FOCUS ON GREEN BUILDING

Weather-Related Losses in the Built Environment: Societal Change and Climate Change

BY ROGER PIELKE, JR.

INTRODUCTION

IT IS NOW COMMON IN POLICY DEBATES to invoke human-caused climate change as a possible cause of economic, public health and catastrophic property losses. A close look at climate change issues and the built environment, including both the larger scale planning issues and the actual set of current and future building assets, shows some interesting and perhaps surprising results. This discussion revolves around the simple question: what are the primary mechanisms by which we can mitigate, adapt to or possibly prevent global losses associated with the built environment? Our research on the possible links between climate change, as it affects hurricane frequency and intensity, and the economic damages of landfalling storms suggests that the debate over the effects of greenhouse gas emissions and storm behavior may be largely irrelevant to governments and insurance companies that bear the losses.

DISASTERS AND CLIMATE CHANGE

Every time a disaster occurs, it isn't long before someone raises the specter of human-caused climate change and its possible role in the event. Some of the more enthusiastic participants in the public debate over climate change have no qualms about linking every extreme event to climate change, sometimes with qualifications, but sometimes not. Others, especially those wanting to go slow on taking action, emphasize that policies require solid cost/benefit analyses buttressed by a full acknowledgement of the uncertainties present in the scientific, economic and technical issues.

A wide range of data sets and analyses from around the world paints a consistent picture: direct economic losses (adjusted for inflation only) have been on the rise in recent decades around the world (Figure 1). Disaster losses have not increased in every region at a constant rate. Some regions, like Australia, have seen decreasing trends.

About the Author

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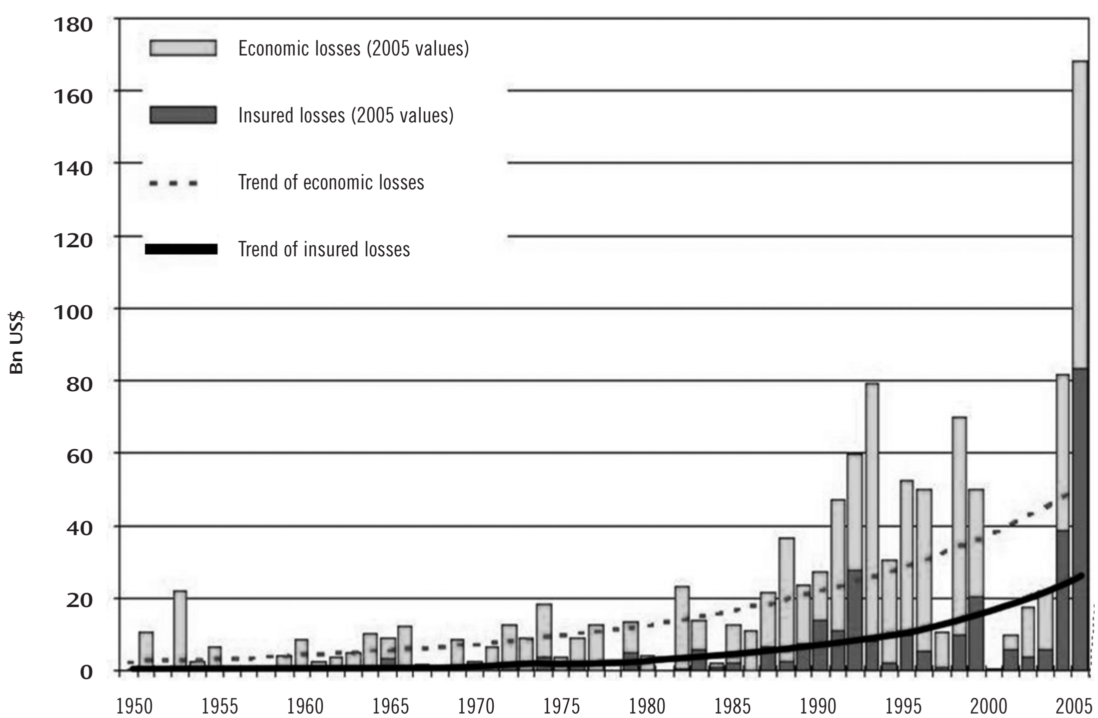
Since the 1980s there has been a particularly large increase in the frequency and magnitude of disasters. The trend in the global numbers of great natural catastrophes since 1950 shows a steep increase in the largest weather-related disasters—from one event in the 1950s to five in recent decades, while geophysical disasters (earthquakes, tsunamis, volcano eruptions) have increased from one to less than two in the same time.[1] Weather-related disasters are therefore the major contributor to increasing losses due to natural disasters.

