HOW DO WE IDENTIFY CLIMATE CHANGE IMPACTS WITHIN COMMUNITY HAZARD MITIGATION?

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Abstract

Climate change presents opportunities as well as increased risk for hazard mitigation. International concern of the risks associated with climate change presents an opportunity to enhance community level mitigation for climate induced natural hazards. However, while the opportunity arises from media focus, raised public awareness and government strategies to adapt to climate change, the impact of climate change on natural hazards may impose a greater risk of more catastrophic events.

The certainties of climate change are increased temperature and associated ocean expansion which will raise sea levels, further exacerbated by melting of icecaps. Sea level rise will be experienced most clearly in the surge events that accompany hazards. Otherwise there remains uncertainty of flow on effects on these changes, and various scenarios have been proposed that predict more severe droughts, floods, tropical cyclones/hurricanes and severe storms. The problem for emergency managers and community researchers is how to isolate likely climate change impacts from ongoing hazard mitigation, awareness and preparedness, and how to incorporate scenarios of increased risk into community hazard preparedness. The paper reviews the state of knowledge of climate change impact on natural hazards and examines the problem of translating this increased risk into community hazard mitigation strategies, and the more complex problem of isolating those hazard risks that specifically relate to climate change and thus require enhanced adaptation strategies on the part of households, communities and local governments.

Introduction

Over the last couple of decades, disaster mitigation has become a central activity of emergency management. The International Decade for Natural Disaster Reduction (IDNDR) gave a strong boost to the enhancement of awareness, preparedness and disaster reduction activities, strengthening the capacities of governments and agencies to institute effective mitigation strategies and focused recovery following catastrophic events. However, as IPCC co-chair Bruce (1999) observed, the end of the IDNDR signified a shift from mitigation of known hazards to the anticipation of greater hazard impacts as a consequence of the emerging consensus on climate change. Just as emergency managers, agencies and governments have assumed responsibility for mitigating the impacts of natural disasters, the emphasis shifted to a future of uncertainty (Powell 1999, ISDR 2008, Klein & McIver 1999). Methods, strategies and policies for mitigation have to respond to uncertain enhanced threats in a changing global climate, that will undoubtedly constrain the capacity of many societies to keep up or even

survive. In shifting emphasis to an uncertain future of emerging hazard impacts in a changing climate, emergency management is faced with having to identify the new threats to which it must respond.

The question that we face as researchers is how to identify what extra mitigation strategies in emergency management and disaster research are required, or more significantly what transformations are needed to respond to the new threats. These are two separate questions: what needs to be added under climate change scenarios implies more of the same emergency management strategies in a worsening climate, whereas transformation questions the fundamentals of emergency management and requires a radically new approach. The phrase that has been added to natural disaster mitigation is adaptation to climate change. Mitigation and adaptation are contradictory terms as mitigation implies a positive reactive approach to reducing the impact, while adaptation to change is a proactive process that shifts to a new state in relation to that which is changing.

Therefore, this paper examines what the world must adapt to and how we need to identify adaptive behaviour as something new and beyond existing hazard mitigation. Disaster research is challenged to respond to the impacts of climate change, and in identifying research priorities it must attempt to separate 'the business as usual' hazard mitigation from the transformative necessities of adaptation. This is primarily a review of some ideas that have been published recently that show what climate change scenarios reveal and how mitigation and vulnerability assessments fit into adaptation, in order to understand where social hazard research needs to go.

Climate Change Impacts

Climate change research has taken place for decades, in a sense culminating in the IPCC documents because these involved extensive international cross disciplinary scientific expertise. As the IPCC scenarios are severe and grim enough (ISDR 2008) recent grimmer scenarios may be acknowledged, but the more conservative IPCC is currently the guiding international structure. The data for climate change is compelling. However, Duerden (2004) states that social scientists have fallen short in climate change research compared to the physical scientists. It has taken the momentum of evidence during this decade to move governments and institutions to an acknowledgement of the need for adaptive action, while the mass of the human population remains largely unaware or unconvinced. "Personal experience takes place in a limited timeframe, making it difficult to separate long-term change from aberrations" (Duerden 2004 p.209). The media feed this uncertainty, as record-breaking disasters make great stories and political debate over climate change is often portrayed as the opinions of scientists. Furthermore Bruce (1999) questioned whether increasing losses from disasters were due to climate change. He also concluded that there is no global trend in tropical cyclones, which are linked to ENSO, but stressed that mitigation has to proceed on the cautionary principle. Compounding factors in hazard impact are the world's rapid population increase and massive developing world urbanisation where people are concentrating into vulnerable coastal settlements where they are cut off from social networks and local knowledge. Finnigan (2005) observes the complexity of social and human ecosystems that may either exacerbate or ameliorate a disaster.

