Risk Management and Climate Risk

Sam Gutterman, FSA, MAAA, CERA, FCAS, FCA, HonFIA

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INTRODUCTION

According to Europe's Copernicus Climate Change Service, if recent atmospheric warming rates continue, the world's goal, as set in the 2015 Paris Agreement, of limiting warming to 1.5°C above pre-industrial levels will be breached in 2030, a decade earlier than expected in 2015. In fact, over the three years from 2023 to 2025, the average temperature has exceeded the oft-cited 1.5°C benchmark. The next El Niño will likely push temperatures even higher.

This warming trend has already led to a wide range of property and health-related losses and damage, which may impose additional costs on many. A panoply of hazards, including floods, droughts, wildfires, extreme temperatures, and storms, drives these losses and damage. Compounding and cascading factors further exacerbate these losses and damage. Even excluding hurricanes, U.S. disaster costs in 2025 exceeded $100 billion. It is also upending and reshaping people's lives, insurance and reinsurance markets, bank lending, and numerous economic sectors.

To reduce losses and damage from climate-related risks, an effective multi-layered risk management system or set of processes will be needed. A necessary component of such a system is to recognize and understand the primary lines of defense against these losses and damage. Risk management can be assessed and practiced from both societal and individual perspectives. Society can often be assessed by governments on a global, national, local, or individual basis, as applicable. The relative roles and responsibilities of the public and private sectors can differ widely, depending on factors such as costs and affordability, benefits, and types of risk.

This essay will, in broad terms, explore these risk defenses in the context of risk management processes.

LINES OF DEFENSE AGAINST RISK

There are three lines of defense that can help manage risk. They are:

1. Mitigation.[1] Eliminate or reduce the frequency or severity of the underlying causes.
2. Ex-ante adaptation. Change the exposure or vulnerability to the hazard.

[1] Mitigation in some contexts refers to overall loss reduction. In climate-related discussions, it is usually used solely to describe efforts to reduce the underlying causes of climate-related hazards.

3. Ex-post adaptation. If the hazard and resulting damage occur despite the use of the first two lines of defense, actions taken during or after the hazard can reduce the resulting loss.

When implementing these defenses (risk management tools), the relative roles and responsibilities of the private and public sectors can differ across the three lines of defense, with both contributing in different ways. The public sector can contribute in several ways, including providing objective information, financial support, and incentives to encourage constructive action.

The two types of adaptation can be distinguished by timing. Ex-ante actions occur before the hazard, while ex-post actions, also called damage control, occur during or after the hazard. When analyzing the value of these second and third lines of defense, vulnerability to specific losses and damage can be assessed using two key factors: exposure and sensitivity.

The general risk management process often follows the flow shown in Figure 1 and incorporates multiple feedback loops, with steps sometimes conducted in a different order.

Figure 1
THE RISK MANAGEMENT PROCESS

A brief description of these steps follows:

- *Identifying objectives and risks* that may threaten health, income, or other resources is usually addressed through a planning process. Particularly vulnerable areas and stakeholders, as well as potential opportunities, are also identified.
- *Assessing* risk probabilities and their expected severity and timing.
- *Controlling* through mitigation or adaptation to eliminate or reduce the probability and severity of losses or damages, as well as taking advantage of co-benefits and reducing co-costs.
- *Measuring* involves estimating the risks, costs, and benefits involved, as well as their timing, on an analytically sound quantitative basis, supported, as applicable, by qualitative analysis. In doing so, transparency regarding the assumptions used should be established and documented, where applicable, to enable independent review in both governmental and business applications. Developing a range that is not overly wide or otherwise communicating the uncertainty involved may be helpful.
- *Financing or transferring/sharing* the risks and expected or actual costs, including those related to mitigation and adaptation, on an ex-ante or ex-post basis.

- *Monitoring to identify new risks and opportunities, reflecting risk appetites dynamically, while recognizing and reporting on the effectiveness of the process, measures in place, and actual costs.*