Climate change and variability are important factors that shape patterns and magnitudes of disaster losses. For example, even after adjusting for changes in inflation, wealth and population in the 1970s and 1980s, the United States experienced approximately $41 billion and $36 billion in hurricane losses, respectively. By contrast, the 1990s and 2000s (through 2005) saw $87 billion and $167 billion (updated data from *Pielke and Landse*a 1998[2]). The 1970s and 1980s were characterized by below-average hurricane activity and storm landfalls, whereas the period since 1995 has seen very active seasons and correspondingly more landfalls, particularly in 2004 and 2005, and now 2008. Similarly in Australia, 13 tropical cyclones made landfall along its east coast from 1966–1975, whereas seven made landfall from 1996–2005.[3] Similar results have been found for floods and other weather events in different regions around the world.

Attribution of a trend to anthropogenic climate change is difficult, according to the Intergovernmental Panel on Climate Change (IPCC). Insufficient record lengths are sometimes the case with respect to climate events, consequently excluding long-term natural variability as causes of observed trends. Other problems arise from inhomogeneous data sets. For instance, hurricane wind speeds were measured by empirical observation of wave characteristics from ships, by using pressure-wind relationships, by measuring velocities of airborne sondes dropped from aircrafts or by Doppler radar techniques. Changing river

Figure 1

Global Disaster Losses, 1950–2005



© 2006 *NatCatSERVICE, Geo Risk Research, Munich, Re* discharges over time might depend on changing land use patterns or changing hydrodynamic characteristics of rivers brought about by hydro-engineering construction work. Since Intergovernmental Panel on Climate Change (IPCC) 2001, additional research results have been published on the changing nature of extremes, and the IPCC reported again on this subject in 2007.

THE ROLE OF SOCIETAL CHANGE IN DISASTER LOSSES

Regardless of what is found with respect to trends in weather extremes, *societal change and economic development* are the principal factors responsible for the documented increasing losses to date. This cannot be stressed enough. *What we build, how we build and where we build are the most important factors in shaping the losses—economic and otherwise—associated with future disasters.* Such results have been found looking at disasters globally and in specific regions and for specific phenomena, such U.S. tornados, hurricanes and floods; Australian weather-related hazards; floods in the United Kingdom; Indian tropical cyclones; Chinese floods and storms; Latin American floods and storms and Caribbean hurricanes.[4]

Societal changes that lead to increasing losses include population growth in exposed locations, increasing wealth at risk to loss, and policies that lead to increased vulnerabilities. Changes in various societal factors vary according to context. For instance, China's economy has grown as fast as 8.5 percent annually, and regions such as Florida in the U.S. have seen population growth at a rate far greater than the U.S. national average.

Figure 2 shows population growth in Miami-Dade County, Florida, from 1900–2000, as well as the number and intensity of storms during the same period. Since 1970, Miami has experienced only one major (Category 3 storm), a rate of one every 38 years, but before 1970, it experienced 10 during a 70-year period, or a rate of one every seven years. In the simplest terms, the property value vulnerable to loss has grown considerably in the last 75 years.

Miami in 1930 is a far cry from Miami today. Given this change in land use and population increase, it is not at all surprising that hurricanes that hit Miami now cause losses that are greater in magnitude.

The illustration of Miami-Dade County is representative of a broader national pattern. Losses during the 1970s through the early 2000s, even with hurricanes Hugo (1989) and Andrew (1992), were far less than those that would have been experienced earlier in the 20th century, considering contemporary levels of development. This suggests that regardless of the nature of changes in the climatology of hurricanes, continued development and accumulation of wealth in vulnerable locations will inevitably lead to greater losses, particularly if storm frequencies exceed those of the less active period of the 1970s–1990s.

Figure 3 shows clearly that land development and societal changes in demographics will be a far more potent contributor to insurance losses than climate change.[5]

