Solutions for the World's Biggest Problems

Costs and Benefits

Edited by

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CAMBRIDGE
UNIVERSITY PRESS

10 Vulnerability to Natural Disasters

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The challenge: global disaster losses are increasing

A wide range of datasets from around the world paint a consistent picture: disaster losses have been increasing rapidly in recent decades. Figure 10.1, produced by Munich Re, is illustrative of the more general conclusions.[1] It is important to recognize that disaster losses do not increase in every region at a constant rate. Some regions may see decreasing trends. Disaster losses typically come in discrete, large values and the trend record is driven by the increase in the costs of the largest disasters, such as hurricanes in the United States.

The economic costs of disasters have largely been driven by events in developed countries, due to their greater wealth. However, disasters in developing countries with smaller loss totals can have much larger effects as they may represent a much larger portion of a country's overall economic activity. Loss of life with respect to disasters has decreased significantly over the past century (Figure 10.2).[2] Much of the human toll of natural disasters occurs in developing countries. For example, the December 2005 Indian Ocean Tsunami killed more than 275,000 people across the region, while Hurricane Katrina, the deadliest natural disaster in the United States in many decades, killed fewer than 1,500 people.

The trend of increasing disaster losses has been driven largely by damage associated with earthquakes, floods, and storms.[3] Figure 10.3

[1] P. Höppe and R. A. Pielke, Jr. (eds.), 2006. Workshop on Climate Change and Disaster Losses: Understanding and Attributing Trends and Projections, Final Workshop Report. Hohenkammer, Germany, 25–26 May. http://sciencepolicy.colorado.edu/sparc/research/projects/extreme_events/munich_workshop/workshop_report.html

[2] www.em-dat.net/documents/figures/global_trends/nb_kill_global.jpg

[3] Red Cross World Disasters Report, 2000–2005. www.ifrc.org/publicat/catalog/autogen/4517.asp. The same is the case with respect to insured damages, see Association of British Insurers, 2005. www.abi.org.uk/Display/File/Child/552/Financial_Risks_of_Climate_Change.pdf

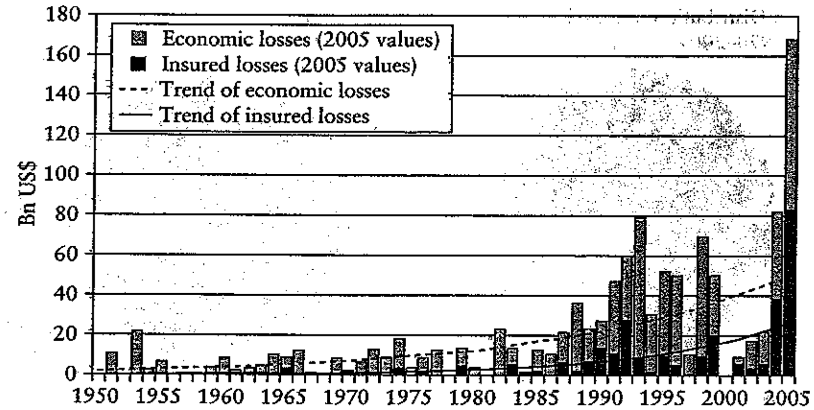


Figure 10.1. Global trend in the economic costs of disasters

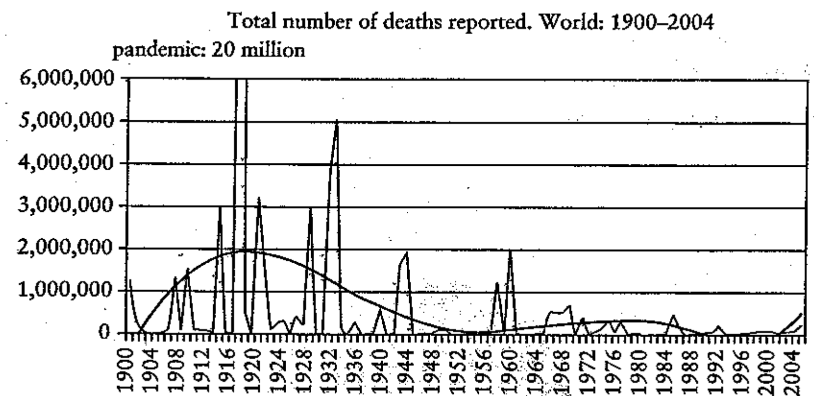


Figure 10.2. Global trend in loss of life disasters. *Source:* www.cred.be.

