 storm (the most extreme storm on the Saffir-Simpson 1-5 scale), heading due west to the Cayman Islands (see Figure 4). Ivan weakened slightly to a Category 4[5] storm as it passed south of Grand Cayman on 11th before slowly turning north on Sunday 12th September 2004, battering the island for 36 hours (Franklin *et al*., 2006). Between 9 and 11am on 12th Sept. wind gusts on Grand Cayman were reported to have reached 171 mph (149kt), with sustained winds of 150 mph (130kt).

The associated 3 meter storm surge plus the 8m waves (ECLAC, 2005), combined with persistent rainfall, lead to accumulations of flood water on Grand Cayman of 308.4 mm (12 inches). This left most of Grand Cayman under water (Franklin *et al*., 2006). Southern parts of the island were up to 45 inches under water, and the northerly parts up to 12 inches under water (ECLAC, 2005).

[5] Category 4 storms with winds of 131-155 mph are 'Extreme' according to the US National Oceanographic and Atmospheric Administration http://www.aoml.noaa.gov/general/lib/laescae.html accessed 11/5/2012.

Figure 4: Storm track of Hurricane Ivan

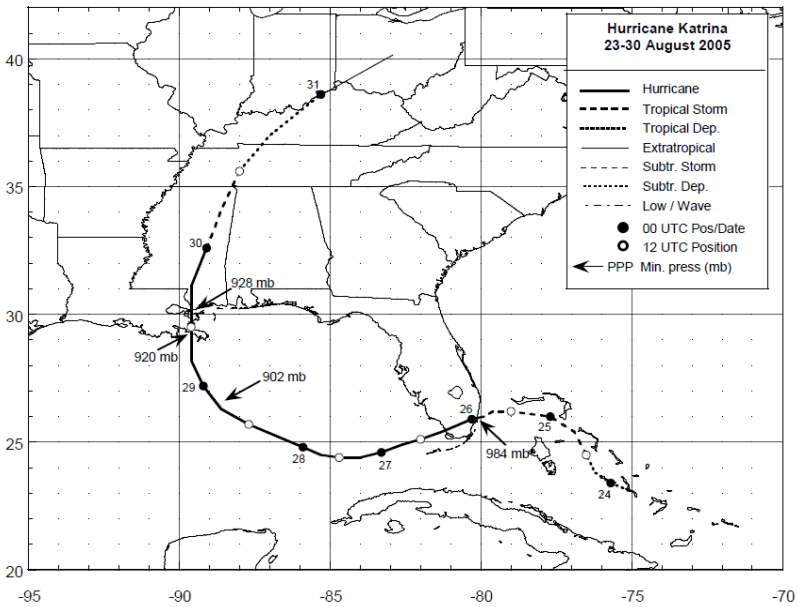


Source: Stewart (2004)

2.2.2 Hurricane Katrina, New Orleans, August 29, 2005.

Hurricane Katrina was an extremely wide but fast moving storm. Before it hit land, Katrina had maximum wind speeds of over 170 mph (Category 5), however Katrina made land as a Category 3 storm with winds of approximately 127 mph (Knabb *et al*., 2005, Graumann *et al*., 2006). It affected New Orleans for less than 15 hours and weakened further into a tropical storm as it moved inland (see Figure 5).

Figure 5: Hurricane Katrina's pathway through the Caribbean



Source: Knabb *et al*. (2005)

Across the region the worst impacts were caused by major flooding from both heavy rainfall and the 6-10m (20-30 feet) storm surge. The impacts were exacerbated in New Orleans as

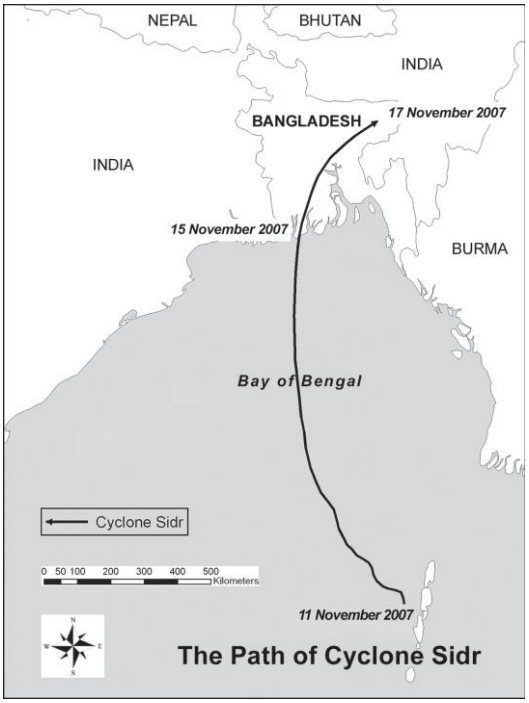
earth levees, designed to manage Mississippi river flooding, and flood walls were overtopped in some places and collapsed in others under the pressure of the flood waters (on the lake side), and storm surge (from the sea side). It is estimated that as a result of the heavy rainfall and the breached levees, 80% of the city was under water (Colten *et al*., 2008). It took 53 days to pump away the water – in part due to Hurricane Rita hitting New Orleans one month later in late September.

2.2.3 Super Cyclone Sidr (11th November 2007)

Super Cyclone Sidr (see Figure 6) hit the southwest coast of Bangladesh on 15th November 2007, striking land at 6.30pm. On landfall, Sidr was a Category 4 storm, with winds reported of up to 138mph (223kph) and storm surges of up to 6 meters (20 feet) (Government of People's Republic of Bangladesh, 2008). Fortunately for the people of Bangladesh, the Category 4 storm landed at a relatively less populated part of the country, in the Sunderbans – the world's largest mangrove forest which served to reduce wind speeds and lessen the storm surge (Government of Bangladesh, 2008).

Again, it was fortunate that it was low tide when Sidr hit, resulting in relatively smaller storm surge waves. The storm moved northwest across land, quickly weakening into a tropical storm, and dissipating on November 16th 2007 (Paul and Dutt, 2010).

Figure 6: Cyclone Sidr pathway through the Bay of Bengal



(Source: Paul and Dutt, 2010)

2.3 Three flood events: in the UK, Pakistan and Queensland, Australia

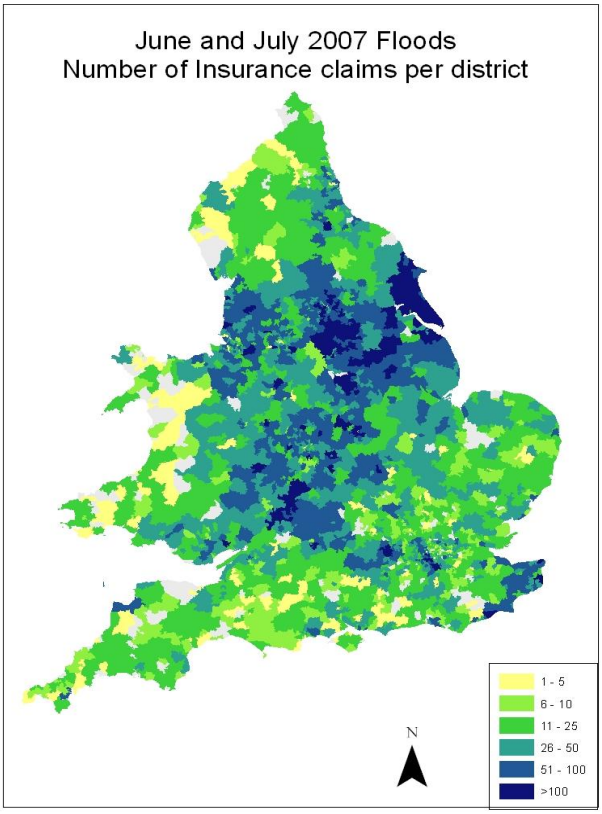
2.2.4 The UK floods, summer 2007

The exceptional 'Summer floods' of 2007 affected all four of the constituent countries of the United Kingdom. The largest impacts were experienced in the north and east of England (in June) and the west Midlands including the rivers Severn and the Thames valley to the west of London in July (Figure 7).

These floods followed the wettest summer since records began a century or more ago, and were caused by extreme rainfall compressed into a short time period.

Two types of flooding occurred. First, the extreme rainfall overloaded drainage systems caused by surface water flooding, particularly in urban areas. Second, fluvial flooding occurred as river systems received the runoff from areas experiencing surface water flooding. About 48,000 houses were flooded as well as 5,000 commercial premises (Environment Agency 2007). The loss of life was some 13; economic losses amounted to £3.2-£3.8 billion ($5.18 – 6.15 billion).

Figure 7: Flooding in England, 2007 – insurance claims per district



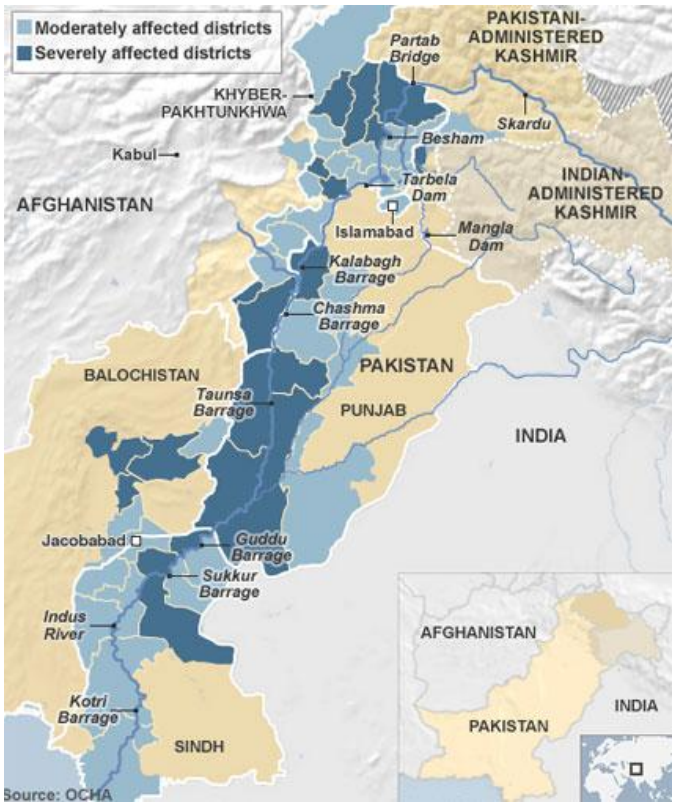
Source: Weathernet/FHRC

2.2.5 The Pakistan floods (2010)

Unprecedented floods in Pakistan were generated by abnormally heavy rains during the monsoon season in July and August 2010, leading to widespread flooding in the Indus River basin (Figure 8).The Indus and its tributaries breached their embankments leading to 20% of this populous country (c. 180 million people) being inundated. Particularly in the south, in Sindh province, floodwaters became stagnant, lengthening flood durations and hampering recovery. The flooding led to catastrophic crop, food stock and livestock losses. It had major adverse impacts on power generation, clean drinking water supplies and other infrastructure.

Many of those affected (7.8m) faced food security issues and potential disease outbreaks, particularly diarrhoea and cholera (Fair 2011). However, pandemics were avoided and food insecurity was largely prevented. The floods reduced the country's economic growth rate by about 2% but it has rebounded since to 4.5% (Fair 2011).

Figure 8: Flood affected areas of Pakistan, 2010

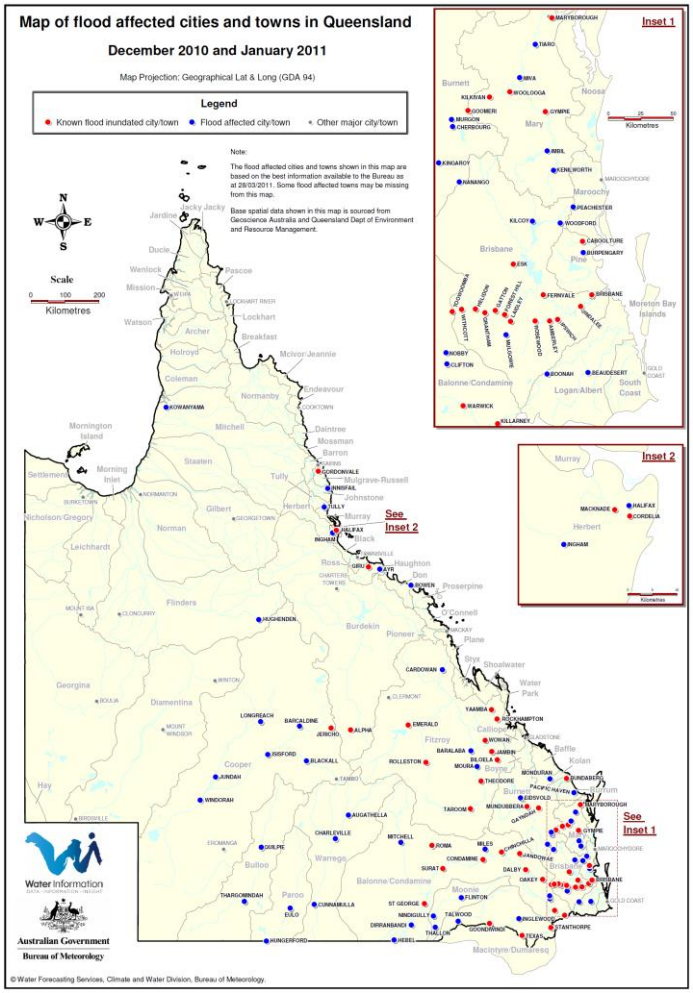


Source:http://www.dfid.gov.uk/Where-we-work/Asia-South/Pakistan/Pakistan-Floods-Monitor/ (accessed on 28.4.12) based on OCHA

2.2.6 Queensland, Australia floods, 2011

The 2010/2011 floods in Queensland began on 24th November 2010 and stretched through into late January 2011. Widespread and prolonged rainfall, caused in part by Tropical Cyclone Tasha, was exacerbated by already saturated catchments from the wetter conditions caused by the 2010 La Nina event. The floods affected an extensive area (Figure 9). In total 35 people were killed with 16 of those being located in the Lockyer Valley where many residents were trapped in their properties by rapidly rising waters. In total the floods affected an estimated 2.5 million people, with over three quarters of the state being declared a disaster zone and over 29 000 homes directly flooded (QFCI, 2012).

Figure 9. Map of flood affected cities and towns in Queensland, Australia, December 2012 and January 2011.



3. Institutional successes and weaknesses

This section of our report contains an analysis of 15 illustrative examples, drawn from our collaborators' detailed reports (these can be provided on request), which describe the role of DRR institutions and the hazard outcomes. We categorise these as "successes", "weaknesses", and situations where conclusions such as this cannot be drawn. It should be noted in this respect that we cannot be unambiguously sure of the causes of success or weakness, this is point is amplified in Section 4 below. Nevertheless we have chosen from amongst the best examples in our collaborators' reports, although this itself is a judgement rather than based on any quantitative metric as a way of measuring success or otherwise.

3.1 Formal institutions: Rules, regulations and laws.

What we mean by formal institutions is a set of systems that regulate and control activities related to Disaster Risk Reduction (DRR). This includes: legal instruments (e.g. Emergency Powers Acts, or property rights) and arrangements (e.g. enforcement of laws), regulations (e.g. Building codes) and government guidance, procedures and embedded policies and plans. Generally the creator of formal institutions is the national government of the country concerned, although some regulatory arrangements may be delegated by the government to regional, hybrid or specialised agencies, or private actors. Almost invariably rules, regulations and laws are formal, written down, and based on legislation or some other arrangement of codification.

Success No. 1: *Strict building codes that are enforced are critical to reducing damages.* In **New Zealand** the Department of Building and Housing, with the help of a special Engineering Advisory Group, modified the already **strict building codes** to take account of greater understanding of liquefaction risk and to provide guidance for foundations in high-earthquake-risk areas. (Dept of Building, 2011) Planning regulations have also been altered in significant ways to define red zones which will be taken out of use and to impose new height restrictions in the city centre. **Chile** also has strict building codes and planning regulations for addressing earthquake risk. The **Cayman Islands'** Building Code mirrors many of the strengths of the strict South Florida Building Code (Government of the Cayman Islands, 2006).

Success No. 2: *Clear mandate and power for the response and recovery agency to take actions as needed.* In the **Cayman Islands**, the Emergency Powers Act (2006) sets out the **transition of powers in the event of a disaster**. Power

passes to the National Hurricane Committee (NHC) - a formal quasi-government organisation – which takes over all aspects of response and recovery. Just prior to hurricane season, that runs from June-December, the NHC undertakes annual planning exercises and ensures that plans are up to date with named individuals responsible for specific actions. This ensures that there is a locally accountable individual (and back up) who can take actions if needed in an emergency situation (Tompkins, 2005).

Weakness No. 1: *Mandatory disaster insurance needs to be enforced. Support for poor households may be needed to ensure there is complete coverage.* Reconstruction after a major disaster is expensive, however the investment that follows a disaster can boost economic growth. **In Turkey**, while there is: a good modern earthquake code since 1998, high public awareness, strengthening of some existing high-risk public buildings such as schools (Gülkan, 2008), there remains patchy uptake of insurance. A **national earthquake insurance scheme, DASK**, has been developed. This is theoretically compulsory, but is not effectively so. The scheme should ensure minimum levels of repair and rebuilding costs for householders. It was introduced in 2000, and by 2012 had c. 4 million policy-holders nationally. However, implementation is not uniform, and is significantly lower in the poorer Eastern Anatolian region where the Van earthquake occurred. In this part of Turkey the take-up rate for the DASK earthquake insurance is 14%, compared with 32% in the Marmara region (DASK, 2009).

Weakness No. 2: *Regulations that require the retrofitting of older buildings to bring them up to code need to be backed up resource provision.* The impact of **New Zealand's Canterbury earthquake** was very severe. Partly this can be attributed to the shocks imposing much higher structural demands than the earthquake code allowed for (Kam *et al*., 2011). Also, much damage was concentrated in the older masonry structures which form the characteristic core of Christchurch (Ingham *et al*., 2011). New Zealand was the first country in the world to start **a compulsory programme of identifying and strengthening older "earthquake-risk buildings"**, but recent progress in this area has been slow. New rules will certainly be needed to speed up the strengthening of these buildings throughout New Zealand. As elsewhere, it is difficult to anticipate events more severe than those already experienced,

and easier to provide regulations for new build structures, and enforce them rigidly, than to retro-fit safety measures into old buildings and historic monuments. Nevertheless if neither is done risk reduction is not maximised.

No judgement possible

Should we avoid developing in flood plains? Under spatial planning legislation in England, **Planning Policy Statement 25** (PPS25) on flood risk and development seeks to avoid unnecessary development in flood risk areas. The Pitt Review (2008) found that this guidance should be strengthened. The background is that England's flood risk areas have been progressively developed leading to rising flood damage potential, which probably contributed to the adverse impact of the 2007 floods. For example, nearly 16,000 dwellings were built in flood risk areas in 2006[6]. What is not clear, however, is how "tough" spatial planning for flood risk reduction should be, given that it is unwise to "sterilise" the floodplain and much development in highly protected areas is socially valuable (Pardoe *et al*,. 2012). Without a much more detailed and forensic analysis of the exact character of the development that is taking place, we cannot be sure that this set of rules and regulation is not working adequately.

The examples above are almost certainly not typical, but do give some insight into the importance of rules, regulations and laws. It would seem at first sight that fault lies in the poor implementation of such arrangements, rather than the good intentions of those making the rules and passing the legislation. It would also appear that there is no significant science deficit here, as much of the risk and response options are well-known. What is apparent, however, is often the scale of future losses cannot be easily anticipated, with the result that damage is greater than would otherwise be the case. However decisions here are not easy, particularly for events with a long return period and measures that are expensive. A balance needs to be struck, but this is dependent significantly on local circumstances and cannot easily or sensibly be the subject of "top-down" rules.

[6] www.planningportal.gov.uk/general/news/stories/2008/jul/2008

3.2 Organisational structures

What we mean by organisational structures are those established by law, providing legal duties and powers, as well as less formal forms of organisation. These include building structures, employees, cross-organisational networks, and the infrastructure that supports the functioning of these organisations. The adequacy of these organisations (e.g. the degree to which they involve civil society) and their powers as well as the manner in which organisations interconnect (either coherently or otherwise) are considered to be a key aspect of institutional arrangements, as is the degree to which organisations are learning and adaptive ones.

Success No. 1: *Pre-disaster inter-organisational coordination is critical to effective response.* In the case of the **Christchurch earthquake,** inter-organisational coordination appears to have been especially successful: the response was exemplary with the **national government working closely with local authorities and communities**. The day after the earthquake, the New Zealand Ministry of Civil Defence declared a national state of emergency and Civil Defence became the lead agency in emergency response. In the immediate moments following the quake, rescue and response was conducted by civilians and the emergency services on duty. The New Zealand Fire Service subsequently coordinated search and rescue, particularly the Urban Search and Rescue (USAR) teams from New Zealand and Australia, UK, USA, Japan, Taiwan, China and Singapore, totalling 150 personnel from New Zealand and 429 from overseas. Emergency department staff at the Christchurch Hospital and health workers across the Canterbury region coped well with the unprecedented emergency (The Lancet, 2010). Immediately after the earthquake, Housing New Zealand provided a temporary accommodation service for the displaced people.

Success No. 2: *Multi-layered, inclusive, participatory, and well trained organisations seem to work well in disaster recovery.* It is clear that the mobilisation of assistance and pressure to evacuate during the more recent **Bangladeshi cyclones** have both been important. The number of volunteers – typically school teachers, social workers, clergy, and community leaders (Haque, 1995: 722) – mobilised in coastal rose from 20,000 in 1991 to over 42,000 in 2007 when Cyclone Sidr hit. The volunteers form part of the **Bangladesh Cyclone Preparedness Programme – a multi-tiered hybrid**

organisation, a public-NGO partnerships between the Bangladesh Red Crescent Society, central government (principally the Disaster Management Bureau, the Meteorological Department) and local government. Since 1972 this partnership has provided cyclone early warnings, delivered through emergency telecommunications, and disseminated through local volunteers. Its strength is the large network of trained local volunteers across the coastal zone who are equipped with bicycles, megaphones and public address systems and disseminate a warning once this has been received by radio or wireless communication.

Weakness No. 1: *Key agencies involved in disaster risk reduction need a clear mandate, with clear objectives*. The tragedy that unfolded in **New Orleans** was caused by many factors. One of the multiple contributing factors was the failure of the Federal Emergency Management Authority (FEMA) – the body responsible for managing disasters at the federal level – to deliver emergency assistance quickly and effectively (US House of Representatives, 2006). Several authors argue that this is due to a redirection of FEMAs interests towards homeland security and away from natural hazard management after the New York attack on September 11th 2001 (Schneider, 2005). This bifurcation of objectives within FEMA introduced a **lack of clarity about the role of the agency in relation to natural hazards**. Other criticisms of FEMA include; the inexperience of the leader in dealing with natural disasters, and post-9/11 centralised nature of the authority which weakened the ability of field personnel to innovate and to apply initiative (Baker and Refsgaard, 2007). This criticism is in sharp contrast with the commendations to the US Coast Guard whose response was widely seen to have saved many lives (US House of Representatives, 2006).

Weakness No. 2: *Inclusion of key stakeholders in DRR should enhance the effectiveness of good planning.* **Flood risk management in the UK** is handled under the Civil Contingencies Act 2004. Professional emergency response organisations (e.g. police, fire, ambulance, local authorities) are responsible for preparedness and response in flood emergencies. Although preparations had been made for flooding, some responders were not fully prepared – largely due to **lack of integration between organisations**. For

example, local media representatives were not involved in local preparedness plans made by Local Resilience Forums which made it difficult for them to undertake their public information roles. Plans to deal with the many hundreds of motorists stranded on motorways and people stranded at a railway station when the rail network failed were insufficient leading to higher than necessary human costs. Utility providers (e.g. water and power companies) – prior to the 2007 floods – had not considered the extent to which critical infrastructure facilities were located in flood risk areas.

No judgement possible

How should we balance the demand for structural and non-structural risk reduction measures? **Pakistan's** flood management organisations do not adopt a **holistic approach** to flood risk management**,** focussing most of their efforts on water resource development rather than disaster management. The dominant mitigation paradigm seeks 'protection' from floods by flood control dams, river training works, levees and other structural solutions (e.g. bridge raising), these promoted by the government through large-scale engineering projects such as the National Flood Protection Plan (Shaukat 2003). This 'protection' paradigm is strongly reflected in administrative processes, procedures and plans. In comparison, complementary non-structural flood management approaches are weakly developed (e.g. floodplain zoning and land use planning, increasing the resilience of buildings by flood proofing them and raising them above flood levels or relocating them). Land use planning policies exist to prevent unwise development of houses in floodplains, but enforcement is weak and there are many 'encroachers' and illegal constructions (Kamal 2004). As in the case of flooding in the UK it is not clear how to find this balance, due to the multiple hazards to which people are exposed, the costs of reducing risks for each of these hazards, and the relative importance of both measures in each context.

The examples above are, again, almost certainly not typical but they show that organisational structures which are not tailored towards natural hazard reduction can mean dysfunctional planning and poor disaster risk reduction performance. Further, a focus on just one aspect of disaster risk reduction by an organisation can reduce the resilience of the entire system. What

we conclude from this is organisations are more likely to be effective in the face of a disaster when they have: clear objectives; a clear mandate; and a willingness to admit to and then learn from mistakes. The study also shows that organisations for disaster risk reduction appear to be more effective when they are inclusive – both of wider society and the private sector, but also of other organisations.

3.3 Informal institutions and behavioural norms

Informal institutions are the informal rules that shape society and societal actions, for example sanctions, taboos, customs, traditions, and codes of conduct (North, 1991). They are rarely written down, and are created through years of social interaction and habit forming. Evidence suggests that rules and laws designed to shape societal behaviour (such as property rights, or Building Codes) are only effective when they are voluntarily adopted, or enforced. Understanding the role of informal institutions, which shape the way in which people interact with formal institutions and organisational structures is critical in understanding how people behave in risky situations and how this affects disaster outcomes.

Success No. 1: *Outreach and information dissemination need to be delivered through mechanisms with which people engage.* Provision of **flood risk information** is now a strength of **England's** preparedness regime. Stemming directly from its lead agency responsibility for flood warnings and its more general responsibility for flood risk management, the Environment Agency has regularly engaged the public, businesses and other organisations in raising awareness of flood risk, flood risk preparedness measures and flood warnings. An annual flood awareness media campaign, a well-developed range of flood risk leaflets providing information and advice and, provision of flood risk information at local farmer's markets, on local radio and at 'flood fairs' are just some of the means used to engage people in flood risk management. The Environment Agency's Floodline Warnings Direct service (a dial and listen telephone flood warning, information and advice service) had been widely publicised including during televised national and regional weather forecasts. The preparedness strategy is based on detailed flood risk mapping which is available to all on-line and which encourages homeowners and others to identify their own particular risk of flooding – although these maps do not show surface water accumulation – leaving some people unprepared.

Success No. 2 and

Weakness No.1: *Inculcating a safety-culture in the wider population can produce long term benefits.* ONEMI (**Chile**'s disaster preparedness and response organisation) operates a national earthquake drill called "Chile Preparado" with an ethos of promoting a culture of emergency preparedness in the community. In addition, Chile Preparado tests the response skills of both the community and the local authorities, by simulating realistic scenarios. Despite communication systems failures from the official tsunami warning system (an initial warning was cancelled by the Navy's Hydrographic and Oceanographic Services), and a tsunami of several meters height affecting over 500 km of coastline (EERI, 2010) along which many tens of thousands of people were at risk, only about 124 people were killed by the tsunami caused by the earthquake. This was largely due to a **high degree of tsunami awareness, resulting from long-standing school tsunami awareness and education programmes**, signage showing evacuation routes and other measures (EERI, 2010). The most vulnerable group were transient and tourist populations who had not had tsunami awareness training. Sadly the opposite was found in **Turkey.** Drawing on accounts of the 2011 Simav earthquake (5.9Mw) , which left three dead and 120 injured, the country's poor safety culture can be illustrated by injuries from the wrong evasive action by two of the three killed who had **jumped from windows to their deaths during the earthquake**. A similar lack of education about how to respond to flood warnings was found in **Australia**. Nine of the **Queensland flood** casualties were drowned when their vehicles were caught in floodwaters and some of these were when **drivers ignored warning** and road closure signs and drove directly into danger (QFCI, 2011).

Weakness No. 2: *Relief workers on the front line, have to be well trained in a variety of scenarios to empower them to use their initiative in 'surprise' situations.* In **Bangladesh** international humanitarian relief is managed through the governmental Disaster and Emergency Response sup-group. This group also ensures that the Armed Forces undertake search and rescue / relief operations (both burying the dead and removing dead livestock). DER coordinates relief operations centrally to ensure that donors are not duplicating assistance (Government of People's Republic of Bangladesh,

2008). However while the response to the 2007 Cyclone Sidr was prompt and active, there was seen to be a **lack of initiative in some local government officials and national NGO workers**. This prevented quick decisions from being made – for example regarding the numbers of households to target, or the types of items to distribute – which meant that the response was top-down, and sometimes not needs-driven (OXFAM, 2008). In some cases this was due to a lack of training and empowerment of ward level officers. The opposite was found in the case of the **US Coast Guard** (USCG) responding to Hurricane Katrina. The USCG undertook regular practices and planning, specifically "**personnel are trained to take responsibility and action**, as needed, based on relevant authorities and guidance" (GAO, 2006: 9). The USCG also promotes principles of leadership and accountability. As Baker and Refsgaard (2007) note: "Authority is routinely delegated to qualified people at the lowest possible level because the USCG believes, as an institution, that this results in the most rapid response and maximizes effectiveness in dynamic environments" (p.338).

No judgement possible

How to fill the knowledge action gap – how to encourage those least likely to prepare or evacuate to act? Key findings from studies to assess who will heed early warning systems have been that elderly and less able-bodied people, as well as those in minority groups, who may not trust the information being delivered are least likely to listen to an early warning system and evacuate their property (Whitehead, 2003, Bateman and Edwards, 2002, Kunreuther, 1996). Conversely those who trust the information, with higher incomes, and those with the means to evacuate are most likely to do so. Approximately 130,000 people did not evacuate after the **Hurricane Katrina evacuation order** – which Colten *et al*. (2008) estimate to be equivalent to the number without their own transport. In a survey of 680 individuals evacuated from the Gulf Coast to Houston shelters after Katrina, about 60% had household incomes of less than $20,000 per annum, and only 50% had full time employment before the storm (Brodie *et al*., 2006). Evacuees explained that they had chosen to stay because: they did not have a car (34%), they underestimated the severity of the aftermath of the storm (28%), they had to care for someone physically unable to leave

or they themselves were physically unable to leave (12%). Finding a way to support the poorest in society respond to early warning systems remains a challenge.

The examples above show the importance of human behaviour in informing disaster outcomes. However human behaviour is shaped by the institutions that exist around us, whether in the form of peer learning, or externally provided engagement – that motivates individuals to become informed about the risks they face. The examples also highlight the importance of training for disasters, not just training on how to deliver an action in a specific context, but training that enables those acting on the front line of disaster response and recovery to act effectively in the face of surprise. Adequate training provided at the local level to empower those on the front line of disasters to make appropriate decisions clearly can have significant benefits.

4. Limitations of the study

It is worth noting that the three background studies (on floods, earthquakes and tropical cyclones) supporting this report were each compiled in four days (FTE); this report was also produced in six days (FTE).

As indicated in our Introduction, above, in a rapid review of this nature it is not possible to establish unambiguous causal relationships between institutions and disaster outcomes. Complex relationships clearly exist between institutions engaged in disaster risk reduction and these outcomes. Institutions shape the formal environment in which decisions are made, but also the informal ones where civil society actors decide whether or not to undertake risk mitigating activities, to engage with preparedness, how to respond as a hazard is unfolding, and what to do during the recovery phase.

Much more detailed research is required in this respect to identify the specific linkages and causal relations in each of the case studies described herein. In this regard, however, this section highlights some of the other limitations of this study. Most importantly, not all of the disasters investigated have the same volume or quality of data on which to make judgements, see Table 1. There is also significant difference in the level of information available to assess the effectiveness of institutional mitigation versus recovery, probably reflecting the nature of the country concerned, and the body of rules, laws and regulations that establish how to reduce risk, but less on the slow progress of recovery. This could be due to methodological issues, or the challenge of obtaining funding for longitudinal research needed to assess the process of recovery.

