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Planning for Natural Hazards — How Can We Mitigate the Impacts?

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Planning for Natural Hazards – How Can We Mitigate the Impacts?

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Abstract
Australia has the same frequency of natural hazards as any other continent; however, the types and impact of hazards are very different. Globally, the deadliest hazards are floods, earthquakes, tropical storms and tsunami. In Australia, the deadliest hazards are heat waves, floods, tropical cyclones and bushfires. Similarly, while the most expensive hazards ranked globally are also floods, earthquakes and tropical cyclones, in Australia, the costliest hazards are tropical storms, floods, wind and bushfires. Our isolated population distribution, together with rugged topography along the eastern and southern coastal fringe where the bulk of the population is concentrated, has lead to a different response to natural hazards in Australia. This paper considers some of the planning, economic and social issues related to hazard management in Australia. Communities are encouraged to be self-reliant with the national government used as a last, but effective, resort for the largest events. Funds from insurance companies and the government are used to maximise recovery in the shortest possible time. The effectiveness of these processes will be challenged by a growing population, variability in natural hazard regimes and climate change. There is a growing consensus that more attention should be directed at mitigation rather than response and recovery.

Introduction
Events such as floods, bushfires, droughts, and cyclones frequently hit the news headlines as they often cause significant loss of life and large-scale economic impacts. Less frequent on a global scale, but often much more damaging events such as volcanic eruptions and tsunami, have garnered significant technical investigation. However, many such occurrences still have devastating impacts on humans and their related infrastructure. Planning to mitigate the impact of such incidents has become even more critical given the prediction of increased climatic extremes associated with global warming and the realisation that the magnitude and frequency of a hazard regime is not stable over time (Nott, 2003). Effective planning to prepare for such events and to enable appropriate reactions to them requires researchers and resource managers to work together on the prediction, assessment, management, and response to natural hazards. The results of research, planning, and other management activities need continuous review to determine research and planning priorities for the future, and improve links between researchers and planners.

In Australia, all levels of government (Federal, State, and Local) have some role to play in natural hazard planning and response. There have been a number of government initiatives in hazard assessment and management, but experience would indicate that much more is required. One of the major requirements is to ensure that the wide range of organisations involved in hazard planning and response (e.g., Bureau of Meteorology, Emergency Management Australia, Geoscience Australia, Federal Department of Transport and Regional Services, State Emergency Management Committees, State Floodplain Management Authorities, State Emergency Services, State Planning Departments, Fire Brigades, and Local Government Authorities) interact in an effective way to develop an integrated approach to the problems. Such interaction is occurring under the auspices of the Council of Australian Governments (COAG, 2002; Ellis et al., 2004) and the Prime Minister's Science, Engineering and Innovation Council. In addition to these government agencies, infrastructure providers, developers, engineering and planning consultants, research organisations (including tertiary education institutions), and financial institutions (such as insurance groups) have key roles to play.

Addressing the problems caused by natural hazards in a holistic way will necessitate scientists, social scientists, economists, policy formulators, engineers, planners, and risk management professionals involved in land use allocation in areas subject to natural hazards bringing all their skills together to assist government agencies in decision-making. Issues that are of significant current importance include:

- Definition of current hazard risk in the context of changing hazard regimes;
- Current methods of assessing natural (and hence economic) risk in land-use decision-making;
- Hazard management decision-making in an increasingly litigious twenty first century;
- Improving methodology, transparency and consistency in land-use decision-making in areas subject to natural hazard;
- Ensuring adequate factoring in of socio-economic considerations in decision-making;
- Linking research activity and decision-making requirements in hazard management.

In dealing with these issues, numerous questions arise, e.g.:

- What is the full spectrum of direct and indirect costs that arise from developing sites known to be subject to natural hazards?
- Specifically, what are the costs of emergency response agencies, community education, impacts on health, social, and community services? What are all the other direct and indirect, immediate, delayed, and long-term costs arising from specific disasters and how can these be evaluated?
- Recognising natural disasters is currently defined in terms of frequency of occurrence. What are the appropriate tools to allow for the annualisation (or averaging) of the costs (direct and indirect) that arise from the natural disasters? What happens if the present magnitude and frequency of a natural hazard is underestimated relative to pre-historic events?