Equation for time-trend line: y=0,0002×6–0,0666×5+5,6467×4–94,031×3–8332,1×2+301972×–732338, R2=0,0824

Source: EM-DAT. The OFDA/CRED International Disaster Database, www.em-dat.net-Université Catholique de Louvain-Brussels-Belgium

indicates that the vast majority of weather-related losses (both insured and total) between 1970 and 2004 are the result of floods and storms.[4]

[4] Association of British Insurers, 2005. www.abi.org.uk/Display/File/Child/552/Financial_Risks_of_Climate_Change.pdf

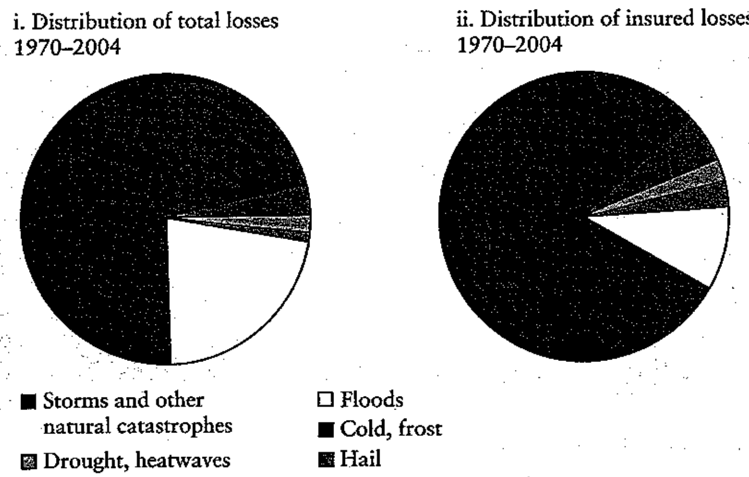


Figure 10.3 Total and insured costs of atmospheric-related disasters worldwide 1970–1994. *Source:* ABI, 2005.

Note: Since 1970 weather-related catastrophes resulted in about $345 bn in total damage, of which $300 bn was insured.

Source: Sigma Date. Swiss Re.

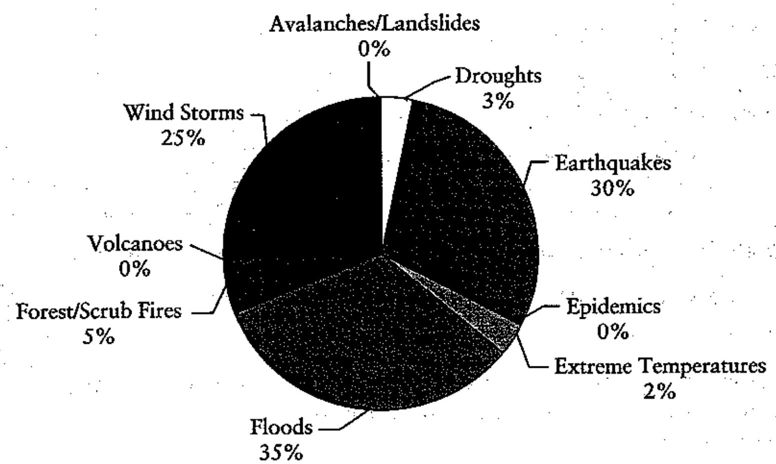
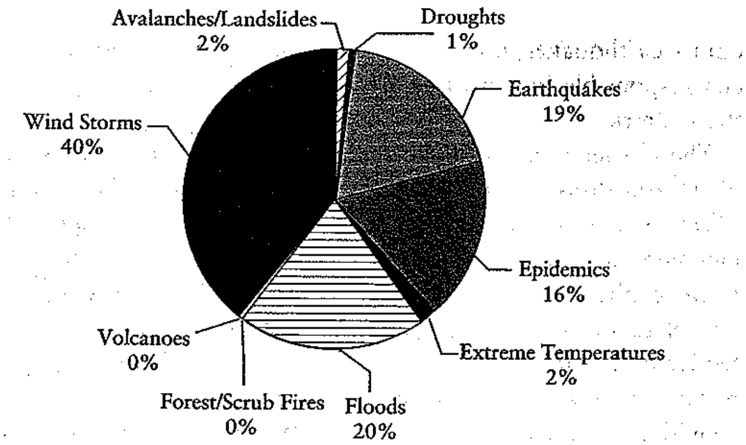


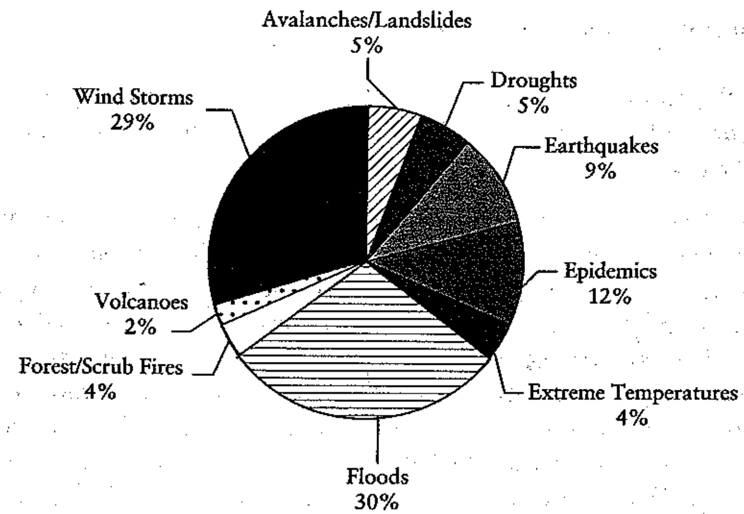
Figure 10.4a Total disaster losses in the 1990s by cause (IFRC, 2000)

Source: International Federation of Red Cross and Red Crescent Societies, 2000.