Table 1: Data characteristics for the nine disasters

	Earthquakes			Tropical cyclones			Floods			
DRR element	*Chile (2010)*	***NZ (2010)***	*Turkey (2011)*	*Cayman Islands (2004)*	***USA (2005)***	*Bangladesh (2007)*	***UK (2007)***	*Australia (2010)*	*Pakistan (2010)*	*Total*
Mitigation	2	**2**	1.5	2	**2**	1	**2**	1.5	1.5	15.5
Preparedness	1.5	**1.5**	1	1	**2**	1.5	**2**	2	1	13.5
Response	1	**1.5**	0.5	0.5	**1.5**	1	**2**	2	2	12
Recovery	2	**2**	0.5	0	**1.5**	1	**1**	1	2	11
Total	6.7	**7**	3.5	3.5	**7**	4.5	**7**	6.5	6.5	

Notes:

0 = no information available; 1 = a little information of low quality; 2 = a lot of verified evidence

Highlight in **bold** shows those countries with the highest level of evidence available.

Highlight with underline shows those countries with least evidence available

It is easy to underestimate the potential additional losses that were avoided in the examples presented through positive institutional action, such as construction of flood defences, creation of cyclone shelters, or on-going information campaigns that are unreported. However, it is worth noting that, in the time available, significantly less critical analysis of events in developing countries was found, in comparison to the developed countries studied. In this respect our case study choice cannot be perfect: some valuable studies were ruled out owing to insufficient data in which we had confidence. In those areas where there is least data available, there is often little historical data collected to make assessments of progress, and some of the material is out of date. In all cases there is significant grey literature, however this is frequently provided by institutions with a vested interest and hence is not adequately critical, or is making a specific point. This varied quality of evidence points to the need for more longitudinal research on all aspects of DRR in under-funded parts of the world, and more resources to be made available to fund rapid response research in remote areas after a disaster.

Conclusions and recommendations for science

The 15 illustrative examples describe a spectrum of outcomes following natural disasters. In each case there are things that worked well and things that did not. This review has tried to find the commonalities that run through the examples with a view to highlighting cross-cutting lessons. The following conclusions emerged from the nine case studies:

- *Importance of building to code.* Modern buildings that meet the building code tend to perform well in the face of all types of disasters studied. Mitigation through improved building standards that are adhered to generates risk reduction.
- *Institutional misalignment* can affect even the most well developed institutional arrangements. For example surface water flooding surprised the UK flood management agencies even though they were well prepared for fluvial and coastal floods.
- *Institutions can easily become unbalanced over time* due to the characters shaping the institution, prevailing social and cultural influences, and resources allocation within the institution. For example flood risk management institutions may be initially designed to focus on hard engineered solutions. An organisational structure can deliver hard engineered solutions is unlikely to be immediately capable of delivering non-structural solutions.
- *Lack of cooperation and coordination between key institutions.* Legal instruments may fail to cross-refer, lower tiers of disaster risk management agencies may not be fully operationalized, agencies may operate independently. Evidence from all the studies shows that cooperation and cross-scale coordination at early stages of mitigation and preparedness are related to effective response and recovery.
- *Early warning systems (EWS) are not achieving their full potential.* While the science behind early warning systems for most (predictable) hazards has improved beyond measure over the last few decades, the complexity of the flood warning chains means that early warnings might not: reach the intended audience; be communicated in a way that engages the target audience; or provide appropriate / timely advice on how to act.
- *Insurance linked to resilience can cushion the impact of economic losses from disasters.* The presence of future financial support after a disaster can provide significant comfort

(despite many problems associated with getting pay-outs in some cases). The absence of insurance premiums linked to risk mitigating activity appears to reduce people's willingness to integrate longer term mitigation measures into their home reconstruction.

- *Community involvement in disaster risk reduction*. Volunteers play a key role in major disaster response. Disaster preparedness agencies reliant on volunteers have shown variable quality in training them and supporting them to deliver relief and support recovery. Volunteers have been shown to be most effective where they are well trained to cope in a variety of scenarios, and have confidence in the processes they are implementing.

4.1 Solutions to the big challenges

- Disaster risk reduction organisations need to reflect on a timely basis if they remain fit for purpose, re-aligning the institutional objectives with wider societal needs, clarifying their objectives, and where necessary re-training staff to ensure these objectives can be met. This is particularly important in a changing climate where the risks are changing.

- Develop plans to enhance cooperation, and communication between emergency responders, both within and between organisations.

- Examine the reasons for the lack of local capacity to respond to and recover from disasters, and develop a range of practical solutions to support low income/less able-bodied people to be respond effectively to early warnings.

- Explore the causes of past 'surprises' within major disasters which have led to institutional failures, to identify training on how to manage for 'surprises' for those working in response and recovery.

- Investigate how to improve robustness of communications systems in disaster. This may involve new methods of communications, e.g. raising flags on top of shelters to inform of status, or building redundancy into systems with multiple communication mechanisms which can act as back-up.

- Identify how to roll out regular awareness training and guidance on how to respond to hazards for transient populations and those with special needs.

4.2 Lessons for science

- investigate the institutional fit of existing DRR institutions, and assess their suitability under a range of future scenarios including climate changes
- draw out lessons from historical surprises that have occurred during or after a natural hazard and have prevented effective institutional delivery of response or recovery
- can game theory inform our understanding of the way in which DRR institutions choose to inter-cooperate and coordinate activities
- examine non-conventional disaster mitigation options including e.g. provision of safe-havens for floods and earthquakes; or household-scale damage assessment tools, to assess how individual homes could be affected by different sized hazards,
- collate information about disasters as soon as possible after the event to explain causes of injuries and death, and successes and failures.
- develop funding models to assess whether disaster mitigation could be built into mortgages to support higher quality post-disaster reconstruction
- develop and apply methods which allow the full range of disaster impacts to be quantified and measured
- while emergency relief is often well monitored, longer term reconstruction and recovery are often not well documented. This is an area for systematic monitoring and evaluation.

Annex 1:The effect of institutions on flood disaster outcomes

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Introduction and conceptual matters

This paper examines the effect of institutions on disaster outcomes following three recent flood disasters. They were all unprecedented within the countries affected and are from different parts of the world. Outcomes are examined in terms of flood damage measured in monetary terms, disruptive impacts and degree of displacement, deaths, impacts on health and other impacts. Institutions which are fit-for-purpose and effective are required for the sound management of disasters through each disaster phase i.e. mitigation, preparedness, response and recovery.

Institutions are defined as rules and conventions which structure and constrain behaviours and which enable choice and action (North 1991; Hodgson, 2006). In this paper we examine three institutional themes; (a) regulatory systems; (b) organisational structures and (c) behavioural norms and social and cultural aspects, viewing each by disaster phase. Regulatory systems include legal instruments and arrangements (e.g. enforcement of laws), regulations and government guidance, procedures and embedded policies and plans. Organisational structures are those established by law, providing legal duties and powers, as well as less formal forms of organisation. The adequacy of these organisations (e.g. the degree to which they involve civil society) and their powers as well as the manner in which organisations interconnect (either coherently or otherwise) is considered to be a key aspect, as is the degree to which organisations are learning and adaptive ones. Finally, behavioural dimensions of institutions include societal awareness of and attitudes towards risk (e.g. flood risk) and responsibilities for managing risk, the organisational cultures of disaster management organisations, the roles played by males and females, and risk amplifying and attenuating factors. It is often difficult to discuss regulatory systems without reference to organisational

arrangements. Equally it is sometimes artificial to separately discuss organisations without also mentioning organisational cultures. Discussion of these themes is therefore sometimes fused together. Funding of disaster management does not fit neatly into the regulatory or organisational themes and may well be influenced by organisational cultures and is therefore examined wherever it appears appropriate to do so.

Methodological limitations

A number of methodological limitations should be recognised in interpreting the evidence in this paper. We have drawn upon selected sources of literature including reports of international agencies (e.g. World Bank); Government and Government agency (e.g. Independent Review, Special Commission) reports; NGO reports; research reports; peer reviewed journal papers and, in a few cases, newspaper reports and grey literature published on the web. This selection is almost certainly not representative of the enormous range of literature of different types available on the three flood disasters examined. Where possible, we have sought to identify and rely on information from international agencies, independent reports commissioned by Government e.g. (post-flood enquiry reports) and NGO reports where there appears to be a high degree of balanced data and comment. But where different views about the adequacy of institutional arrangements have come to light, we have sought to capture them. In addition, the relatively short timeframe since the Pakistan floods (2010) and the Queensland floods (2010/11) means that peer-reviewed literature about the floods is still quite limited and it has been difficult to examine fully the reconstruction after the event.

The quality of information available to us in preparing this report is variable (Tables 1- 3). In no case did we find that there was no information but in some cases we found that information was either to some extent lacking or of low quality (scored 2).

Key to tables 1-3

0 = there is no information

1 = there is little information of low quality

2 = there is a lot of verified evidence

Table 1: UK floods 2007: Assessed quality of information

Disaster cycle stage	Regulatory aspects	Organisational aspects	Behavioural aspects
Mitigation	2	2	2
Preparedness	2	2	2
Response	2	2	2
Recovery	1	1	1

Table 2: Queensland foods 2010/11: Assessed quality of information

Disaster cycle stage	Regulatory aspects	Organisational aspects	Behavioural aspects
Mitigation	**1**	**2**	**2**
Preparedness	**2**	**2**	**2**
Response	**2**	**2**	**2**
Recovery	**1**	**1**	**1**

Table 3: Pakistan flood 2010: Assessed quality of information

Disaster cycle stage	Regulatory aspects	Organisational aspects	Behavioural aspects
Mitigation	2	1	2

Disaster cycle stage	Regulatory aspects	Organisational aspects	Behavioural aspects
Preparedness	1	1	1
Response	2	2	2
Recovery	2	2	2

Attributing causation in institutional analysis is often problematic. It is possible to identify the impacts of floods in some detail. We can also identify shortcomings in institutional arrangements. However, it is often very difficult to make a causal link between a particular institutional shortcoming and an impact and it is even more difficult to weigh the causal importance of each of a range of institutional failings on particular impacts. However, in some cases it is possible to indicate that had a particular action been taken, and taken effectively, it is likely that a particular circumstance and the impacts associated with it would not have occurred. 'Probabilistic' statements of causality of this kind are made above in some cases. Causal links may also be made by (a) comparing impacted populations with similar non-impacted ones (i.e. a control population), or by (b) carefully comparing before and after data. We have not discovered many examples in the literature relating to (a) for the three selected flood disasters but the data on flood impacts present an implicit means of gauging causation (in an overall sense) between institutional shortcomings and flood impacts.

The three selected flood disasters

This paper evaluates the effect of institutions on the outcome of three flood disasters: the 2010-11 flood disaster in Queensland and Victoria, Australia; the 2007 'summer' floods in England and the 2010 floods in Pakistan. Although the size of the area affected, the numbers affected and the cost of each of these floods is different (Table 4), each challenged the national institutional response as well as, in the case of the Pakistan floods, the international response.

Table 4: Headline impact indicators for the three flood disasters

Impact indicator	The 2007 floods in England	Australia 2010-11 floods	Pakistan 2010 floods
Area flooded		78% of Queensland state declared disaster zone[5] (i.e. 1,445,000 km^2)	796,095 km^2[9]
Agricultural land affected	45,000 ha		2.4 million ha[11]
Livestock lost			Millions[11]
Number of people affected	48,000 households + 7,000 businesses + 140,000 properties lost water supplies for 7 days + [4]	2.5 million [5]	20,553,176 million[8]
Number of properties flooded	55,000[1]	29,000 [5]	1.6 million houses[10]
Number of people evacuated or made homeless	c.7,000[3] evacuated	5, 900[12] evacuated	8 million displaced from their homes[8]
Number of deaths (injuries)	13[2]	33 [5]	c. 2,000 (3,000+)[8]
Cost	£3.2-£3.8 billion[2]	AUS$5 billion[5] with an estimated between AUS $10	$9.7 billion[8]

Impact indicator	The 2007 floods in England	Australia 2010-11 floods	Pakistan 2010 floods
		and 30 billion cost to Australia's GDP[13]	
Cost converted to US $ (April 2012)	$5.18 – 6.15 billion	$5.13 billion	$9.7 billion

Independent Government Review (2008)

[2] Chatterton, J, Viavattene, C, Morris, J, Penning-Rowsell, E, Tapsell, S (2010)

[3] Paranjothy, S, Gallacher, J, Amlot, R, Rubin,G, Page, L, Baxter, T, Wight, J, Kirrage, D, McNaught, R, Palmer, S (2011)

[4] Environment Agency (2007)

[5] Queensland Flood Commission of Inquiry (2012)

[8] Kronstadt, K, Sheikh, P, Vaughn, B (2010

(9) Wikipedia

(10) Hashmi, H, Siddiqui, Q, Ghumman, A, Kamal, M, Mughal, H (2012)

(11) Fair, C (2011)

(12) House of Representatives Standing Committee on Economics, 2011

(13) http://www.abc.net.au/news/2011-01-18/flood-costs-tipped-to-top-30b/1909700

The summer floods of 2007 in England

The 'Summer floods' of 2007 affected all four of the constituent countries of the United Kingdom, although the largest impacts were experienced in England which is the main focus of this case study (because different institutional arrangements apply elsewhere in the UK, especially in Scotland). These floods were exceptional and in England they followed the wettest summer since records began and extreme levels of cyclonic rainfall compressed into a short time period. In June the floods struck the north and east of England and in July they struck the south and west including the river Thames valley to the west of London. They led to the largest

civil emergency in British history. Two types of flooding occurred. First, the extreme rainfall caused surface water flooding, particularly in urban areas, as drainage systems became overloaded. Secondly, fluvial flooding occurred as fluvial systems received the runoff from areas experiencing surface water flooding. About 48,000 houses were flooded as well as 5,000 commercial premises (Environment Agency 2007) (Table 4). Although not on a scale comparable to the floods in Queensland, Australia and Pakistan, these floods were unprecedented in the UK, had an estimated 'dollar impact' (Chatterton *et al*., 2010) similar to that in Queensland and about 58% of that in Pakistan. They posed a severe challenge to the Environment Agency (the flood risk management agency for England and Wales), local authorities and infrastructure providers particularly the drinking water treatment and supply industry in one region and electricity providers generally. The floods adversely affected a far larger area than that experiencing flooding because transportation systems were disrupted and a large community in Gloucestershire lost its public supplies of potable water for well over a week (unusual and unacceptable in the UK). Structural and temporary flood defences prevented a great deal of flood damage, flood forecasting and warning for fluvial flooding mostly functioned adequately and a major flood response and recovery programme was launched with considerable success. Even so, many institutional shortcomings were revealed by these floods which led to an independent review being undertaken by Lord Pitt which in turn led to the publication of the 'Pitt Review' in 2008 (Independent Government Review 2008) which contains 138 recommendations for improving flood management. Detailed information on the 2007 flood impacts is contained in Table 5. In follow up surveys of 2,200 respondents in areas affected by the floods between one third and a half of respondents reported health concerns, especially relating to anxiety and depression. A comparative survey within and adjacent to flood areas suggested that flood victims were about six times more likely to exhibit psychiatric distress than those who had not experienced flooding (Chatterton *et al*., 2010).

Figure 1: Residential insurance flood damage cost claims by district, 2007 floods in England and Wales (Source: Weathernet/FHRC)

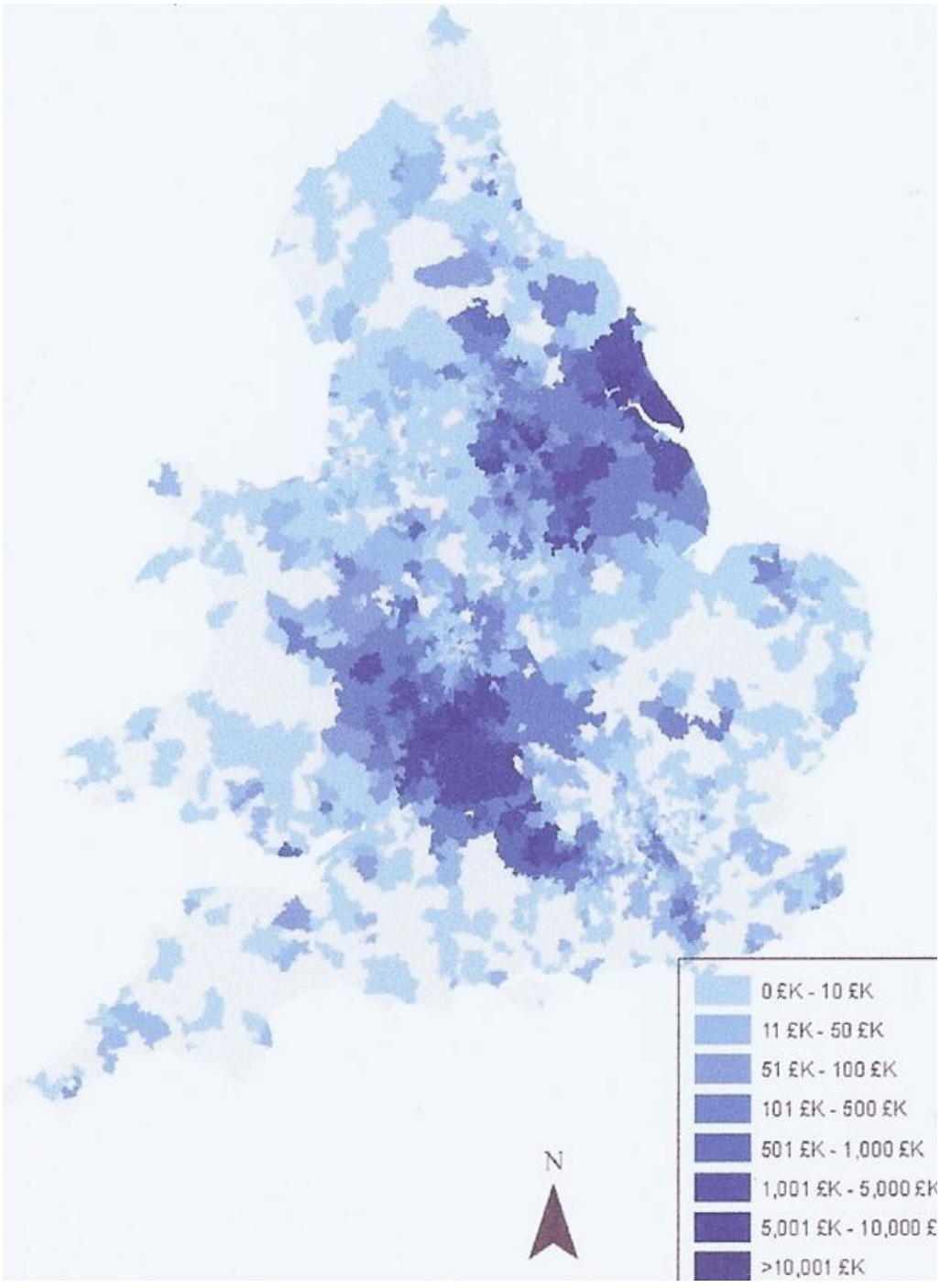


Table 5: Detailed analysis of the economic impacts in the 2007 floods in England (Chatterton *et al*., 2010)

Impact	Best estimate £ million	% of total	Possible range £ million	% insured	Basis for estimates	Uncertainty score (see text)
Households (buildings and contents)	1,200	38%	1,010-1,430	76%	Adjusted Insurance estimates	2
Businesses (buildings, contents and disruption)	740	23%	550-800	95%	Adjusted insurance estimates	2
Temporary accommodation	94	3%	85-103	95%	Insurance claims	2
Vehicles (motors)	80	3%	72-88	95%	Adjusted insurance estimates	2
Local Government – infrastructure (excluding roads (£83 million)) and non-emergency services	134 (219 incl roads)	4% (7%)	123-151 (198-242)	45%	Audited accounts of LGAs	1
Emergency services, (LGA, police, fire and rescue)	8	<1%	7-9	45%	Audited accounts of LGAs, police and fire/rescue	1
Environment Agency (23% of costs for emergency)	19	1%	17-21	?	Audited accounts	1
Utilities (electricity, gas, water)	325	10%	253-436	32%	Company accounts, user WTP/A for services	2-3
Communications (roads (including LGA), rail, telecom)	227	7%	151-303	50% Mainly LGA road damage	Company sources, extra travel costs	2-4
Public health and fatalities (including distress, impact on education and fatalities)	287	9%	187-387	n/a	Research Literature, standard estimates, LGA accounts	3-4
Agriculture	50	2%	30-66	5%	Farm survey	2
Unquantified costs;, tourism, nature conservation, community services, Military services	n/a	n/a	n/a			
Total	3,164	100%	2,521-3795	63 %		2 overall

The 2011 floods in Queensland

The 2010/2011 floods in Queensland also affected parts of the neighbouring state of Victoria but by far the worst impacts were felt in Queensland. There were in fact a series of floods beginning on 24th November 2010 and stretching through into late January 2011. Widespread and prolonged rainfall, caused in part by Tropical Cyclone Tasha, was exacerbated by already saturated catchments from the wetter conditions caused by the 2010 La Nina event. December 2010 was reported to be Queensland's wettest on record with a state average rainfall total of 209 mm which is 154% above normal (Australian Bureau of Meteorology, 2011). The flooding experienced in Queensland was mixed with some areas such as Toowoomba experienced sudden flash flooding whereas other locations for example Rockhampton had a week to prepare. The floods affected an extensive area (see Figure 2) with almost every river in Queensland south of the Tropic of Capricorn and east of the towns of Longreach and Charleville at some point being in flood during the period of the floods with some areas such as Chincilla and Condamine being flooded repeatedly (House of Representatives Standing Committee on Economics, 2011). The most destructive of the floods occurred during the 10-12 January period when areas in South East of the State were impacted with major flooding occurring on the Lockyer, Bremer and Brisbane Rivers. In total 35 people were killed during the floods with 16 of those being located in the Lockyer Valley where many residents were caught out and trapped in their properties by rapidly rising waters. It was estimated that the floods affected 2.5 million people in total with over 78% of the state being declared a disaster zone and over 29 000 homes directly flooded (QFCI, 2012). Table 6 provides more detailed information about the impacts of the floods although comprehensive damage information in particular in relation to the cost of reconstruction, is still emerging.

The widespread nature of the floods meant that areas neighbouring those directly flooded were also badly impacted with many areas becoming isolated and roads impassable. The extent and long duration of the floods meant that resources were stretched with authorities and emergency services having to react and respond in many different areas of the State. In addition, the Australian Defence Force were mobilised in order to support and assist local councils and other organisations preparing to and responding to flooding. The extensive damage caused led to the Australian Government to form the Queensland Reconstruction Authority (http://www.qldreconstruction.org.au/) to coordinate and implement a plan for reconstruction and to support and work with local councils to allow communities to recover from the floods. Similar to the UK floods in 2007 the scale of the disaster led to in-depth investigation about the

causes, successes and limitations of floodplain management and their authorities and the establishment of the Commission of Inquiry into the Queensland Floods in January 2011. The final report delivered in March 2012 provides over 150 separate points of consideration/recommendation for future management and response to flooding (QFCI, 2012)

Figure 2: The extent of flooding in the 2010/2011 floods in Queensland

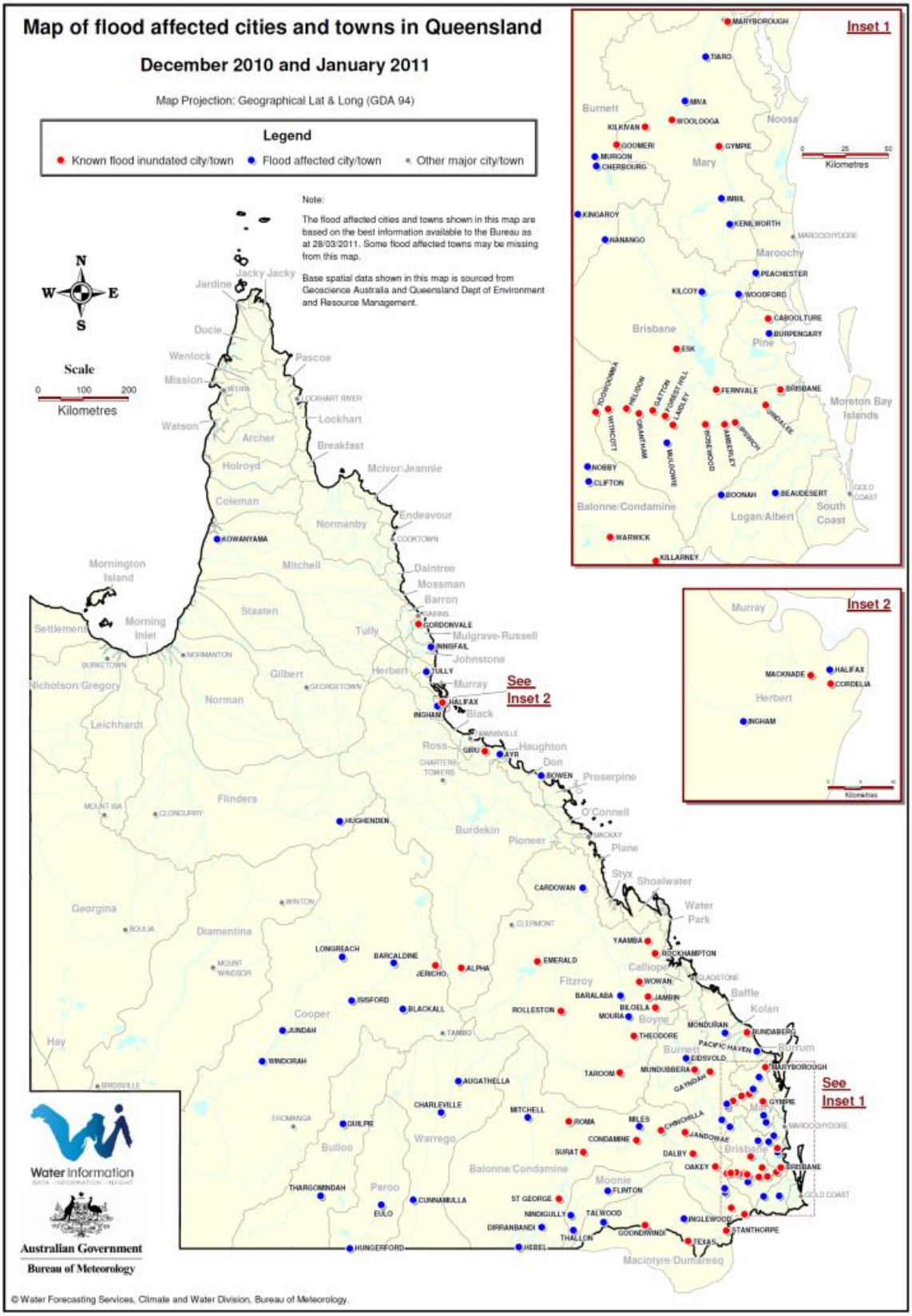


Table 6: Summary of the impacts of the Queensland floods

Impact	Numbers/Cost	Source
Residential properties affected	29,000 properties were flooded during the 2010/2011 Queensland floods. However, it has been difficult to find a division between residential and other properties. But new construction of housing as a result of the floods was estimate do to be around 15 000 homes, valued at around AUS$4billion over a two year period. A 5% boost to Australia's total house construction industry.	QCFI (2012) IBISworld Special report (2011)
Businesses	Lost productivity was said to be significant as it as necessary to close Brisbane's CBD and a reported slowing in both domestic and international tourism with estimated losses of AUS$590million (0.7% reduction). The report suggests that damages to businesses were lessened by the greater reliance on steel and concrete as building materials, rather than timber and plasterboard. It is estimated here that there will be approximately. AUS$1 to $2 billion additional spending on premises within the commercial sector.	IBISworld Special report (2011)
Insured losses	Estimated to total AUS$ 3.7 Billion	Wilson (2012)
Communications (road, rail, telecom)	Over 9000 km of Queensland's 33 000km (or about 27 per cent) of the road network were affected. In SE Queensland roads were the state assets which sustained the most damage. 3000 km of rail track in Queensland was impacted with the heavy duty freight track the Central Queensland Coal Network also be impacted. Wilson (2012) puts the	QCFI (2012)

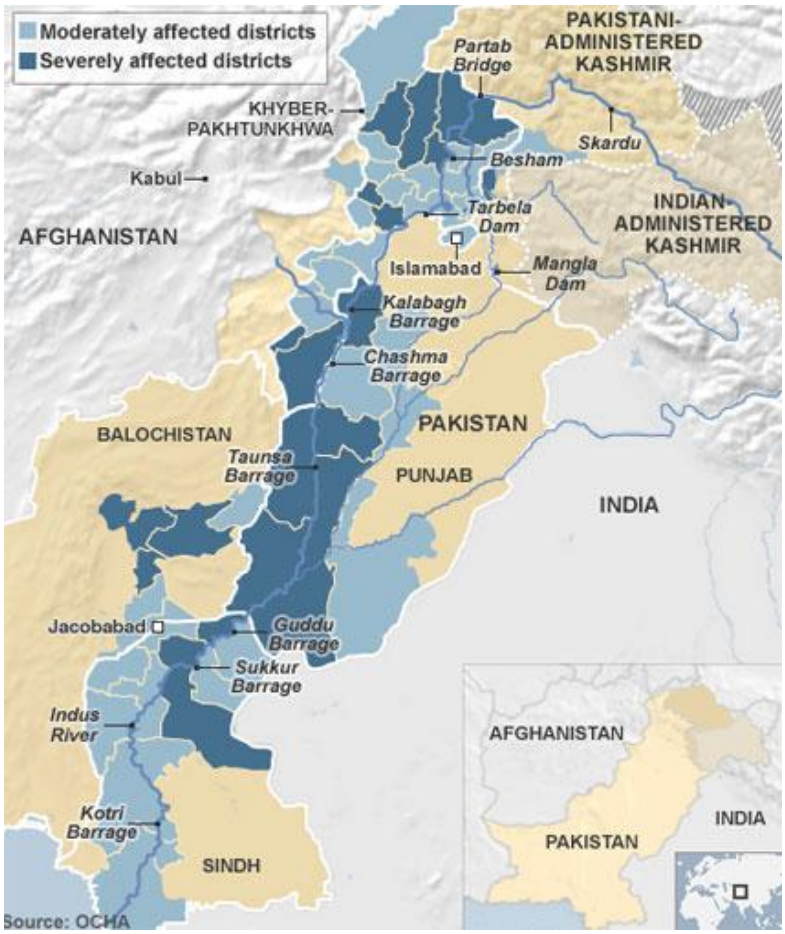
Impact	Numbers/Cost	Source
	cost of repair for infrastructure at AUS$6.8 billion.	
Public health	There were 33 flood related deaths during the Queensland 2010/2011 floods. Although there is some evidence of the other health impacts (e.g. water and mosquito-borne diseases) estimates of costs or numbers are limited.	QCFI (2012)
Agriculture	An estimated $1.6 billion worth of crops having been destroyed. (In particular affected sugarcane, cotton, some vegetables and grains). This is expected to flow on to a short-term price spike for food, with prices expected to rise by up to 200%.	IBISworld Special report (2011)
Mining	Eighty-five per cent of Queensland coal mines were impacted: either fully closing or were working at reduced capacity. This was estimated to be a loss of AUS$5.7 billion (2.2%) of Queensland's gross state product. Only 75% of pre-flood production had been recovered by May 2011.	QCFI (2012)
Transport	Linked to agriculture and mining are heavy losses to the transport sector which was estimated to have lost AUS$467 million in January 2011 due to a reduction in the ability to transport goods. With shipping, rail and highways all being impacted.	IBISworld Special report (2011)
Utilities	The damage to the Ergon Energy's electricity network was estimated to be AUS$6 million, which is considered to be quite minor and only a tenth of the damage caused by Cyclone Yasi. 128 sewerage pump stations operated by Queensland Urban Utilities were affected along with 9 sewerage	QCFI (2012) QCFI

Impact	Numbers/Cost	Source
	treatment plans which many had critical failures due to the inundation of electrical systems. The estimated cost to repair is $173m	(2012) Wilson (2012)

The 2010 floods in Pakistan

Unprecedented floods in **Pakistan** were generated by abnormally heavy rains during the monsoon season in **July and August 2010**. These rains led to widespread flooding in the Indus River basin which traverses Pakistan from north to south (Figure 3).The Indus and its tributaries breached their embankments leading to 20% of this populous country (c. 180 million people) being inundated Table 4). Particularly in the south, in Sindh province, floodwaters became stagnant lengthening flood durations and hampering recovery. The flooding led to catastrophic crop, food stock and livestock losses. It had major adverse impacts on power generation and supplies, clean drinking water supplies and other infrastructure. Many of those affected (7.8m) faced food security issues and potential disease outbreaks, particularly diarrhoea and cholera (Fair 2011). However, pandemics were avoided and food insecurity was largely prevented. Many farmers lost their livelihoods and food prices rose dramatically since the floods placing a strain on the whole population. These problems are overlain on a population struggling with poverty (about one-third of the population are classed as poor), worsening social and regional inequality, an inept civilian government the legitimacy of which is waning because it is unable to provide the public services needed by many, corruption, religious militancy, insurgency and political instability particularly in the provinces bordering Afghanistan, major environmental problems (e.g. a growing water shortage, deforestation) and the need to recover also from the major 2005 earthquake. Following a macroeconomic reform programme, Pakistan's economy has been growing and per capita income has doubled in the past decade but the country remains a low income one with severe national fiscal constraints. The 2010 floods reduced the country's economic growth rate by about 2% but it has rebounded since to 4.5% (Fair 2011).