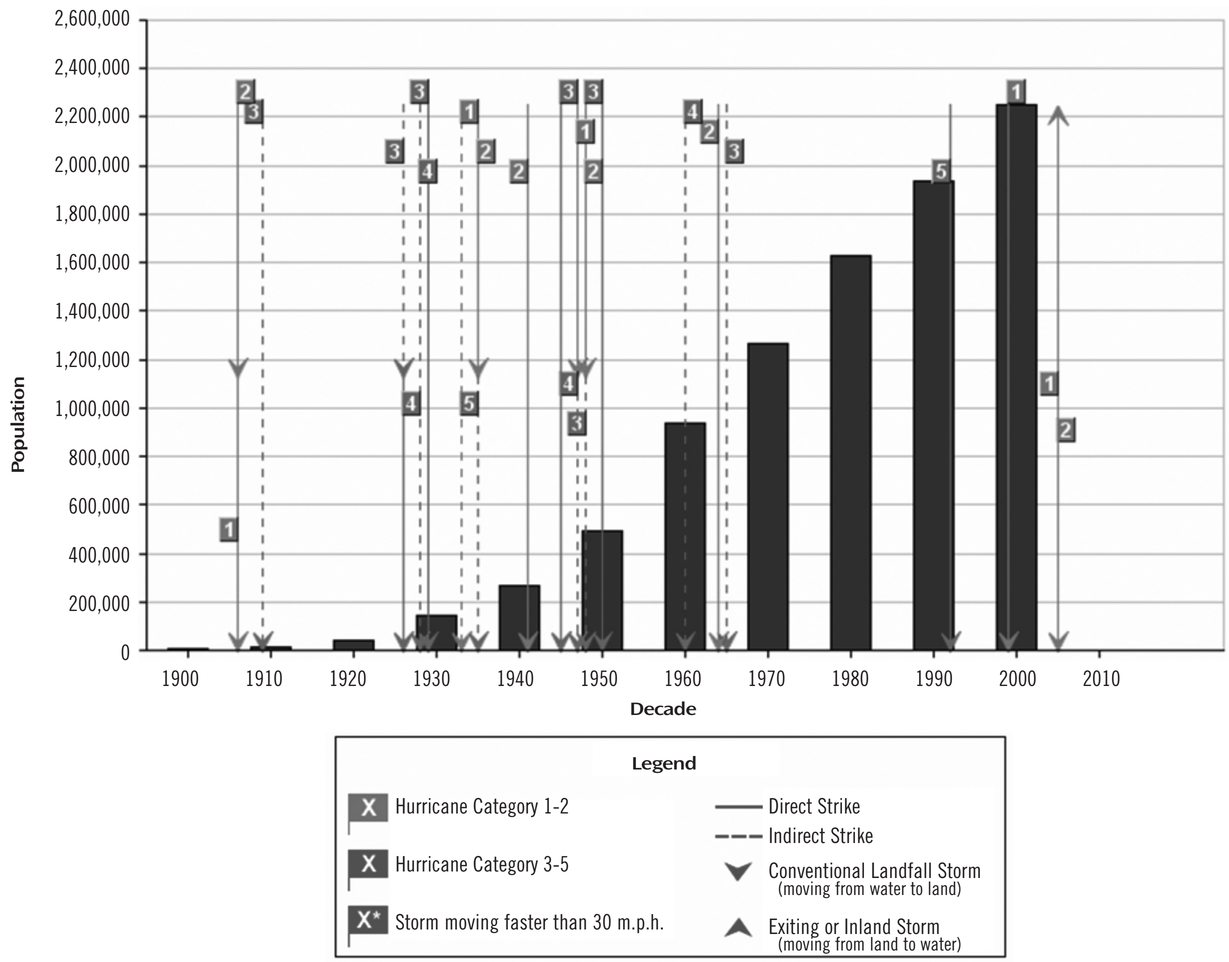
The impact of extreme weather events varies between the developing and the developed world. While the developed world sees the highest absolute direct economic losses from weather extremes, the largest numbers of casualties and people affected occur in poorer communities. Unsustainable exploitation of natural resources in many regions in the world may exacerbate the impact of natural disasters (for instance, deforestation may increase the frequency and intensity of floods). The relative role of disaster mitigation activities in addressing disaster losses remains poorly documented and understood. Recent studies comparing relevant cost-benefit analyses conclude, in spite of the methodological challenges, that the benefit-to-cost ratio of investments in disaster mitigation are about 2–4.[6]

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 greenhouse gas emissions. Long-time series disaster loss data for some regions are either unavailable or of poor quality for various phenomena, particularly before the 1980s (e.g., for China) and the 1970s (Australia, Canada, Caribbean, Central America, China, Europe, India, Japan, Korea, and U.S.). The historical loss record is strongly influenced by a small number of large events such as Hurricane Katrina, which accounted for about 50 percent of global storm and flood losses in 2005. Thus, there is a strong element of chance in short-term records.