In this paper, we examine some of the issues concerning the planning for, and management response to, natural hazards, with particular emphasis on Australia and the south-west Pacific region. An overview of the current global information on the prevalence of hazards and their social and economic impact is presented first. This is followed by commentary on some of the current hazard planning and management activities and areas that need further attention.

Natural Hazards – An Overview of Occurrences and Impacts

A natural hazard is any naturally occurring geological, climatic or biologic phenomona that significantly threatens human life, health or mental state. When the event is sudden, catastrophic or deadly, it becomes a natural disaster. When the impact of a natural hazard is not minimised by effective prevention, preparation, and recovery strategies, it has the potential to become a disaster. For example, although massive evacuation reduced the initial deathtoll from Hurricane Katrina in the southern United States in August 2005, the lack of planning and preparation for the subsequent flooding of New Orleans turned a short-term event into a long-term disaster that destroyed more property and threatened far more lives in the days and months afterwards.

Figure 1 plots the number of hazards by region across the globe over the period 1975-2001 (based on WHO, 2002). The data excludes epidemics or famine, but includes most geologic and climatic hazard events over this period. The most hazardous regions in the world are eastern Asia, the Indian sub-continent, and southeastern Asia. The risk of natural hazards in the Australian region is, surprisingly, little different from the rest of the world over this short time period. This is surprising because most Australians would consider that they live in a region that does not experience many natural disasters. The global incidences of hazards over the 20th century are presented in Table 1. Each disaster in this table killed 10 or more people, affected more than 100 people, generated a state of emergency, or required international assistance. The global distribution of hazards reflects the dominance of climate. All tolled, climatic hazards account for 86.2% of the significant hazard events of the 20th century. The most frequent hazard is tornadoes, the majority of which occur in the United States of America. Over the latter half of the 20th century, their frequency—more than 250 events per year—exceeds any other natural hazard. Climatically induced floods and tropical cyclones follow this phenomenon in frequency. Tsunami—ranked fourth—is the most frequent geological hazard, followed by damaging earthquakes with nine significant events per year. The incidence of tsunami appears incongruous given the fact that tsunami are predominantly caused by earthquakes and fewer than 2% of earthquakes generate tsunami (Bryant, 2005). Table 1 is country based. Tsunami are one of the few hazards that have the potential to affect many countries up to 12,000 km from the generating source of a single triggering event.

Figure 1: Global incidence of natural hazards by region 1975-2001 (based on WHO, 2002).

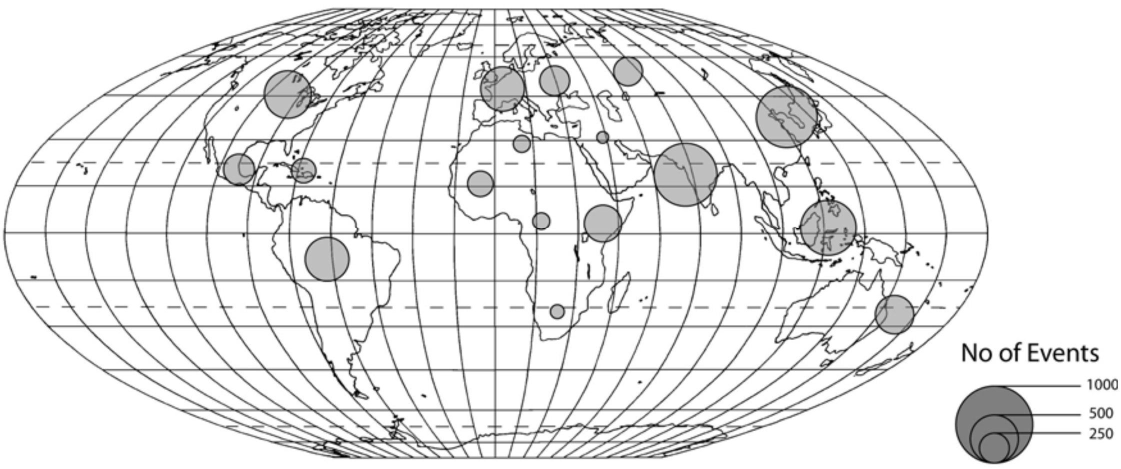


Table 1: Frequency of natural hazards during the 20th century. Tsunami data come from the Intergovernmental Oceanographic Commission (2003). Tornado statistics for the US are for the 1950-1995 period only (High Plains Regional Climate Center, 2003). All other data based upon WHO (2002).