Figure 3 Flood affected areas of Pakistan, 2010



Source:http://www.dfid.gov.uk/Where-we-work/Asia-South/Pakistan/Pakistan-Floods-Monitor/ (accessed on 28.4.12) based on OCHA

Regulatory aspects

Mitigation

In terms of mitigation, in each of the three flood disasters the regulatory focus either proved to be either somewhat unfit for purpose or marginalised in some way. In England, the regulatory regime largely satisfactorily addressed river flooding but inadequately addressed the management of surface water flooding which affected two-thirds of the properties flooded in 2007. In Queensland, the focus of the regulatory system had become water scarcity and security as well as bush fires, so that flood risk management was largely set aside in recent national legislative initiatives. In Pakistan, flood risk management was driven mainly by water resource management, irrigation and power generation regulatory considerations rather than by imperatives more closely connected with flood risk management needs. This common feature is a reflection of both historico-cultural factors and the recent national experience which, for example, in Australia was of drought and wild fire rather than floods. The general effect of these regulatory weaknesses was almost certainly higher flood losses than would have

otherwise been the case. A second characteristic is that, with the exception of Australia and Queensland, the regulatory systems first and foremost interprets flood mitigation in predominantly 'structural' engineering terms and 'non-structural' measures have been less well developed. Again, particularly in Pakistan but also to some extent in England, this probably led to higher flood losses than would otherwise be so.

England has a complex regulatory system for floods and flood management. The legislation proved to be fragmented, inadequate in various ways and in need of streamlining under a single unifying Act. Legal responsibilities and powers for local flood mitigation, particularly for the management of surface water flooding, were inadequate. Addressing these numerous local flood problems was beyond the capability of the Environment Agency which focused on fluvial and coastal flooding and in hindsight it became clear that local authority ownership and legal responsibility for these local problems needed to be established. In addition, the mitigation emphasis of legislation at the time of the 2007 floods was on 'flood defence' and by structural (i.e. engineering) measures rather than a broader flood risk management strategy. However, important seeds of change towards the latter were contained in a Government consultation process launched in 2004 which has since led to a national flood risk management strategy which raises the profile of non-structural flood measures. Even so, the 2007 floods revealed that more needed to be done to strengthen mitigation. Indeed, the Association of British Insurers (ABI) (which acts on behalf of the private sector insurance industry which provides flood insurance) argues that insufficient is being spent by Government on the nation's flood defences (e.g. ABI 2007).

The recent emphasis on flood defence meant that the potential of building resilience and resistance measures to reduce flood damage had not been realised leading to higher flood damage and disruption that would have otherwise been the case. Insufficient attention was given to flood resilience measures including in the national Building Regulations. Government guidance supporting the legislation was also shown to be insufficient in many ways (see Independent Government Review 2008). Under spatial planning legislation, Planning Policy Statement 25 (PPS25) on flood risk and development seeks to avoid unnecessary development in flood risk areas. This guidance requires planners and developers to undertake flood risk assessments and to follow guidance on risk mitigation strategies such as avoidance of floodplain development or ensuring that absolutely necessary developments are resilient ones. The Pitt Review (Independent Government Review 2008) found that this guidance should be strengthened. The background is that England's flood risk areas have been progressively

developed leading to a rapidly accumulating flood damage potential which contributed to the adverse impact of the 2007 floods. For example, nearly 16,000 dwellings were built in flood risk areas in 2006 (www.planningportal.gov.uk/general/news/stories/ 2008/jul/2008).

The regulatory system in Queensland represents a relatively balanced approach to flood mitigation and has incorporated a combination of structural and non-structural measures since at least the 1950s. Flood control dams and levees reduce the flood risk in some cases; flood forecasting and warning systems have been developed; and spatial planning approaches all combine in a 'floodplain management' approach. The regulatory system is complex because it is influenced by national (federal), state and local regulatory regimes. The State Government of Queensland has the heaviest regulatory burden and the main responsibilities for water regulation and management of flood risk (Godden and Kung, 2011). The 2010/2011 flooding water law and responsibilities for development control lies with the State Government. Overall guidance for flood management is provided by the National Government through a policy document entitled *Floodplain Management in Australia: Best Practice Principles and Guidelines* (CSIRO, 2000). This currently provides overarching guidance to States and Territory Governments about the principles of flood management, but is due to be replaced by revised guidance in June 2012. The current document provides the basics of flood management and encourages a consistent approach, but it lacks detail on how the different elements of management and mitigation are in practice translated into the State and Territory and more local contexts.

Although Australia and Queensland rely upon the mitigation of flood risk through spatial planning, the 2011 floods confirmed some critical weaknesses in this regulatory regime. The *Sustainable Planning Act* (2009) (Queensland) is the principle planning law providing a joined up system of planning utilising the "Integrated Development Assessment system" which utilises one individual to manage and administer an application and therefore integrates the planning process across a number of agencies. Of most interest to flooding are the state planning polices which when implemented by the Minister for Local Government have to be followed as if they were law. At the time of the 2010/2011 floods there was one policy relevant to flooding entitled the State Planning Policy 1/03 *Mitigating the Adverse Impacts of Flood, Bushfire and Landslide*. This policy applies to the whole of Queensland in relation to flooding and is a "statutory instrument expressing the State's interest in minimising the adverse impacts of these three natural hazards on people, property, economic activity, and the environment when making decisions about development" (Queensland Government, DLGP and DES, 2003, p1).

Its aim is to prevent development which fails the 'unacceptable risk' test, i.e. those developments should not go ahead which would cause an unacceptable risk to people or property. The aim is to ensure that community infrastructure which potentially contains vulnerable people (such as hospitals and educational establishments) and critical community infrastructure (such as state-controlled roads or railways) are not affected by flooding or that development which significantly increases the number of people in the flood zone (such as residential development, shopping centres, industrial uses etc) is prevented. The importance of this was illustrated in 2010/2011 where flooding affected 128 sewerage pump stations and 9 treatment plants operated by Queensland Urban Utilities, impacting on the sewerage system serving around 1.25 million people (QFCI, 2012; p221) Following the floods it was recognised that there was a need to strengthen these planning regulations. A Temporary State Planning Policy (TSSP) 2/11 *Planning for stronger, more resilient floodplains – Part 1 Interim measures to support floodplain management in existing planning schemes* was therefore introduced in September 2011 to permit Local Governments to amend existing planning schemes and aims to improve the safety of communities and minimise the potential for future flood damage through immediate implementation of some of the measures.

However, it is clear from concerns emanating from the Queensland Commission that the efficacy of Queensland's spatial planning approach to flood mitigation is severely compromised by the absence of flood mapping within planning schemes in Queensland. Failure to mandate this activity within legislation is a critical shortcoming. To provide some immediate assistance to council planners, the Queensland Reconstruction Authority has also created a series of maps (Interim Floodplain Assessment Overlays). QFCI (2012) states that the Queensland Government has acknowledged that there needs to be a shift in the approach to planning recognised through the launch of draft guidelines *Planning for stronger more resilient floodplains: Part 2 – Measures to support floodplain management in future planning schemes* (Queensland Reconstruction Authority, 2012) which is a review of the State policy dealing with flooding and planning. These guidelines aim to get councils to further integrated floodplain management principles into future planning schemes and advocate a much clearer process of hazard assessment and integration with planning for emergencies. However, it appears that there have been no changes to the legislative powers as schemes will still need to comply with the *Sustainable Planning Act* (2009) so it will remain to be seen how councils implement these measures and how effective they will be at preventing development in at risk areas. A further issue with the current regulatory regime for flood mitigation activities is the blanket adoption of the 1: 100 year flood risk datum as a central standard for floodplain management and urban

development control. This fixed control factor does not incorporate non-linear hydrometeorological change and needs to be redesigned in order to reflect the changing nature of the hazard (under climate change) and society's actions to adapt and mitigate (Godden and Kung 2011). There is a further issue from a planning perspective as SPP 1/03 requires councils to nominate a flood event (known as the defined flood event). Most councils have adopted the 1 in 100 year flood zone for this planning regulation, however this is heavily criticised by the Queensland Floods Commission (QFCI, 2012) as it only permits two areas to be designated: inside the area at risk and outside of that area. Selecting this one reference event does not deal with those floods which are less frequent but more severe, nor those which occur more frequently. The Commission draws on the case of Ipswich where river levels can vary considerably and that the consequences of a 1% flood here would be much more severe than the same probability flood in Brisbane, reinforcing the need to investigate and present planning information for a range of events including up to the probable maximum flood.

It is exceptionally difficult to trace the 2011 flood consequences of these shortcomings in regulatory regime in Queensland but unwise development within floodplains has almost certainly occurred thereby increasing flood damage potential leading to larger flood losses than would have been the case if the spatial planning regime had been tighter. Progress in enhancing the regulatory regime prior to the 2011 floods was less than ideal. Godden and Kung (2011) argue that in regulatory terms flood management has been largely marginalised in favour of concentrating on the problems of water scarcity and ensuing future water security (elsewhere in Australia, for example in Victoria and Western Australia, bush fire risk has focused regulatory attention). Indeed, flood management and response did not feature heavily in the National Water Initiative (2004), the main instrument guiding water law reform throughout Australia.

Compared to England, Pakistan's management of floods is currently addressed in a non-holistic manner and the promotion and funding of a particular physical flood mitigation (i.e. 'flood control') focus most closely linked to water resource development policy rather than to disaster management policy: an approach which has its roots in the colonial era (i.e. pre-1956) (Mustafa and Wrathall 2011). Otherwise, until after the devastating earthquake of 2005, Pakistan had followed a traditional relief oriented approach to managing flood disasters, largely disconnected from physical flood mitigation (Action Aid & I-SAPS 2011a, 2011b). The dominant mitigation paradigm is a physical (i.e. structural) 'protection' from floods characterised by flood control dams, river training works, levees and other structural solutions (e.g. bridge raising)

promoted by government through large-scale engineering projects such as the Indus Basin Development Project (1960), five-year water resource development plans and a National Flood Protection Plan (Shaukat 2003). The primacy of flood control projects was reconfirmed in March 2012 when the Pakistani Prime Minister instructed Government departments to mobilise resources for the completion of 'flood control projects' [(a).] This 'protection' paradigm is strongly reflected in administrative processes, procedures and plans. The approach integrates water storage and conveyance using canals for irrigation purposes with flood storage and control provided by dams and power generation. Although structural flood control measures clearly have an important place in managing floods and droughts in Pakistan, they have become entrenched even though levees are breached (sometimes deliberately to protect infrastructure and for safety reasons) and river beds silt up heavily with eroded material raising river bed levels thereby reducing the effectiveness of protection measures. It is claimed that the long-term reduction in channel capacity is one of the key contributory factors worsening the impact of the 2010 floods (Mustafa and Wrathall 2011). In comparison, complementary non-structural flood management approaches (e.g. floodplain zoning and land use planning, increasing the resilience of buildings by flood proofing and them and raising them above flood levels or relocating them) are weakly developed. Discussion of non-structural measures often emphasises flood forecasting and warning rather than going more extensively into the range of non-structural measures now commonly employed in Western European countries (Kamal 2004, Shaukat 2004). There has been little effort in Pakistan to further develop and enforce a regulatory system for the physical infrastructure of settlements and to design and construct it with the physical constraints of flooding in mind. Land use planning policies exist to prevent unwise development of houses in floodplains but enforcement is weak and there are many 'encroachers' and illegal constructions (Kamal 2004). Formal and informal settlements and infrastructure have expanded rapidly with little recognition of their impacts in diverting or constraining the natural flow pathways of rivers or in building up flood loss potential. Much of the infrastructure is substandard in quality and inadequately maintained by government authorities so that canals are not properly desilted, culverts and sluice gates become blocked with debris and embankments fail (Oxley, 2011).

Preparedness

Following the 2007 floods in England, the Government was accused by some leading politicians and members of the public of a lack of preparedness (BBC 2007, Booth 2007, Independent Review Group 2008, p115). There were both strengths and weaknesses in the regulatory system as it applied to preparedness. In 1996, by Ministerial Directive, the

Environment Agency was given lead responsibility for flood warnings leading to a focus and investment in flood warning systems. Learning from some severe shortcomings in river flood forecasting and warnings highlighted by floods in 1998, the Environment Agency concentrated on improving river and coastal flood warnings. However, although severe weather warnings and fluvial flood warnings worked well in 2007, many of the summer's flood emergencies were caused by surface water or groundwater flooding for which the flood warning service was not designed but which are likely to increase in frequency as a result of climate change (Office of Science and Technology 2004). In this way the regulatory system was flawed because the policies and plans that were developed following the Ministerial Directive in 1996 failed to take account of the need for warnings for floods other than river and coastal ones. The consequence was that the human costs of flooding (e.g. anxiety, hardship, ill-health effects) were higher, property damage saving was lower, than could have been the case. Since the 2007 floods the Environment Agency and Met Office working together have been addressing this issue.

Provision of flood risk information is now a strength of England's preparedness regime. Stemming directly from its lead agency responsibility for flood warnings and its more general responsibility for flood risk management, the Environment Agency has regularly engaged the public, businesses and other organisations in raising awareness of flood risk, flood risk preparedness measures and flood warnings. An annual flood awareness media campaign, a well-developed range of flood risk leaflets providing information and advice and, provision of flood risk information at local farmer's markets, on local radio and at 'flood fairs' are just some of the means used to engage people in flood risk management. The Environment Agency's Floodline Warnings Direct service (a dial and listen telephone flood warning, information and advice service) had been widely publicised including during televised national and regional weather forecasts. The preparedness strategy is based on detailed flood risk mapping which is available to all on-line and which encourages homeowners and others to identify their own particular risk of flooding. Consequently many people were caught unaware. A problem with this flood risk mapping is that to date it has not shown areas at risk from surface water flooding.

Under the Civil Contingencies Act 2004, professional emergency response organisations (e.g. police, fire, ambulance, local authorities) were responsible for taking steps to prepare to respond in flood emergencies. Although preparations had been made for flooding, some responders were not as ready as they should have been and some shortcomings were identified in translated the legislation into action. For example, local media representatives

were not involved in local preparedness plans made by Local Resilience Forums which made it difficult for them to undertake their public information roles. Plans to deal with the many hundreds of motorists stranded on motorways and people stranded at a railway station when the rail network failed were insufficient leading to higher than necessary human costs. However, the most serious case of lack of preparedness involved the utility providers (e.g. water and power companies). Until the 2007 floods, the extent to which critical infrastructure facilities were located in flood risk areas in England was neglected but utility vulnerability was dramatically highlighted in the floods leading to human and other costs than otherwise could have been avoided. The floods led to the loss of public drinking water and electricity supplies with 500,000 people losing essential services (140,000 lost their water supplies for 17 days). A dam nearly breached necessitating emergency evacuation of the downstream population and a major electricity sub-station became within a whisker of being flooded. Much of England's utility infrastructure is owned and operated by private utility companies although there are also publicly owned providers of essential services. Under separate legislation the private utilities are licensed and economically regulated with the emphasis being on efficiency and value for money. These companies are also required to take on board the concerns of Government departments (McBain *et al*. 2010). However, the 2007 floods and subsequent analysis revealed that a large number of utility installations are located in flood risk areas in England, that regulation should extend to resilience to floods, that utility managers were poorly integrated into wider flood preparedness measures and the balance between security of information and sharing information between utilities and professional emergency response organisations was sometimes wrong (Independent Government Review 2008). The exposure of schools to flood risk appears also to have been underestimated: in Hull nearly 100 schools were damaged in the floods and children's education and normal family life was disrupted as a consequence. Other shortcomings in the regulatory arrangements for preparedness were that there was a lack of a lead Government department plan for flooding and also a lack of a national strategic framework for dealing with flood emergencies.

EMA (2009a) contend that the main instrument used for developing preparedness activities in **Queensland** should be within the flood emergency plan which also deals with flood response. The initial step of the plan is to better understand and identify those areas at risk from flooding and the characteristics of those communities who would be affected. However, this aspect of preparation was not as developed as it might have been and the lack of information provided in a mapped format has been criticised following the 2010/2011 event. Not only has it had a negative impact upon making planning decisions, but it is also seen as one of the main barriers

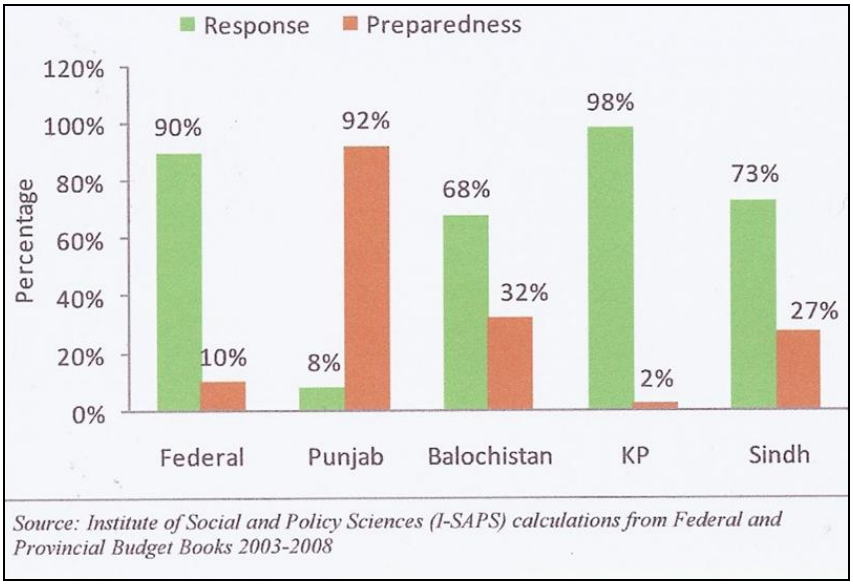
to effectively communicating risk and developing community preparedness for flood events. This has led directly to QFCI (2012) recommending that both the "Councils and Queensland Government should display on their websites all flood mapping they have commissioned or adopted" (2.16) and that "Flood maps and property specific flooding information intended for use by the general public, should be readily interpretable" (2.17). Despite these recommendations there is no clear guidance about whether the need to provide maps will be strengthened within the regulatory framework.

Liability issues are seen to be a barrier by some including the Queensland Local Government Association. Queensland councils currently do not have any statutory protections or immunity to liability in relation to providing flood information or related to planning decisions about development in flood risk areas. Although there was mixed evidence for this during the Queensland Flood Commission's investigations, the Queensland State Government is looking into developing some legislation and strengthening the regulatory framework which provides some immunity from liability for local councils.

Apart from flood forecasting and warning, regulatory measures to promote flood disaster preparedness appear to be lacking in **Pakistan** and, compared to response, expenditure on preparedness has been low in all provinces other than the Punjab where the reverse is the case (Figure 4). Shortcomings in the funding and capacity of Provincial Disaster Management Agencies contributes to this problem. Kamal (2004) reports some effective preparedness activities at provincial level to mobilise local flood awareness and resources, he also observes that local communities are sometime vocal about mismanagement and lack of preparedness by state owned agencies. Apparently preparedness measures do not reach many because of resource constraints in preparedness agencies. According to Action Aid & I-SAP (2011b) the level of preparedness for the 2010 floods was inadequate. However, collection of hydrometeorological data, including river level monitoring, and flood forecasting has been promoted through flood protection projects so that flood warnings may be disseminated to district authorities and public representatives as well as rescue and relief agencies (Shaukat 2003). A comprehensive programme to enhance Pakistan's flood forecasting and warning capability was conceived by Government after the 1992 floods. As a result weather radars were installed, high frequency radios were acquired and a computer-based forecasting system for the Indus and its major tributaries was introduced together with telecommunication systems for hydrometeorological data acquisition (Kamal 2004). However, developing effective flood forecasting capability is a lengthy process and much further development is required in

Pakistan as it currently suffers from many shortcomings. Not surprisingly, it is claimed that in the 2010 floods warnings and related information management were often faulty and inadequate (Action Aid & I-SAP, 2011b). Although Pakistan has one of the highest cell phone

Figure 4: Expenditure on Preparedness and Response 2003-2008, Pakistan (Action Aid & I-SAPS, 2011b)



penetrations in the world (86% for men, 40% for women), cell phone potential as a conduit for emergency information and flood warning is currently not well exploited (Mustafa and Wrathall 2011). Flood warning systems need to extent down to the local, village level but often this level is least well served.

The 2007 flood in **England** brought a multi-agency **response** which was stretched to the limit and beyond. The regulatory framework for response had both strengths and weaknesses. Among the strengths were well-established and trained professional emergency responders experienced in responding to many types of emergencies including floods, working within recently overhauled legislation (i.e. the Civil Contingencies Act (CCA) 2004) in which emergencies and major incidents are defined. Originally set up by the Police in the 1980s, a command and control structure (Gold, Silver, Bronze depending upon the scale and severity of the disaster) was also well-established (with a national level Cabinet Office 'Platinum' counterpart called COBR). This 2004 legislation required responders to ensure their functions can continue during an emergency and set up Resilience Forums through which Category 1 and 2 (i.e. principal and secondary) responders were charged with sharing information, raising public awareness and coordinating preparedness and response thereby enhancing resilience to

disasters. Even so the unprecedented floods of 2007 revealed significant weaknesses in this regulatory and organisational system (Independent Review Group 2008). There was a degree of confusion between responders about whose responsibility it was to consult with partners and to advise on whether a multi-agency response should be triggered in the light of severe weather warnings. There were also different opinions about how should lead Gold Commands. Government 'guidance' (a mechanism used to support legislation) on arrangements for the provision of emergency supplies for emergency responders proved to be inadequate: the arrangements were ad-hoc and unsatisfactory. The most extreme case of the need for emergency supplies involved the delivery of drinking water to 350,000 people who had lost their main supply. The urgency of this situation necessitated local Gold Command requiring logistical sourcing and distribution assistance from the central government crisis machinery, COBR. However the problem extended to all manner of supplies needed including sandbags, medical supplies, cooking equipment, power generators etc. Mutual-aid arrangements, whereby one agency provides supplies to another proved to be only partly structured, and also required better 'guidance' and agreements. The Armed Forces can support civil operations under a Military Aid to the Civil Communities (MACA) scheme, although they have no statutory duty to do so. They provided logistical and other assistance but the events revealed that Armed Forces personnel are sometimes not well integrated into the civilian command and control structure. Lack of clarity about responsibilities for undertaking and coordinating search and rescue placed both the public and responders at unnecessary risk (Independent Review Group 2008). Fully funded national capability for flood rescue with a lead agency was not in place or underpinned by legislation setting out a statutory duty (e.g. there was no flood rescue duty on the Fire and Rescue Authorities in the Fire and Rescue Services Act 2004).

Response

Six months after the 2010 floods in **Pakistan**, Oxfam (2011) evaluated the humanitarian **response** and the **recovery and reconstruction** effort. They concluded that the response had achieved significant success. Many lives had been saved, the spread of disease had been controlled and many had received assistance. Despite severe logistical obstacles, the Pakistan government had launched a major relief operation supported by UN agencies, NGOs and local relief organisations. Several donor governments and millions of individuals in Pakistan and around the world acted quickly and responded generously. Even so there were many shortcomings. The 2010 floods presented a major challenge to new institutional arrangements for disaster management very early after their inception. Following shortcomings

revealed by the devastating earthquake of 2005, Pakistan promulgated a National Disaster Management Ordinance (2006) leading to the National Disaster Management Act of 2010 which established a National Disaster Management Agency (NMDA) at federal level. This agency works with provincial and district level disaster management agencies. Despite Oxfam's conclusions, the Government's response was criticised as slow, disastrous or inadequate by many individuals and agencies (e.g. Khan 2012; Fair 2010). Like others (e.g. Mustafa and Wrathall 2011), Khan (2012) argues that the intensity of the 2010 floods would have presented a major challenge to almost any national government and that Pakistan's shortage of financial and other resources contributed to the less than adequate response. Action Aid & I-SAPS (2011a,b) point to numerous legal impediments, institutional shortcomings and serious governance challenges – many of them stemming from the regulatory system – which contributed to a sluggish response to the floods (Table 5). The 2010 Act illustrates the institutional disconnect between flood mitigation and flood disaster management because mitigation, as well as capacity building, are not included within the Act's definition of disaster management (Action Aid & I-SAPS, 2011a).

Table 5: Institutional shortcomings associated with the National Disaster Management Act 2010 (Source: Action Aid & I-SAPS, 2001, a b)

• Failure to cross-refer to relevant laws and institutions
• Inability to align disaster related institutions vertically and horizontally
• Failures in operationalising regional and local disaster management institutions
• Indecisiveness of multiple stakeholders operating at district, provincial and federal levels
• Concerns over transparency in implementing strategies and plans
• Overlapping and duplicated response and relief efforts
• Disconnections between preparedness and response efforts

- The workability and effectiveness of the legal framework is impeded by overlapping laws and institutional jurisdictions and the 2010 Act prescribes no special measures for addressing these issues

Three levels of disaster management and response exist for **Queensland** under the Disaster Management Act (2003): state, district and local. The state disaster management group prepare a state disaster management plan but much responsibility is placed upon the local councils which are responsibility for the preparation and review of disaster management plans and which are considered to "represent the front line in Queensland's disaster management arrangements" (State Disaster Management Group, 2010; p7). A range of organisations are involved in the response to flooding and are involved at differing levels of governance; including Emergency Management Queensland, State Emergency Services and other blue light services including fire and rescue, police and ambulance. The overall disaster framework was considered by the Interim Queensland Floods Commission (QFCI, 2011) to be a suitable mechanism and that when it was implemented as intended it was considered to work effectively (p115) showing confidence in the regulatory and organisational approaches. However a number of weaknesses were identified; many of these related to the large range of organisations involved. For instance, weaknesses were attributed to a lack of awareness about the roles and responsibilities of local government, the Queensland Policy and other disaster agencies. Additionally, communication between the different tiers of disaster management (local, district and state) was considered also to need improvement.

Recovery

Evidence from **England** and the Pitt Review (Independent Government Review 2008) suggests that recovery arrangements generally worked well following the 2007 floods although not all flood victims would agree with this assessment (especially those in Hull who had to live in temporary accommodation for many months). In the 2007 floods 14,500 households had to move into temporary accommodation and 10 months later 4,750 households were still not back in their homes (Chatterton *et al*., 2010). Successful outcomes were evident where roles and responsibilities were clearly understood and where there was good leadership. There were, however, a number of shortcomings in the regulatory and organisational system for recovery.

The Government's philosophy regarding recovery is that recovery is best managed by local authorities supported where necessary by central government where necessary. The Local Government Act 2007 provides local authority with this recovery leadership role although it was generally understood before 2007 that local authorities managed recovery from floods. However, in the 2007 floods not all local authorities had well rehearsed plans for recovery and the need to exercise recovery as well as response was not always understood. Recovery is also planned by sub-groups of the multi-agency Resilience Forums established under the CCA 2004 and these appeared to work well except where in some cases the flood recovery spanned more than a single local authority area where inconsistencies arose. Government 'guidance' on the efficient management of emergencies turned out to be much more detailed for the response phase than the recovery phase and this led the Pitt review to recommend that all central government guidance on recovery should be updated and improved. In England, as well as private flood insurance claims, flood recovery is supported from a range of funding sources available to local authorities, businesses and individuals. Examples include a Flood Recovery Grant introduced for the 2007 flood recovery and payable to local authorities to aid recovery and then to individuals in greatest need, the Bellwin Scheme which pays flood compensation to local authorities for immediate uninsurable costs of response and recovery. A considerable amount of recovery funding was forthcoming from the various sources of funds available but the Pitt Review concluded that central government should have a pre-planned (formula style) rather than the ad-hoc arrangements to contribute to the costs of recovery.

The 2007 floods and the 'Pitt Review' (Independent Government Review 2008) stimulated significant changes to the regulatory system including a new unified Flood and Water Management Act 2010 which among other things places responsibilities on local authorities to manage local flood risks, a Lead Government Department Plan for flooding (Defra 2011) and a unified National Flood Emergency Framework (Defra 2010) which clarifies roles and responsibilities in the multi-agency response to flood emergencies arising from all sources of flooding. The latter framework is intended to enhance institutional arrangements set out in the Civil Contingencies Act 2004 (which introduced a single framework for all civil emergencies including flooding and helpfully emphasised the need for resilience building but which, in the event of the 2007 floods, provided insufficient clarity relating to roles and responsibilities and related matters for flood emergencies).

Disaster recovery in **Pakistan** suffers from the same shortcomings of the regulatory framework (Table 2). There are relatively large number of current pieces of legislation relating to

calamities and disasters (Action Aid & I-SAP 2010) but often they do not cross-refer and they create a complex relief and recovery picture. Institutional muddle arises from this and leads to sluggishness and other insufficiencies. Two points of background are important in how governance plays out in the program of recovery. Firstly, in Pakistan there is currently a vacuum in local elected government but civil servants are present at the district level and are responsible for relief and recovery (World Bank 2010). How local needs are assessed and how responsibilities are shared at this level is therefore open to question. Secondly, some observers suggest that the Government does not have an effective mechanism to coordinate the different administrative levels, donors and NGOs (World Bank 2010). Corruption and the failure of funding to get through to local levels is a concern. Given the low profile of local flood resilience measures in Pakistan, it is likely that reconstruction has focused on trying to return to the status quo rather than better adaptation and preparedness for future floods - a concern registered by the World Bank (2010). One year after the floods OXFAM reported that about 37,000 were still living in camps in Sindh province alone and that 800,000 families are still without homes and many flood defences have not been repaired (http://www.oxfamamerica.org/press/pressreleases/one-year-on-pakistan-still-unprepared-for-monsoon-floods).

Under the State of **Queensland's** Disaster Management Act (2003) disaster management groups set the framework for recovery from events such as flooding. This brings some consistency in regulatory approach to recovery management. In theory, the establishment of recovery organisations at the same scale that recovery occurs brings the potential for a joined up and coordinated approach. In addition, there are a range of different funds providing financial and economic assistance that were enacted following the Queensland floods many of which provided relief to different victims (individual, community, small businesses, industry) are granted and administered at different levels of government. Figure 5 provides details of these and it is important to highlight that a number of these funds provide incentives for mitigation and require States to implement a disaster mitigation strategy for state-owned assets.

In addition to existing legislation, the national Australian Government has shown to be flexible and committed to supporting those affected by the Queensland floods of 2010/2011. They used an Act of Parliament to establish the *Queensland Reconstruction Authority* (QldRA) on 21st February 2011 to co-ordinate and manage the recovery and reconstruction of areas affected by the Queensland Floods. The organisation was "vested with the power and authority to take charge of the reconstruction process and facilitate effective interaction

between the concerned line departments at the State and local levels" (World Bank, 2011, p12). As well as having a remit to oversee the recovery efforts they also had a forward thinking remit in enhancing preparedness for the future.