Figures 10.4b Total deaths in the 1990s by cause (IFRC, 2000)

Source: International Federation of Red Cross and Red Crescent Societies, 2000.



Figures 10.4c Total number of disasters in the 1990s by cause (IFRC, 2000)

Source: International Federation of Red Cross and Red Crescent Societies, 2000.

Figures 10.4a–c show the distribution of disasters by phenomena in terms of the total damage, loss of life, and number of disasters for the decade of the 1990s.[5] A consistent picture emerges from this

[5] Data from the Red Cross World Disasters Report, 2000. www.ifrc.org/publicat/catalog/autogen/4517.asp

data – earthquakes, floods, and windstorms are the primary phenomena responsible for disasters around the world according to each of these metrics.

The challenge facing policymakers in the face of increasing costs of natural disasters and a significant human toll is that many cost-effective solutions are understood and in-hand but remain unimplemented in developed and developing countries alike. A significant part of the challenge is to frame the natural disaster challenge properly as one of reducing vulnerability in exposed locations, rather than ineffective efforts to modulate events themselves. This challenge appears to have been well understood in the context of earthquakes, but less so with respect to atmospheric hazards. The challenge of reducing vulnerability is difficult, in part, because of the lack of understanding of the benefits and costs of improving resilience to extreme events.

Solutions, costs, and benefits

1. Properly frame the disaster challenge as one of reducing vulnerability, and not modulating extreme events via energy policies

The impacts of climate on society result from the interaction of a climate event and societal vulnerability to experiencing impacts. To understand this interaction requires a comprehensive perspective on the drivers of disaster losses. Such a perspective can be achieved via a sensitivity analysis of the integrated effects of drivers on loss totals (Pielke, in press). The goal of such a sensitivity analysis methodology is to examine various combinations of climate change and societal conditions (and the relationship of the two) to assess future economic impacts. Here we use the global economic impacts of tropical cyclones to illustrate the relative potential for different approaches to their mitigation. The goal of such a sensitivity analysis is not to perform a cost–benefit analysis of policy options. Nor is the goal to predict future impacts or to select arbitrarily among different scientific understandings. Rather the goal is to explore the potential effectiveness of alternative approaches to addressing future tropical cyclone losses in the context of a wide range of assumptions about the future.

In order to assess possible future damage due to tropical cyclones relative to today requires a number of assumptions. Pielke (in press) uses

Table 10.1. ***Assumptions of the sensitivity analysis in Pielke (in press) to 2050***

Societal change
Annual combined increase in wealth and population (based on expert projections):
2.5% and 4.7%
Climate change
Total increase in tropical cyclone intensity
18% (based on an expert elicitation): and 36% (twice highest value)
Relationship of climate change to damage
Damage varies as (based on a literature review):
3rd, 6th, 9th power of the storm intensity

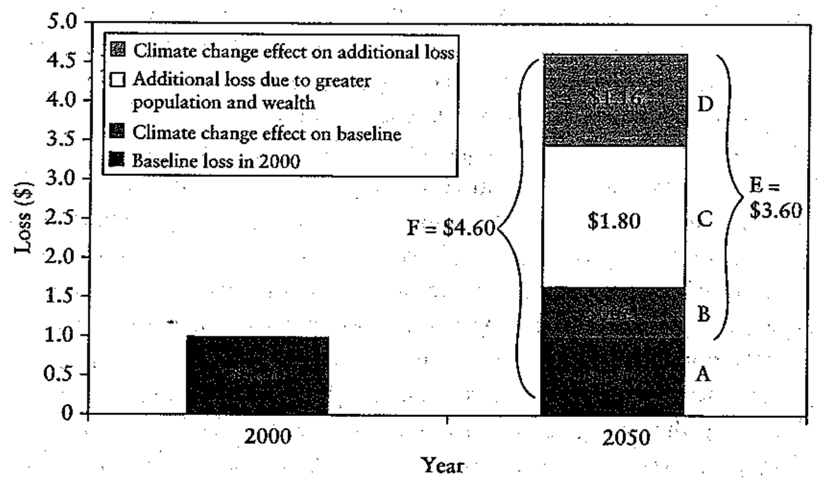


Figure 10.5. Display of values presented in Table 10.1

assumptions about societal change, climate change, and the relationship of climate change to damage. Table 10.1 summarizes these assumptions, which are documented in detail in Pielke (in press).[6] The various assumptions result in a two by two by three table of results,

[6] Note that the assumptions in Nordhaus (2006), cited by Stern, are within the bounds of the assumptions used by Pielke (in press).

which are intended to encompass the range of present expectations for the future.