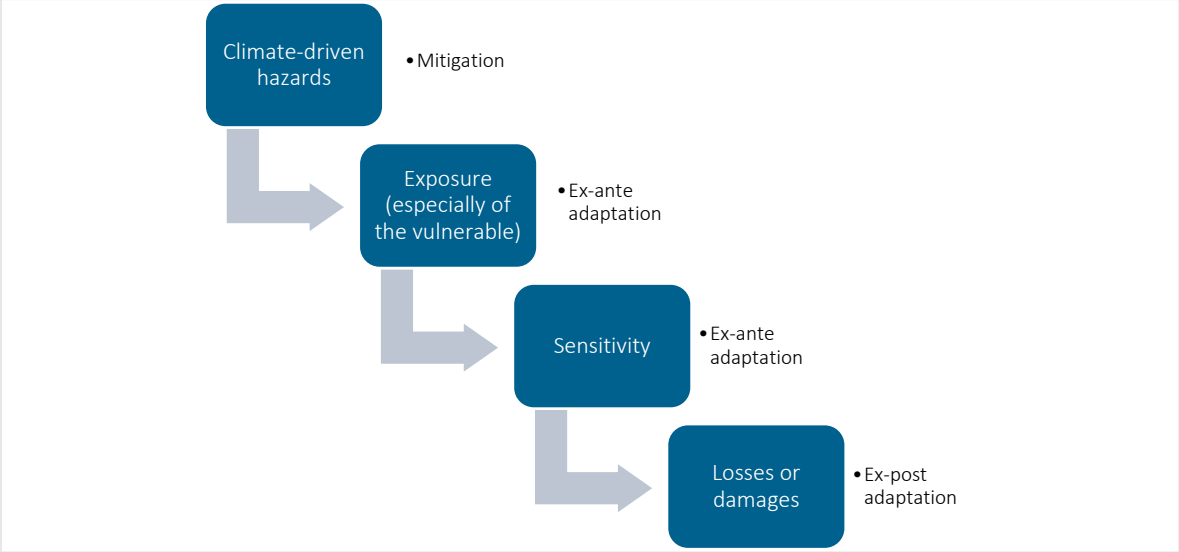
An actuary can be involved in each of these steps in a formal process, from identifying and evaluating potential risks to developing and assessing mitigation and adaptation measures, establishing and measuring progress toward objectives, managing the risk (e.g., through avoidance, financing through self-retention or (re)insurance, and transferring), and monitoring the results. One example of actuarial involvement is conducting cost-benefit analyses to evaluate possible approaches to implementing investments in mitigation or adaptation. This process can also be applied in a less formal way, particularly when applied to an individual or household.

RISK MANAGEMENT OF CLIMATE RISK

In this essay, I focus on applying the risk management process to climate-related risks. Note that a similar approach can be applied to other external causes of losses or damage.

In Figure 2, the corresponding lines of defense are listed to the right of each central element in the risk management process.

Figure 2
CLIMATE RISK LINES OF DEFENSE



Whether a risk assessment is conducted from the perspective of an individual, a business, or the public sector, the first step is to identify the entity or area of concern, the risks involved, the key sources/drivers of these risks, and the timeframe for the assessment. In addressing climate and climate-related risks, several climatic factors (e.g., temperature, precipitation, humidity, and wind) are influenced by a range of underlying factors. Some are natural, such as solar radiation and clouds, while others are directly or indirectly influenced by human activities, such as greenhouse gas emissions from energy production and use and transportation.

Although climate change will increasingly exacerbate losses and damage from climate-related perils, my focus here is on the total climate-related losses and damage associated with these considerable perils. This holistic focus is partly due to the complexity and controversy surrounding the extent to which these perils

are generated by or result from human behavior, which underlies and justifies much of the mitigation investment. As our climate changes, these losses and damages will inevitably increase over time, making this an even more important issue. But bottom line, I am concerned here with preventing or reducing the resultant losses and damage, regardless of their attribution.

The following addresses both direct and indirect drivers of these losses and damage. To illustrate the importance of indirect losses, second or third-order consequences of climate-related hazards include reduced housing values in flood-prone or nearby locations, declines in asset values due to anticipated adverse effects of climate change, death or ill health from poor air quality caused by fossil fuel combustion and wildfire smoke, and vector-borne diseases due to the expansion of mosquito or tick ranges.

Given the potential severity of these hazards, a range of mitigation and adaptation actions (both ex ante and ex post) should be considered key components of a risk management process. The effectiveness of these efforts will determine the extent of losses and damage we will experience.

Mitigation and adaptation approaches constitute the lines of defense against climate-related damage. An elaboration of each line of defense follows.

- *Mitigation*, the first line of defense, reduces the effects of certain underlying causes of climate risk, primarily by lowering greenhouse gas emissions, thereby reducing their buildup in the atmosphere and the oceans. This can be done, for example, by reducing emissions, capturing and storing emissions through natural or man-made means, such as increasing the use of renewable energy, reducing emissions from transportation, expanding carbon sinks, or enhancing technological innovations and their implementation.

  Although greenhouse gas emissions are significant contributors to the hazards discussed here, they aren't the only ones. Other human behaviors and activities can also be important drivers, for example, inadequately maintained power lines, careless use of fire in dry forests, and failure to undertake traditional flood control methods. Some of these may be difficult to eliminate.