The quantitative attribution of trends in storm and flood losses due to greenhouse gas emissions is unlikely to be answered unequivocally in the near future because the problems described above are expected to persist. As a consequence, we urge decision-makers not to expect

Figure 2

Hurricane Strikes vs. Population for Miami-Dade County, Florida



Hurricane Strike Data: National Hurricane Center

Population Data: U.S. Census Bureau

NOTE: There may be discrepancies between the strike data shown in this chart and the HURDAT strike data used in the Historical Hurricanes Tracks Tool.

The National Hurricane Center is currently updating the strike data used for these charts.

For more information visit http://www.aomi.nosa .gov/hrd/data_sub/re_anal.html.

NOTE: Population data is current as of 2000 U.S. Census. X-axis on graphs depict years through 2010 to illustrate storms that have occurred from 2000-2006.

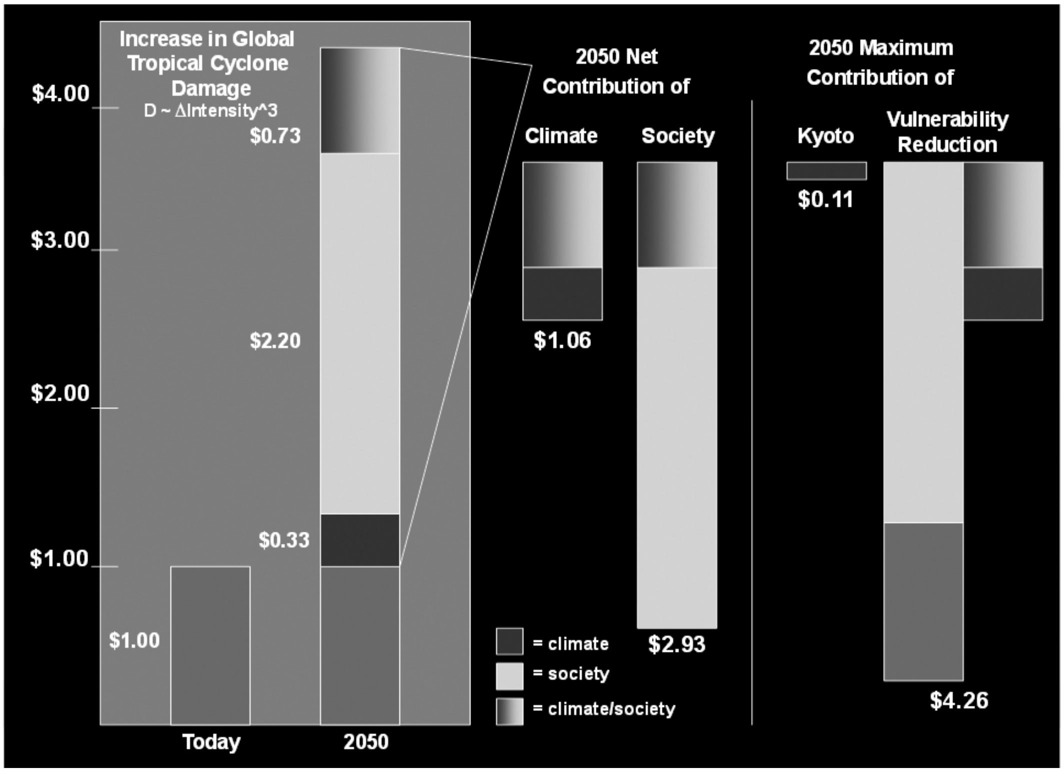
Source: National Oceanic and Atmospheric Administration

definitive answers to questions about the linkage of growing disaster losses and anthropogenic climate change, as this will remain an important area of study for years to come. Such uncertainty need not preclude proactive decision-making. Adaptation to extreme weather events should play a central role in reducing societal vulnerabilities to climate and climate change. There are three main reasons for this conclusion:

1. Adaptation to climate variability and extremes has always been necessary, and future adaptation can be most effectively designed if it continues and builds upon experience. Declining global and U.S. trends over the long term in mortality and morbidity (or injury) rates due to various extreme weather events suggest that adaptation might successfully aid

Figure 3

Future Damages Attributable to Climate and Societal Choices Until 2050



Source: Pielke (2007)

in containing economic losses. Mitigation of greenhouse gas emissions will take a substantial amount of time to become effective, and in the meantime, adaptation will become increasingly necessary. The nature of a policy response to climate change will differ in adaptation as opposed to arresting or reversing this change. Therefore, more and more pressure may be brought to bear on the regulation of real estate development to further the goals of climate change mitigation;

2. There is a current adaptation deficit, and practices of maladaptation and unsustainable development are serving to increase vulnerability in many places. In particular, the insufficient pricing of adaptation and its benefits in terms of goods and services preserved in the face of changes and extreme losses leads to inappropriate valuation of risk-reducing measures in investment and financial calculations at both the public and private sector levels, particularly in developing countries;