ISDR (2008) summarises IPCC predicted impacts by 2100 as:
1. surface temperature increase 1.1 – 6.4 degrees C
2. Sea level rise of the 18 - 59 cms
3. Oceans become more acidic
4. Hot extremes, heat waves and heavy rain to be more frequent
5. Less precipitation in the sub tropics and more in high latitudes
6. More intense cyclones
7. Storm surges associated with tropical cyclones and sea level rise

8. Inequality between regions -- coastal lowlands and small islands are the most vulnerable while Africa is extremely vulnerable.
Barratt et al (2009) provide an Australian emphasis that is not only more specific but is also less conservative than the IPCC which they add to. They predict: tropical storms extending further polewards, increased frequency of extreme weather, heatwaves, warmer ocean temperatures, glacial and ice sheet melting, changes to local ecosystems, health risks from disasters and heat waves, infectious and mosquito borne diseases and loss of food security.

Apart from the increasing severity and frequency of events, these consequences stress the inequality of impacts between places, uncertainty and the compounding local factors of disease, collapse of food production and lack of water (ISDR 2008, Barratt et al 2009, Handmer et al 1999, Prabhakar et al 2009, Davidson et al 2003). Predictions of climate change promise a difficult future in which more disasters will impact upon an increasing and more vulnerable population. Understanding of vulnerability is critical in order to map ways in which societies may be encouraged to adapt.

Vulnerability

All communities and institutions are vulnerable to natural hazards. In developing strategies for mitigation, a great deal of research has been carried out to define both vulnerability and resilience (Blaikie et al 1994, Buckle 1999, King & MacGregor 2000 for example). Vulnerability and resilience, underpinned by concepts such as social risk theory (Davidson et al 2003), social capital, collective action, common property resources (Adger 2003) gave direction to mitigation strategies and policies. In a changing world these have to be reassessed. Strong themes in vulnerability and climate change are the need for adaptation to be local (Adger 2000, Davidson et al 2003 for example), the vulnerability of resource dependent communities (Adger 2000, Duerden 2004, Hay & Mimura 2006) and changes to ecosystems adversely impacting on sustainability. Davidson et al (2003) identified problems of adaptation in:
1. Rural resource dependent communities and their ability to adapt proactively
2. The nature of specific ecosystems
3. Change in the resource base
4. Community members' underestimation of climate change risk
5. Multiple compounding factors.
Handmer et al (1999) reinforce the point that globally adaptation is effective, but that at the local level vulnerability is extremely unequal, such that some populations simply will not survive in their current locations. This introduces migration as an adaptive strategy -- certainly not part of emergency management thinking, which is focused on relatively static local communities.

There is an extensive literature from agencies and advisors that stress concepts such as sustainability, resilience, and flexibility. Examples such as IUCN (2003), The Informal Taskforce on Climate Change (2008, reporting to in the UNFCCC working group and citing the Hyogo framework) and researchers (Chen 2008, Tobin 1999, Powell 1999) suggest that adaptation and mitigation are achievable within existing emergency management frameworks. These views are basically optimistic although they still stress uncertainty.

Tobin (1999) stressed sustainability and community resilience, while admitting that these were then, and continue to be, difficult to organise in a practical plan. Sustainable and resilient communities should "be able to withstand extreme geophysical processes and recover rapidly from disasters" (Tobin 1999 p.15). Characteristics of these communities (p.16) will be:
1. Lowered levels of risk through reduced exposure
2. Reduced levels of vulnerability
3. Ongoing planning for sustainability and resilience

4. Support from agencies and government
5. Partnerships and cooperation of different levels of government
6. Strengthened social networks
7. Appropriate scales of planning.

Hay & Mimura (2006) saw sustainability as achievable only within an integrated ecosystem coping capacity. Birkmann and Fernando (2007) referred to 'coping capacity' as a positive element rather than the negativity of susceptibility. However, coping is a very low level adaptive behaviour that clearly denies sustainability. The problem with sustainability is that climate change is clearly not only a severe threat, but all current human practices become unsustainable in a changing future. There is thus the problem that many existing "hazard response and mitigation practices often sustain communities as they are, and merely perpetuate the disaster-damage cycle rather than addressing the root cause of the problems" (Tobin 1999 p.23).