Figure 5 National Disaster Relief and Recovery Arrangement (NDRRA) Assistance Scheme (Source: World Bank, 2011, p20)

Category A	Category B	Category C	Category D
Emergent Assistance Grant Essential Household Contents Grant (Means Tested) Structural Assistance Grant (Means Tested) Personal Counseling Counter Disaster Operations	Essentials Services & Safety Reconnection Restoration of Essential Public Assets Freight Subsidy (Primary Producer Only) Concessional loans to small business & non profit	Special Grants to Small Business & Primary Producers for clean up & repair Community Recovery Package	Rural resilience Fund (Assistance to Industry & Community in clean up, business council support measures Exceptional concessional loans for primary producers, businesses & charities Local Council Package for Damage local infrastructure

The establishment of this authority is considered to be one of the main strengths of the government response to the floods as the organisation was given power through the creation of a statutory authority with a strong mandate and the integration of reconstruction within part of normal government business, but it has also taken a 'softer' role in its support of local councils to develop local ownership of developing future flood resilience (World Bank, 2011). A further strengthening factor for recovery is the existence of a number of measures for assessing the success of reconstruction and recovery and in particular improving preparedness and future mitigation. The national government's *National Strategy for Resilience* is a framework for medium to long term successes where as the Value for Money Strategy was used for more immediate reconstruction and planning activities. Furthermore, the Australian Government also introduced a "flood levy" for 2011-12 through two pieces of legislation (Tax Laws Amendment (Temporary Flood Reconstruction Levy) Act 2011 and Income Tax Rates Amendment (Temporary Flood Reconstruction Levy) Act 2011) designed to raise funds from higher rate tax-payers for recovering from the floods. Although the final total is not yet available the Australian Treasury estimated that this would raise AUS$ 1.7 billion (Australian Government Treasury website, Accessed May 2012).

Organisational structures

Mitigation

The organisational structure for flood risk management in England firstly comprises a central Government lead department (Defra); a Governmental agency (the Environment Agency) which has duties and permissive powers for flood risk management on England's main rivers (i.e. the principal elements of the river system) and along parts of the coast (for tidal flooding and sea defences); and local authorities with responsibilities and powers for non-main rivers (often small urban tributaries). Maritime authorities (i.e. local authorities with coasts) are responsible for tidal flooding and sea defences in their areas. In addition, a fundamental aspect of English law is that riparian owners (i.e. land owners whose land is adjacent to a watercourse) have drainage and flood defence responsibilities as well as rights. There are also Internal Drainage Boards (essentially farmer's cooperatives) with drainage duties in certain low-lying areas. In addition the spatial planning system has an important mitigation function in diverting development proposals away from flood risk zones. This organisational system worked reasonably well in the 2007 floods except that (a) responsibilities for alleviating local surface water flooding had been neglected in the structure and the law and (b) flood damage potential had been allowed to accumulate through development in floodplains. The spatial planning system had slowed the rate of floodplain encroachment but it by no means prevented it.

England's agencies have a strong historical scientific and engineering disciplinary foundation and orientation. However, by the time of the 2007 floods this organisational structure and culture had evolved into a mature, multi-disciplinary, broad based one in which ecologists, architects, spatial planners and social scientists had begun to play an important role. The earlier mitigation focus on 'flood defence' by structural means was complemented by a drive to develop a 'portfolio' approach to flood risk management with combinations of structural and non-structural measures. Flood–sensitive design of new developments (for example incorporating sustainable drainage systems and safe evacuation routes) and the flood resistance and resilience of buildings (new builds and through retrofitting) had become a major focus with numerous 'flood products' (e.g. flood shields and aprons) being marketed. Spatial planning organisations and developers had become fully engaged in flood risk assessment based planning processes designed to avoid or reduce the accumulation of flood damage potential in flood risk areas (this process started in the late 1940s but has required progressively tighter legislation and guidance to hold back floodplain encroachment which appears to be almost inexorable). Large businesses were already involved in risk assessments and business continuity planning which was receiving renewed encouragement from the

Environment Agency. Despite the broadening of flood risk management strategy led by Defra (the central government department responsible for flood risk management) and the Environment Agency during the early years of the 2000-2010 decade, avoidance and reduction of flood damages was still largely provided by large-scale structural means. Comparatively few at-risk properties had been made flood resilient by 2007 and the positive effects of PPS25 on development in flood risk areas were only just beginning to be felt. Since 2007 these processes and their positive effects have gathered pace.

The main Water Act 2000 (Queensland) designates the mitigation responsibilities of the water authorities in relation to flooding in Australia but functions related to floodplain management are quite limited. The Act sets out (in Schedule 4 (p728)) that the main functions of the Water Authority related to floodplain management are to undertake flood prevention, floodwater control and drainage (including stormwater drainage). Councils are considered responsible for the development of floodplain management plans which in Australia are quite varied documents dealing with emergency management plans, structural mitigation measures and land planning and building controls. The Commission considered Councils to be at the correct scale to best understand the needs of local people and the local flood risk, as well as being the most appropriate agencies to engage with residents. Therefore, in the most part, local councils are responsible for implementing management plans which deal with multiple aspects of flood management. They are also primarily responsible for levees and the lack of a centralised authority to oversee these activities or a co-ordinated maintenance plan is seen as a failing in the approach (Phillips, 2012). The Queensland Flood Commission (QFCI, 2012; p61) suggests that “many councils had not implemented a comprehensive management plan that accords with best practice principles”. But the QFCI then qualifies this suggestion by stating that these principles are not mandatory and that with limited resources and knowledge (due to the disparity between the sizes of the councils) many councils found themselves unable to implement all or some of best practices recommendations. Flood studies are the backbone of flood risk assessments and for establishing the informational basis for strategic and spatial planning. Local councils have a responsibility to undertake these studies and to update them but local councils’ resources are currently limited in this regard. Such flood studies be undertaken on a catchment-wide basis necessitating the co-operation between councils. Improving the quality of flood data and the sharing of data featured heavily in a number of recommendations by the Queensland Flood Commission (QFCI, 2012). For instance, the panel of experts recommended that a central repository of flood study data should be created.

As part of the Water Supply (Safety and Reliability) Act (2008) dam owners have to prepare a flood mitigation manual which is a clear indication to owners that they need to consider flood mitigation. A critical shortcoming of organisational arrangements, reported on by the QFCI (2011), is that there is currently no statutory obligation for a dam owner to comply with its flood mitigation manual (although there is a question about whether dam owners might be found negligent or liable by not following their flood mitigation manual). DERM (Department of Environment and Resource Management) is responsible for the regulation of dam safety and providing technical advice in relation to dams, urban drainage and pollution from flooding. In addition the Queensland Water Commission (http://www.qwc.qld.gov.au/) is a statutory body established in 2006 to respond primarily to drought, however they also have the requirement to consider flood mitigation and dam safety. Investigations after the 2010/2011 floods suggested that in the most part dam operators acted appropriately and that the performance of the dams was considered to be “satisfactory” (QFCI, 2012, p43). However in the case of the Wivenhoe Dam evidence from the engineers about the operating procedures during 2010/11 are being questioned and legal action being taken against the government in relation to the flood damage caused by the release strategy of this dam. Therefore, communities impacted by the release of water from dams remained critical about the lack of awareness of what was occurring and there was concern by the Queensland Floods Commission (2012) that a failure of planning, outdated procedures, complying with existing plans and communicating actions both to other authorities and the community may have impacted upon both the flood outcomes and community confidence in the 2010/11 floods.

Although local council have spatial planning responsibilities there are some overarching roles which should act as checks on inappropriate development. The Department of Local Government and Planning has an oversight role for planning (under the SPP 1/03 guidelines) to ensure that the overarching state outcomes for preventing flooding are risk prone areas are achieved: this can result in councils imposing conditions on developers or in councils amending schemes. Additionally, the Department of Community Safety (DCS) are responsible for reviewing draft planning schemes for compliance with SPP 1/03 and to consult with DERM for guidance about hazard management. However, the QFCI (2012) provides examples where this process has not adequately prevented inappropriate development and where the resulting schemes do not comply with SPP 1/03. QFCI contends that the DCS is often unaware about whether or not their observations have been taken into account. Failings of the checking process reduced the effectiveness of the regulatory instruments to prevent inappropriate development in hazardous areas which were directly affected in the 2010/2011 floods.

The Queensland Government does not currently offer a state-administered buy-back scheme (where property owners willingly sell their properties to remove them from the at-risk area). However, joint national and state government schemes have permitted buy-back in a minor number of cases. Some of the larger local councils have also adopted this approach on a small scale to enable the return of the high risk land to non-residential uses. Funding is the main barrier to the wider implementation of this approach but the QFCI (2012) advocates a wider adoption of such measures through seeking funding from the Natural Disaster Resilience Program.

Within the organisational structure for flood disaster management in Pakistan, the most well resourced and influential organisations tend to those water resource, irrigation and flood agencies with a flood mitigation responsibility, as well as those involved in hydrometeorological data collection and forecasting (an element of response). In the development of flood risk management institutions this is often the case: organisations tend to have a strong engineering and scientific base. One measure of the degree of advancement of a country's flood risk management policy is the extent to which such organisations are complemented in flood risk management by others say, with environmental management, land use planning, building design and resilience and insurance expertise, powers and influence on policy and practice. In this respect, as well as in others (e.g. clarity of legal responsibilities (including inter-agency coordination) and powers, Pakistan may be considered to be at a relatively early stage of flood institution evolution.

Preparedness

The private insurance industry underpins flood preparedness in England because, through an agreement with the Government, it currently provides flood insurance cover to households and businesses on a commercial basis, usually as a standard part of structure and contents insurance policies. Average flood insurance coverage is relatively high but ownership of cover is sometimes quite limited in areas of low socio-economic status. After the 2007 floods flood insurance companies received over 160,000 claims and paid out £3 billion (Association of British Insurers 2007). Local councils often self-insure or purchase their own disaster insurance cover but in some cases in the 2007 floods this cover proved to far too limited. Flood insurance cushioned the financial and human consequences of the floods for many and aided recovery, although this was often offset by delays and anxieties associated with dealing with insurers. Some of those without flood insurance received financial and other assistance from flood recovery and compensation schemes. Although the forecasting and warning system for river flooding was effective during the 2007 floods, the Pitt Review concluded that the Environment

Agency and the Met Office should integrate these services in future in order to maximise improvements in capabilities and to develop more integrated weather and flood warnings for all sources of flooding (a joint Flood Forecasting Centre has since been established). Channels for direct dissemination of flood warnings from the Environment Agency to the public and professional responders (thereby avoiding the potential complications created by intermediaries) were well established and practiced by the time of the 2007 floods employing a multi-media approach. Flood preparedness had also been successfully advanced by the many local flood action committees which now exist in England, and by the National Flood Forum (a charitable organisation which supports individuals and communities at risk from flooding). These organisations raise flood risk awareness and provide information and advice on flood preparedness and risk reduction measures). These organisations complement the Environment Agency which also encourages and provides information on flood preparedness measures for householders, school children and businesses. The lack of preparedness of utility companies (relating to critical infrastructure) and their disconnectedness from Resilience Forums, as well as preparedness issues surrounding some flood response organisations is discussed above. Given the unprecedented nature of the floods, the Environment Agency found that its staffing became very stretched and it was unprepared to manage the large amount of requests for information which it received from the public, the media, politicians and government officials throughout the flood emergency.

Preparedness through household insurance cover for floods is currently non-existent in Pakistan: only in the last few months has the Prime Minister instructed Government departments to examine how such insurance can be provided in future. Organisations with flood preparedness know-how, powers and adequate funding are clearly under-developed within flood disaster management in Pakistan, yet there is a major flood preparedness need including a need to inform and educate the population about such preparedness. This is because of a structural and funding emphasis on mitigation and to some extent also on relief. The formation of the NDMA in 2010 indicates an intention to shift from the traditional, reactive response and relief approach to a more proactive one but much remains to be done. This is not to say that flood preparedness initiatives are not being taken. Indeed, there is evidence that at least some Provincial Disaster Management Authorities (PDMAs) (e.g. in Punjab) with NGOs, civil administrations and the public representatives to increase levels of flood preparedness in order, for example, to reduce response times (Action Aid & I-SAPS 2011b). However, at the same time PDMAs and District Disaster Management Authorities (DDMAs)

claim that their capacities are too small to take on many of the tasks required (Action Aid & I-SAPs).

Emergency Management **Queensland** (EMQ) is the organisation who has the overall remit for leading disaster preparedness activities in Queensland, supported by Emergency Management Australia which co-ordinates activities at the national level. It has functions which include monitoring the performance of disaster management groups, providing disaster management training, and arranging the resupply of goods to affected communities and managing other groups such as the State Emergency Services (SES). One of EMQ's main functions is to oversee and review the completion and effectiveness of disaster management plans, a responsibility which as criticised following the 2010/2011 floods for the lack of a consistent approach to review and failing to ensure that all councils were complying with the relevant regulatory approaches. In addition, it is contended that EMQ needed to take a more proactive approach to monitoring and assisting local councils in the preparations for flooding. In addition, there was a lack of consistent training for councils and arrangements failed to comply with recent changes to the Disaster Management Act (2003). A reduction in national government financing of training is viewed as a contributing factor. QFCI (2011, p120) observes that "there is a general acceptance that an increased emphasis on training in disaster management roles and responsibilities would enhance Queensland's overall disaster preparedness and response".

The slow onset nature of the 2010/2011 floods permitted some 'during-event' preparation among councils which had experienced flooding earlier in 2010. As a result these councils responded better than those unaffected in the earlier event (QFCI, 2011). Preparations included filling and delivering over 300,000 sandbags in Brisbane alone, the construction of temporary and new levees as well as the inspection of existing ones, and watercourse maintenance to clear vegetation and maintain channel conveyance. However, there were noticeable differences between local council's preparations, described in the Interim Queensland Flood Commission report as being dependent on the same factors which limited their ability to respond to floods. These factors included "geographic differences and vulnerability to particular types of disasters; the priority they gave to disaster management; their experience in dealing with disasters; the resources available for disaster management; and the expertise and training of their staff" (QFCI, 2011). This inconsistency of approach is a fundamental issue with management by organisations at a lower spatial scale.

The degree of preparedness afforded by the private insurance industry in Queensland was limited. Most insurance policies covered a property for damage by stormwater (and in some

cases flash flood) but not the damage caused by most other floods. In many cases residents failed to realise that they were not covered by their insurance policies for flooding. This lack of awareness is compounded by quite complicated flood definitions (QFCI, 2012). Despite this, the insurers which provided data to the Queensland Flood Commission reported that they accepted 73% of all of their household claims, although insurers were criticised for the length of time it took to settle claims.

Response and recovery

Organisational aspects of the multi-agency response and recovery in **England** are largely discussed above in connection with the regulatory system. The multi-agency response to floods in 1998 was heavily criticised at the time and led to demands for a much improved and 'seamless' response in future. Presented with a different challenge in 2007, the response cannot be described as seamless as there were some significant shortcomings (discussed above) (Independent Government Review 2008). Recovery proved to be a lengthy and very challenging process for some badly affected families, especially those who had to be rehoused for many months in temporary accommodation of limited standard. Surveillance of flood victims in Hull showed that many of the mental health impacts of flooding were caused by people being treated badly by the various companies and agencies involved in flood recovery (Chatterton *et al*., 2010). England has developed a high quality process of post-flood review in order to learn lessons about easy of improving all aspects of flood disaster management. Reviews of performance in managing floods are comprehensive and publicly available. For the 2007 floods the Pitt Review (Independent Government Review 2008) and the reviews by the Environment Agency (2007), ABI (2007) and other organisations (e.g. Coulthard *et al*., 2007) are examples of this learning process. The latest evidence is that many concerted actions have taken place since to enhance institutional arrangements.

Emergency Management Australia (EMA) is the national government organisation responsible for coordinating emergency management and response across Australia including within **Queensland**. EMA aims to support State governments in developing emergency plans. EMA also takes a lead in developing best practices for emergency management, including a range of manuals (EMA, 1999, EMA 2009a; 2009b; 2009c), and delivering education and training programmes. Flood management disaster response and recovery efforts have multi-tier institutional arrangements. Each Disaster management group established as part of the State of Queensland's Disaster Management Act (2003) is served by Community Recovery Committees (CRC) and recovery plans at the State, District and local levels. The World Bank

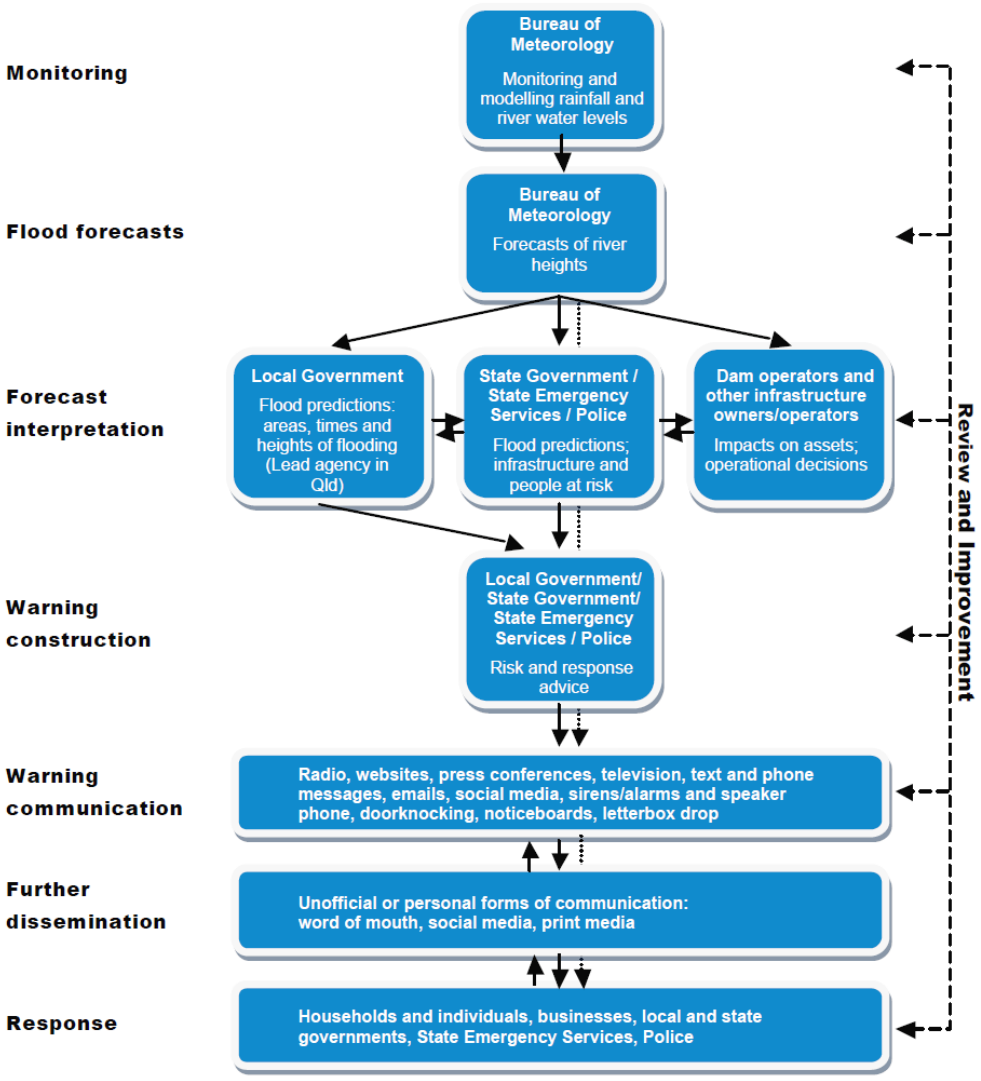
(2011; p11) described the roles and responsibilities of these organisations as including: inter-agency coordination, development and review of annual recovery plans, monitoring preparedness levels and activities, support and advice on disaster recovery services in disaster events and liaising with EMQ and out-of-state organisations. Although it is the role of the state-level EMQ to lead the co-ordination of response and recovery organisations, Queensland State Policy is responsible for coordinating the response phase of disaster management and, in particular, during the disaster itself. A number of different organisations perform other functions in response to flooding including the State Emergency Services (SES) - an almost entirely voluntary organisation which provides support to the other emergency services; Queensland Fire and Rescue whose swift water rescue team were called upon to provide rescues during the 2010/2011 floods; and the Queensland Ambulance Services which took on the role of coordinating aero-medical services as well as their routine duties. As well as these emergency services there are many other organisations (such as utilities, communications etc.) which also are required to respond in order to maintain public assets and services. Additionally, the Australian Red Cross and the Australian Defence Force were significantly involved in response and recovery, the former assisting in the management of evacuation centres and the latter in deploying helicopters to assist in evacuations and the re-supply of isolated communities. Both organisations were commended in their response despite not being fully integrated into the disaster plans: their future inclusion into pre-emptive disaster planning was recommended. In the case of the Australian Defence Force this appears to be an oversight as they are included within the disaster management group in many other areas of Australia (QFCI, 2011).

There was concern following the 2010/2011 Queensland floods that coordination of organisations involved in response and the early stages of recovery were not as joined up as they might have been. Queensland United Utilities were critical of the lack of direct communication with the state disaster management group which liaised with a more intermediary organisation (the SEQ Water Grid) rather than directly with company operatives despite the need to maintain essential services to the public. Despite these criticisms about communication between organisations, the World Bank argues that the framework for recovery following flooding is well organised - “The fusion and interplay of State and lower-tier departments helps ensure both central-level monitoring and coordination, standard-setting in advice and recovery, as well as decentralised decision making, and fostering of strong regional and local capacities for the implementation of disaster management and recover plans” (World Bank, 2011; p11).

The overarching responsibility for flood forecasting and warning in Australia lies at the national government level with Commonwealth Bureau of Meteorology. Within the state of Queensland an organisation called the Queensland Flood Warning Consultative Committee (FWCC) which coordinates the operation of flood warning service within Queensland and combines government efforts at national, state and local government level with the Queensland's flood warnings being operated out of a Bureau of Meteorology office in Brisbane. Figure 6 illustrates the complexity of organisations and responsibilities within the sphere of flood warning in Australia. Local councils have a significant role to play in flood warning, they are responsible for the translation of the likely impact that a flood prediction will have upon local communities, and as part of this the councils are required to provide householders with information about likely inundation to individual properties. The Queensland Commission indicate (QFCI, 2011) indicate that they should continue to assume the role of issuing flash flood alerts. However, there are also recommendations that the Bureau of Meteorology should issue warnings directly to the pubic via their website, or re-publish warnings provided by councils, to try to ensure that those who directly visit their website are warned. Despite these new recommendations, the reliance is still on local councils (some of which are well resourced and capable and others of which are resource and knowledge limited) provides a fragmented and variable approach to flood warning across Queensland. A number of warning communication and dissemination mechanisms were used during the 2010/2011 floods including; SMS, radio and other media, social media, community service announcements, internet-based information and door-knocking. The radio was considered to be an effective means of flood warning communication during the floods and was widely used alongside text messaging. In small communities which could suffer rapid-onset flooding the use of sirens to improve flood warning is being investigated.

The situation in Queensland for flood warnings is complicated by the number of dams which regulate water flows and therefore need to be opened or closed depending upon flow conditions. Dam operators are required to be involved in the emergency response to floods and sharing information with other responders. In some cases dam operators successfully notified residents downstream of their dams that they had to open their spillways which permitted residents to take appropriate action, but this was not successful in all cases (QFCI, 2011) in particular where power supplies were interrupted. There are calls for dam operators to be better integrated into the emergency response frameworks.

Figure 6: Roles of different organisations in flood warning



Source: Queensland Government, 2011, p9 – figure originally compiled by the Science, Engineering and Technology Panel

As well as emergency plans which are required under the Disaster Management Act (2003), local councils have to prepare evacuation plans as part of the Queensland Disaster Management Planning Guidelines for Local Government (Queensland Local Government Association, 2005). This requires local councils to nominate evacuation centres but there is currently no requirement for these locations to be publicly advertised prior to a flood. Although there is an intention to allow flexibility so that authorities can nominate those centres which are most suitable depending on the nature of a disaster, there is some evidence from the 2010/2011 flood that the public were more easily and efficiently able to evacuate in those places where the evacuation centres were publicly known.

The primary response to the floods in **Pakistan** was from the politically powerful army (Kronstadt *et al*., 2010). The military used its forces to evacuate people and to distribute supplies. In comparison the civilian government response appeared to be weak. There was little coordination between military and the civilian government response and little oversight of the military response by the civilian government (Kronstadt *et al*., 2010). As well as these leadership and coordination difficulties, organisational complexity, overlapping jurisdictions and lack of capacity adversely affected the response. Here the shortcomings are similar to those affecting preparedness above. Khan (2012) argues that the NMDA was unable to fully utilise those resources which were available to it, claiming that only a small proportion of the helicopters which could have been made available (by the army and others) were harnessed for rescue and provision of basic supplies during the emergency. Flood preparedness, response and recovery initiatives are required at district level as well as other levels, but there DDMAs are generally weak and poorly funded organisations – the law does not provide for a mandatory and legally enforceable mechanism for functionalizing these organisations (Action Aid & I-SAP 2011a). Although there is investment in flood forecasting technology, early warning systems require enhancement so that they function well at the local/public level as well as at other levels. Instances of deliberate releases of floodwaters from reservoirs without any public warning are cited (Action Aid & I-SAPs 2011b). Oxfam (2011) reports that, partly owing to the slow international aid response, millions of flood-affected people waited weeks or months for any assistance and aid at all.

Following the 2010 floods, flood recovery and reconstruction planning in **Pakistan** appears to have been muddled by organisational complexity and duplication, slowness, cumbersome aid distribution systems and lack of resources. A good example is identified by Action Aid & I-SAP (2011b) who report a number of parallel and uncoordinated efforts at reconstruction planning. The recent establishment of a 'Flood Reconstruction Unit' at the national Planning Commission to prepare a flood reconstruction plan was happening while a number of parallel planning processes were being undertaken at the NDMA. At the same time, the 5 year National Development Plan was being finalised independent of flood reconstruction plans. Oxfam (2011) reported that six months after the flood, levels of malnutrition had skyrocketed, one million internally displaced persons were over-wintering with flimsy shelter. They called for a nationally-led and more accountable and transparent reconstruction process and one which is pro-poor led. Hindsight review and post-flood learning should be embedded within organisational processes. Both Government and NGOs have undertaken such reviews in order to learn lessons from the 2007 floods but it appears that in the past there has been a lack of

effectiveness in both learning these lessons and translating them into positive actions designed to avoid or reduce the impacts of flood disasters.

Behavioural norms and social and cultural aspects

Mitigation

Although engineering oriented, the organisational culture of England's flood risk management agencies has shifted towards acceptance of non-structural means of flood mitigation alongside more conventional structural assets. The annual expenditure on flood risk management in England is now approximately two-thirds on structural measures and their maintenance, and one-third on 'non-asset' measures. Apart from the positive effect of river flood warnings and response to them in the 2007 floods, the flood damage reducing potential of non-asset measures was nowhere near being realised in these floods and is a contributory factor to the large flood loss experienced. However, the at-risk public often prefer structural solutions to non-structural ones, such as flood warnings which allow moveable property to be moved above anticipated flood levels or property resilience measures, because they usually require greater participation and appear to offer a lower quality solution to flood risks (Priest *et al*., 2010). In these cases the consequences of the possible failure of structural solutions or for their design standard to be exceeded is largely neglected. Therefore where a flood risk needs to be addressed, public attitudes are sometimes such that 'non-asset' solutions are perceived of as second-class ones. Equity arguments are sometimes used to support the case for structural solutions: on the basis that if people in another flood risk location benefit from flood defences, it is unfair not to refuse this option to those living elsewhere. On the other hand, sometimes environmental or amenity considerations come to the fore where, for example, flood embankments might obscure river views or impede access to the river, and the opposite is the case. There are also examples of towns which lie almost entirely within a flood risk zone (e.g. Kings Lynn) where at one stage the local council set the risk of flooding aside and ignored it because of the threat to development and growth in the town.

Within organisations within Queensland there is a large focus on planning (both strategic and emergency) in relation to natural events including flooding with multi-agency and multi-hazard planning; however there is evidence from the 2010/2011 event that this planning in different areas was not as co-ordinated or integrated as it might have been and in particular did not sufficiently involve communities. Due to the widespread scale and long duration of the floods it is difficult to identify directly whether failings that did occur were related to the sheer size of the event in some cases or due to insufficiently planning. As well as flood mitigation through the

construction of levees (temporary or permanent) there are a number of dams in Queensland which have flood mitigation capabilities. As discussed previously there is some contention about the performance of dam operators with some being considered to be satisfactory and others' water release strategies coming under question. In addition, there was come criticism about the lack of regulation of some dam operators' planning procedures and that existing plans were not given adequate attention and being maintained (CFQI, 2011). It might be stated that prior to the 2010/2011 floods the priority for dam operators was on maintaining water security, rather than also preparing for flood conditions.

Although in Australia there is much focus on non-structural measures and a broadening of floodplain management; with a strong focus on spatial planning and the prevention of development in the floodplains, buy-back schemes whereby areas are cleared of existing development, the raising of existing properties and designing new build to account for flooding (such as flood proofing or raising floor levels) (Queensland Government, 2011). Although this is the overriding philosophy it is difficult in practise to assess the uptake of these measures and therefore their impact during the 2010/2011 Queensland floods. The adoption of these types of approaches is often reliant on a high awareness of floods, strong regulatory activity (whereby these types of measures are mandated) or previous (and often repeated) experience of flooding. As stated previously buy-back schemes are virtually non-existent in Queensland (Phillips, 2012) due to the lack of funding and therefore without a buyer most residents will be unable to afford to take the loss to move out of the flood plain. There is also no one state authority which is responsible for alerting prospective property buyers about flood risk (Phillips, 2012) and flood mapping is severely lacking, therefore awareness of flooding and the potential for people to take ownership of their own risks and implement non-structural responses is limited. Although some areas of Queensland have experienced flooding in the recent past, the widespread nature of this event means that many people have been flooded for the first time which will have limited prior individual mitigation efforts.

In general, the regulatory system, organisational responsibilities and implementation of floodplain management, response and recovery is fragmented in Queensland as it is in the rest of Australia. Although in many cases this has permitted the development of well practiced a knowledgeable experts (such as EMA, SES etc) and a better understanding of best practice, it might be argued that this degree of division has hindered floodplain management. In the case of Queensland much of the floodplain management, mitigation, planning, response, awareness-raising and flood studies are to be undertaken at the council level. This localised

approach in theory allows local circumstances and nuances of flood hazard and community to be accounted for, however in reality the efficiency and success by which all of these functions are delivered varies quite considerably between (and sometimes within) councils. The Queensland Flood Commission Inquiry (QFCI, 2011; 2012) has acknowledged these deficiencies and many of the recommendations relate to assisting councils in the provision of their flood management duties. The success of these changes however, remain to be seen in particular in relation to some of the smaller councils which may continue to struggle to provide (and prioritise) flood management due to lack of knowledge, experience and resourcing.

Flood policy and practice has been a somewhat peripheral area for Pakistani water managers. Although there is a Federal Flood Commission which is responsible for remodelling flood mitigation policy and a Flood Forecasting Division in the Pakistan Meteorological Department, flood management tends not to be centre-stage in some of the key water and irrigation authorities (e.g. the Water and Power Development Authority, Provincial Irrigation and Drainage Authorities, Area Water Boards) which, nevertheless, have important 'fingers in the pie' of flood management. For example, the priority for dam and barrage managers is always irrigation and power generation with flood control as an afterthought. This means that flood management is sometimes not to the fore and, when it is, dominant disciplinary and professional backgrounds (i.e. civil engineering), attitudes and orientations bred through institutional cultures and training, limit concerns to physical flood risk and exposure reduction. The influence of social and environmental scientists in these water management agencies is almost invisible. Pakistani managers tend not to be sensitive to the need to adapt to the natural rhythms of rivers and instead maintain an attitude of heroic engineering to control rivers (Mustafa and Wrathall 2011). Sometimes engineers are not particularly comfortable with people-oriented solutions to flood problems which may be viewed as difficult or messy, and then it is all too easy to rely on solutions bred of an engineering ethos. As a result, flood protection works are conceived and implemented without any involvement of local beneficiaries or those for whom they may have an adverse impact.