Type of Hazard	*No of Events*
Tornadoes (US)[1]	9476
Flood	2389
Tropical Cyclone	1337
Tsunami	986
Earthquake	899
Wind (other)	793
Drought	782
Landslide	448
Wild fire	269
Extreme temperature	259
Temperate winter storm	240
Volcano	168
Tornadoes (non-US)	84
Famine	77
Storm surge	18

[1]for F2-F5 tornadoes 1950-1995

The economic cost of the biggest 100 of these hazard events is summarized over the 20th century in Table 2 (based upon WHO, 2002). Values are reported in US dollars and do not take into account inflation. The hundred most expensive natural disasters of the 20th century caused a total of $US631 billion in damage. Earthquakes, while only ranking fifth in occurrence, have been the costliest hazard ($US249 billion or 39.4% of the total), followed by floods ($US207 billion or 32.7% of the total), tropical storms ($US80 billion or 12.7% of the total), and windstorms ($US44 billion or 7% of the total). The single largest event was the Kobe earthquake of 20 January 1995, which cost $US131.5 billion. While this event is familiar, the second most expensive disaster of the 20th century, floods in the European part of the former Soviet Union on 27 April 1991, which cost $US60 billion, is virtually unknown.

The percentage of damage caused by each hazard in Australia over the comparable period is also tallied in Table 2 (based upon Blong, 2004). The figures are in stark contrast to the global picture. In Australia, 93.6% of the damage to buildings is caused by climatic hazards. Tropical cyclones (30.1% of the total versus 12.7% globally) are the most damaging hazard followed by wind storms (22.6% versus 7.0%) and wild fire (19.8% versus 3.2%). Earthquakes only account for 6.0% of the damage to buildings in Australia, whereas they account for 39.4% of damage worldwide. Earthquakes, landslides and tsunami provide minimal economic threat in this country. As a result, Australia’s response to disasters in terms of recovery and rehabilitation differs from that elsewhere in the world. Some of these differences will be discussed subsequently.

Table 2: Cost of natural hazards globally, summarized by type of hazard for the 100 biggest events, 1900-2001 (based upon WHO, 2002). Added to the table is the percent damage to buildings for each hazard in Australia over a comparable period, 1900-2003 (based upon Blong, 2004).

Type of Hazard	Global Cost	Global cost as a percentage	As a percentage in Australia
Earthquake	$248,624,900,000	39.4	6.0
Flood	$206,639,800,000	32.7	21.4
Tropical storm	$80,077,700,000	12.7	30.1
Wind Storm	$43,890,000,000	7.0	22.6
Wild Fire	$20,212,800,000	3.2	19.8
Drought	$16,800,000,000	2.7	not assessed
Cold wave	$9,555,000,000	1.5	not assessed
Heat wave	$5,450,000,000	0.9	not assessed
Total	**$631,250,200,000**	**100.0**	**99.9**

Table 3 presents the accumulated number of deaths, injuries and homeless persons for each type of hazard globally for the 20th century (based on Bryant, 2005). Also presented is the largest event in terms of death for each type of hazard. The greatest hazard during the 20th century was flooding accounting for 66.0% of deaths; however, much of this was due to civil unrest. Half of the 6.9 million death toll occurred in China in the 1930s where neglect and deliberate sabotage augmented the severity of flooding (Bryant, 2005). Earthquakes and tropical cyclones account for the other significant death tolls of the 20th century (17.5% and 11.1% respectively). The table has been updated to include the 26 December 2004 Indian Ocean tsunami. Because that event killed 228,432 people, tsunami now ranks fourth in terms of death toll. Before then, tsunami ranked eighth in terms of death toll in the 20th century. Interestingly, during the first three years of the 21st century, 4,242 deaths have been caused by unseasonally cold temperatures. This is 60% of the total for the whole of the 20th century despite the perception of global warming. In contrast, the death toll from a heat wave in France in 2003 resulted in 15,000 deaths, more than could be attributed to this cause during the whole of the 20th century. Obviously, the statistics presented in Table 3 underestimate actual deaths, mainly because data were simply not collected for some hazards until recent times.