Climate Change Vulnerability Assessments

Vulnerability assessments have not been static. As institutional capacity has responded to mitigation, opportunities have opened up, but simultaneously the threat of climate change has loomed. Mitigation can no longer aim at sustainability, but adaptation is more about survival than sustainability. Social capital and collective action are still central to resilience and will drive some adaptation strategies. Adger (2003) illustrates how social capital operates at different scales from the individual through communities to the state, although he also acknowledges that the contribution of social capital and vulnerability assessments to adaptation are "contested policy and research areas" (p.401). Schroter et al (2005) presented five criteria for climate change vulnerability assessment:

1. Flexible knowledge base 2. Place based -- local – scale 3. Interconnectedness of change
4. Differential adaptive capacity 5. The future draws from the past;

and they added eight steps towards the achievement of such a vulnerability assessment:

1. Defining the area along with stakeholders
2. Know the place over time
3. Hypothesise vulnerability
4. Develop a causal model of vulnerability
5. Develop indicators for vulnerable elements
6. Operationalise the model
7. Project future vulnerability
8. Communicate vulnerability clearly.

This method has a lot in common with the IACCIUS assessment (Guillaume et al 2008), which applies it to a real location in Darwin, Australia.

Gopalakrishnan and Okada (2007) also presented a key elements for vulnerability:

1. Awareness and accessibility 2. Autonomy 3. Affordability 4. Accountability
5. Adaptability 6. Efficiency 7. Equity 8. Sustainability.

It is unfortunate that this ends with sustainability despite criticism in their paper of the failure of mitigation, aid, relief agencies, laws, regulations and culture, particularly in the United States, and the need for an overhaul of the institutional aspects of disaster risk management.

Fussel & Klein (2006) identified what they term generations of climate change vulnerability assessments as a series of trends (p.303):

1. From linear to complex chains of analysis
2. From non adaptive to perfectly adaptive to realistically adaptive agents
3. From simplistic to sophisticated to pluralistic consideration of alternatives
4. From strictly quantitative to quantitative and qualitative analyses
5. From science driven to policy driven assessments
6. From analyses that dictate to users, to involvement of users in the assessment process.

The range of types of adaptation in contrast to types of mitigation are further illustrated in their table 1 which is reproduced below.

Table 1. Characteristics of mitigation and adaptation

	Mitigation of climate change	Adaptation to climate change
Benefited systems	All Systems	Selected systems
Scale of the fact	Global	Local to regional
Lifetime	Centuries	Years to centuries
Lead time	Decades	Immediate to decades
Effectiveness	Certain	Generally less certain
Ancillary benefits	Sometimes	Mostly
Polluter pays	Typically yes	Not necessarily
Payer benefits	Only little	Almost fully
Monitoring	Relatively easy	More difficult

Source: Fussel & Klein 2006, p.303

Strategies for adaptation are clearly radically different from those for mitigation. They then present a categorisation of the generation of vulnerability assessments as:
1st generation of vulnerability assessments -- importance of non-climatic factors
2nd generation -- ability of the system to adapt
3rd generation -- adaptation policy assessments -- uncertainty and involvement of stakeholders.

Vulnerability Mitigation to Climate Change Adaptation

'Generations' of vulnerability assessments are not necessarily chronological as different institutions and societies are facing unequalled problems and situations. Ten years ago Handmer et al (1999) stated that emergency management is structured to maintain the status quo. They suggested five themes of societal impact:
1. Vulnerability and resilience -- geographical variability
2. Globalisation -- inequality of the market, media and economy
3. Institutional capacity -- governance issues
4. Uncertainty and ignorance
5. The physical environment -- ecosystem and vulnerability and resilience.

Klein & McIver (1999), presenting to the IPCC in Costa Rica listed clear adaptation messages: uncertainty, past experience, autonomous planned adaptation, reactive or proactive, the time needed to adapt, data and information, maladaptation, the vulnerability, technology, governance, water and drought, coastal vulnerability, biodiversity, health and lack of insurance for most people. Pielke & Sarewitz (2005) saw a problem with adaptation having only costs. Initially this may be the case, but in the long-term adaptation might transform into a new sustainability. Their paper argues that the impacts of climate change are social (although environmentalists might take issue), but that while society has a past history of adaptation, it has no experience in successfully modifying climate. This reinforces the argument that mitigation (including carbon trading and emissions reduction) is much less likely to be successful than adaptation to a changing global climate.