3. In all socio-economic sectors, as effects of climate variability and extremes occur, adaptation policies and measures are used to help reduce exposure and effects. Climate change, regardless of cause, may require a broader perspective in adaptive capacity than has been the case in the past. Generally these activities are in the domain of specialized professionals such as agronomists for agriculture, engineers and hydro-meteorologists for water management, irrigation, flood control, etc.; structural and design engineers for infrastructure, buildings, etc.; and public health officials for infectious and vector-borne diseases. The work of these professionals is not explicitly referred to as adaptation, but may be described as plant breeding and

selection, flood control or flood damage reduction, and so forth. The current practices of adaptation are not sufficient to prevent the growth of losses resulting from climate change, variability and extremes.

Decision-making processes that are dependent upon unequivocal quantitative linkages between disaster losses and anthropogenic climate change should be reconsidered in the context of this continuing uncertainty. Decision-makers might embrace more fully an alternative approach to decision-making, e.g., one based on no-regrets vulnerability reduction or proactive risk management.

Mitigation of greenhouse gas emissions also should play a central role in response to anthropogenic climate change, though it cannot decrease the hazard risk for several (or more) decades. Carbon dioxide contributes most to the anthropogenic greenhouse effect and is primarily released by burning fossil fuels like coal, oil or natural gas.[7] Once released into the atmosphere, carbon dioxide has an average residence time in the atmosphere of up to 200 years. This means that emission reductions of carbon dioxide cannot reduce its concentration in the short term and therefore cannot result in immediate changes to the climate system. Emission reductions, however, influence the future levels of carbon dioxide in the atmosphere and thus the further increase in global temperatures and the potential for more frequent and intense extreme events. Emission reductions are likely to reduce the risk of abrupt climate changes and climate processes that could become irreversible.

STRATEGIES AFFECTING REAL ESTATE

The major factors underlying increasing disaster losses are already apparent. Further research in this area will be useful, but it will not change the conclusion that effective policies must focus on both adaptation as well as mitigation. Real estate adaptation strategies to reduce losses and decrease vulnerability involve two types of options. One includes increased costs related to acceptance of more disaster-sensitive building codes (which would be passed on to the consumer) or pricing property insurance premiums to fully account for the increased risks on coastal developments that do not provide for disaster-resistant building techniques. Other options, perhaps more politically challenging to implement, include regulation of real estate to prevent new projects in vulnerable areas or creating taxing schemes to force the construction of disaste-resistant developments. The latter option would simply mean less development in vulnerable but economically (and often aesthetically) valuable locations.

Our work shows that once losses are properly normalized, the general consensus is that increased property losses are not predominantly the result of climate change but societal changes. Thus, if the task is to reduce these losses, the best short-term strategy is one of adaptation combined with an eye toward mitigation in the long term. ■

ENDNOTES

1. Munich Re, 2005. "Annual Review: Natural Catastrophes 2004," *http://www.munichre.com/publications/302-04321_en.pdf?rdm=71234%20.*

2. Pielke, Jr., R. A. and C. W. Landsea, 1998. "Normalized Hurricane Damages in the United States: 1925-95." *Weather Forecast*., 13, pp. 621-631.

3. Crompton, R.P. 2005. "Indexing the Insurance Council of Australia Natural Disaster Event List." Report prepared for the Insurance Council of Australia, Risk Frontiers.

4. These are documented in our report: *http://sciencepolicy.colorado.edu/sparc/research/projects/extreme_events/munich_workshop/workshop_report.html.*

5. For a more detailed explanation of the data sets and assumptions, please see Pielke, Jr., R. A., 2007. "Future Economic Damage from Tropical Cyclones: Sensitivities to Societal and Climate Changes," *Philosophical Transactions of the Royal Society*, Vol. 365, No. 1860, pp. 1-13, and Pielke, Jr., R. A. (with contributions from P. Hoeppe and S. McIntyre), 2008. "Case Studies in Disaster Losses and Climate Change," pp. 131-140 in the "Proceedings of the 15th 'Aha Huliko'a Winter Workshop on Extreme Events," University of Hawaii, Honolulu, January 2007.

6. Mechler, R., 2005. "Cost-benefit Analysis of Natural Disaster Risk Management in Developing and Emerging Countries." Long Study. Interim report for GTZ.

7. Other relevant greenhouse gases include methane, nitrous oxide, chlorofluorocarbons and water vapor.