The number of injured and displaced people due to natural catastrophes in the 20th century is also presented in Table 3. Often hazard statistics concentrate upon death, not realizing that the walking wounded, mentally gutted, and the homeless put a greater, more lasting burden, upon society. Eighteen times more people were made homeless by floods in the 20th century than were killed. This ratio rises to 30 and 344 times respectively for tropical cyclones and extra-tropical storms. For example, the ice storm of January 1998 that paralyzed Montreal killed twenty-five people. However 4,000 times this number—up to 100,000 people—were made homeless for up to one month afterwards because of the failure of electricity supplies as temperatures dipped to -40°C. Similar statistics emerged for Hurricane Katrina, which struck the United States Gulf Coast on 29 August 2005 and displaced 1,000,000 for up to 6 months.

Table 3 also incorporates death tolls in Australia for the period 1788-2003 (based upon Blong, 2004). Values are also expressed as percentages to permit comparison to global statistics. Australian death tolls for each hazard type are in stark contrast to global numbers. For example, while flooding is just as prevalent in Australia as elsewhere in the world (Bryant, 2005), the proportion of deaths due to this phenomenon is one-third

Table 3: Number of people killed, injured or displaced globally due to natural hazards during the 20th century (based upon WHO, 2002). Tsunami statistics updated to 26 December 2004. Before then, tsunami ranked eighth in terms of death in the 20th century. Added to the table are the number and percentage of deaths in Australia, 1788-2003 (based upon Blong, 2004).

Type of Hazard	**Global deaths**	**Global deaths (%)**	**Deaths in Australia**	**Deaths in Australia (%)**	**Global Injuries**	**Global Homeless**	**Largest death toll event and date**	**Death toll of largest event**
Floods	6 851 740	66.01	2 292	22.08%	1 033 572	123 009 662	China, July 1931	3 700 000
Earthquakes	1 816 119	17.50	16	0.15%	1 147 676	8 953 296	Tangshan, China, July 1976	242 000
Tropical cyclones	1 147 877	11.06	2 163	20.84%	906 311	34 272 470	Bangladesh, Nov 1970	300 000
Tsunami[1]	337 693	3.25	5[2]	0.05%	125 789	1 500 000	Indian Ocean, Dec 26 2004	228 432
Volcano	96 770	0.93	0	0.00%	11 154	197 790	Martinique, May 1902	12 000
Landslides, avalanches, mud flows	60 501	0.53	95	0.92%	8 071	3 759 329	Soviet Union, 1949	4 000
Extra-tropical storms	36 681	0.35	774	7.46%	117 925	12 606 891	Northern Europe, Feb 1953	2 541
Heat wave	14 732	0.14	4 287[3]	41.30%	1 364	0	India, May 1998	3 000
Tornado	7 917	0.08	52	0.50%	27 887	575 511	Bangladesh, Apr 1989	400
Cold wave	6 807	0.07		0.00%	1 307	17 340	India, Dec 1982	800
Fires	2 503	0.02	696	6.71%	1 658	140 776	USA, Oct 1918	1 000
Total	**10 379 340**	**100.00**	**10 380**	**100.00%**	**3 382 714**	**185 033 065**		

[1]Data from National Geophysical Data Centre Tsunami Database (2005) and Intergovernmental Oceanographic Commission (2003).

[2]The freak wave event at Bondi, Sydney on 6 February 1938 may have been due to a small tsunami. Five people drowned.

[3]This value is a minimal value.

the global value (22.1% versus 66.0%). This fact not only reflects the low population density and distribution pattern in Australia, but also the fact that other hazards are more deadly than elsewhere in the world. Nowhere is this more apparent than with heat waves. As mentioned above, the death toll from heat waves globally has not been adequately assessed. A better job at assessment has been carried out in Australia, although the final total is still incomplete. Heat waves account for 41.3% of all deaths from natural disasters in Australia, whereas they have been responsible for only about 0.1% elsewhere. The importance of this hazard has decreased dramatically with the advent of air conditioning in many homes and public buildings.

The frequency of other climatic hazards will not decrease in the future. For example, category five tropical cyclones are more common in Australia. Despite Australia's scattered and isolated population centres in the tropics, such storms, when they affect settlements, have killed significant numbers of people (20.84% of all deaths due to hazards since European occupation). Similarly, the proportion of deaths for extra-tropical storms and fires is significantly higher in Australia than globally (7.46% versus 0.35% and 6.71% versus 0.02% respectively). Australia is either affected by numerous deadly hazards or has poor mitigation strategies in place to reduce death tolls from a range of hazards that are a minimal threat to life elsewhere in the world. If the historic distribution of deaths amongst hazards were to remain constant as Australia's population increases, then Australia may find itself with unacceptable loss of life compared to the rest of the world. Fortunately, death rates have decreased three orders of magnitude in the last two centuries in Australia from 100 to 0.05 people per 100,000 population per year between 1800 and 2000 (Blong, 2004).