Preparedness

The English public's willingness to engage in flood preparedness measures is conditioned by flood risk awareness. Those who were aware took precautions and made preparations; those who were not took and made none with negative consequences. In England, in all but the most frequently flooded or obviously at risk coastal locations, raising flood risk awareness and knowledge of mitigation options is a constant battle because complacency is commonplace. This is despite a continuous flood risk awareness raising process by the Environment Agency.

It is especially so where populations are mobile, where they are not close to rivers but nevertheless in a flood risk zone and where there has been little effort to maintain a collective memory of past floods. Often there is little understanding of potential climate change effects on rising flood levels. Limited flood risk awareness was compounded in the 2007 floods by an institutional system which, in hindsight, had neglected surface water flood risks and therefore did little to raise awareness of them. All of this contributed to people being surprised to discover that they were at risk and to higher flood losses (financial and human) than otherwise would be the case.

Community flood preparedness performance in Queensland was of mixed quality for the 2011 floods. There were national and state-level delivered flood risk awareness schemes but local government is perceived as playing the central role in educating community members about the risks posed by natural hazards and encouraging preparation and appropriate response. Flood preparedness was reliant on councils having the resources and inclination to undertake preparedness activities. Since resource constraints and motivations varied, so did the success of this preparedness (with Rockhampton Regional Council, Mackay Regional Council and Emerald Shire Council amongst others providing some good examples (QFCI, 2011)). Preparedness was seriously hindered by the general lack of flood maps which provide consistent, accessible information to the public about flood risk. The QFCI Interim report (2011, p122) makes the quite damming statement that “Community members in many of the flooded areas indicated that they were not aware of, or had not understood the risk of flooding in their local area; the meaning and significance of flood warnings; whom they should contact for assistance in a disaster situation; or when to evacuate and the location of evacuation centres. In some regions the community were given very little, if any, disaster preparation and management advice before the floods”. It difficult to attribute direct causation between these failings and the flood impact in terms of the number of lives which might have been saved or injuries prevented or the total damage that might have been avoided, but a lack of individual or community flood preparedness will have impacted negatively in all of these areas. Failure to include those affected within the planning for flood emergencies was a further criticism following the 2010/2011 floods.

In Pakistan the adoption of a higher level of flood preparedness at the local and individual household levels tends to be compromised by habitual behaviours which expose people and their possessions to floods. Kamal (2004) refers to the habitual tendency of individual cultivators, intent on earning a living, to plant crops in fertile river beds and floodplains between

the first and second line of levees and also build permanent stone/bush made dwellings there. Encroachment into floodplains in this way is precluded by planning laws but these are weakly enforced allowing these behaviours to persist. In attempt to change these kind of behaviours, in some locations the government is allocating land outside of the river bed to cultivators and NGOs are encouraging women to develop bread making and stitching skills to earn income. In some cases, the government has paid market prices for land occupied by encroachers to get them to move to higher land. Beyond these problems, generally flood preparedness is often lacking because of lackadaisical attitudes and lack of flood awareness, information and education although some attempts are made to enhance these. Discrimination against women is rife. Kamal (2004) reports that involvement of women in flood preparedness, and flood management in general, is non-existent compared to men although some NGOs are trying to alter this.

Response and recovery

In England in general, but depending on the circumstances, the public's response to flood warnings has improved over the past 15 years. Factors which helped in 2007 included the personalised flood warnings which property occupants received and efforts to raise awareness of those living and working in floodplains of flood warning codes, their meaning and appropriate ways of responding to warnings. However, although the Environment Agency offered to provide flood warnings via its multi-media Flood Warnings Direct service to property owners on an opt-in basis, a significant proportion of those at risk from flooding fail to opt in, or opt out at some point after opting in. Anxiety about flood risk, countered by personal denial of the risk, is one of a number of psychological factors likely to be at play. The public's willingness to engage in flood recovery varied after the 2007 floods, but on the whole people were willing to play their part. Coulthard *et al*. (2007) refer to the extraordinary levels of goodwill, comradeship and willingness to help neighbours during the floods in Hull, a badly affected city.

Lack of specificity in flood warning messages disseminated in Queensland was, in some cases, a major barrier to the public responding appropriately. The Bureau of Meteorology provided some warnings of flooding in January which provided information in relation to the flood levels reached in 1974. This assisted in some residents to better comprehend the scale of the flooding that might be encountered but this frame of reference tends only to be useful to those who experienced and recall the 1974 event. In the 2011 floods there were different types of evacuation response evidencing different levels of flood awareness and willingness to respond. Some residents self-evacuated prior to being asked to, others voluntarily evacuated after being requested to by the authorities whereas other households had to be mandatorily evacuated.

The district disaster co-ordinator has the authority to force individuals to leave their property once an official disaster has occurred. In total over 5,900 people evacuated from 3,600 homes (House of Representatives Standing Committee on Economics, 2011). Lack of education about how to respond to flood warnings influenced the number of fatalities during the floods. Nine of the casualties were drowned when their vehicles were caught in floodwaters and some of these were when drivers ignored warning and road closure signs and drove directly into danger (QFCI, 2011). This is quite a common behavioural scenario in floods and similar scenarios evolved in Europe, and particularly the USA, where individuals underestimate the danger of floodwaters to their vehicles and to themselves. Providing better education and information specifically about this issue is required to reduce this type of flood fatality.

The World Bank (2011) praised the response and early recovery from the Queensland floods and suggests that much of this success can be attributed to prior disaster management and arrangements and preparedness for disaster. The early efforts to try to recover quickly from the floods was commended, with close to AUS$800 million being paid out in different types of disaster assistance and AUS$310m being paid in insurance claims by March 2011. In addition, 409 of the 411 schools affected were reopened in their original locations, although reinstatement of damaged schools may not have been the most appropriate recovery responses in some cases. Despite some financial relief being paid in a timely manner, many affected residents criticised the lengthy wait for their insurance claims to be settled.

Kendall *et al*. (2011) argue that recovery strategies tend to focus on individuals in isolation or on “impersonal State-wide or regional response” but ignore the scale between these two which is the community. They argue that by doing this the value of communities in recovery is misrepresented and underestimated. During the Queensland floods there were good examples of communities getting together to coordinate relief. However, Kendell *et al*. (2011) argue that not all communities are in a similar position to undertake recovery actions. Self-governance and group action is, they argue, more likely in affluent or educated communities than more vulnerable communities which might be left to broker their own recovery. However, the Queensland Recovery Authority recognised the importance of engaging communities within the reconstruction process and instigated a number of initiatives and tools including the Join Forces programme (http://www.qldreconstruction.org.au/join-forces), the Build Back Navigator (providing advice on building, insurance claims, temporary accommodation and where to get financial support http://www.qldreconstruction.org.au/build-back) and maps which provide information about assistance and location in relation to the 2010/2011 flood

line(http://www.qldreconstruction.org.au/interactive-map/). This link with communities and the use of the media in order to provide information are seen as some of the great successes of the recovery process in Queensland (World Bank, 2011). In addition, the community response to the Queensland 2010/2011 floods is quite indicative of attitudes in parts of Australia that there is the need to assist others and for communities to help themselves and take some responsibility for the rebuilding of communities following flooding.

In Pakistan flood response and recovery activities, as well as flood mitigation, are adversely affected by corruption and political patronage. An Indian 'think-tank', the Institute for Defence Studies and Analyses (ISDA) (2011) reports that in Pakistan water management is rendered ineffective by relaxed attitudes, political orientation and institutionalised corruption. For example, Bisht (2010) comments on the cosy relationship between the forest denuding 'timber mafia' in Pakistan and the political leadership in North Sindh when deforestation is a likely cause of worsening floods. Bisht also refers to corrupt practices within relief and recovery operations (ISDA 2011), and does the World Bank (IEG/World Bank 2010), and Fair (2011) reports that international agencies are weary of channelling assistance through potentially corrupt governmental channels while avoiding cooperating too closely with the army.

Analysis

This section summarises some of the key messages from the evaluations above.

Institutional resilience leading to successes

It is easy to underestimate the flood losses which were avoided in each of the three flood disasters through the positive impact of institutional arrangements present in each country before, during and after the event. In particular it is easy to underestimate the beneficial effect of flood protection infrastructure extant at the time of these disasters, and it is difficult to estimate the losses avoided. It is also difficult to assess the positive impacts of the rapid flood recovery in Queensland and the measures taken to avoid epidemics and food scarcity in Pakistan after the floods there. The evidence is, then, that a great deal of institutional resilience is helpfully 'locked' into existing institutions. However, the evidence reveals that there are limits to these resiliencies including serious ones.

Institutional misalignment and marginalisation

Even apparently well-developed and tried and tested institutional arrangements can prove to be misaligned when it comes to addressing particular flood disasters. This was the case in England in 2007 when flood risk management and related agencies were faced with

widespread and serious flooding from sources for which institutional arrangements were not well designed. Here institutional arrangements had been designed principally to manage fluvial and tidal flooding. These institutions (e.g. the regulatory system, preparedness measures, and warning systems) proved to be resilient for the fluvial flooding which occurred but were ill-designed to cope with surface water flooding which affected two-thirds of the properties flooded. Institutional misalignment occurred in a different manner in Pakistan. Here, flood risk management is often secondary in water resource development, irrigation and power development institutional arrangements so that, when presented with unprecedented floods in 2010, institutional arrangements (e.g. structural flood protection measures, early warning systems) proved only partly effective or ineffective. Failure to prioritise flood risk management and to make progress with it stems from this marginalisation and, in Queensland it may well have contributed to institutional arrangements being less resilient in the 2011 floods than might have otherwise been the case. In all of these cases, there appears to have been a failure, through high level governmental and other risk assessment processes, to adequately identify the full nature of flood risk, its potential severity and its potential impacts, and to align institutional arrangements more satisfactorily to these risks.

Unbalanced institutional development

Almost worldwide, there is a consistent pattern in the evolution of flood risk management institutions. These institutions usually begin with the early founding governmental meteorological services and river engineering agencies and have a strong scientific and engineering orientation. They subsequently gain weather forecasting and flood protection responsibilities and funding streams through being embedded in successive laws. Consequently, the flood risk management solutions which these laws and organisations promote are structural engineering ones (e.g. flood control dams, river training, and levees) and weather/flood forecasting and warning ones. Typically non-structural flood management measures which focus on the control of development and floodplain zoning, flood sensitive and flood resilient development design, reducing the vulnerability of people to floods and local community initiatives are introduced much later, often through other legislative and organisational arrangements (including informal ones) and initially largely disconnected from flood risk management institutions. These solutions are founded partly in different concerns and disciplines (i.e. not engineering) with which the traditional organisations find difficulty in integrating and which may be seen as a challenge to conventional organisations. In the most advanced situations, multi-disciplinary flood management teams are formed and a balanced

approach is developed, genuinely combining conventional structural and unconventional structural and non-structural measures into portfolios of flood management strategies.

Within this institutional evolutionary model, Pakistan is located at a post-early stage of development. Its flood risk management and flood disaster management institutions, founded in colonial times, are characterised by an unbalanced emphasis on structural solutions (which are nevertheless needed and which undoubtedly saved many lives and reduced flood losses during the 2010 floods but which are vulnerable to the actions of aggressive, silting river systems) which are largely disconnected flood relief institutions. In the middle ground, although planning laws exist to prevent floodplain encroachment these laws are often unenforced and ineffective and have poor resonance with underlying livelihood and social issues which drive encroachment. Flood sensitive urban and utility infrastructure design is hardly developed. Over the past 25 years England has transformed its deeply historical and traditional flood risk management institutions into advanced, more balanced ones which now seek to address flood management using a portfolio of traditional structural and less conventional non-structural measures, although the full impact of this approach has yet to be realised and was not realised when the 2007 floods occurred. Partly owing to low population density, relatively late development, and very large and aggressive river systems which are extremely costly to embank, Queensland's flood institutions appear to have developed with potentially greater balance almost from the start. Here flood control dams are important, and levee systems protect some of the larger, more densely developed, urban centres but a spatial planning approach has been important for some time as has flood forecasting and warning. Unfortunately, the 2011 floods revealed many shortcomings and weaknesses in spatial planning to reduce flood disaster potential.

Institutional resilience undermined by institutional incoherence

Institutional arrangements are almost always complex involving a raft of laws, many organisations (both formal and informal), organisational layering, a requirement for numerous effective interconnections, coordination, multiple funding streams and, often, constant institutional reform and change. Maintaining institutional coherence is therefore likely to be challenging. In each of the cases evaluated in this paper there are examples of lack of coordination or cooperation, problems caused by overlapping jurisdictions and uneven and inadequate funding. In one case study, or more', there was poor alignment and therefore disconnection between organisational layers, duplication, lack of leadership and other shortcomings. Pakistan's institutions are the most heavily criticised for incoherence with legal instruments failing to cross-refer, there is vertical and horizontal misalignment, failure to

operationalise lower tier disaster management institutions and so on. Sometimes institutional arrangements proved to be muddled and unworkable, stifling necessary actions.

High variability in flood disaster preparedness

Perhaps not surprisingly, the three flood disasters reveal a high degree of variability and numerous insufficiencies in flood preparedness. Although preparedness weaknesses are identifiable in the aftermath of the 2007 floods in England, levels of organisational preparedness were reasonably high but individual flood risk awareness was much less than ideal. England's flood preparedness is founded in high quality flood risk mapping which provides a firm platform for easy public access to flood risk information, fluvial and coastal flood warnings and flood warning response by professional responders and the public. Even so surface water flood risks had not been mapped (this process is currently ongoing), with consequent low public awareness, and there was no flood warning system for this type of flooding. Response preparedness was well developed but even so the unprecedented floods proved challenging revealing severe resource supply logistical problems. In Pakistan the civilian government and its disaster relief capacity was soon overwhelmed by the unprecedented demands arising from the floods. Flood preparedness was often poor or non-existent at the local level. There were many preparedness shortcomings in Queensland, perhaps the most important ones originating from the lack of high quality flood risk mapping – a critical institutional weakness.

Early warning systems

Early warning systems for floods exist in England, Pakistan and Queensland. They are based on the evolving science of flood forecasting in which uncertainties are inherent. Flood forecasting, warning and warning response systems are characterised by a chain of linkages between climate and meteorological scientists, flood forecasters, flood warning managers, professional emergency responders, infrastructure providers and the public. Because numerous organisations are involved and because of the complexity of the flood warning chain, scientific uncertainty, time constraints acting upon forecasting and warning dissemination, and behavioural factors, bringing these systems to their full potential for saving lives and damage is very challenging and not often achieved (Parker and Priest 2012). Many of the symptoms of under-performing flood warning systems were exhibited in these flood disasters, including shortcomings in flood forecasting, lack of flood warning coverage, less than optimal warning dissemination media being employed, warnings being sent but not received, warnings taking too long and warnings not being understood or sufficiently explicit to elicit appropriate response.

Insurance

Despite the frequency of complaints by flood victims of the stress of dealing with insurance companies as well as misunderstandings about insurance coverage, in both England and Queensland the damaging impact of the floods was cushioned for many by possession of flood insurance. In particular the rapidity of flood insurance claim settlements in Queensland appears to have been a success story. This is an essential institutional mechanism for aiding effective flood recovery but, unfortunately, it was absent in Pakistan. Possession of flood insurance can aid an unthinking return to the flood risk status quo and the degree to which insurers insist on flood resilience measures being installed as a condition of flood insurance purchase and/or pay-out is vital. The evidence from England suggests that in most cases the purchase of flood insurance is not well linked to resilience incentives.

Recovery

There are several good examples of Government's adapting rapidly to flood disaster recovery needs by introducing innovative Government funding designed to aid flood recovery. The outstanding example is from Queensland where by Act of Parliament a special reconstruction authority was rapidly introduced to aid reconstruction and recovery. In England a special flood recovery grant was rapidly introduced to supplement an existing grant scheme that would have otherwise been inadequate. Although rapid adaptations of this type are to be praised, they also underscore the fact that adequate financial systems were not already in place for flood recovery. At best in both England and Queensland institutional arrangements for recovery worked well, but at worst they failed and in the case of England the failure to get over 4,000 households back into their homes before 8 months after the floods was problematic and exacerbated mental health and other health issues. In Pakistan the recovery was inhibited by organisational muddle, present in specific instances in England and Queensland but on nothing like the scale experience in Pakistan. For the 800,000 still without homes one year after the flood, the recovery itself was a disaster: the mental and physical health issues faced by these people are unknown but cannot be ignored.

Effect of institutions on disaster outcomes

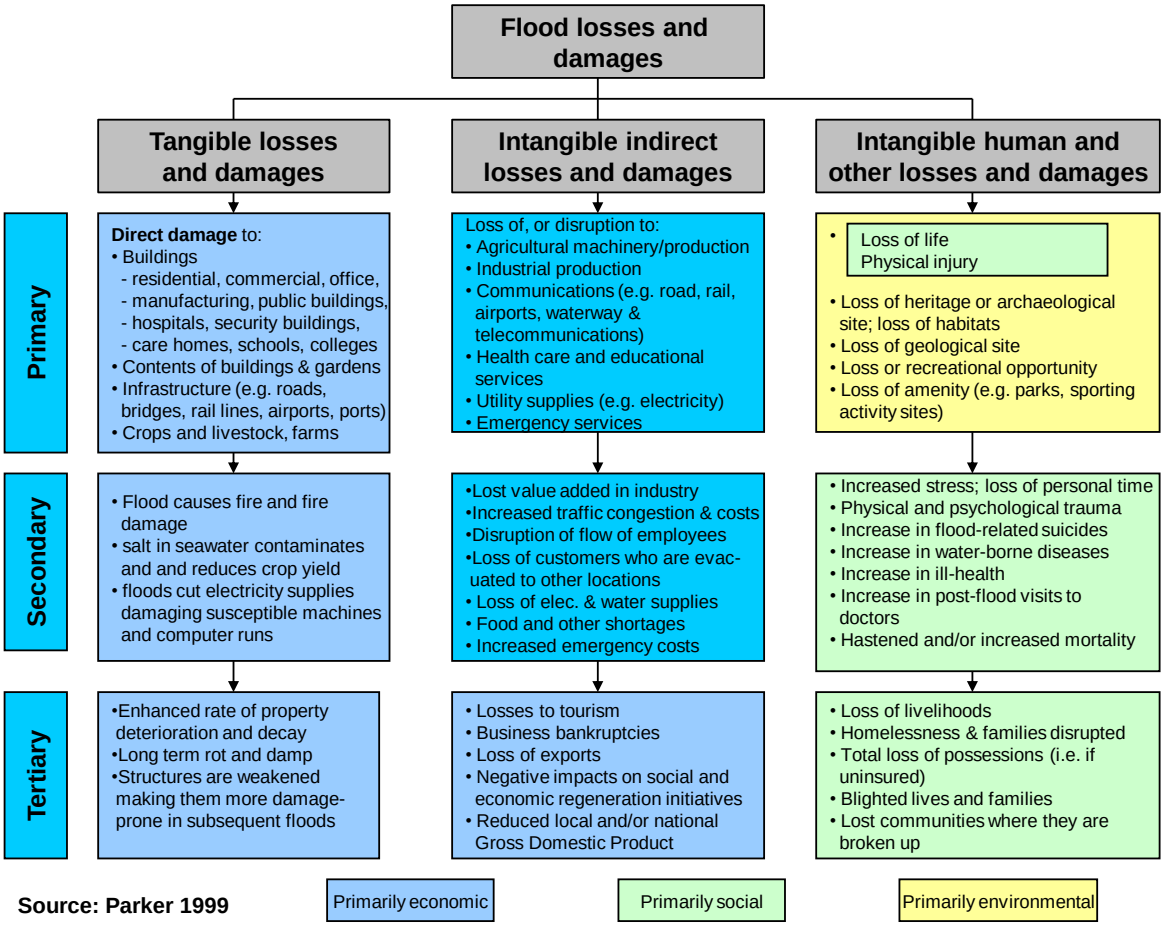
The effect of institutions on the outcomes of these three flood disasters was both positive and negative. In England and in Pakistan damage to property must have been significantly reduced by the existing flood protection infrastructure although there is no way of knowing the extent to which the presence of flood protection encouraged additional occupation of flood risk zones thereby creating greater flood damage potential. In Pakistan lives must have been saved by this infrastructure. Where they worked tolerably well, as along England's rivers and in

some parts of the Indus catchment, there is little doubt that flood warning systems increased personal security and reduced property losses. In England spatial planning in the decades prior to the 2007 flood must have slowed development in flood risk areas although clearly it did not prevent it contributing to flood losses in 2007. Whether this is the case in Queensland appears to be unresearched. In Pakistan some of the many encroachments into river bed flood risk zones had been removed reducing loss of life potential, but the failure to remove many others contributed very significantly to flood deaths in 2010. Institutional shortcomings can amplify the impact of floods and the institutional muddles and inadequacies in Pakistan's institutional arrangements must have produced such an impact. The failure in England to align the regulatory system to address surface water flood risks must have contributed significantly to surface water flood damage and householder stress. The general slowness to introduce flood resilience measures into houses and into infrastructure installations in all three countries would have greatly increased damage potential.

Scientific recommendations

Enhance and disseminate practical disaster vulnerability assessment instruments which allow physical, systemic, social, economic and institutional vulnerabilities to be assessed together in an integrated manner

Develop and apply methods which allow the full range of flood disaster impacts to be quantified and measured utilising a comprehensive categorisation of impacts such as that below:



Source: Parker 1999

1. There is the need to ensure that there is the capacity within the scientific community to undertake integrated assessments of hazards. Although interdisciplinary within flood risk science is nothing new, the quality of the integration of different disciplines and the usefulness of the outcomes are potentially questionable. Therefore, developing new approaches assessment and different ways of working are fundamental to investigating the impact of institutions and other measures on flood outcomes.

2. Examine non-conventional flood mitigation options, including resilience building, provision of safe havens etc. which may be suitable for communities which cannot be removed and relocated from flood risk areas.

3. The scale of assessment is important in understanding the strengths and limitations of different institutions in impacting the outcome from floods. Often assessments are

undertaken only at a narrow range of spatial and temporal scales which fail to understand the complex inter-linkages of impacts.

Recommendations for action

1. Review institutional arrangements to ensure that they are satisfactorily aligned to, and have the capacity to address, flood disaster risks and inform this process by a comprehensive risk assessment of the range of such risks arising from all sources.
2. Strengthen flood risk management through an enhanced emphasis on combining structural with non-structural flood management measures.
3. Address the common disciplinary bias towards structural, engineering solutions to flood problems by developing multi-disciplinary teams of flood management administrators and practitioners.
4. Institutional connections between flood management agencies and spatial planning agencies need special attention and strengthening so that land use planning and zoning is fully viewed as an integral working component of flood risk management.
5. Enhance flood mapping capacity and take climate change impacts on flood extent into account. (High quality and comprehensive flood risk mapping is required as a fundamental pre-requisite for effective land use planning and zoning of flood risk areas, for flood warning and for flood risk awareness-raising. It is also required for hydrological and hydraulic modelling of floods).
6. Review the adequacy and capacity of institutional arrangements for flood recovery, including shortcomings which contribute to and exacerbate mental health problems of flood victims which are currently under-reported and only partly recognised.
7. Examine the reasons for lack of local capacity and funding for flood preparedness including local flood data collection, flood mapping and flood risk awareness raising and develop a range of potential practical solutions.
8. The feasibility of providing flood disaster (indeed all-hazard) insurance in countries where flood insurance is currently unavailable is an urgent need and requires close examination.
9. Strategies and resources are required to improve the at-risk public's awareness of flood risk, flood warning response and flood mitigation actions (e.g. building resilience measures).

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Annex 2: A survey of the effect of institutions on disaster outcomes following earthquakes

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Key recommendations for institutions and scientific advancements

Preventable deaths should be the key message to all institutions involved in disaster management. Implementation of code and effective preparedness programmes save lives and the seismic community need to work together to identify and prioritise actions and research to help prevent deaths, physical destruction and reduce social and economic impacts.

The following recommendations are established from lessons learnt from the three surveyed earthquakes in this review. It follows the classification of institutions as suggested by North, 1990.

1) formal rules/laws,
2) organisational structures e.g. buildings, premises.
3) informal rules e.g. behaviour.

Rules and Regulations

1. Engineering analysis and scientific research needs to be used to modify building codes, risk maps and land use zoning. In depth studies of actual buildings after earthquakes provide valuable information for the appraisal of the adequacy of codes and regulations and need to be standardised and promoted.
2. Upgrade the building stock in earthquake-risk areas by promoting the application of the earthquake code, and progressive replacement of older building stock, with priority for schools and highest-risk areas.
3. Revise building codes to include more realistic estimates of the ground shaking levels which need to be designed for; and to include design for post-event repair as a standard design approach.

4. Explore mechanisms to encourage building owners to adhere rigorously to existing building codes, e.g. adoption of mandatory earthquake insurance schemes. In poorer earthquake-risk countries, promote capacity-building to support building code enforcement.

Organisational Structure

5. Promote equality. There is a tendency to focus efforts on areas of political and commercial importance, e.g. Istanbul, which has the same hazard as Van. The lack of awareness of marginalised populations is detrimental to disaster outcomes.
6. Emergency plans need to be redundant, flexible, and detailed to handle the unexpected in very large disasters. In addition different plans are needed to address the needs of rural and poorer regions, even in the same country.
7. Improve robustness of tsunami warning technology and apply tsunami awareness training to transient populations.
8. Recognise the competing personal and professional demands that are made on staff after a disaster and include contingencies in emergency plans.
9. Recognise vulnerabilities in communication and power systems and make comprehensive backup plans to avoid complete communication collapse.
10. Strengthen local capacities and synergies with governmental and non-governmental organisations
11. Coordination of the many ordinary and extraordinary organisations involved in both relief and recovery needs to be defined and rehearsed well before any disaster e.g. ShakeOuts.

Behavioural norms/social and cultural factors

12. Promote a “safety culture” of earthquake awareness and mitigation action in areas where it is missing.
13. Educate the population, comprehensively and continually, about what will happen during the event.
14. Education is crucial but practical drills are as important. Comprehensive earthquake drills including joint Government, private sector, NGO, emergency responder, and community exercises are essential before the event to rehearse evasive actions and management procedures.
15. Develop and improve seismic loss estimation models to provide realistic scenarios for planning community-based resilience.
16. There needs to be comprehensive public consultation on the strategic options for change and stakeholder involvement in strategic planning decisions.

Recommendations for scientific advancement

1. ***Form alliances in scientific research***. Seismologists, engineers, urban planners, public health specialists and emergency doctors need to work together to help prioritise research. For example, understanding the ways buildings collapse and the causes of deaths and types of injuries to help guide S&R personnel, prepare emergency rooms and stockpile aid. Understanding will also help target methods of strengthening buildings.
2. Develop and test ***cost-effective methods*** for the strengthening of older, historic buildings.
3. Rethink the concept of design: ***design for repair*** in developed country and ***for life safety*** in developing countries.
4. Develop techniques for ***systematic post-event surveying*** of affected populations and buildings to determine levels of mitigation action carried out pre-event and their relationship to prior institutional actions, and institute an international programme of conducting such surveys.
5. Research to ***define key indicators*** to monitor recovery, for example construction of permanent homes and the restitution of livelihoods and local economies.

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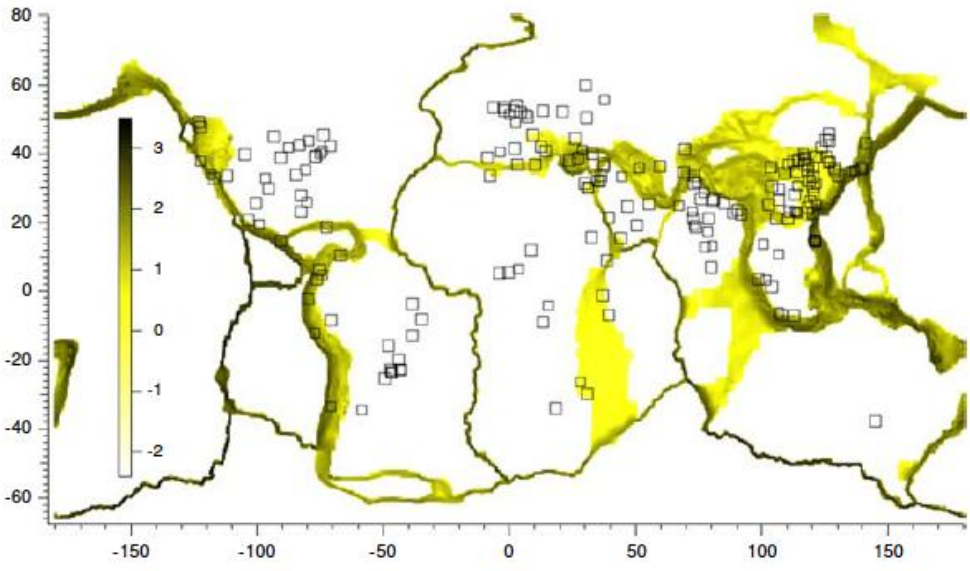
1. Introduction

Recent earthquakes in Haiti, New Zealand and Japan are painful reminders that damage and death from a natural disaster often has much less to do with the strength of an earthquake than they do with the preparedness, or lack thereof among institutions and the affected population. There is no evidence that earthquakes themselves are becoming stronger or more frequent but with the ever increasing global population concentrating in megacities, the outcomes of earthquakes could in the future be much more severe unless we take action.

Figure 1 shows the locations of the world's megacities housing more than two million people and their proximity to zones of the high plate boundary strain rate, as calculated by Kreemer *et al*., (2003). Areas of high strain (in brown) are where recurrence intervals of large earthquakes are of the order of 100 to 200 years.

Figure 1 shows the locations of 194 supercities (each with a 2005 population exceeding 2 million) and their proximity to zones of high plate boundary strain rate (Kreemer *et al*., 2003). (diagram from Bilham, 2009).



For earthquakes, which cannot be predicted, the best strategy is to focus on the four phases of the Disaster Risk Reduction (DRR) Cycle and control the consequences by mitigation strategies and preparedness programmes.

This report presents a survey of the effect of institutions on disaster outcomes following recent earthquakes, based on the four phases of the DRR cycle. The review will start with a brief description of the three selected earthquakes. The events have been chosen as the recorded ground motions were similar, though for the Chile event, a much larger area was exposed. This is followed by four sections focusing ***Mitigation, Preparedness, Response and Recovery***. For each earthquake, the effectiveness of the respective institutions in delivering the four elements of the DRR cycle is examined using evidence from literature and personal experience on post-earthquake reconnaissance missions. Where possible, ways to improve the outcomes of the earthquakes are explored and suggested.

The last section of this review concludes with lessons learnt from the three events.

2. The Selected Earthquakes

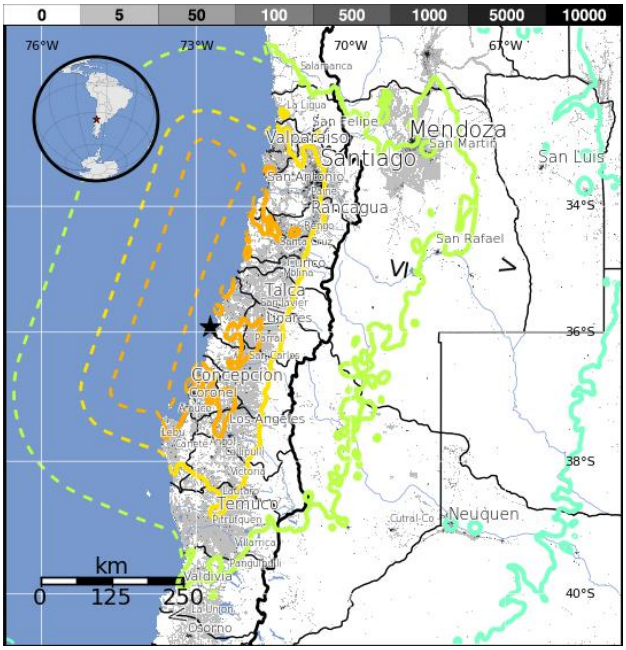
2.1 The Maule, Chile Earthquake of 27th February, 2010

The Maule Chile earthquake of 8.8Mw occurred at dawn (3.34am) on the 27 February 2010 at a depth of 35km. The epicentre was located 60km southeast of the nearest city in the Maule region (400km south of the city of Santiago). The earthquake generated a tsunami, affecting 500km of coastline, where a section of the earth's crust called the Nazca Plate subducted under the South American Plate.