The analysis begins with $1.00 in damages today and asks how that will increase by 2050. Table 10.1 and Figure 10.5 illustrate the analysis step by step by assuming that all tropical cyclones increase in intensity by 18 percent by 2050, population/wealth increases by 180 percent above today's levels, and damage is proportional to the cube of the intensity. From Table 10.1, of total costs of tropical cyclone damage in 2050, the fraction that can be addressed, in principle, if the intensity of tropical cyclones is intentionally modulated by stabilizing the climate such that intensities remain at their current levels is $1.80 (B + D), and the part that can be addressed, in principle, by reducing vulnerability is $4.60 (F). Assuming (unrealistically) (a) an instantaneous reduction of greenhouse gases to 2006 levels, and (b) no commitment to climate change due to past emissions, then at the theoretical limit, climate stabilization policies could reduce the increase in future damages from $3.60 to $1.80, that is, a 50 percent reduction.

A more realistic exercise would focus on the potential effectiveness of more realistic policy proposals. Here we illustrate the potential effectiveness of efforts to reduce greenhouse gas emissions with a hypothetical emissions reduction policy that leads to a 10 percent reduction in the projected increase in atmospheric greenhouse gas concentrations in 2050. Carbon dioxide concentrations are about 380 parts per million (ppm) in 2006, and assuming that carbon dioxide concentrations will be 500 ppm in 2050 under business as usual, a 10 percent reduction equates to a 12 ppm decrease (i.e., 10 percent = 12/[500 − 380]).[7] Assuming that greenhouse gas reductions have an instantaneous (i.e., contemporaneous with the reductions) and proportional (i.e., a 50 percent decrease in emissions decreases the projected increase in tropical cyclone intensity by 50 percent) effect on tropical cyclone intensity,[8] then policies that lead to a 10 percent decrease in atmospheric carbon dioxide concentrations in 2050 would (under the assumptions here) decrease the projected increase in hurricane intensities by 10 percent in 2050. The corresponding reduction in projected damages as described in Table 10.2 would be therefore about $0.21 (i.e., the increase in intensity would be reduced from 18 to 16.2 percent, see Table 10.3 details) reducing losses in 2050 from $4.60 to $4.39, a reduction of about 4.5 percent. Under these assumptions 100 percent success in implementation of a policy about five times more ambitious than Kyoto is the equivalent in its effect of about a 4.5 percent success rate in addressing ever-increasing vulnerability through efforts to build societal resilience.

Greenhouse gas mitigation may certainly be justified for other reasons, such as its cost-effectiveness, but if the case of tropical cyclones is representative of other disaster-related phenomena, then even if greenhouse gas mitigation polices were cost-free, vulnerability reduction would still have far greater potential to address the mounting toll of disaster losses because emissions reduction policies can address only a subset of the multiple causes of increasing losses. It should be underscored that this exercise was conducted using conservative projected societal changes (i.e., wealth, population) as well as unrealistic assumptions about climate behavior. Using larger societal changes and more realistic assumptions about climate science would result in a larger potential effectiveness ratio in favor of vulnerability reduction. Thus, the effectiveness of mitigation is certainly overstated in this analysis. These results are robust even under the full range of assumptions about changes in tropical cyclone intensities.

[7] By contrast under the Kyoto Protocol if fully and successfully implemented by 2012 (including participation of the United States and Australia), the corresponding carbon dioxide reduction would be 2 ppm by 2012 and, absent other policies, about 2.5 ppm by 2050.

[8] Of course, the real climate system does not work in this way, and the effects of mitigation on hurricane behavior remains poorly understood, but it is certainly less direct than the oversimplification offered here.

Table 10.2. ***An overview of the approach in Pielke (in press)***

Assumptions for 2050:
1. Change in tropical cyclone intensity = 18%
2. Change in population and wealth above present baseline = 180%
3. Damage function = cubic

A = tropical cyclone damages today = $1.00
B = increase in tropical cyclone damages in 2050 = 64%, i.e., damage increase = (($1.00 * 0.18))^3-$1.00 = $0.64
C = increase in tropical cyclone damage in 2050 = Today's damage + 180% increase = $1.00 * 1.80 = $1.80
D = combined effect of B and C = $1.80 * 0.64 = $1.16
E = Total increase in costs = B + C + D = $0.64 + $1.80 + $1.16 = $3.60
F = Total tropical cyclone economic damage in 2050 = A + E = $4.60

Table 10.3. ***Various scenarios for future economic losses from tropical cyclones in 2050, as a function of climate change, societal change, and windspeed-loss damage function***

10.3a. 18% increase in intensity by 2050

Societal change	180%	180%	180%	600%	600%	600%
Damage function	Cubic	6th power	9th power	Cubic	6th power	9th power
Climate	0.64	1.70	3.44	0.64	1.70	3.44
Society	1.80	1.80	1.80	6.00	6.00	6.00
Climate/Society	1.16	3.06	6.18	3.86	10.20	20.61
Total damage	4.60	7.56	12.42	11.50	18.90	31.05
Maximum effect of 10% reduction in 2050 CO_2 concentrations	0.21	0.67	1.60	0.52	1.66	4.01
Maximum mitigation	1.80	4.76	9.62	4.50	11.90	24.05
Maximum vulnerability reduction	4.60	7.56	12.42	11.50	18.90	31.05