Prabhakar et al (2009) present a framework for adaptation in which local stakeholders must be innovators, not simply players, with climate change mainstreamed into emergency management at the local level. This was the practical approach adopted in the Integrated Assessment of Climate Change Impacts on Urban Settlements (IACCIUS) project that used Darwin as a case study (Li 2009, Guillaume et al 2008). The study reconstructed the hazard a history of the city and showed that it is an extremely hazard prone settlement. Despite having only existed since the mid-1800s, Darwin is the only Australian city to have been destroyed four times, once by Japanese bombing but on three occasions as a consequence of tropical

cyclones. After Cyclone Tracy in 1974 most of the population was evacuated following extensive destruction of housing and infrastructure. It is threatened by a tropical cyclone most years with a number of category five storms having passed very close to the city. It is also vulnerable to flood, drought and heatwave. All of these are predicted to increase in severity under conditions of climate change. Darwin's hazard history suggests a place that is extremely resilient. However, a large proportion of its population is short term. This adds to the lack of awareness of local hazards, but it also means that many of the people who experienced a disaster in the past have moved on afterwards. This reduces some of the communal memory and hazard knowledge, but it also means that it is the place rather than its population that is resilient. Li (2009), who was a major contributor to the IACCIUS project, carried out PhD research over an extended period in the city, analysing community perceptions of risk. She found an extreme variability in people's perception of existing hazard risks, in common with many studies of vulnerability, awareness and preparedness (Anderson-Berry & King 2005). Li particularly identified a divergence between recent arrivals, long-term residents and hazard/emergency management experts. The weak perception of existing risk presents a serious problem for dealing with future enhanced risks.

From a base of hazard history the IACCIUS study of Darwin then created identifiable hazard regions, termed Emergency Management Units (EMU), based on existing suburbs. For each of these the local climate was identified and quantified with information on physical vulnerability, and population vulnerability then added using available data in order to be replicable at the local government level. This places a constraint on the quality of data that can be used in such a study, but it is no help to local councils or city governments to place unrealistic requirements of data collection and surveys. Each EMU is mapped and defined and contains detailed summaries of exposure, population, economy, infrastructure, natural resources and environment, age and health, education, culture, society, the built environment etc, adaptive capacity of government, households and occupations. Also listed are future required adaptations of planning, legislation, infrastructure and community actions, as well as a summary of primary climate change hazard impacts.

The Darwin study also identified two critical research questions. Firstly, the theme of this paper, is the problem of isolating climate change impacts from ongoing hazard mitigation. The Darwin study attempts to identify the local level adaptations that may emerge as the climate warms, but confronts the issue of when existing natural hazard mitigation, awareness and preparedness move into emerging impacts of climate change. As government funding is set aside for climate change adaptation, and research that relates to this, it quickly becomes a political issue. Secondly the study raised a fundamental sustainability issue -- how to build residential houses that will withstand extreme cyclonic winds while coping with both the existing heat and humidity and the expected increase in heat and humidity under climate change conditions. Throughout the world existing buildings in cyclone/hurricane/typhoon prone regions are not residentially sustainable in terms of their resilience to hazards, or comfort or energy use.

Furthermore, the Darwin study prompted denial from the Northern Territory Government, which objected to suggestions of category five cyclones occurring more frequently (despite the hazard history of the place) and the report's suggestion that in the event of an extreme cyclone, and given that cyclone shelters can only accommodate 10% of the population, a mass evacuation may have to be recommended (despite the fact that such a mass evacuation has occurred in Darwin's past history). The dire predictions of climate change impacts are still politically unacceptable. Governments have not absorbed their reality, let alone the general community.

Discussion and Conclusions

Darwin was resilient because it was in a strategic position, despite the dangers of cyclones and war, and a climate that is relatively stressful for part of the year. Climate change may make it agriculturally richer so that its local resource base may improve. However it is likely to continue to be its position that determines its future resilience rather than resources. Several of the papers reviewed here have identified resource dependency as a contributor to vulnerability. Climate change will impact resources directly through increasing drought and vegetation change. Communities that experience a long-term decline in their resource base will be much less resilient to the shocks of short-term disasters.

Additionally many papers have pointed to the vulnerability of ecosystems. Low lying coastal plains and islands will experience repeated shocks through ocean inundation accompanying tropical cyclones, storm surge, high tide and ocean swells from distant storms, and coastal flooding as a consequence of increased rainfall. Some environments will be unable to support existing populations, let alone an increase as global population continues to grow at a completely unsustainable rate. Coral atolls and whole countries such as Tuvalu and the Maldives are immediate examples of extreme vulnerability, but most of the world's population and the world's cities are located at very low altitudes close to oceans. Some cities are already being inundated and it is particularly their commercial and industrial areas that are the most vulnerable, and therefore their economies and the basis of their existence. This represents a compounding of resource loss and ecosystem damage that may be expected to increase in bursts of catastrophes.