The map below is taken from US Geological Survey (USGS) and shows the intensity of ground motions, according to the Modified Mercalli Scale[7] (MMI) and the exposure of the affected area in grey (for more information, visit http://earthquake.usgs.gov/earthquakes/pager/). An important point to note here is the size of the affected area. The same maps will be shown for the other two earthquakes in this report for ease of comparison.

Figure 1: ShakeMap showing the level of ground shaking, population exposed and exposed cities (from USGS PAGER http://earthquake.usgs.gov/earthquakes/pager/events/us/2010tfan/index.html) for the Maule, Chile 2010 event.
The maximum MMI was VII, as depicted by the orange contour (USGS); the right hand photo shows a recently completed 23-story Torre O'Higgins 241 office tower in Concepción suffered partial storey collapses (source EERI)

[7] For more information on the Modified Mercalli Scale (MMI) and the colour scaling, refer to http://earthquake.usgs.gov/learn/topics/mercalli.php

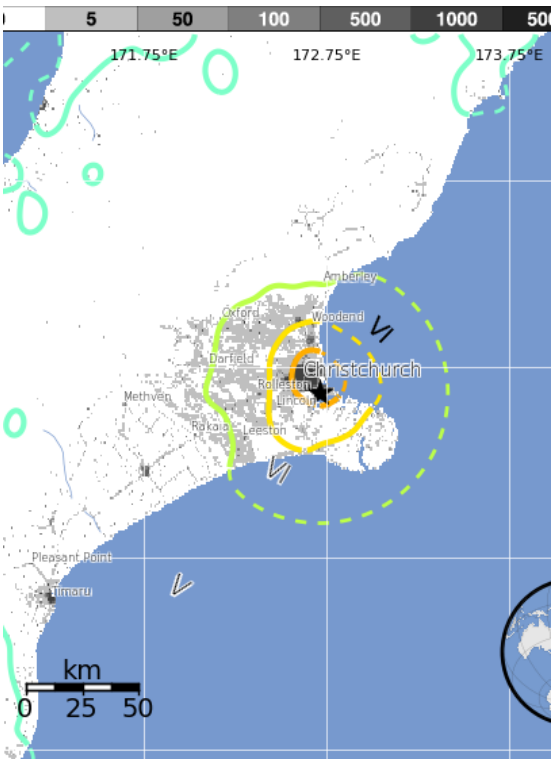


The earthquake and successive tsunami caused hundreds of deaths and serious damage to homes and other infrastructure, primarily in the Maule and Bío Bío regions. Since the earthquake happened in the middle of the night and on a weekend, most people were asleep in their homes. In total, 521 people were killed with 56 still considered missing and 124 of the deaths were attributed to the ensuing tsunami. Nearly 370,000 buildings, equivalent to 11% of building stock in the affected area were destroyed or damaged.

2.2 The Canterbury, New Zealand earthquake sequence from September 10, 2010

On September 4, 2010, a 7.1Mw struck the Canterbury Plain region in New Zealand's South Island but it caused no fatalities though many of the unreinforced masonry building in the Central Business District (CBD) suffered damage. The Canterbury Plain is a region of relatively low seismicity in New Zealand and the structure that ruptured was a previously unmapped fault (Gledhill *et al*., 2011). Compared to the average New Zealand aftershock decay model, the aftershock sequence was relatively under-productive for the first 5 months until February 22, 2011, when a Mw6.3 aftershock occurred 7 km northwest of the city of Christchurch and caused 185 deaths and over 7,000 injuries. Over 70% of the 185 confirmed deaths are attributed to the collapse of two mid-rise reinforced concrete (RC) office buildings in the CBD from this lunchtime event. A ground shaking and exposure map from the USGS and a picture of the collapsed Canterbury Television building is shown in the figure below. 75% of the occupants in this 6 storey building died.

Figure 2: ShakeMap showing the level of ground shaking, population exposed and exposed cities (from USGS PAGER) for the Christchurch, NZ earthquake in 2011 source: NZ Herald. The maximum MMI was VII, as depicted by the orange contour.

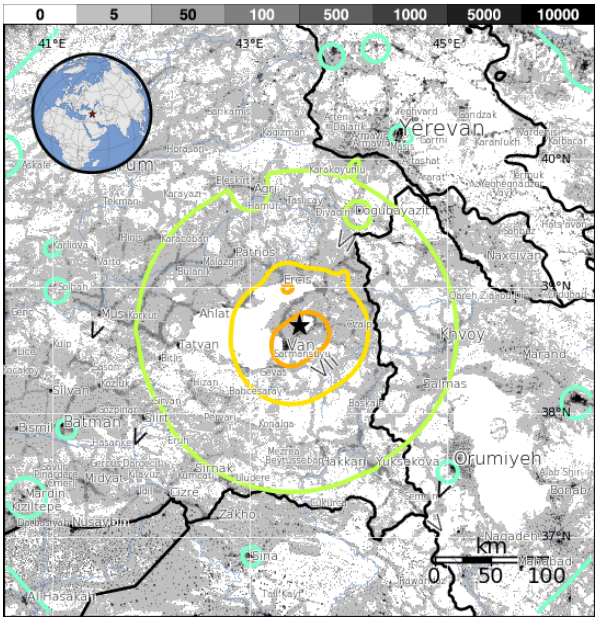


2.3 The Van Earthquake of 23rd October 2011

A 7.1 Mw earthquake struck eastern Turkey near the city of Van on Sunday, 23 October 2011 at 13:41 local time. This was followed by a 5.6Mw earthquake on the November 9th, which brought down a hotel housing international relief workers. The 23 October earthquake killed 604, wounded more than 4000, and left tens of thousands homeless. The second earthquake killed 40 people. In total, 14,000 buildings were deemed uninhabitable from the two earthquakes.

A ground shaking and exposure map from the USGS of the 7.1Mw Van earthquake and a picture of the collapsed buildings in the town of Erciş are shown in Figure 3.

Figure 3: ShakeMap showing the level of ground shaking, population exposed and exposed cities (from USGS PAGER) for the Van, Turkey earthquake in 2011. The maximum MMI was VII, as depicted by the orange contour. Right hand photo shows soft-storey collapses of typical mid-rise reinforced concrete frame buildings (source: KOERI)



3. Earthquake Mitigation

Earthquake risk differs from other natural hazard risks in two basic ways, which fundamentally affect the appropriate mitigation strategy. First, earthquakes occur largely without warning, and therefore protection of the population by means of warnings and evacuation is not possible. The earthquake will occur when people are carrying out their normal daily occupations, at school, at work, in the home or travelling and protection must be provided in these locations. Secondly, the vast majority of deaths and injuries in earthquakes occur because of the collapse or destruction of buildings; and therefore mitigation strategies need to focus on ensuring that buildings in earthquake-prone areas are able to resist the largest likely ground-shaking (and any other associated effects, landslides, liquefaction, fire, tsunami). The centrality of this basic strategy for earthquake risk mitigation is overwhelmingly supported by the research literature (Coburn and Spence, 2002, Bolt, 1999, Dowrick 2003), According to Comerio (2004), all earthquake risk mitigation strategies fall into one of the following four categories:

- Land-use regulation
- Building codes and building-for-safety measures

- Public awareness-raising
- Insurance

Land-use regulation can be used (as in Turkey, Gülkan 2011) to ensure that urban development does not take place in the highest-risk locations e.g. on soil deposits which will amplify ground motions, in locations potentially subject to landslides or tsunamis, or close to known active fault-rupture zones. Due to the twin pressures of land-shortage and land speculation, even if land-use regulations have been adopted in the past they have often been ineffective (Johnson, 2011).

Formal ***building codes*** are documents which define, for different methods of building, the forces which should be designed for, the arrangement of the structural elements, and the quality of materials and workmanship required to provide adequate resistance to the earthquake likely to be experienced in a building's lifetime. Although nearly all countries have earthquake design codes, they are not always mandatory, even for multi-storey apartment buildings; and even where they are, they are often not adequately enforced, both because there is a lack of trained engineers who are able to implement them in design; and because local authorities do not have the capacity, or the will, to exert the kind of supervision and control over the building process which is needed, creating opportunities for corruption (Johnson 2011, Gülkan 2010, Bilham 2009). An alternative to formal codes are informal community-based approaches to building control which recognise the variety of local materials that are likely to be used, the capacity of the local builders largely responsible, and aim to provide simple, easily understood rules of size, materials, wall thickness, opening positions etc , and recognise the need for training programmes to develop the necessary understanding and skills. (Coburn *et al*.,1994).

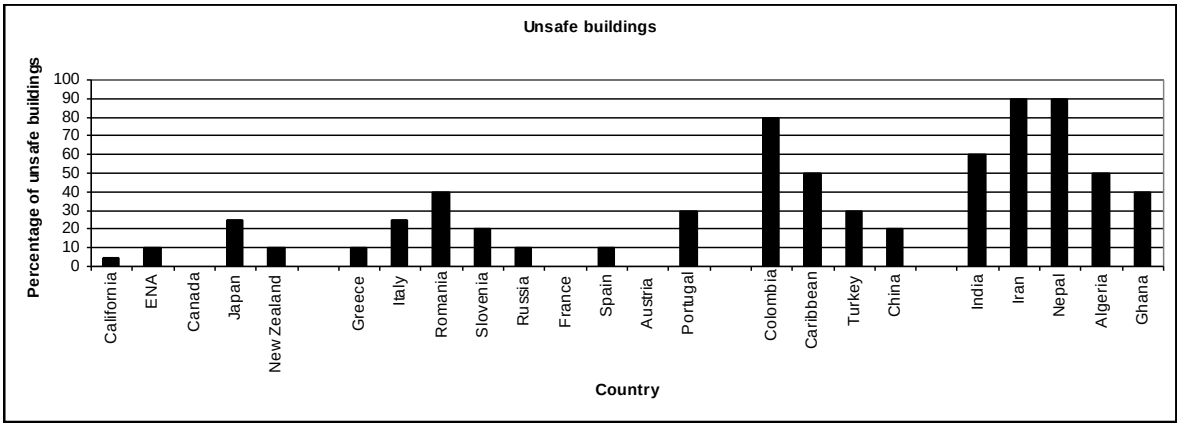
Public awareness is an essential element of both these strategies. Whether the formal or informal approach is to be used, success has been found to depend crucially on the extent to which owners and occupants themselves understand the earthquake risk, and are prepared to insist on earthquake-resistant design being incorporated into the buildings they will occupy (Olshansky,2005). Experience of a recent earthquake is by far the most effective means to build such public awareness, but many institutional actions including school programmes, earthquake-awareness days, or large-scale earthquake simulation events can be used to help build a "safety culture" (Comerio 2004, Coburn and Spence 2007).

Earthquake insurance is potentially a very important component of earthquake risk mitigation. Not only does earthquake insurance provide, for individual building-owners, the funding needed for post-disaster recovery and reconstruction, thus building community resilience; but it can also be an effective instrument for encouraging pre-event risk-mitigating behaviour through linking insurance premiums to building quality or to the application of a building code. In countries where insurance penetration is low, various organisational actions can be taken to stimulate its take-up. At the household level, micro-insurance is one option currently being developed (Stojanovski *et al*., 2010); while Earthquake Catastrophe Bonds can be used by Governments as an alternative funding mechanism to provide funding for relief and recovery (SwissRe, 2012).

3.1 Global progress in earthquake risk mitigation

In a recent survey of the successes and failures of earthquake risk mitigation since 1960, Spence (2007) distinguished four groups of countries. The *success stories* were those countries (USA, Japan, and New Zealand) which had made clear and effective progress in tackling earthquake risk. A second group (including most of the European countries), the *slow progressers* had made some, but limited progress partly because of low public awareness. A third group of poorer countries the *movers*, were found to have made a great deal of progress in recent years, through a combination of experience of recent earthquakes, and rapid economic development (Turkey, China and Colombia were in this group). In a fourth *growing risk* category was a group of relatively poor countries (including Iran, India, Nepal, Algeria) where in spite of dedicated work by many dedicated professionals, little was being done at a national level to counter the growing risks from uncontrolled urbanisation. Figure 4 shows one measure of the relative risks reported in the survey, the proportion of the national building stocks in the four groups considered to be “unsafe” (i.e. likely to be seriously damaged or collapse in the event of a foreseeable earthquake). While in the *success stories*, typically less than 10% were considered unsafe, in the *growing risk* countries up to 90% of the building stock was considered unsafe.

Figure 4: Proportion of unsafe buildings in national building stocks in 25 countries/regions (based on Spence 2007)



3.2 Limitations of current mitigation research

One limitation in much research on earthquake risk mitigation is the difficulty of producing clear definitions of disaster outcomes. Metrics frequently used to measure overall outcomes include numbers of deaths and injuries, economic losses, numbers of houses or buildings destroyed, and numbers of homeless. This data is commonly derived from either the EMDAT database of CRED (*www.**emdat**.be*) or Munich Re NatCat Service (*www.**munichre**.com*) databases. Apart from numbers of deaths caused, all of these metrics suffer from lack of precision in the definition; and all of them are derived not from field research, but from official government or relief agency figures which may be distorted. To investigate impacts of mitigation activity, cohort studies among victims or those vulnerable to disasters are often used, for instance to investigate causes of death and injury (So 14WCEE, Petal, 2011), the influence of socio-economic and demographic variables on disaster outcomes, or individual mitigation responses to various potential strategies (Rossetto, 2011). But such studies are not regularly carried out, tend to be on a relatively small scale, and for a variety of reasons it is difficult to make them truly representative of the populations at risk (So, 2009).

Similar post-event cohort studies of samples of affected buildings have been widely used to define the relative vulnerability of different classes of buildings (eg reinforced concrete vs masonry), and these have led to a relatively robust classification of building vulnerabilities in many countries, which can be used as a basis to define and test apparent improvement in building standards over time (Coburn and Spence, 2002). Nevertheless, methods to test the overall impact of large-scale government policy initiatives against disaster outcomes remain elusive, not least because of the infrequency of events providing testable data.

3.3 Mitigation Experience in recent events

The Canterbury, New Zealand earthquake sequence from Sept 10 2010

New Zealand has long been regarded as being among the success stories in earthquake risk mitigation. Its earthquake design codes, based on local research and the first to adopt the capacity design concept, are among the most advanced in the world, and the level of enforcement in new buildings has been high. New Zealand was the first country in the world to start a compulsory programme of identifying and strengthening older "earthquake-risk buildings", but recent progress in this area has been slow. Although there have been few destructive earthquakes the Napier earthquake in 1931, New Zealand's public awareness of earthquake risk and the need to counter it is very high (Dowrick 2003, Meggett 2006); and a compulsory national insurance scheme (EQC) for householders has been in place for many decades, which includes requirements for minimum standards of building, leading to a progressive reduction of the worst risks.

In spite of this risk mitigation context, the impact of the Canterbury earthquake sequence starting in Sept 2010 was very severe. Partly this can be attributed to characteristics of the ground motion and the sequence of shocks, which imposed much higher structural demands than the earthquake code allowed for (Kam *et al*., 2011). Also, a great deal of the damage was concentrated in the older masonry structures which form the characteristic core of Christchurch (Ingham *et al*., 2011), and was exacerbated by widespread ground liquefaction, and by the frequency of aftershocks with a damaging level of ground motion. It could be said that given these extreme conditions, the performance of most building structures was good: even though they suffered much damage, loss of life was relatively low (the principal aim of the design codes), and largely concentrated in two older reinforced concrete structures which would be due for strengthening under current regulations. Additionally, insurance payouts will enable most owners to repair or rebuild their damaged buildings. Nevertheless, in terms of the overall economic cost, the Canterbury earthquakes, with about $15bn loss, of which 80% is insured (SwissRE, 2012), rates as among the most costly to date; and the cultural cost, through the loss of perhaps 90% of the entire Central Business District (Marriott, 2012), including the iconic late 19C cathedral, is huge. Lessons for future earthquake risk mitigation are many: they will certainly include developing new building regulations and codes which allow both for the higher ground motions which must now be expected, but also require "design for repair", not just for life safety. New rules will certainly be needed to speed up strengthening of older earthquake risk and historic buildings (throughout New Zealand); and new land-use requirements

restricting construction in areas subject to liquefaction. How these changes are adopted in New Zealand will provide valuable pointers for other countries.

The Maule, Chile earthquake of Feb 27th 2010

Chile was not one of the countries reported in the earthquake mitigation survey described above, but like New Zealand, should be counted among the "success stories". Its location along the coast adjacent to the subduction zone boundary between the Nazca and South American Plates has resulted in many strong earthquakes in the last 70 years, those in 1940 and 1960 having been particularly devastating. Overall along the Chilean coast there have been 13 earthquakes of magnitude 7.0 or greater since 1973. (USGS, 2012). As a result, the population has a high awareness of the earthquake risk. Earthquake codes, first introduced in 1928, have been regularly updated, and the implementation rate in modern buildings has been high. In addition, Chile has a law that holds building owners liable for the first 10 years of a building's life for any losses resulting from inadequate application of the building code during construction. This law was cited as the prime reason for the good performance of the engineered structures (ARC, 2011).

In rural areas, the traditional practice of building in adobe construction was prohibited since the 1960 earthquake, and masonry construction is permitted only if reinforced or confined masonry is used. There has also been a longstanding programme of strengthening older masonry buildings of historic importance.

For tsunami protection a warning system is in place, and in some areas, waterfront buildings were designed to survive tsunami impacts. Chile does not have a compulsory national earthquake insurance scheme, but residential insurance penetration at 0.03% of GDP is at a comparable level with Japan and California (SwissRe, 2012), and commercial insurance penetration is much higher.

As a result of this mitigation work, the impact of the 27th Feb 2010 earthquake, although severe, was much less than it might have been. Given the magnitude of the earthquake, the strength of the ground shaking, and the very large areas affected by strong ground shaking, the number of collapsed buildings, and the death toll from building collapse was relatively small. Most modern buildings survived without collapse (although there was widespread damage). A large number of older unreinforced masonry buildings were destroyed in the earthquake though

many of these were already abandoned (EEFIT, 2010). The economic loss from this event was $30bn of which 27% was insured (SwissRe 2012).

The Van, Turkey earthquake of 23 October 2011.

Turkey was categorised as one of the *movers* in the 2007 survey, on account of the significant progress in earthquake mitigation achieved following the 1999 Kocaeli earthquake (Gülkan, 2011). A good modern earthquake code has been in place from 1998, and some progress is being made towards better implementation of standards through improving local authority capability and through the training of well-qualified earthquake engineers; land use legislation is being used to prohibit construction in high-risk areas. Public awareness is high, particularly in the Marmara Sea and Istanbul regions where the 1999 earthquake was strongly felt. Some strengthening of existing high-risk public buildings such as schools has been taking place (Gülkan, 2008). In addition, a national earthquake insurance scheme, DASK (theoretically, but not effectively, compulsory) which ensures minimum levels of repair and rebuilding costs for householders, was introduced in 2000, which by 2012 had close to 4 million policy-holders nationally. However, mitigation achievement is not uniform nationally, and is significantly lower in the poorer Eastern Anatolian region where the Van earthquake occurred. In this part of Turkey, for example the take-up rate for the DASK earthquake Insurance is 14% by comparison with 32% in the Marmara region (DASK, 2009).

The earthquake of 23 October was located between the cities of Van and Erciş, and therefore a test of the mitigation progress of Eastern Anatolia. These cities have not been affected by an earthquake since the M5.9 Van-Erciş event in 1941, which few alive today will remember, and it has been reported that earthquake awareness is not high in this region (Yenidogan, 2012). Much of the housing in the area, whether urban or rural is of unreinforced masonry or adobe construction which suffered serious damage or collapse (Erdik *et al*., 2012) in the areas of strongest shaking. The relatively smaller number of reinforced concrete frame buildings performed better, although there were some collapses amongst older buildings. The total death toll was 604, broadly in line with modelling estimates given the building stock (Erdik *et al*., 2012). SwissRe (2012) have estimated that the total damage for the event was $0.75bn, only about 4% of which was insured, so insurance loss is very small.

4. Earthquake preparedness

Recent earthquake and tsunamis have highlighted the need for disaster preparedness, especially for tsunamis where early warnings are available and can save many lives. In addition, in rural communities where roads are frequently cut off following a disaster, a preparedness programme can help families and communities reduce the effects of an earthquake while increasing their ability to effectively respond until external assistance arrives.

Three main components to earthquake preparedness examined are:

1. Hazard assessments and maps
2. Earthquake scenarios
3. Earthquake drills

The provision of ***seismic hazard assessments and maps*** by seismologists stating probable levels of ground motio in a given region is vital. Based on studies of likely ground motions and variations of these motions due to soil and topographical effects, ***earthquake scenarios*** can then be used to model the likely effect on the exposed population inhabiting buildings or carrying out daily activities. The scenarios help authorities target the most vulnerable areas, prioritise their mitigation programmes and prepare emergency plans. Based on these scenarios and emergency plans, ***earthquake drills*** can be carried out.

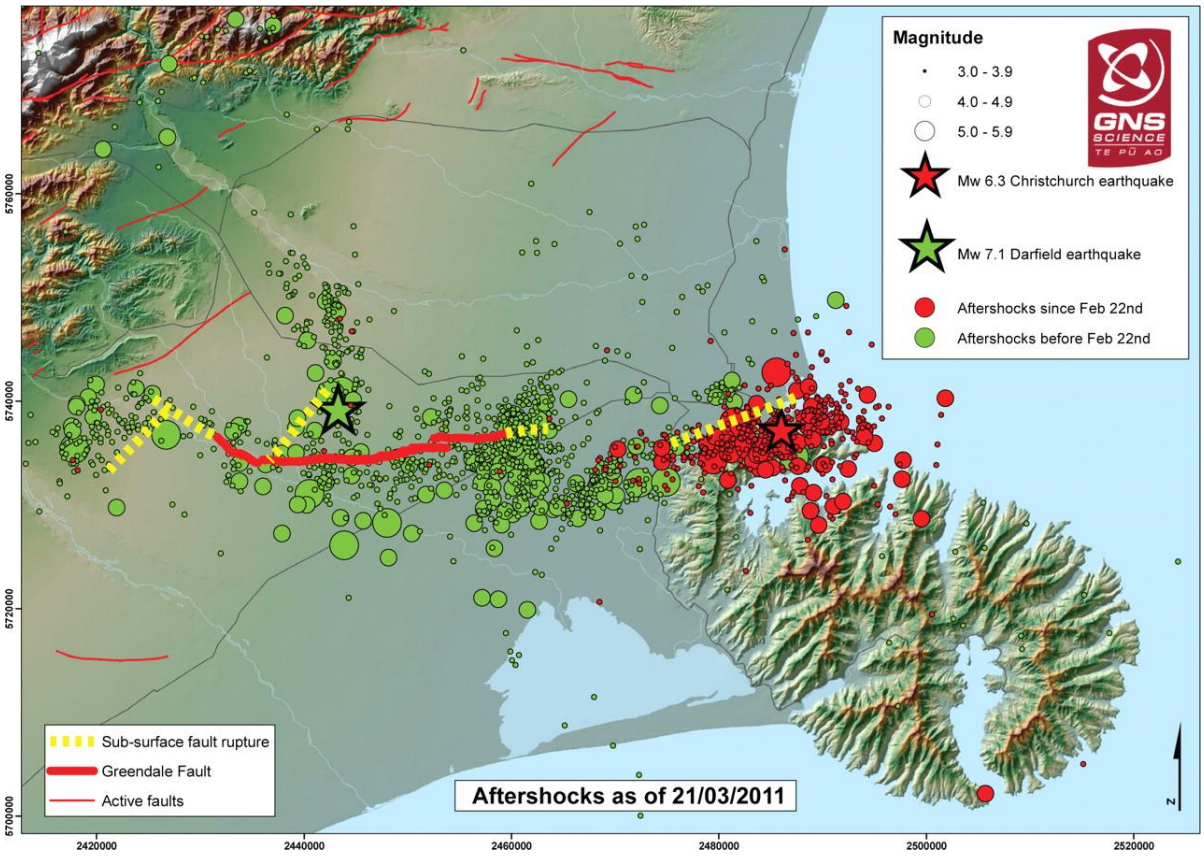
In particular, it is worth highlighting the ShakeOut earthquake drill which has been held annually in California since 2008 and has now been extended to other parts of the US, British Colombia, Guam, Puerto Rico, Japan and New Zealand. Additional areas considering ShakeOut drills are southeast states in the US (Georgia, South Carolina, North Carolina, and possibly Virginia), Hawaii, Alaska (2014), Turkey and Chile.

Figure 5: The first Japanese ShakeOut, in the Chiyoda ward of central Tokyo, occurred on March 9, 2012 two days prior to the anniversary of the 2011 Tohoku earthquake and tsunami enhanced regular earthquake drills of schools and businesses

4.1 Evidence and effectiveness of preparedness measures in recent events

All of the three countries have active scientific communities dedicated to earthquake research. Seismic hazard maps and scenarios exist for the regions where the recent earthquakes happen but what is evident is the need for a constant review of the science behind these outputs, to bring the tools developed in scientific research institutions to the forefront of national mitigation and preparedness programmes. Seismological information from each new event must be used to inform and update models, e.g. Figure 6 shows the previously unrecognised Greendale fault (Gledhill *et al*., 2011) from the Canterbury earthquake sequence of 2010-2011.

Figure 6: Map of the Canterbury region showing epicentres of the Darfield and Christchurch earthquake sequences. (GNS Science)



In ***New Zealand*** the Ministry of Defence and Emergency Management, formed in 1999 was set up to provide strategic policy advice on New Zealand's capability to manage and be resilient to the social and economic costs of disasters. A National Civil Defence Emergency Management Plan Order was put in place in 2005 and the Ministry started the 'Get Ready Get Thru' campaign. In addition, the New Zealand Red Cross advises citizens to take steps to help lessen the effects of a disaster with proper planning and emergency kits. In 2009, a smaller drill was held along the New Zealand West Coast and had 8,000 participants and following the ***Canterbury sequence***, 2012 will be the first year of New Zealand ShakeOut http://www.shakeout.govt.nz/.

In ***Chile***, Brian Tucker, president of GeoHazards International, a nonprofit organization based in Palo Alto, California was recently quoted as saying "on a per-capita basis, Chile has more world-renowned seismologists and earthquake engineers than anywhere else," and the performance of modern engineered structures in the Maule demonstrated this as highlighted in the mitigation section of this report. However, as explained in the subsequent section on

response, the well-formed management derived from this scientific knowledge did not materialise.

In ***Turkey***, the earthquake itself was no surprise to seismologists. In the seismic hazard map shown in Figure 7, the region of Van has the highest postulated hazard level. The most important lesson, however, from the Van earthquake is that earthquake awareness needs to be raised to create the conditions for improved mitigation strategies. Preparedness training programmes are now being undertaken by the Turkish Red Crescent (TRC, 2012). In addition, these programmes must also cater for social inequality and geographical importance of regions. (CEDIM, 2012).

Figure 7: Seismic hazard map for the Van region (USGS)

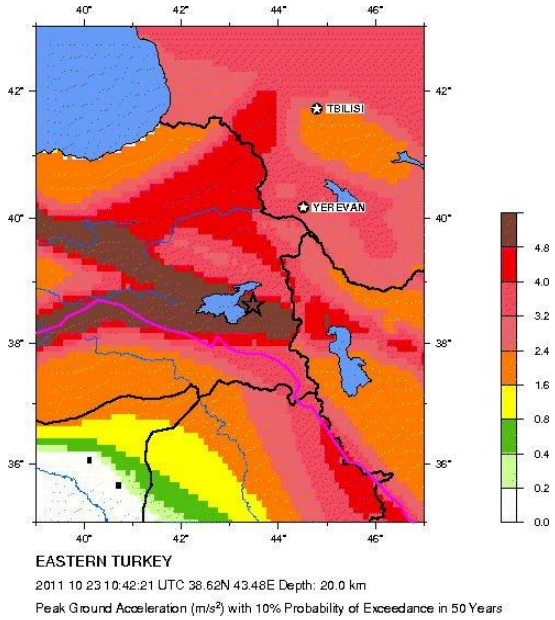


Figure 8: The New Zealand ShakeOut will be held in September 2012 hope to attract more than 100,000 participants

Disaster preparedness and response in ***Chile*** is managed through a centralised federal agency (ONEMI) that coordinates response across various agencies and among federal, regional, and local jurisdictional levels in Chile. ONEMI operates a national earthquake drill called “Chile Preparado” with an ethos of promoting a culture of emergency preparedness in the community. In addition, Chile Preparado tests the response skills of both the community and the local authorities, by simulating realistic scenarios.

For the ***Maule event***, at first glance it would seem that the preparedness programmes were effective. Though 12 million people, three quarters of the population of the country, were in areas that felt strong shaking, the death toll was just over 500.

However, there were difficulties with the tsunami warning system. An initial warning was cancelled by the Navy’s Hydrographic and Oceanographic Services and the warning had to be subsequently announced on the radio by Chilean president. Remarkably, only about 124 people were killed by the tsunami, in spite of run-up heights of several meters over 500 km of coastline (EERI, 2010) along which many tens of thousands of people were at risk, and in spite of the failure of the official warning system. This was largely due to a high degree of tsunami awareness, resulting from long-standing school tsunami awareness and education programmes, signage showing evacuation routes and other measures (EERI, 2010). The most

vulnerable group were transient and tourist populations who had not had tsunami awareness training.

A key lesson from Chile was that one of the most important preparations for the disaster came from relationships formed before the event. The communities with strong connections between different government services generally fared well. The initial response and resilience of individuals and communities was another important component. Communication system failures limited the ability of a central government to assist impacted communities, or to issue tsunami warnings. It also delayed the response since the government did not know (in some case for several days) the impact and needs of local governments.

In ***Turkey*** no information was found to access the level of public awareness for the region of Van but drawing from accounts from the 5.9Mw Simav earthquake in the same year in the western province of Kütahya, which left three dead and injured over 120, perhaps the country's lack of preparedness for earthquakes can be illustrated by injuries from the wrong evasive action by two of the three killed who had jumped from windows to their deaths during the earthquake.

In November 2009, books about earthquake safety were distributed to schools, but earthquake drills are not conducted in every school in Turkey (Zulfikar, 2012). Practical education and drills should be encouraged by the AFAD (Disaster and Emergency Management Directorate). In addition, the AFAD English website does not contain any information on emergency plans nor 'dos and don'ts' in the event of an earthquake, a problem identified in Chile's preparedness campaign.

5. Response to Earthquakes

The first criterion for assessing response is the existence of the following four capabilities:

a. Search and rescue
b. Medical response
c. Relief supplies and deployment
d. Housing

All three studied countries have well established disaster and emergency management plans. New Zealand is headed by the Ministry of Civil Defence & Emergency Management, the

Chileans have the National Emergency Management Office (ONEMI) and Turkish efforts are led by AFAD and The Turkish Red Crescent. However, to be effective, response relies heavily on a good organisational structure able to deploy and mobilise these resources in a timely manner. The sections below review the successes and failures of these institutions at an organisational and behavioural level in response to the three selected events.

Figure 9: A forklift transfers tents for distribution to earthquake victims at Van's airport on October 28, 2011 (source: Reuters)

A day after the ***Christchurch earthquake,*** the Ministry of Civil Defence in New Zealand declared a national state of emergency and Civil Defence became the lead agency in emergency response.

In the immediate moments following the quake, rescue and response was conducted by civilians and emergency services on duty. The New Zealand Fire Service subsequently coordinated search and rescue, particularly the Urban Search and Rescue (USAR) teams from New Zealand and Australia, UK, USA, Japan, Taiwan, China and Singapore, totalling 150 personnel from New Zealand and 429 from overseas (New Zealand Herald). Emergency department staff at the Christchurch Hospital and health workers across the Canterbury region coped well with the unprecedented emergency (The Lancet, 2010). Immediately after the earthquake, Housing New Zealand provided a temporary accommodation service to the displaced people.