10.3b. 36% increase in intensity by 2050

Societal change	180%	180%	180%	600%	600%	600%
Damage function	Cubic	6th power	9th power	Cubic	6th power	9th power
Climate	1.52	5.33	14.92	1.52	5.33	14.92
Society	1.80	1.80	1.80	6.00	6.00	6.00
Climate/Society	2.73	9.59	26.85	9.09	31.97	89.50
Total damage	7.04	17.72	44.57	17.61	44.29	111.42
Maximum effect of 10% reduction in 2050 CO_2 concentrations	0.54	2.63	9.56	1.36	6.59	23.90
Maximum mitigation	4.24	14.92	41.77	10.61	37.29	104.42
Maximum vulnerability reduction	7.04	17.72	44.57	17.61	44.29	111.42

For a range of assumptions about intensity change and changes in population/wealth, the growth of $1.00 in global tropical cyclone damage today into damage in 2050 using damage functions that assume damage as being proportional to the 3rd, 6th, and 9th powers of windspeed. The first column of Table 10.3a shows the values from Table 10.2. Values expressed in constant 2007 dollars.

Table 10.3 illustrates the results under a range of different assumptions. The column headings refer to the assumptions used in the calculations about increase in tropical cyclone intensity and growth in combined population and wealth. The first column of Table 10.3a provides the values presented in Table 10.2 and Figure 10.1. Within the table the values presented reflect three different damage functions.

Under these various assumptions, the largest *maximum potential effectiveness* of a 10 percent reduction in the projected increase in greenhouse gas concentrations by 2050 for reducing future global tropical cyclone damage is far less than the maximum potential effectiveness of adaptation (i.e., reducing the vulnerability of people and property) by a ratio of about 8 to 1 under the maximum change in intensity resulting from the expert elicitation and about 5 to 1 when arbitrarily doubling the maximum change in intensity. Alternatively, under the assumptions most favorable to vulnerability reduction, the ratios are 22 to 1 and 13 to 1.

Table 10.3 also shows the potential effectiveness of instantaneous climate stabilization at 2006 values. Under no scenario does this form of mitigation result in a greater potential effectiveness than vulnerability reduction. It is therefore appropriate to conclude that vulnerability reduction is potentially more effective under any theoretically possible mitigation scenario. Under any plausible mitigation scenario, vulnerability reduction vastly exceeds mitigation in terms of its potential effectiveness. These conclusions are qualitatively insensitive to the magnitude of the projected increase in tropical cyclone intensity or population scenarios. The longer the timescale, the greater the role of the societal factors, assuming continued growth in wealth and/or population.

To emphasize, the analysis presented here should not be interpreted as an argument against mitigation of greenhouse gases. And there is no suggestion here that human-caused climate change is not real or should not be of concern. Instead, this simple analysis under the most favorable assumptions for mitigation indicates that in the coming decades any realistically achievable mitigation policies can have at best only a very small and perhaps imperceptible effect on global tropical cyclone damage, whatever the costs of those policies might happen to be. This reality explains why adaptation necessarily must be at the center of climate policy discussions and must be viewed as a complement to mitigation policies, rather than simply as the costs of failed mitigation, as suggested, for example, by the Stern Review on the Economics of

Climate Change. It also helps to explain why mitigation policies in the short term necessarily must be focused on their non-climate benefits.

Most importantly these results show how misleading it is to use tropical cyclone damage as a reason for greenhouse gas mitigation when other actions have far more potential effectiveness. The images of storm-spawned death and destruction are no doubt compelling, but it is misleading or disingenuous to suggest that energy policies can have an appreciable effect on future damages. The only way to arrive at tropical cyclone damages that exceed the societal factors is to hold societal change constant and focus only on the climate component, which is in fact what some studies have done in the past. Climate change is real and policy action on mitigation makes sense, but when compared with available alternatives for addressing the escalating costs of tropical cyclones. Those interested in honest advocacy and effective policy should keep these issues separate.

2. *There is a pressing need for improved information on the costs and benefits of vulnerability reduction policies and practices, the impacts of natural disasters, as well as the relative vulnerability of different countries and communities, in order to prioritize disaster mitigation projects and programs more effectively*

If reducing vulnerability is preferred to efforts to modulate extreme events through energy policies, then what are specific examples of beneficial vulnerability reduction policies?

Formal evaluation of specific options for reducing disaster vulnerability remains difficult because "natural hazards and related vulnerability are rarely considered in the design and appraisal of development projects. Similarly, monitoring and evaluation are still relatively neglected in disaster reduction, especially where impact evaluation is concerned."[9] There are a number of benefit–cost estimates that circulate in the disaster community that suggest that "disaster mitigation pays," typically by a ratio of 3 to 1 or higher. Of such estimates Benson and Twigg (2004, pp. 13–14)[10] write:

[9] C. Benson and J. Twigg, 2004. 'Measuring Mitigation': Methodologies for assessing natural hazard risks and the net benefits of mitigation – A scoping study, ProVention Consortium. www.proventionconsortium.org/themes/default/pdfs/MM_scoping_study.pdf. [10] Ibid.