Planning

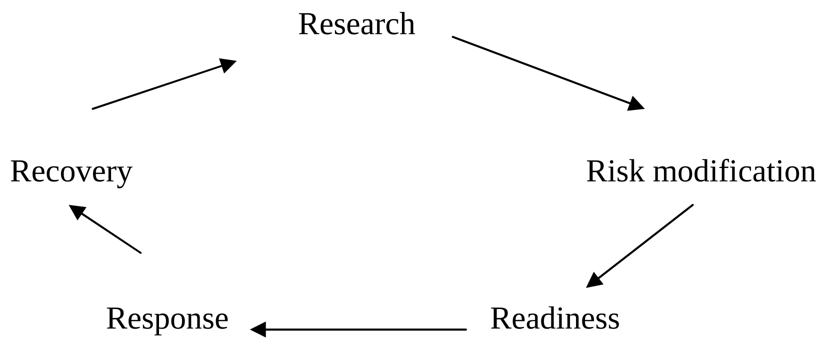
Planning is a major activity in many organisations with responsibility for managing urban and rural areas, infrastructure developments and protection of human life. This includes work on dealing with natural hazards. Outcomes include the Risk Management Chain (AS/NZS, 2004, Blong, 1995):

Analysis/Identification
↓
Assessment/Evaluation
↓
Treat/Transfer
↓
Mitigation/Reduction

Floodplain management planning has established that good plans should include four major objectives (NSW Government, 2005):

- Development compatible with flood hazard;
- Meeting future development needs;
- Data collection/flood study;
- Management study leading to management plan.

The Bush Fire Planning Cycle is considered to consist of 5 Rs (Ellis et al, 2004):



Each of these researchers emphasise that prevention is impossible. These examples, while very useful in their own right, illustrate one of the key issues in our current approaches to hazard management – it is a sectoral approach (flooding, fire, etc.). Much greater integration is required, as this will also contribute to a more accurate prioritising of risk, and will facilitate an examination of the consequences of combinations of hazards, e.g., cyclones can cause both wind and flood damage.

Planning, by its very nature, is meant to consider future situations. Forward projections are the key to better capacity to deal with the hazard when it occurs and to minimise the effort required in recovery. The requirement to examine fully the real costs of any new development, in terms not only of the actual establishment costs, but also in the longer term ‘maintenance’ is critical to decision-making with regard to new developments. More work is needed on investigation of pre- and post-hazard assessments of infrastructure development requirements.

Another issue needing careful consideration is the location of responsibility for many aspects of our lives within the different tiers of government. Overall, there appears to be a general devolution of regulation from higher tiers of government to lower, and even to individuals. With regard to hazard management, however, one question that arises is how much can be done at the LGA/household level? In general, the types of events that are usually designated as natural hazards are not compatible with the range of skills and resources available at the normal household level.

Much current, planning decision-making is also based to some degree on models. Different models are needed for the prediction of impacts/consequences of different hazard types. Uncertainty in future predictions is high as we have about 30-40 years of relevant data to start projecting for the next 200 years. There appears to be an urgent need for more cooperative research to develop hazard models. To complicate the situation, much of the current hazard/risk assessment is based on impacts on structures, not on full economic or social costs (see, e.g., Bureau of Transport Economics, 2001). It should also be noted that that there may be substantial differences between individual state responses and attitudes towards hazard mitigation in Australia.

Economic Issues

Much of the economic analysis of hazard impacts has been undertaken by the insurance industry. As pointed out by Graeme Adams (NRMA Insurance Group, pers. comm., 2005), insurance is a community service. Risk management is not the same as insurance as insurance is about predicting the costs of events. Two additional points of note are: a) that the impacts of decisions today will be with us for some time (e.g., 60% of NRMA insured homes are > 20 yrs old); and b) response to natural hazards represents about

50% of home insurance premiums (Graeme Adams, NRMA Insurance Group, pers. comm., 2005).