Figure 10: A makeshift shelter in Hagley Park Christchurch (source: NZ Herald)

To all intents and purposes the response to the Christchurch earthquake was exemplary with national government working closely with local authorities and communities. The New Zealand response was generally praised by the international disaster management community for its coordination efforts and the use of satellite imagery to help with search and rescue efforts. However, the Christchurch City Council decided on a policy of 'business as usual' after the first earthquake and did not adequately cordon off damaged buildings in the city centre (Heather, 2011). The Engineering Advisory Group reported that there was also confusion about the system of inspecting and tagging building damage (Hare *et al*., 2012). This meant the when the much more destructive earthquake struck six months later many people were injured in the streets from falling masonry or trapped in buildings that should have been closed.

By contrast, in ***Chile***, the immediate response to the earthquake and tsunami was much more challenging for emergency personnel and search and rescue teams. The main issue was the loss of communications. The national response to the event was marked by confusion and a lack of clear situational awareness. Immediately following the earthquake, there was confusion about whether or not a tsunami would follow. It was reported that the outgoing president, based on misinformation from the Navy's Hydrographic and Oceanographic Institute, initially announced that there was no threat of tsunami, and then minutes later warned that there was a threat. Few people in the tsunami-impacted areas heard either announcement since communications with Santiago were lost, and according to officials from the City of Talca, the first wave hit before a tsunami warning could have been issued (ARC, 2011).

The emergency response plans were inadequate and failed at all jurisdictional levels for the response to the February 27th earthquake in Chile. Within the health sector, regional and local representatives stated their plans were inadequate and never "taken off the shelf," since the plans were not designed to cope with disasters of this magnitude (ARC, 2011). Planned response was further disrupted because many emergency response facilities were destroyed and unusable (EERI, 2011. The regional emergency operation centre for the Health Ministry in Concepción was also severely damaged and all of their communication equipment was destroyed or inaccessible.

ONEMI acknowledged that the communications systems and plans that existed at the time of the event clearly failed, leaving the agency initially unable to communicate with the impacted areas. ONEMI indicated that the absence of any major disasters in Chile for over 20 years and the resulting reduction in their profile and funding were contributing factors to this failure. This was not, however, the case. The instinctive response and cultural awareness of the local communities actually saved lives. In the health sector, these instinctive responses resulted in the rapid evacuation of hospitals without centralised control in the early response phase. (ARC, 2011) In fact, many lives were lost and effective coordination to support life-sustaining efforts was gravely impacted due to a lack of inter- and intra-agency coordination (ARC, 2011). And in spite of efforts by the Emergency Committee formed by the new government, the central government's initial slow emergency response led to some looting and breakdown in civic order in the region.

Although their disaster role has been traditionally limited in Chile, the Chilean Red Cross volunteers were among the first to assist people in the impacted areas (ARC, 2011). The Chilean Red Cross mobilised more than 1,700 volunteers to provide assistance for the earthquake response, providing health services, food, water, clothing, tents, and sanitation support services. Local fire and police departments and the police also provided support with limited resources, personnel, and initially no outside support. The Army was widely praised for its effectiveness and comportment in maintaining post-disaster order, but it was not deployed immediately for various reasons.

Figure 11: A police officer guards a street in Talcahuano, Chile (Source: Associated Press)

The relief operations in ***Turkey*** after the Van earthquake were coordinated by the AFAD and the Turkish Red Crescent. Local search and rescue, medical and first aid personnel from 48 different provinces and 39 different institutions were deployed to the region. In all, 4,446 search-rescue personnel were deployed and 252 people were rescued. This statistic of number of rescued over the total number of rescuers deployed again raises the question of efficiency of search and rescue operations, providing a clear argument for national governments to promote mitigation to save lives and resources.

Figure 12: Search and rescue efforts at Erciş after the Van earthquake

In the first days after the earthquake, the Turkish government rejected all offers of help on the grounds that it was not needed. However, it soon became clear that there were not enough tents, food had not been distributed well enough to reach all survivors equally, and there had been a general lack of organisation. A number of trucks carrying equipment and food had been looted, and health officials had repeatedly warned against the spread of diarrhoea and other diseases.

The total aid received from 30 countries, UNHCR and OCHA is shown in the Table below. The response and governance is further complicated by the political setting in the region of Van.

Table 1: List of aid items sent to the Van region (source: AFAD)

Province and Districts	Type of the Material										
	Family Sheltering Tent	Mevlana House (Set)	Blanket (Sum)	Tent General Purpose	Heater and Stove (Sum)	Sleeping Bag (Sum)	Kitchen Set	Various Food (Kg)	Food Package (Sum)	Provision (Sum)	Bed (Sum)
Van/Center	41.657	3.194	162.147	402	3.902	7.633	17.779	1.680.620	41.419	11.944	14.400
Van/Erciş	11.184	450	50.538	7	2.904	15.978	3.717	367.079	12.948	12.000	810
Other	285	150	705	-	-	-	-	-	-	-	-
Total	53.126	3.794	213.390	409	6.806	23.611	21.496	2.047.699	54.367	23.944	15.210

5.1 Limitations to this report

Information on the Van earthquake was limited as many documents are written in Turkish and also possibly bias as the main two references on relief were written by the responsible disaster management agencies.

6. Earthquake Recovery

Disasters leave huge scars in people's lives, the economy and infrastructure. Yet despite the damage they can be catalysts to 'build back better'. Typically lasting about 18 months, there is a window of opportunity for better ways of doing things to take hold.

Economic recovery is usually the most serious issue facing communities in the post-disaster period. (Bolton,1996). Land use is also important and there are essentially three choices: rebuild in the original place, partially move to a safer adjacent neighbourhood or relocate to a new place. The decision depends largely on the degree of damage, the willingness of the inhabitants to move, the difficulty of mitigating future risk and the economic implications of the move (Ye, 1996)

In planning recovery Hass (1977) suggests that a number of fundamental issues should guide the planning process. This idea is adapted in the following headings.

- Governance: normal or extraordinary decision-making?
- Regulation: what codes and regulations are in place and should these be modified?
- Consultation: how are public informed and community and stakeholder engaged?
- Plans: what economic development, land use and transportation plans are in place?
- Information: what base line damage assessment and risk data is available?
- Funding: how can elevated needs for public expenditure be financed?
- Monitoring: who should monitor and evaluate recovery, and how should this be done?

6.1 Governance

Many organisations are involved in recovery. Some of these are regular local, regional and national authorities, some are earthquake specific. In all there may be as many as fifty key players. The roles and remit of these different organisations overlap and there is a need to coordinate their efforts.

In many countries, however, it is unclear which agency, organisation or department is responsible for planning post-disaster recovery. There is often tension between local, regional

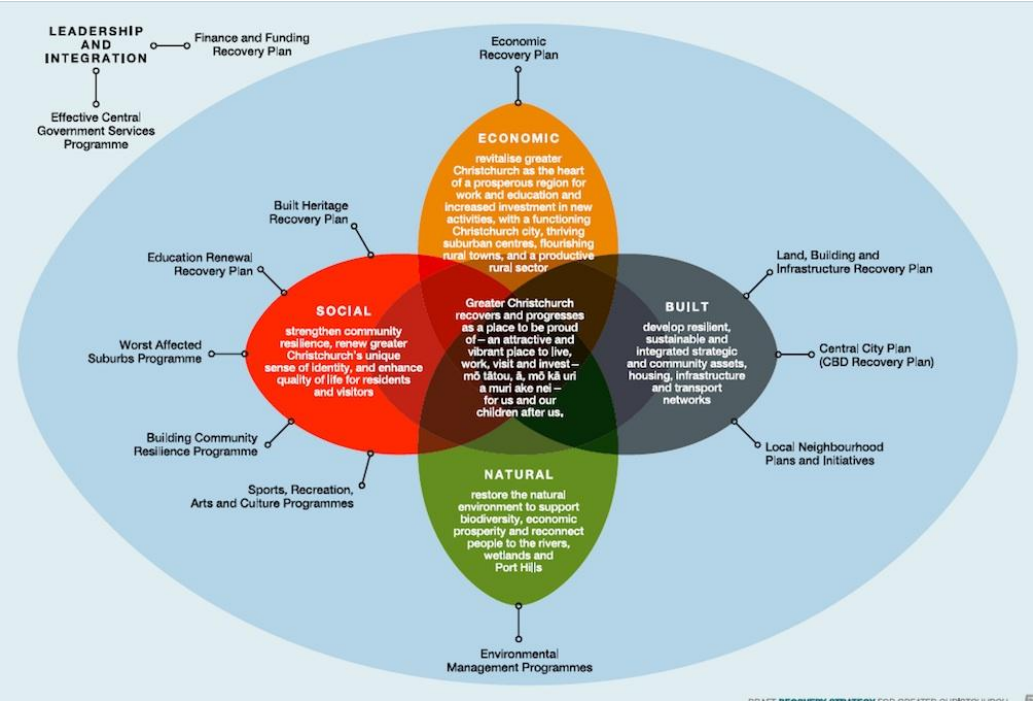
and national authorities. Local officials often begin planning for recovery after a disaster occurs and fail to involve regional land use planners in decision-making. Equally national planning often fails effectively to address local needs. (Smith, 2010)

In ***New Zealand*** after the 6.3Mw earthquake in February 2011, legislation was passed giving the Minister and the Canterbury Earthquake Authority (CERA) wide ranging powers to manage recovery and reconstruction. CERA has been effective in coordinating planning policy. (CERA, 2012) However, there has also been criticism that local authorities have been sidelined, especially in deciding on the programme of demolition in the city centre. (Lochead, 2012)

Chile appointed a national coordinator of the urban reconstruction programme who quickly determined that the State is unable reconstruct everything or even control the process of recovery centrally. Responsibility was delegated to each region, town council and community to develop its own plans. A group of 10 architects/planners was seconded to the Regional Government to assist the affected local authorities.

In ***Turkey*** relief and recovery was coordinated from the centre by the Vice Prime Minister. Its recent report asserts that the work of Governmental institutions, NGOs and the private sector was well coordinated. (AFAD, 2012) However, one of the key issues is the politics of Eastern Turkey and central government fears that aid might be diverted to the Kurdistan Workers' Party (PKK). Various commentators have suggested that this has meant that aid, especially support for trade and small businesses, has not been co-ordinated in an effective way. (Tokyay, 2011; Raufoglu, 2012)

Figure 13: Recovery Strategy for Christchurch, CERA, 2011, showing how various plans and programmes fit together



6.2 Regulation

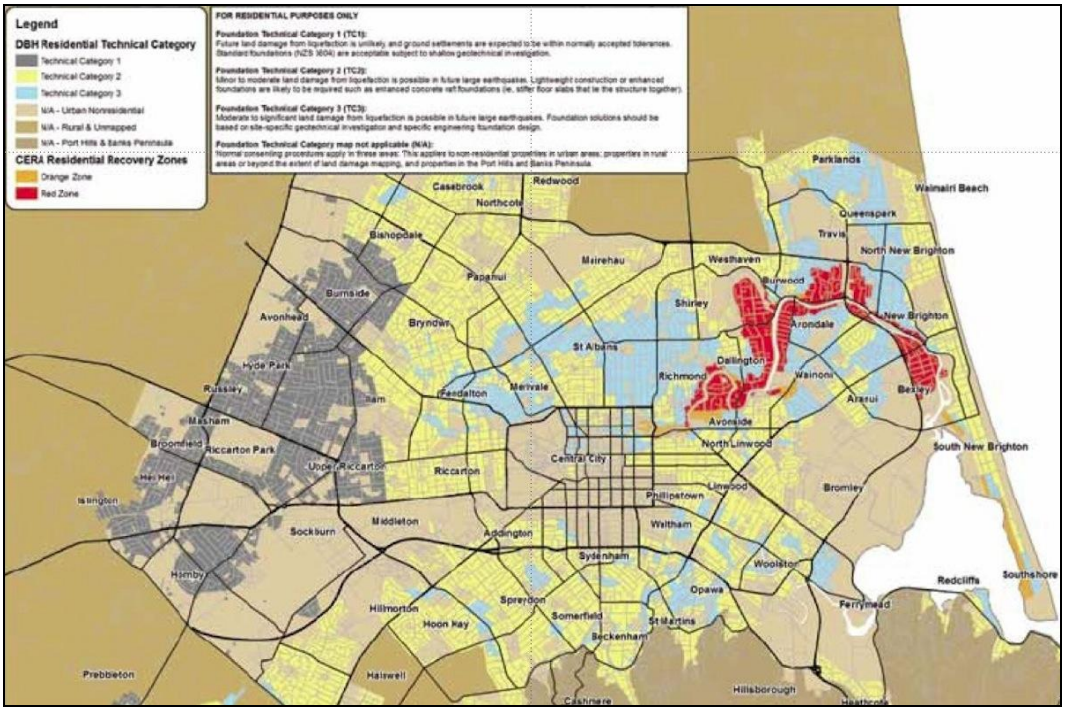
Building codes use engineering and scientific analysis of building performance to define acceptable standards of construction. Planning regulations take risk from natural hazards into account in defining where land can be built on and developed. The effective implementation of codes and regulations reduces building damage and saves lives.

In ***New Zealand*** the Department of Building and Housing, with the help of a special Engineering Advisory Group, modified the already strict building codes to take account of greater understanding of liquefaction risk and to provide guidance for foundations in high-risk areas. (Dept of Building, 2011) Planning regulations have also been altered in significant ways to define red zones which will be taken out of use and to impose new height restrictions in the city centre.

Chile also has strict building codes and planning regulations. In April 2011 the Government declared its intent to incorporate tsunami risk mitigation into Chilean urban planning law, but there is little planning experience of how to consider this risk and determine its impact on land use regulations and building codes. Current urban planning law does not define minimum building height and materiality and it is impossible to insist the type of buildings constructed in tsunami run-up areas. Most critical facilities are located in vulnerable areas and it is difficult to

move these facilities to safe areas. There is no technical certainty that new tsunami housing and proposed mitigation works can withstand large magnitude tsunami. The need to rebuild homes is faster than the planning process and people have started to rebuild their homes in the same disaster prone areas. (Bustos Erwenne, 2011).

Figure 14: Christchurch new land use zoning. Grey: low liquefaction risk, normal foundations; Yellow: some risk, more foundation engineering; Blue: elevated risk, specific site design required; Red: land taken out of use



6.3 Consultation

Many commentators have argued that the process of recovery will be more successful if the affected community, residents and business, are involved in strategic decisions about the future of their place (Clarke *et al*., 2010). But after a disaster many people will be traumatised about what has happened to their families and businesses and may be angry about any delays. This means that effective consultation is not straight-forward.

In ***New Zealand*** the level of public engagement was unprecedented. There were 6 weeks of public consultation and 100 meetings with stakeholders. Despite this the authorities felt a lot more communication still needed to be done. In ***Chile***, Master Plans were presented to the community and publicised at various meetings and workshops. This consultation period typically lasted 7 weeks and most plans were approved at the end of October 2010. In ***Turkey*** planning recovery is managed centrally by AFAD and there is evidence that that the needs of the local population either in terms of housing or business support were not considered

properly. The temporary housing, although erected quickly, is climatically and culturally unsuitable (CEDIM, 2011) and new government houses being built by the Housing Administration of Turkey (TOKI) are regarded as poor value for money and there are concerns that both these housing types will become permanent ghettos with social problems (Jozuka, 2012).

Figure 15: Christchurch City Council Share an Idea public consultation campaign

6.4 Plans

In a developed country there is likely to be a range of pre existing and special earthquake related plans and programmes. These should be the starting point for planning recovery. They will, most likely, need adapting in the light of the disaster. For example, land previously zoned for development should be taken out of use because of elevated risk or an opportunity presents itself to improve the transportation network or the amenity of parts of the city.

In ***New Zealand*** economic and urban development strategies, and land use and transportation plans were in place before the earthquakes. Although these plans needed modifying, they provided a sound basis for planning.

In ***Chile*** there were regional strategic plans in place and the local planning teams focused on devising master plans to guide reconstruction (MINVU, 2011; Cartes, 2011).

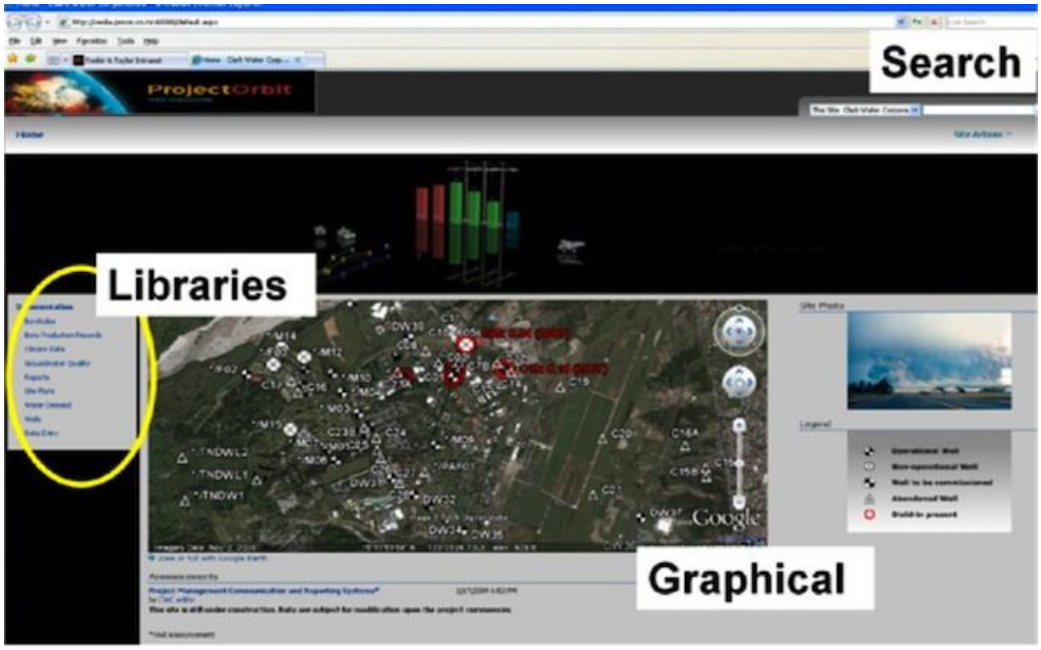
6.5 Information

Two types of information are needed after a major disaster. Immediately after the event there is a need for information about damage to buildings, roads and bridges and about the level of relief and shelter required. Almost simultaneously teams of people begin planning the process of recovery at an urban scale and they need a different type of aggregate information about all aspects of the places affected.

In ***New Zealand*** extensive engineering and science has gone into understanding the earthquakes, the resultant damage and the development of clear guidance. In particular, a system of zoning land was devised based on the risk of liquefaction and the type of foundation required (EDC, 2010). Tonkin & Taylor, a firm of consulting engineers collated all the survey data, insurance claim and other information into a GIS and made it available to all the players. (Platt, 2012)

In ***Chile*** the ministries and regional governments worked with different data and graphics systems and there was no time to coordinate information, nor were there sufficient trained personnel. The Chilean team working on coastal settlement reconstruction tried and failed to build this database in time to be useful and believe that as a consequence master planning took eight months longer than it would have done with good information (Platt, 2011).

Figure 16: Orbit GIS Information system used in New Zealand to manage all survey, claims and other data.



6.6 Funding

Reconstruction after major disasters is hugely expensive. Losses in ***New Zealand*** are about 20% of GDP and in ***Chile*** about 13% (Daniell and Vervaeck, 2011). Yet the investment that follows a disaster can be a boost to the economy. In Chile the economy grew by 6-7% in 2011 and commentators attribute some of this growth to reconstruction. In Christchurch it is estimated that NZ$20 billion will be invested in the city and 15,000 jobs created in construction.

In ***New Zealand*** the level of insurance penetration is extremely high. Less than ½% of all damaged dwellings are uninsured and most non-residential buildings in the CBD were fully insured. The government insurance scheme will pay losses of more than NZ$7 billion and private insurers will pay upwards of a further NZ$10 billion towards the cost of rebuilding Christchurch. The Government expects to spend an additional $8.5 billion. One of the more difficult issues is that authorities are keen to have buildings seismic strengthened, but there is a question about who pays for the enhanced performance.

In ***Chile*** the government has assessed damages and losses at US$30 billion, and estimates total public spending for reconstruction will come to $12 billion. The government will fund this spending through moderate tax increases, reserves, budget reallocations, sale of assets and, most significantly, through concessionary schemes with the private sector. The planners,

however, have little control over financial decisions and the exchequer has the final say in approving plans.

In ***Turkey*** the total cost of disaster relief and recovery is estimated at US$663million. The insured losses are estimated between US$55million and US$200million. There is Government financial support in the form of grants and credit. However, there are concerns that only 20% of people who applied for Government credit have received it. Trades people who have lost everything have difficulty guaranteeing the loan and those with land fear mortgaging it.

6.7 Monitoring

There is a need for a systematic approach to monitoring and evaluating recovery that promotes transparency and warns if the reconstruction is not going to plan. Operationally, effective monitoring is necessary to improve coordination, situational understanding and decision-making. Strategically, it would provide accountability to ministers, boards of directors, and the public.

In ***New Zealand***, as in many other countries, it is not clear who will independently monitor and evaluate recovery. The authorities in ***Chile*** recognised the importance of monitoring is important and there were plans to set up a government monitoring unit, but these may not get funded (Platt, 2012).

7. Lessons from the three selected earthquakes

7.1 Mitigation

1. Although losses from the three studied events were severe, evidence from the field investigations shows that, in all three, modern buildings for the most part performed well. In contrast to the three major fatal events of the last 5 years in Kashmir 2005, Wenchuan 2008 and Haiti 2010, the overall death tolls were in the hundreds, rather than tens of thousands, and this is certainly a measure of the mitigation achievements in each of the affected countries.
2. For the future, the lessons for New Zealand, Chile and Turkey and elsewhere are that mitigation through improved building standards is effective. The main improvement needed is to put in place measures that ensure that existing codes and design guidance are adopted.
3. This is particularly a concern for older buildings; and programmes for assessing and strengthening such buildings, or progressively replacing them with more earthquake

resistant buildings need to be put in place. This is a concern not just for the rebuilding in the affected areas, but also in adjacent areas at risk of comparable events.

4. There is evidence that recent events (Christchurch and Tohoku, Japan) have produced ground motions which exceed those which were allowed for in the existing codes of practice. Indeed Wyss (forthcoming) has claimed that the macroseismic intensities reported for the last 60 earthquakes with M≥7.5 were all significantly larger than expected. There is therefore a clear need for a review of the return period of the events considered in design within new codes of practice.

7.2 Preparedness

5. The events have shown that, even where buildings are designed for life-safety and no collapse, the damage can often be so severe that the building needs to be demolished. There is an obvious need for a new “design for repair” concept to be more widely adopted in codes of practice; the additional costs of such design could be justified against the lower expected lifetime damage.
6. For buildings and areas of historic importance, the Chile and New Zealand events have provided important tests of the effectiveness of a range of strengthening measures adopted. These experiences need to be studied, with a view to an accelerated programme of strengthening; otherwise much important cultural heritage will be lost.
7. The Chile event produced convincing evidence, from the relatively small life loss, of the efficacy of tsunami education of the general public; however there is clearly a need for more robust warning systems, and for tsunami awareness training to be extended to transient populations.
8. In Chile, a breakdown of communications and a changing government caused confusions. Local resilience and cultural awareness on the other hand were clear strengths.
9. In Turkey the hazard is recognised but not communicated. Preparedness is also complicated by the unstable political situation in Eastern Turkey.

7.3 Response

10. The New Zealand response was well organised and brought out the local community spirit. They were particular successful in identifying specific target areas for international aid.
11. Chile was hampered by an initial lack of communications and the complacency of the central plus downsizing of local ONEMI offices made matters worse. The event brought to light the need to address transient populations in disaster preparedness. In addition, more

involvement of the Chilean Red Cross and extending their responsibilities would also have improved the response outcomes.

12. Turkey was reluctant to ask for international help to start with and delayed the distribution of much needed shelter and supplies to the affected communities. A massive search and rescue operation was deployed with over 4,000 rescuers rescuing 225 people in total. This call to question the effectiveness of resources allocated to response and need to redirect resources to mitigation to save more lives.
13. It is essential to collect all possible data about each disaster when it happens. Many of the consequences of the three earthquakes have not yet been quantified, for example, examining the causes of injuries. Each disaster provides a unique opportunity to learn how society is affected by the events and provide valuable knowledge to support researchers and authorities in eradicating preventable injuries and deaths.

7.4 Recovery

14. In New Zealand there have been governance issues and CERA, the temporary earthquake authority, has been criticised for side-lining local authorities, especially in deciding on the programme of demolition in the city centre.
15. Also in New Zealand, science and engineering know-how were harnessed effectively to modify building codes and land use zones and extensive information from surveys, claims and imagery analysis was made available to all parties.
16. In Chile, the planners were hampered by a lack of baseline data and damage information and took 6-8 months longer to produce plans than it might have done.
17. Effective community engagement is crucial. Despite extensive public consultation in New Zealand, authorities feel they could have done more.
18. Monitoring recovery is not sufficiently developed in any of the case study counties and there is a need for a systematic approach to monitoring and evaluating recovery that promotes transparency and warns if the reconstruction is not going to plan.

Evidence of institutional resilience for each of the earthquakes

(0 = no information; 1 – there is a little information of low quality; 2 = there is a lot of verified evidence)

Role of formal institutions at different phases of the DRR		Chile (2010)	Christchurch (2011)	Van (2011)
Mitigation	Raising awareness	2	2	2
	Building codes, enforcement and professional education	2	2	1
	Insurance	2	2	2
Preparedness	Risk assessments	2	2	2
	Earthquake drills	1	1	0
Response	Relief mobilisation and SAR	2	1	1
	International aid management	0	2	0
Recovery	Reconstruction needs	2	2	1
	Changes to policies and master planning	2	2	0

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Annex 3:The effect of institutions on disaster outcomes from tropical cyclones

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1. Introduction

This report scopes the impacts of three similarly sized tropical cyclones (Hurricane Ivan – 2004, Hurricane Katrina - 2005 and Cyclone Sidr – 2007) in three equally exposed locations (Cayman Islands, New Orleans, Bangladesh), with similar geophysical conditions (coastal, low-lying, easily inundated by storm surges), but with varying degrees of adaptive capacity and sensitivity to the hazard.

The institutional contribution to disaster risk reduction (DRR) is reviewed, with a view to highlighting the elements of DRR which appear to have contributed to disaster outcomes. It is not possible to make a direct link between the presence/absence of an institution and the magnitude of the disaster, due to the complex multi-faceted nature of disasters. A wide spectrum of institutions involved in disaster risk reduction is considered in this report. Following North (1990), institutions are framed as:

- Formal laws, rules and regulations
- Organisational structures
- Informal behaviours, including social and cultural contexts

The features of the institutions are presented and their role in DRR is discussed. The way in which the institution has delivered its potential services is evaluated, and possible areas for improvement are noted.

After this introduction, the report has four additional sections, the second section briefly summarises the meteorological characteristics of the tropical cyclones. The body of the report is in the third section which assesses the role of institutions in the four elements of the disaster risk reduction cycle, notably: mitigation, preparedness, response and recovery. Some comments are added after each sub-section on possible reasons for the high level or low level or damage associated with that tropical cyclones. The final section considers areas of consistent success or failure that run across the case studies, and offers recommendations for science.

2. The events and their impacts

2.1 Cyclone Sidr, Bangladesh, November 15, 2007

Super Cyclone Sidr (see Figure 1) hit the southwest coast of Bangladesh on 15th November 2007, striking land at 6.30pm. Fortunately for the people of Bangladesh, the storm landed at a relatively less populated part of the country, in the Sunderbans – the world's largest mangrove forest which served to reduce wind speeds and lessen the storm surge (Government of Bangladesh, 2008). On landfall, Sidr was a category 4 storm (on the Saffir-Simpson 1-5 scale[9]), with winds reported of up to 136mph and storm surges of up to 20 feet – approximately 6 meters (Government of People's Republic of Bangladesh, 2008). Again, it was fortunately that it was low tide when Sidr hit, resulting in relatively smaller storm surge waves. The storm moved northwest across land, quickly weakening into a tropical storm, and dissipating on November 16th 2007 (Paul and Dutt, 2010).

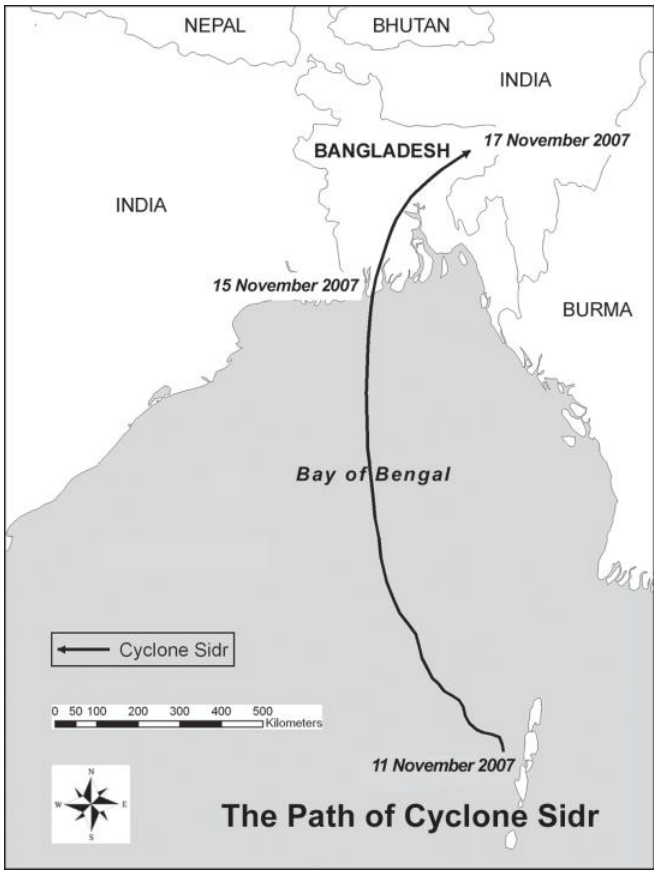


Figure 1: Cyclone Sidr pathway through the Bay of Bengal

Source: (Paul and Dutt, 2010)

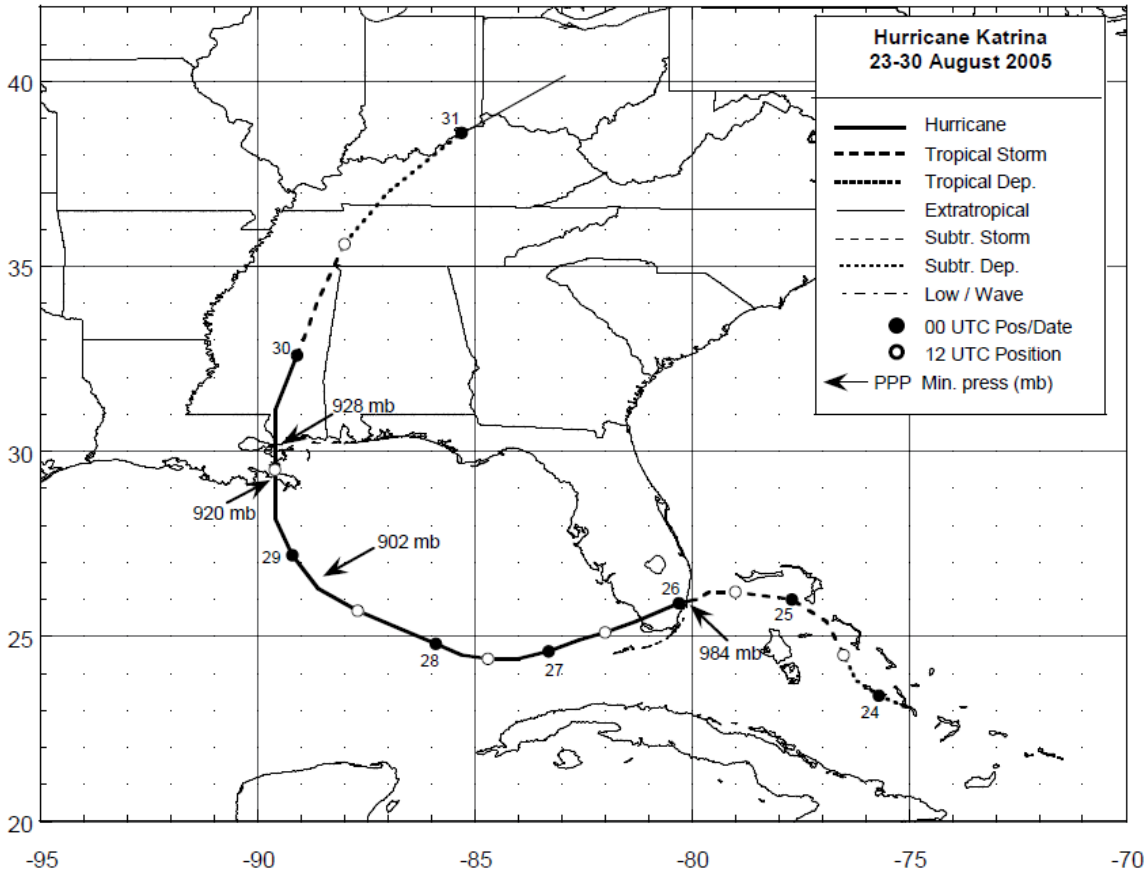
[9] Category 1 storms with winds of 74-95mph are considered 'Minimal', Category 2 with winds of 96-110mph are rated Moderate, Category 3 storms with winds of 111-130mph are considered 'Extensive', Category 4 storms with winds of 131-155 mph are' Extreme', and Category 5 storms with winds >155mph are recorded as 'Catastrophic' (according to the US National Oceanographic and Atmospheric Administration http://www.aoml.noaa.gov/general/lib/laescae.html accessed 11/5/2012.