> However, there is surprisingly little evidence in support of many broad-brush statements. Detailed underlying calculations are not available, suggesting that they may, in fact, be no more than "back-of the-envelope" – if informed – estimates. Even if they are based on more extensive calculations, the fact that the workings underlying them are not readily available can cast doubts on their legitimacy, particularly if figures involve some valuation of non-tangibles. Of course, financial analysis of loss and the cost of investments needed to avoid loss may not be sufficient to ensure greater attention to natural hazard risk, as demonstrated from experience elsewhere (for instance, in relation to disease, water pollution and illiteracy). But proof of net financial benefits is almost undoubtedly a first, very necessary step in making a case for the importance of analysing hazard-related risks.

The lack of a well-developed body of cost–benefit analyses of the value of disaster mitigation sets the stage for a chicken-and-egg problem. Because such studies do not exist, it can be difficult to compare projects or policies focused on disaster mitigation with other sorts of development policies; hence disaster mitigation policies are at risk of being overlooked in any systematic comparison of costs and benefits across different policy alternatives. But if such projects are overlooked, then there is less incentive to call for and support rigorous cost–benefit studies. One consequence of this dynamic is that funds for disaster relief in the aftermath of a horrific disaster are, in many cases, easier to secure than funds for long-term reduction of vulnerability to disasters, which may have supported efforts that would have reduced the need for post-disaster relief. This vicious cycle is well appreciated by observers of disaster policy but remains entrenched.[11]

Thus, one recommendation is for increasing attention to the need for rigorous cost–benefit analyses of disaster mitigation policy alternatives and practices. To put this another way, irrespective of how such studies turn out (in terms of relative costs and benefits), there is a substantial benefit to decision making related to disasters to be gained from a more rigorous understanding of the value of disaster mitigation. More fundamentally, there is also a pressing need for more rigorous information on the impacts of disasters,[12] as well as indicators of relative

[11] B. Wisner, P. Blaikie, T. Cannon, and I. Davis, 2004, *At Risk: Natural Hazards, People's Vulnerability and Disasters*. Wiltshire: Routledge.

[12] For example, C. Benson and E. Clay, 2004, *Understanding the Economic and Financial Impacts of Natural Disasters*. Disaster Risk Management Series No.4.

vulnerability[13] in order to help prioritize disaster mitigation investments. Even in the United States and Europe, where response to disasters is generally quite successful as measured by lives lost and community recovery from disasters, there is exceedingly little information available on the costs and benefits of disaster mitigation, as well as the role of government investments in disasters on outcomes.[14]

3. *Even in the absence of well-developed studies of the costs and benefits of disaster mitigation, there are many proven and promising options for cost-effective disaster mitigation*

Actions to reduce the impacts of natural disasters are many and varied around the world. Some of these actions are developed in the longer term, such as building codes, evacuation plans, and emergency response plans. Some of these longer-term plans require additional action in the short term in the face of an impending threat, such as an order of evacuation.

In some instances not only has a cost–benefit analysis not been attempted, but neither has a more general risk assessment. Hurricane evacuation in the United States is an example of such a situation. Hurricane forecasts of storm tracks have improved steadily over the past three decades or so, yet at the same time the area of coastline warned per storm has increased over the same time period. This suggests that decision makers (including forecasters and emergency managers) have possibly become more risk-averse over time and have used advances in the science of forecasting to reduce the chances of leaving part of the population unwarned. Of course, such strategies have costs, in the form of a greater number of people warned unnecessarily. But to date there has been little demand for the quantification of the costs, benefits, and risks associated with different approaches to the challenge of hurricane evacuation in the face of uncertainty.[15] Arguably, the case of hurricane

Footnote 12 (*cont.*)
Washington DC: World Bank. www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000012009_20040420135752

13 UNDRO, 1990, *Preliminary Study on the Identification of Disaster-Prone Countries Based on Economic Impact.* New York/Geneva: United Nations Disaster Relief Organization.

14 C. Meade and M. Abbott, 2003, *Assessing Federal Research and Development for Hazard Loss Reduction*, RAND, Santa Monica, CA.

15 R. A. Pielke, Jr., 1999, Hurricane Forecasting. *Science*, 284, 1123.

evacuation is representative of the broader challenges of evaluating existing disaster mitigation policies in terms of their costs, benefits, and risks.

There are new and innovative policy options that have been proposed for disaster mitigation that will likely stimulate demand for greater attention to costs and benefits. Among these are the securitization of risk through financial products such as catastrophe bonds and derivatives[16] and the provision of micro-finance[17] in developing countries as a tool of disaster recovery in ways that reduce long-term vulnerabilities. One example is a reinsurance contract developed by Axa Re to underwrite the possibility of drought in Ethiopia for the World Food Programme.[18] The way that the program works is that Axa Re and the World Food Programme agree upon a specific climate metric that can be objectively measured, such as seasonal rainfall total in a particular region. Such measures should ideally be closely correlated with the impact of concern, in this case famine. The World Food Programme pays a premium calculated on the expected probability of the anomalous rainfall. If the rainfall exceeds the threshold, then Axa Re keeps the premium, and if it falls below the threshold, Axa Re pays out on the contract, freeing up resources for famine relief. In this manner risks can be shared and the World Food Programme can free resources for other activities knowing that it has hedged its risks. This program serves as a model that might be applied in other areas, tapping the risk sharing and liquidity of financial markets to hedge against the uncertainty of negative outcomes. Such policies are not widespread, however, and they have not been subject to rigorous evaluation of costs and benefits. Nonetheless, they have strong support among many disaster experts.