There are also indirect resource and ecosystem losses that will undermine existing industries, especially tourism. The loss of ski tourism, rainforest and reef tourism would devastate local economies and make recovery from a short-term disaster more difficult or even impossible.

Diversification has long been an economic strategy to make communities and regions more resilient and sustainable and it is for this reason that single resource, and even single ecosystem communities and places are seen as highly vulnerable. Climate change will impact places unevenly, and unequally, but as ubiquitous necessities such as water and food are reduced, the resilience of many apparently sustainable and diversified communities will also be compromised. Diversification has inevitably contributed to the very complex settlements and networks of industrialised society which may be extremely vulnerable to shocks and resource constraints that unequally target a component or specific area of a complex system, thereby damaging the functioning of the whole.

Less directly evident in the literature, but an implicit consequence of increased frequency of flood, cyclone intensity and drought, is the compounding effect of repeated disasters. It is clear from post disaster studies that people's awareness and preparedness for natural disaster is increased through direct experience of such events. However, each disaster is a terminal crisis for some households (apart from death or severe injury). Farms, small businesses and larger businesses or organisations that were marginally viable fail to recover from a disaster. Additionally some people are so traumatised as to leave the region permanently, while other families on low incomes may find themselves unable to rebuild or to pay the increased rents that follow reconstruction. Over a decade or more communities may regain a new population and new businesses, but if the place or region is successively impacted by natural disasters, before recovery is complete, it may never recover and may experience a long-term decline in economy and population. This is exacerbated by climate change related resource decline and change.

In the literature reviewed here, reference is made to the non-viability of specific locations and ecosystems. The mechanism of population loss is primarily migration. Migration is an adaptation, the most significant and widespread throughout human history. Climate change

impacts of natural disasters and ecosystem change will prompt enormous migrations, internally within countries and most probably across international borders. This may even be organised as war or collapse into civil war and anarchy (complex humanitarian disasters). Migration is rarely a state policy, but it will be the strongest most immediate adaptation that is most easily accessed by individuals and families.

Emergency management has adopted resilience as a key feature of safeguarding communities or building safe communities. Resilience is the ability to bounce back. Thus by reducing vulnerability and enhancing resilience the impacts of natural hazards may be mitigated or lessened, and the community bounces back in recovery. This implies a general return to the pre-disaster status quo. Even if we know that a place will never be the same as it was before the disaster, the idea in many people's and agencies minds is to get back to normal, which relates to the pre-disaster way of life. Yet climate change predicts a state of change in which things will not be the same again. Society will not bounce back, it is going to have to bounce forward, to adapt to a significantly different ecology.

In a similar way sustainability relates to resilience by desiring to maintain a working ecosystem that will sustain communities and their resource use into future generations. Sustainability is extensively used amongst strategies for disaster mitigation and climate change adaptation. The problem is that virtually nothing human beings are doing, or the way we are doing it, now, is sustainable when confronted by the impacts of climate change. Adaptation demands change. Mitigating the process of climate change demands change; change in economy, resource use, organisation, governance and social priorities and relationships. Climate change suggests that we have lost the opportunity to achieve sustainability, or a sustainable stability. As a word and concept sustainability has been so misused as almost to have become the status quo. The climate and responses to its extremes are no longer sustainable.

In returning to the research question of separating climate change adaptive actions for existing mitigation it must be concluded that these are completely separate approaches. Adaptation demands change and change is not mitigation, although mitigation strategies may continue to be practised and will also have to change into quite new approaches. It has been argued that emergency management is based on a protection of existing communities and their lifestyles and economies -- the status quo -- while driving response and recovery to return to the pre-crisis state. This will not contribute to adaptation -- to the change that is required to move to a new way of life, a new community in a changing ecosystem.

Much of the solution to this adaptation problem for emergency management lies within many of the alternative approaches which are emerging. Ideas that are repeated throughout the literature are that climate change adaptation must be flexible, local, community-based, stakeholder driven and that it must involve all of government and community agencies and institutions. Climate change adaptation is not the sole responsibility of emergency management. It will happen at household and community level and to be effective it must involve change and adaptation in all of our societies' supporting organisations and agencies. The question for researchers is how we identify adaptive change as a process that is quite separate from mitigation that is currently aimed at preserving current communities. We must not see climate change adaptation as a mere add on to existing natural disaster risk mitigation. Community and household adaptive behaviour and capacity to worsening disasters is a completely new direction for emergency management and social research.

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