Most professionals working in the field of management and response to natural hazards indicate that more funds should be directed to mitigation and less to response (e.g., Major General H. Howard, Chair, NSW Emergency Management Committee, pers. comm., 2005). It has also been observed that funds injected post hazard can be beneficial, but there will be limitations on effectiveness as many of the people impacted by an extreme natural hazard are not operating in a normal way due to the trauma induced by the event. It is important, therefore, that decision-makers in hazard management put in place mechanisms to minimise the requirements for post-event massive injections of funds.

In terms of economic analyses, several authors (see, e.g., Ellis et al 2004; Bappenas, 2005) have noted that when assessing economic aspects of natural hazard management, there is a relatively good degree of confidence in property information because of major previous efforts to collect information in that sphere. Other features have not received the same degree of investigation, and as a result, the reliability of data and economic projections must be significantly lower.

Social Issues

When considering management of hazards and the risks that they represent, a number of key issues need consideration. These include communication, visualisation, and an understanding of human modes of thought. The communication and visualisation issues overlap significantly as preparation of good visual materials on risks, their origins, processes, and impacts provides the community and decision-makers with a way of better understanding what is happening. From the community perspective, this will assist members in their personal decision-making with regard to hazards, by improving their understanding of the risks involved. In the government sector, visualisation can help managers convince elected decision-makers on the benefits of a particular course of action. Given the recent advances in technology, it should be possible to generate effective visual means to assist in information transfer about hazards.

A number of significant questions need further research with regard to how humans deal with hazards. These include:

- How good are people's understanding of environmental risks generally and hazards specifically?
- What is the range of attitudes and practices in relation to environmental variability and uncertainty?
- Why do some issues capture attention more than others do?
- Why do people acquire insurance?
- What makes people act the way they do when a natural hazard occurs (e.g., why do some people attempt to ford swollen rivers when their lives are not in immediate danger)?
- How important is local knowledge in the effectiveness of hazard response managers?
- How much effort is being made to assist recovery managers to capture information about affected people, and what is done with the information collected?

Vulnerability and resilience are other personal attributes that need further investigation. Resilience as a human attribute cannot be overemphasised. Floods, fires, and cyclones have been shown to generate great community cohesion, and all over the world, people are amazed at the capacity of those impacted by severe events to recover in a reasonable period. In many cases, the community response to a disaster has been a learning exercise, both for the community members and their leaders. Our understanding of what motivates people to think the way they do about hazards has often focussed on post-incident recovery; we need to develop greater knowledge about people's thinking at times well away from any immediate hazard. As noted by Michael Muston (pers. comm., 2005) "We need to understand more about ourselves if we are to improve hazard planning."

In the period after a major natural hazard, emphasis is placed upon assisting people to deal with the situation they find themselves in, and to provide food, shelter, and comfort. Immediately following this most stressful period, much valuable information could be generated by systematic interview research with recovery managers, religious leaders and even some of the victims to capture anecdotes, narratives and stories from their experiences, so that we can garner a better understanding of how people have reacted in the circumstances. In this way, we can improve our understanding of human vulnerability and resilience in the face of natural hazards. Resilience here is not just the capacity to bounce back after a catastrophe, but to live with and cope with the variability/uncertainty.

A final point that should be researched is the identification of appropriate social indicators of the impacts of natural hazards. Once potential indicators have been developed, measurement techniques will also need investigation. A number of programs have been working on development of indicators (e.g., National State of the Environment Reporting), but, to date, no specific focus has been placed on the capacity to deal with natural hazards.

Conclusions

Natural hazards present a continuing threat to Australia and other countries worldwide. The threat from some hazards is expected to increase with the projected changes in global climate. The nature of the damage caused by natural disasters varies from country to country depending on population density and distribution, quality of infrastructure development and extent of economic development. The planning to address natural hazards has progressed in recent years, but in many countries continues to be somewhat sectoral, and much greater integration is required. This integration of planning will also contribute to improved prioritizing of risk and examination of combinations of hazards.

More funds need to be directed to mitigation of hazards and less to response, as this will minimize the requirements for post-event massive injections of funds. This will also lead to better planned and managed budgets, with all sectors of the community in a stronger position to deal with the hazards. A good deal more research is needed in addressing the social aspects of hazards and disaster impacts, especially into how humans deal with hazards. This includes investigations of how people view hazards and the associated risks, why they act the way they do in response to hazard warnings and events, and what are the best mechanisms to assist post-disaster recovery. In this way we can improve our understanding of human capacity to live with the uncertainty associated with natural hazards.

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