4. *There are large ancillary benefits associated with more general progress with respect to human development and poverty reduction associated with vulnerability reduction related to natural disasters*

Simply because the financial costs of natural disasters are increasing does not necessarily reflect an underlying policy problem, or if a

16 www.axa.com/lib/axa/uploads/cpsocietes/2006/United_nations_PR_20060306.pdf

17 www.proventionconsortium.org/themes/default/pdfs/microfin_guidebook.pdf

18 www.wfp.org/english/?ModuleID=137&Key=2030

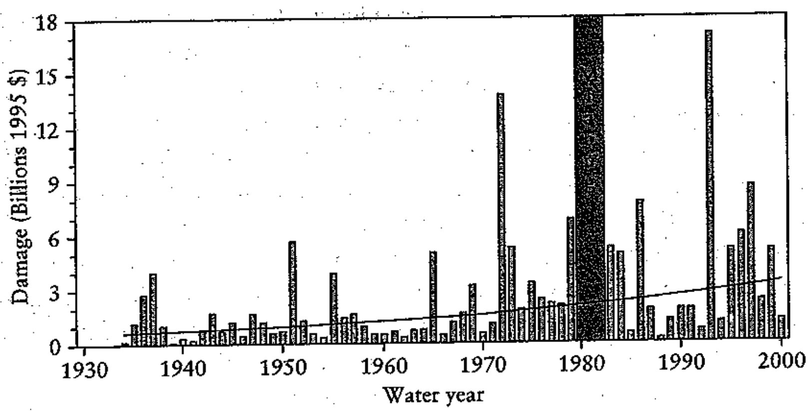


Figure 10.6a. Trends in US flood damage, 1934–2000, adjusted for inflation.

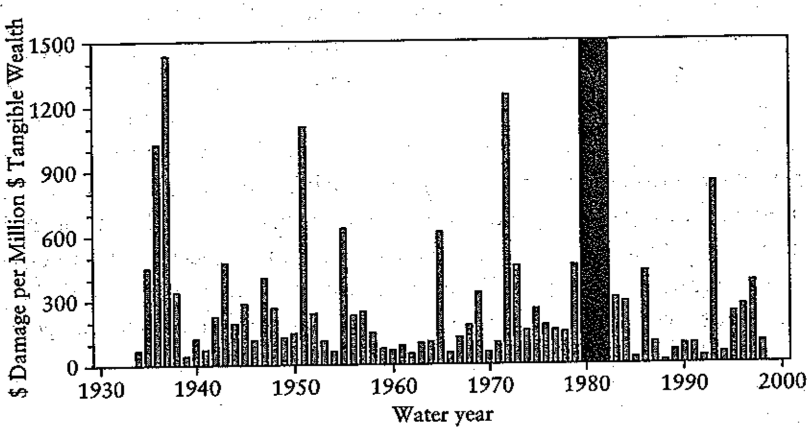


Figure 10.6b. Trends in US flood damage per unit of wealth, 1934–1998.

problem does exist, the magnitude of the challenge. The case of flood damage in the United States provides some insights to this perhaps counterintuitive situation. Figures 10.6a and 10.6b show two different perspectives on flood damage in the United States from 1934 to 2000. In Figure 10.6a the data is simply adjusted for inflation, showing a clear upward trend in damage. However, Figure 10.6b shows the same data expressed in terms of per-unit-national-wealth, and shows no trend.

This figure provides some evidence that overall growth in national wealth is an important factor in how we think about the impacts of natural disasters. Although damage may be rising, this is due to the fact that there is more to be damaged, and floods may in some cases have a decreasing effect on the economy even as losses increase. Of course, disaster mitigation policies likely have played some role in shaping trends in various metrics of damage.

Such an analysis is significant in particular for thinking about the impacts of disasters on developing countries, where disasters may be smaller in absolute terms than in developed countries, but far greater as a fraction of national economic activity. This suggests that there are considerable ancillary benefits to development and economic growth, particularly if done in a manner cognizant with disaster risks. Hazards scholar Dennis Mileti has frequently called for disaster mitigation to occupy a more central role in all of development planning, rather than as a separate category of policy activity.[19]

Conclusions

Once we understand that the chief reason for increasing disaster losses is the role of demographics in making a country vulnerable to disaster, we can better focus responses on managing vulnerability. But the narrow focus of the climate debate to date on emissions reductions has worked against a clear focus on vulnerability. The UN Framework Convention, for example, has refused to fund disaster preparedness efforts unless states could demonstrate exactly how the disasters they feared were linked to climate change. Consider, too, the amount spent on scientific research. According to a recent RAND study, US funding for disaster loss-reduction research in 2003 amounted to about $127 million – only 7 percent of the amount invested in climate-change research for that year.