2.2 Hurricane Katrina, New Orleans, August 29, 2005

After its genesis southeast of the Bahamas, Hurricane Katrina, became an extremely large storm, moving west and then northwest through the Gulf of México (see Figure 2). Before it hit land, Katrina had maximum wind speeds of over 170 mph (making it a category 5, i.e. most severe, storm). Katrina landed early in the morning on August 29th 2005, as a very strong Category 3 storm, with winds of approximately 127 mph (Knabb *et al*., 2005, Graumann *et al*., 2006).

The storm weakened into a tropical storm as it moved inland, with flooding from the heavy rainfall causing most of the worst impacts. The storm brought with it a 6-10m (20 to 30 ft) storm surge, causing major flooding across the region.

Figure 2: Hurricane Katrina's pathway through the Caribbean



Source: (Knabb *et al*., 2005)

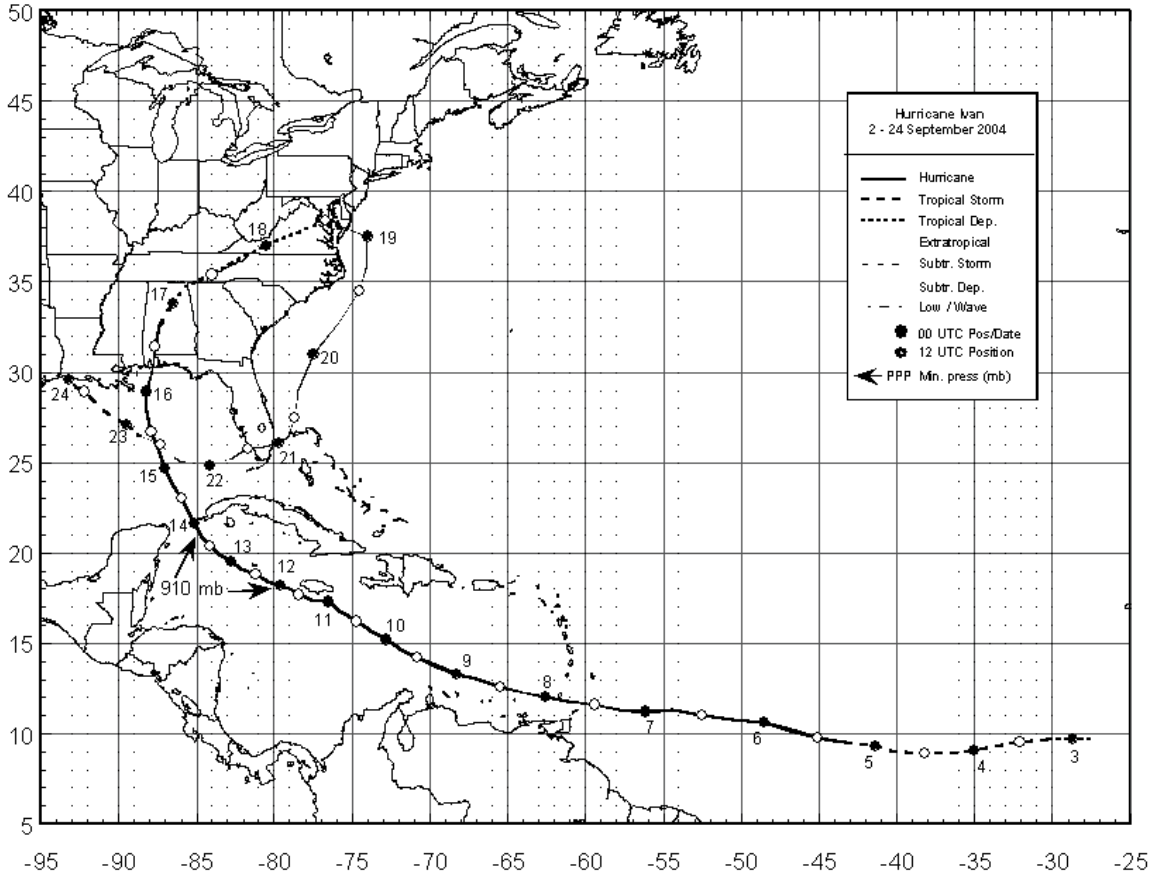
The impacts were exacerbated in New Orleans as the earth levees and flood walls – designed to hold back flood waters from Lake Pontchartrain, and the Caribbean Sea (on either side of New Orleans) – were overtopped in some places and collapsed in others under the pressure of the flood waters (on the lake side), and storm surge (from the Sea side). It is estimated that as a result of the heavy rainfall and the breached levees, 80% of the city was under water (Colten

et al., 2008). It took 53 days to pump away the water – in part due to Hurricane Rita hitting New Orleans in late September.

2.3 Hurricane Ivan, Cayman Islands, September 11-12 2004

Hurricane Ivan started as a classical 'Cape Verde' depression (Stewart, 2004). It passed Jamaica as a major Category 5 storm, heading due west to the Cayman Islands (see Figure 3). During this period Ivan weakened slightly to a major category 4 storm as it passed south of Grand Cayman on 11th and the moved north on Sunday 12th September 2004 (Franklin *et al*., 2006). Between 9 and 11am wind gusts were reported to have reached 171 mph (149kt), with sustained winds of 150 mph (130kt). The associated 3 meter storm surge and 8m wave height (ECLAC, 2005) combined with persistent rainfall, lead to accumulations of flood water on Grand Cayman of 308.4 mm (12 inches) (Franklin *et al*., 2006). This left most of Grand Cayman under water (Franklin *et al*., 2006). Southern parts of the island were up to 45 inches under water, and the northerly parts up to 12 inches under water (ECLAC, 2005).

Figure 3: Storm track of Hurricane Ivan



Source: (Stewart, 2004)http://www.nhc.noaa.gov/prelims/2004ivan1.gif

3. Cyclone Sidr – impacts and institutional influence

The Bay of Bengal is prone to tropical cyclones, with storms affecting the area (including India, Bangladesh, and Burma) almost every year, and major storms occurring on average every three years. Bangladesh has been affected by major storms in 1970, 1991, 1997 and 2007. Since the mass tragedy caused by the 1970 storm, when at least 500,000 people died, fatalities associated with tropical cyclones have been reducing. In 1997, when a major storm occurred there were 138,000 fatalities. Sidr in 2007 had severe consequences, but these were significantly less severe than earlier events. 55,282 were injured, and 3,406 people lost their lives. Total damages (including indirect losses) were estimated at: US$1.4-1.7 billion or 2.6% of GDP (to , damage to housing stock accounted for 50% of the damages, to agriculture (26%), transport (8%), with some damage to schools, water service provision, and other infrastructure (Government of Bangladesh, 2008). Drinking water was contaminated by debris and saline water from the storm surge, and sanitation infrastructure was destroyed

3.1 Mitigation

The Bangladesh Standing Orders on Disasters (Government of the People's Republic of Bangladesh, 1997 - translated into English in 1999), set out a work programme for the management of natural disasters. This included recommendations on the construction of cyclone shelters. By 2010, the Government of Bangladesh had constructed 2852 cyclone shelters, although 262 are not useable (Government of the People's Republic of Bangladesh, 2010). The Standing orders recommended the construction and maintenance of '*killas'* – raised earthen mounds used for sheltering livestock – built above the height of maximum storm surges. In 1991 only about 190 *killas* existed (Choudhury, 1994), however many were a long distance from human shelter and infrequently used, they were also often without upkeep and prone to erosion. The Standing Orders further recommended additional embankment construction in high risk areas, with sluice gates to allow trapped water to escape, regular embankment maintenance, and forestation of these embankments to prevent erosion and to act as additional storm buffers (Government of the People's Republic of Bangladesh, 1997 - translated into English in 1999). Despite these recommendations, embankments can trap saline water on the landward side, thereby adding to health risks, and damaging crops, they deprive flood plains of needed sediment, and they require constant investment to ensure the drainage systems work, and they are in a good state of repair (Hossain and Sakai, 2008).

Now in 2012, the Government of Bangladesh is working to develop a National Disaster Management Act (Government of the People's Republic of Bangladesh, 2010). In 2004 a 5

year programme of action, the Comprehensive Disaster Management programme (CDMP), was introduced by the Bangladeshi Ministry of Food and Disaster Management in partnership with the UK DFID, UNDP, and more recently the European Union. One component of this has been to shift the focus of policy and planning from response to comprehensive risk reduction.

3.2 Preparedness and response

In 1972[10], following the devastating 1970 storm, a major programme of cyclone preparedness was initiated in Bangladesh – The Cyclone Preparedness Programme. Driven by the Bangladesh Red Crescent Society and the local and national government (the latter through the Disaster Management Bureau and the Meteorological Department) this programme was designed to improve local cyclone preparedness coastal areas, through emergency telecommunications, enhanced early warnings, and the creation of new cyclone shelters (Paul and Dutt, 2010). The specific aim of the programme was "to minimize loss of lives and properties in cyclonic disaster by strengthening the capacity in disaster management of the costal people of Bangladesh". The programme ensured that the Bangladesh Storm Warning Centre produces forecasts, which are converted to warnings, and disseminated to a large network of trained volunteers equipped with megaphones, and public address systems. Researchers interviewing residents in the cyclone-prone area of Chittagong in 1991 noted that the early warning system was already working quite well and was successful in alerting people to the risk (Haque, 1995).

The Cyclone Preparedness Programme, through the Bangladesh Meteorological Department (BMD) issued both cyclone forecasts and advisory warnings through the multi-tiered network, in the days preceding Sidr. The warnings were sent regularly, and when the fourth level of warning occurred, trained volunteers (estimated to be in the region of 44,000) activated their community based warning systems, using megaphones (Government of Bangladesh, 2008).

3.3 Recovery

The Recovery phase was led by the Gov. of Bangladesh, through the Disaster and Emergency Response (DER) subgroup of the Local Consultative Group (LCG). This group coordinated international relief (donors and NGOs) and initial recovery planning. For example, as soon as the storm cleared, the Armed Forces launched their search and rescue / relief operations, this involved both burying the dead and removing dead livestock. Initial humanitarian relief was directed towards food aid, nutrition, water and sanitation shelter and disease surveillance. This

coordination ensured that donors were not duplicating assistance: IFRC and World Vision distributed plastic sheets, blankets, and cash, plus rice, lentils, and oil, whereas the World Food Programme (WFP) distributed high energy biscuits and rice (Government of Bangladesh, 2008).

Affected families had their loan payments to the Grameen Bank, BRAC and ASA (micro-financiers) waived (Government of Bangladesh, 2008). However, some communities argued that grace periods of 3-6 months were not long enough to recover financially from the impacts of the storm (OXFAM, 2008).

The main critique of the response, which was considered to be prompt and active, was the lack of empowerment of some officials in government and in national NGOs, which prevented quick decisions from being made – for example regarding the numbers of households to target, or the types of items to distribute – which meant that the response was top-down, and sometimes not needs-driven (OXFAM, 2008)

3.4 Reasons for reducing fatalities in Bangladesh

The impact of these storms has changed significantly over time, and this is arguably a result of the change in disaster risk reduction evident in the country. Reductions in fatalities appear to have been achieved due to luck (Sidr passed over less densely populated areas, and on the back of a low tide), plus four main institutional changes over the past 30 years in Bangladesh:

i. Construction of physical infrastructure to mitigate risk: largely cyclone shelters doubling as schools e.g. 3 million people were evacuated and 1.5 accommodated in cyclone shelters
ii. Investments in Disaster Risk Reduction generally, e.g. meteorological forecasting, Early Warning Systems, effective communication systems (Tod *et al*., 2008, Government of Bangladesh, 2008)
iii. More effective community-based management of risk, e.g. investments in education, training and awareness (Government of Bangladesh, 2008, Penning-Rowsell *et al*., 2011)
iv. Rising levels of income. There has been a proliferation of mobile phone use that supported early warning message communication. It has been estimated that by 2050

[10] Prior to 1972, cyclones were detected by coastal radar and satellite images; warning systems alerted the capital Dhaka, but did not extend to rural or coastal areas, (Haque, 1995).

98% of the population will live in brick houses – which should see a continued reduction in the number of fatalities associated with cyclones (Dasgupta *et al*., 2010)

4. Hurricane Katrina Impacts and Institutional influence

The Gulf of México/Caribbean basin is prone to tropical cyclones, with an annual 'hurricane'[11] season from June to December annually. Between 1900 and 2004, the United States has been hit by 65 major tropical cyclones of magnitude Category 3 or higher (with wind speeds greater than 111mph) – approximately 6 every 10 years. Of these storms: 3 have been Category 5; 13 were Category 4, and 49 were Category 3 (Brodie *et al*., 2006). Since 1716 New Orleans has been experienced 27 major riverine or storm-induced disasters, i.e. it has a disaster on average every 11 years (Kates *et al*., 2006).

Katrina brought with her 0.5 inches of rain per hour, for 5 hours, with rainfall accumulations reaching 8-10 inches in many places (Stewart, 2004). Overtopping, plus breaks in the levees caused approximately 80% of the city to become flooded and to remain so for several weeks (Haulman, 2006). Although the number of fatalities associated with Katrina are not confirmed estimates vary from 1053 (National Weather Centre/NOAA, 2006) 6 weeks after the event, to 1500 people across Louisiana (Colten *et al*., 2008) to 1800 (Graumann *et al*., 2006) It is generally agreed that over 1.7 million people lost power, it took several weeks before this was restored; drinking water supplied were affected due to a broken water main; both New Orleans airports were flooded and closed; most of the major and minor roads out of the city were impassable on the 30th August (Stewart, 2004). It is estimated that 250,000 people were displaced, and that total damages were estimated to be in the region of US$125 billion (Graumann *et al*., 2006). Twelve months after Katrina, only 29% of schools were operational, and the population of the city was at 49% of pre-Katrina levels (Colten *et al*., 2008).

4.1 Mitigation

Investments in risk mitigating technologies included the modification of the Mississippi delta leading, construction of dams and earthen levees to hold back lake waters, and dykes to prevent coastal flooding. These activities have a variety of impacts. For example, mangrove forests – which act as a buffer against storm surges and wind damage – have been reducing in area by about 100km^2/year (Britsch and Dunbar, 1993), largely due to the engineering of the Mississippi river, which is now almost completely leveed to prevent overtopping. This prevents the sediment flowing into the Delta and the mangrove forest (Day *et al*., 2007). Tropical

[11] Tropical cyclones in the Caribbean basin are referred to as 'hurricanes'.

cyclones and large riverine floods produce enough sediment to maintain healthy mangroves (Turner *et al*., 2006).

4.2 Preparedness and response

In 2004, state, national and volunteer organisations came to gather to evaluate how effectively they could manage a hypothetical category 3 storm (Hurricane Pam) that might affect the Gulf of México states. The conclusions were that the poor and the marginalised groups in society were unlikely to evacuate due to lack of transport, and that a failure of the levee system could result in significant loss of life (Congleton, 2006). In the same year academics estimated what might happen in the event of a category 4 storm affecting New Orleans (Laska, 2004). While time and resources was spent on this preparedness planning, the impacts on the poor and disenfranchised were still not taken into account in state and national plans (Laska and Morrow, 2006)

Early warnings for tropical cyclones in the Gulf of México are provided by the US National Hurricane Centre (NHC) based in Miami. The NHC through their hurricane early warning system, gave New Orleans residents 32 hours' notice of the impending location of landfall and magnitude of Katrina (Knabb *et al*., 2005). Many studies have been undertaken in the United States to assess what proportion of the population will listen to early warning systems, and which groups are most likely to evacuate (Whitehead, 2003, Bateman and Edwards, 2002, Kunreuther, 1996).

Key findings have been that elderly and disabled people, as well as those in minority groups, who may not trust the information being delivered are least likely to listen to an early warning system and evacuate their property (Brodie *et al*., 2006). Conversely those who trust the information source, those with higher incomes, and those with the means to evacuate are most likely to do so (Brodie *et al*., 2006) –and did so. Approximately 130,000 residents and visitors did not evacuate the city – which (Colten *et al*., 2008) estimate to be equivalent to the number without their own transport. In a survey of 680 randomly selected individuals who had been evacuated from the Gulf Coast to Houston shelters after Katrina, more than 90% were African American, about 60% had household incomes of less than $20,000 per annum, about 50% had full time employment before the storm (Brodie *et al*., 2006). In short, the majority were on low incomes, with low rates of home ownerships, with little if any health insurance and low educational levels. Of this group 49% said that they had heard the order to evacuate the city, and the clear instructions given on how to leave, although 61% of those surveyed said that they had chosen not to evacuate. Evacuees explained that they had chosen to stay because: they

did not have a car (34%), they underestimated the severity of the aftermath of the storm (28%), they had to care for someone physically unable to leave or they themselves were physically unable to leave (12%) (Brodie *et al*., 2006)

A variety of institutions were involved in the processes of mitigating disaster risk in New Orleans, from the city level DRR committees, to the state and federal level actors. Initial analysis showed that the governmental organisations responsible for disaster response lacked the standard characteristics of effective bureaucracies, i.e. well-established procedures, effective leadership and clear objectives (Schneider, 2005: 515). The Federal Emergency Management Authority (FEMA) – the body responsible for managing disasters at the federal level – has been criticised for having been slow to respond, and for failing to deliver appropriate and rapid emergency response (Baker and Refsgaard, 2007). Several authors argue that this is due to a redirection of FEMAs interests towards homeland security and away from natural hazard management after September 11th 2001 (Schneider, 2005). This bifurcation of objectives within FEMA introduced a lack of clarity about the role of the agency in relation to natural hazards. Other criticisms include; the inexperience of the leader in dealing with natural disasters, and post-9/11 centralised nature of the authority which weakened the ability of field personnel innovate (Baker and Refsgaard, 2007).

There was a very slow high-level recognition of the extent of the emergency in New Orleans, by the President, Governor of Louisiana, and the Secretary of Homeland Security (SHS). The SHS needed to indicate that the disaster was a “catastrophic incident” for accelerated federal assistance; while he indicated that the event was of national significance, he did not use this key term to expedite assistance, as such it was not dealt with as an extreme emergency (Baker and Refsgaard, 2007). The president cut short a vacation to fly over the affected area 2 days later (31st August), on the same day that 40,000 Federal troops had been requested by the State Governor (Haulman, 2006). Once federal assistance had been sought, the Federal Emergency Management Authority asked the Department of Defence for military assistance. The US Air Force were involved in the relief effort sending helicopters and 8000 personnel. The first priority was search and rescue – getting victims away from flooded homes, and into dry areas, then the focus was on getting refugees from the shelters in new Orleans to the international airport where medical treatment and supplies were located (Haulman, 2006). The response to Katrina took longer than the response to any similar disaster in US history (Colten *et al*., 2008) .

In contrast to FEMA, the US Coast Guard (USCG) was seen to be effective in responding to the impacts of Katrina as they unfolded, for example: they moved staff out of vulnerable locations, evacuated dependents of staff from the area to be affected, pre-positioned communication equipment, managed the expectation of commanders and their teams, and established a variety of communication channels in case one system went down (US GAO, 2006). This effectiveness appears to have created this capacity: the USCG undertook regular practices and planning, specifically "personnel are trained to take responsibility and action, as needed, based on relevant authorities and guidance" (US GAO, 2006: 9). The USCG also promotes principles of leadership and accountability. As Baker and Refsgaard (2007) note:

> "Authority is routinely delegated to qualified people at the lowest possible level because the USCG believes, as an institution, that this results in the most rapid response and maximizes effectiveness in dynamic environments" (p.338)

Volunteers across Louisiana proved to be an important element of the response, saving many lives in the early hours after the storm (Colten *et al*., 2008). However, the volunteers were mostly uncoordinated, operating on an ad hoc basis. For example, American Red Cross volunteers would set themselves up in car parks to hand out vouchers, become overwhelmed and have to call the Coast Guard to manage the security (US House of Representatives, 2006)

Communications systems were central to the response but largely failed. This is despite the fact that after 9/11 the inability of communications system to function in an emergency, specifically to communicate between law enforcement, fire departments, and emergency medical services was recognised by the US Conference of Mayors. New Orleans received $ 5,510,412 to address this issue in 2003. Yet by the time Katrina hit in August 2005 only $275,428 of this had been spent (US House of Representatives, 2006). This has been referred to as a failure of initiative (US House of Representatives, 2006).

4.3. Recovery

There are four main post disaster periods: emergency, restoration, reconstruction and commemorative/ betterment reconstruction. The emergency period in New Orleans extended over 6 weeks, due to the various failures noted above, plus the impact of additional rainfall and flooding caused by Hurricane Rita in late September (Kates *et al*., 2006).

After the emergency search and rescue, establishing law and order, restoration begins with essential repairs to resume urban life. At the state and city level, recovery planning was hampered by conflict between i) the need for speed vs the need for deliberation on process;

and ii) the need for professional assessment vs community / residents assessments of priorities in recovery (Nelson *et al*., 2007). This is a normal feature of recovery processes, however the reconstruction of New Orleans was hampered by many of the features that made NO distinctive, for example relating to African American culture and politics (Kates *et al*., 2006). In their study 10 months after the hurricane, Kates *et al* (2006) found that the reconstruction had not enabled a fairer and more equitable city, but had opened many of the debates about equity and justice in the city, whereby the higher ground communities – often the wealthier ones, were being rebuilt first. Nonetheless, one year after Katrina, there remained severe housing shortages, and basic utilities still remain inaccessible to many (Colten *et al*., 2008).

4.4. Causes of the crisis and lessons learned

- The long term modification of the Mississippi river, and alteration of delta processes clearly had an impact on the area. The creation of levees not built to withstand major hurricanes, and their lack of upkeep appear to be central to the disaster unfolding (Kates *et al*., 2006).
- An undertrained and ill prepared lead agency in the form of FEMA (US House of Representatives, 2006)
- A lack of lesson learning from the training exercise with hypothetical Hurricane Pam
- A lack of effort to work with the poorest and most marginalised groups in New Orleans to support their evacuation
- A break down in communications were a key issue in the post Katrina disaster, there needs to be greater sensitivity given to communication of Early Warning Systems (EWS) and evacuation messages to ensure that the message is heard and understood by minority groups, and those groups least likely to evacuate (Colten *et al*., 2008).
- Poor management of law and order in the recovery phase
- Lack of system of neighbourhood sanctuaries (public buildings such as schools or community centres with upper floors than could be converted to shelters) (Kates *et al*., 2006)

5. Hurricane Ivan and Institutional influence

The Cayman Islands are a group of 3 low lying islands in the north west Caribbean, west of Jamaica and south of Cuba, with a pre-Ivan population of 42,000 (Government of the Cayman Islands, 2000). The damage caused by Hurricane Ivan was extreme as “Nearly every location on Grand Cayman became submerged at some point during Ivan’s passage, a consequence of a 3m storm surge topped by large battering waves” (Franklin *et al*., 2006: 1014). Ninety five

percent of homes and structures were damaged or destroyed by Ivan – about 75% of this damage came from flood damage (ECLAC, 2005). Damage costs amounted to US$1.85 billion. In spite of this, there were only two fatalities from the event (McCarthy, 2005)

5.1 Mitigation

The islands are low lying and have not built sea defences. However the extensive tourism and residential development of Seven Mile Beach (along most of the western side of the island) has led to significant removal of mangrove forest, and to worsening levels of erosion. Construction of canals throughout the islands, both for dredging of sand for construction and to create canal-side homes, have further reduced the coverage of natural mangrove ecosystems. However the Building Code on the islands requires construction to an equivalent of the South Florida Building Code – with roof ties to hold rooves on to walls, roof braces to support gable ends from collapsing, and requirements for building up the level of the floor, and using bricks and mortar constructions (2006a, Chief Building Control Officer, 2009).

The Government of the Cayman Islands have invested in cyclone shelters, building new school buildings as shelters, with neighbourhoods clearly informed about designated neighbourhood shelters, shelter wardens assigned, and basic stocks in place in the shelters (ECLAC, 2005). In 2012 there are 15 hurricane shelters in Grand Cayman – 6 of which are also Emergency Medical Centres (Cayman Islands' Government, 2012). In addition, the financial services – which act as a mainstay of the Caymanian economy – have invested in upgrading their building stock to provide shelter to their employees during major storms (Tompkins and Hurlston, 2011). This public and private acknowledgement of their roles in disaster preparedness and risk mitigation has been a key component in the DRR strategy in the Cayman Islands (Tompkins and Hurlston, 2011).

5.2 Preparedness and response

The islands have invested heavily in rethinking their organisations that manage natural hazards after a slow and ineffective response to Hurricane Gilbert in 1988 (Tompkins and Hurlston, 2003). Following this period, the islands invested in enhancing the capacity of the government, the private sector and NGOs on the island to work collaboratively to address disasters. The Emergency Powers Law (2006b) was established setting out the transition of powers in the event of a disaster. Power passes to the National Hurricane Committee (NHC) which takes over all aspects of response and recovery. The NHC evolved from a group of committed volunteer civil servants and members of society, to a formal quasi-government organisation (Tompkins, 2005).

The National Hurricane Committee takes annual preparedness and planning seriously. Usually in April time (just prior to hurricane season June-December) the NHC undertakes annual planning exercises and ensures that plans are up to date with named individuals responsible for specific actions. This ensures that there is a locally accountable individual (and back up) who can take actions if needed in an emergency situation (Tompkins, 2005).

Early warning systems are taken from the US National Hurricane Centre, and repeated throughout the Cayman Islands via print, electronic and television and radio media. The warnings provide information on the approaching storm, its expected place of impact and time until impact. The warnings are updated regularly and are supplemented by advice to residents on what to do to prepare (National Hurricane Committee, 2006). The emergency services also travel around the islands with a megaphone on a car advising people to evacuate or to board up their homes. In Ivan 17% of the population (6000 people) were evacuated form the properties and given places in government shelters (ECLAC, 2005).

5.3 Recovery

The government prioritised opening of the airport, getting the main utilities connected in the capital George Town and then bringing services back to the wider population across the islands. One day after the event – when the airport was underwater, airport services restarted, and some major roads were made passable (ECLAC, 2005). Basic food, water and supplies were distributed through the NHC.

Foreign assistance arrived in the form of Royal Navy ships who provided law and order, notably at the open supermarkets and petrol stations to ensure there was an orderly approach. The hotels reopened where they could to provide accommodation for those made homeless, as well as emergency workers (ECLAC, 2005).

Just less than one quarter of residents, 10,470 people, left the Cayman Islands during the period 9-30th September 2004 (ECLAC, 2005). It is not clear how many of those who were not Caymanian, chose not to return after the event.

5.4 Reasons for limited loss of life

Four features appear to make the NHC effective: i) it is supported, and mostly trusted, by the wider population – as it recruits volunteer committee members from the private sector, NGOs and civil society and has been shown to be effective in emergencies; ii) it is a learning based institution – whereby it reflects on mistakes made every year during the annual planning process; iii) risk reduction is its central tenet; and iv) there is buy-in from critical stakeholders,

i.e. private sector actors with access to resources (such as heavy equipment, earth movers) that are often needed by the Government (Tompkins *et al*., 2008). In addition, the following features were important:

- Buildings largely conform to the South Florida Building Code – one of the most stringent in terms of standards for construction in hurricane prone areas
- Extensive preparedness planning and drills for the entire civil service
- Ivan happened at the weekend, giving residents a weekend to prepare.
- The islands are low-lying and so are not affected by the more violent higher level winds
- Locally accountable and responsible individuals charged with making decisions locally.

6. Limitations to research on the role of institutions in tropical cyclone disasters outcomes

- Most of the research undertaken is a post-hoc analysis, in locations where there has been an event. There is far less literature available which investigates pre-hazard preparedness, or makes an assessment of the quality of preparedness before a disaster.
- Within the area of recovery research, there is more research on search and rescue and relief efforts, rather than in longer term recovery
- There is no standardised methodology used to evaluate the success of institutional engagement across events

A clearly articulated methodology for assessing the effectiveness of all the different dimensions of institutions on disaster outcomes is needed.

7. Conclusions and recommendations for science

There are several consistent messages of successes and failures that run through the case studies:

7.1 Successes

- Importance of community involvement: Role of volunteers and mobilisation of large numbers of organised and disorganised in all three events provided important support for distressed people / action being taken
- Effective communication systems are critical – Bangladesh Red Crescent Society was effective, the US Coast Guard was effective, the NHC was effective however the FEMA system failed. There are many lessons to be learned. Distributed systems, with multiple

forms of communication, with managed expectations of those using and relying on the systems

- Learning based organisations that constantly reflect on what is known and what can be undertaken to improve disaster outcomes

7.2 Failures

- Lack of adequate and appropriate cyclone shelters for the size of the population. These can be effectively doubled up as community centres, schools or other official sites. Their presence of adequate numbers of adequately strong structures, however provided, saves lives.
- Lack of focus on enhancing DRR capacity. Often this is a less politically desirable option than building infrastructure, e.g. levees, however this is critical to mobilise volunteers and ensure that entire communities are prepared for disasters.
- Lack of integration of communication systems between emergency responders

7.3 Key lessons learned from each case study

- Need for clarity of objectives of the national disaster risk management agency, and a clear mandate for action
- Evacuation plans for low income, and less able bodied people to escape from harms way
- Importance of building socio-ecological resilience into systems, e.g. Mississippi Delta had been heavily managed to reduce dynamic nature of coast but in so doing disconnecting river and coastal processes. Research now suggests that system dynamism should be reintroduced into the delta to prevent future disasters (Day *et al*., 2007)
- Coordination of volunteers – how to ensure that all are acting as one coordinated team, when there are multiple agencies and multiple organisations trying to deliver different outcomes.
- How to manage ‘surprises’ i.e. back to back storms and massive rainfall and overtopping of flood defences?
- Communication systems, how to ensure function even with surprises. Clarity of communications, both prior to and after a hazard.

7.4 Questions needing answering

- How to engage those not engaged in DRR, notably the most marginalised, the poor and the excluded?
- How to support low income households to prepare without resources?
- How to make communications systems robust in the face of surprise?
- What is the role of social media in supporting wider uptake of EWS?

- How to build community resilience in areas of urban decay?

7.5 Actions for science community

- More work in conjunction with low income communities – funding is needed to support this
- More work with those most disadvantaged after an event – why / how to minimise those losses
- How to enhance the impact of scientific research in hazards and disasters community e.g. more opportunities for academia and media to work together

Evidence of institutional resilience for each of the tropical cyclones

(0 = no information; 1 – there is a little information of low quality; 2 = there is a lot of verified evidence)

Role of formal institutions at different phases of the DRR		Cayman / Ivan (2004)	Bangladesh/ Sidr (2007)	USA / Katrina (2005)
Mitigation	Infrastructure	1	1	2
	Building codes, enforcement	2	1	2
	Insurance	1	0	1
Preparedness	Testing / EWS	1	1	2
	Planning and preparedness	1	2	2
Response	Relief mobilisation	1	1	2
	Aid management	0	1	1
Recovery	Search and rescue/law and order	0	0	2
	Restoration and reconstruction	0	1	1

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