This is not to say that many thousands of people and hundreds of organizations worldwide are not productively confronting disaster vulnerability, but their efforts do not begin to address the magnitude of the problem. Thousands of participants from most of the world's nations, along with scientists and political advocates, have come together every year since 1995 to work toward concerted international

[19] D. Mileti, 1999, *Disasters by Design*. Washington, DC: Joseph Henry Press.

action on climate change. But, when the UN World Conference on Disaster Reduction met in January 2005, it was the first such meeting in more than a decade.

Yet we know that effective action is possible to reduce disaster losses even in the face of poverty and dense population. During the 2004 hurricane season, Haiti and the Dominican Republic, both on the island of Hispaniola, provided a powerful lesson in this regard. As Julia Taft of the UN Development Program explained: "In the Dominican Republic, which has invested in hurricane shelters and emergency evacuation networks, the death toll was fewer than ten, as compared to an estimated two thousand in Haiti . . . Haitians were a hundred times more likely to die in an equivalent storm than Dominicans." Most tools needed to reduce disaster vulnerability already exist, such as risk assessment techniques, better building codes and code enforcement, land-use standards, and emergency-preparedness plans. The question is: Why is disaster vulnerability so low on the list of global development priorities? Says Brian Tucker, president of GeoHazards International: "The most serious flaw in our current efforts is the lack of a globally accepted standard of acceptable disaster vulnerability, and an action plan to put every country on course to achieve this standard. Then we would have a means to measure progress and to make it clear which countries are doing well and which are not. We need a natural disaster equivalent to the Kyoto Protocol."[20]

In principle, fruitful action on both climate change and disasters should proceed simultaneously. In practice, this will not happen until the issues of climate change and disaster vulnerability are clearly separated in the eyes of the media, the public, environmental activists, scientists, and policymakers. The accompanying text box presents twenty consensus recommendations at a workshop organized by Munich Re in spring 2006 on disasters and climate change. There are good reasons for more substantial action on energy policies, particularly in the United States; and there are good reasons for concern about the growing toll of disaster losses around the world. But suggestions that the escalating disaster losses should motivate action on energy policy simply cannot lead to an effective approach to disaster management.

[20] D. Sarewitz, and R. A. Pielke, Jr., 2005, Rising Tide, *The New Republic*, January 6.

Text Box: Consensus (unanimous) statements of the Hohenkammer workshop (Höppe and Pielke 2006):[21]

1. Climate change is real, and has a significant human component related to greenhouse gases.
2. Direct economic losses of global disasters have increased in recent decades with particularly large increases since the 1980s.
3. The increases in disaster losses primarily result from weather-related events, in particular storms and floods.
4. Climate change and variability are factors which influence trends in disasters.
5. Although there are peer-reviewed papers indicating trends in storms and floods there is still scientific debate over the attribution to anthropogenic climate change or natural climate variability. There is also concern over geophysical data quality.
6. IPCC (2001) did not achieve detection and attribution of trends in extreme events at the global level.
7. High-quality long-term disaster loss records exist, some of which are suitable for research purposes, such as to identify the effects of climate and/or climate change on the loss records.
8. Analyses of long-term records of disaster losses indicate that societal change and economic development are the principal factors responsible for the documented increasing losses to date.
9. The vulnerability of communities to natural disasters is determined by their economic development and other social characteristics.
10. There is evidence that changing patterns of extreme events are drivers for recent increases in global losses.
11. Because of issues related to data quality, the stochastic nature of extreme event impacts, length of time series, and various societal factors present in the disaster loss record, it is still not possible to determine the portion of the increase in damages that might be attributed to climate change due to GHG emissions
12. For future decades the IPCC (2001) expects increases in the occurrence and/or intensity of some extreme events as a result

of anthropogenic climate change. Such increases will further increase losses in the absence of disaster reduction measures.

13. In the near future the quantitative link (attribution) of trends in storm and flood losses to climate changes related to GHG emissions is unlikely to be answered unequivocally.

Policy implications identified by the workshop participants

14. Adaptation to extreme weather events should play a central role in reducing societal vulnerabilities to climate and climate change.
15. Mitigation of GHG emissions should also play a central role in response to anthropogenic climate change, though it does not have an effect for several decades on the hazard risk.
16. We recommend further research on different combinations of adaptation and mitigation policies.
17. We recommend the creation of an open-source disaster database according to agreed-upon standards.
18. In addition to fundamental research on climate, research priorities should consider needs of decision makers in areas related to both adaptation and mitigation.
19. For improved understanding of loss trends, there is a need to continue to collect and improve long-term and homogenous datasets related to both climate parameters and disaster losses.
20. The community needs to agree upon peer-reviewed procedures for normalizing economic loss data.

[21] P. Höppe and R. Pielke, Jr., 2006, *Workshop on Climate Change and Disaster Losses.*

PART III

Governance