  Prospects for significant global mitigation efforts, at least in the short term, are less favorable than a decade ago, as evidenced by current results, including record-setting 2025 emissions (hopefully at peak levels) and record-high ocean temperatures. Even if emissions begin to decline, greenhouse gas concentrations will persist in the atmosphere for decades or even centuries. Mitigation efforts will have to continue for a long time—almost every climate projection assumes that at some point we will begin to reduce atmospheric concentrations (below net-zero), which may be optimistic.

  In any case, technological improvements and scale will help, such as inexpensive solar panels and enhanced battery storage. Although the contributions of individual decarbonization efforts may seem minuscule compared with global goals, they will help if these efforts are sufficiently widespread.
- *Adaptation (ex-ante).* The second line of defense is modifying existing resources or developing new ones, whether in location or form, to eliminate or reduce potential climate-related damage to properties or individual lives, thereby reducing losses. Until relatively recently, adaptation has been given less priority than mitigation, both globally and, at times, at regional, national, local, or individual levels. However, this relative emphasis appears to be evolving as these losses increase and receive more media attention. Some action is taken at multiple levels (e.g., local regulation can set a minimum adaptation level, individuals can adopt a more stringent level, governments

can establish tax or other incentives, and insurance companies can provide their own premium or coverage incentives).
    - Ex-ante adaptation can modify the social environment (e.g., public services such as flood protection and emergency health care infrastructure), individual property (e.g., fire extinguishers, air conditioners, and zoning outside of flood zones), or individual behavior (e.g., maintaining good health, keeping air conditioners on during a heat wave, and following evacuation procedures). These measures can vary by hazard, though some remain the same (e.g., vaccines, bug spray, or bed nets against infectious diseases, whose use can increase as temperatures warm).
    - Limits on construction in unsafe urban areas (e.g., in a fire or flood zone) or on the use of hazardous building materials. In some cases, insurance regulators force insurance companies to hold down insurance rates in unsafe areas, thereby subsidizing immigration into those areas, while home values are discounted at the same time due to these risks. The pressure to hold down house prices can lead to skimping on safety features, which may, in turn, increase losses and damage.
    - Establishing an effective early warning system for potential heat, storms, or floods can be especially effective in reducing exposure to damage. Of course, this assumes that people pay proper attention to these warnings.
    - Some adaptations can serve multiple purposes. For example, improvements to public health infrastructure and emergency transportation can both reduce losses from climate risk, as well as from other causes. For instance, during a 2003 heatwave, Parisians experienced tens of thousands of avoidable deaths due to inadequate public health emergency infrastructure; subsequent improvements significantly reduced the number of such fatalities during a similar heatwave in 2013.
- *Adaptation (ex-post).* To the extent not eliminated or diminished by mitigation or ex-ante adaptation, the third line of defense, sometimes referred to as ex-post adaptation or loss prevention, involves managing losses or damage during or after an extreme weather event. This defense can help minimize the ultimate losses from climate-induced damage. Financial recovery may come from insurance, which can offset a portion of the economic cost of these damages. At the same time, public, community, or charitable assistance can be a significant factor in alleviating some of the remaining adverse effects.
    - In most cases, it is preferable to rely on ex-ante rather than ex-post adaptation. However, it is common to think that “such an event will never happen to me.” Insurance and public help can sometimes serve as a backstop.
    - A key element of the recovery process is learning lessons from previously incurred losses or damage, especially by planning for enhanced future adaptation, ranging from improving building structures to relocating from high-risk areas.

Each of these defenses can target either climate-specific or broader risks. An example of the latter is enhanced public health services and infrastructure that can reduce both climate-related and general healthcare risks. Insurance can provide incentives for actions, such as premium discounts for adaptive building features or preventive healthcare, thereby reducing individuals' vulnerability by promoting good health.

When deciding how much to invest in these three lines of defense, trade-offs are inevitable, as in other risk management processes. Limited budgets can constrain action, even when the investments are financially justifiable. The default option is ex-post adaptation, to the extent available and effective, which people are stuck with in any case. These decisions apply not only at the national level, where financial resources must

be allocated to other priority areas such as education, national defense, social welfare, and healthcare, but also at the state, community, and individual levels.

PROJECTIONS AND ESTIMATES OF LOSSES AND DAMAGES

An actuary may be called upon to develop projections and estimates of losses and damage from climate-related perils as part of a risk management system, typically through a cost-benefit analysis. In some cases, these are formal, e.g., through a firm's risk management committee, as described in a report with documented assumptions. If conducted by an individual for their household, they are usually developed informally, possibly relying solely on common sense. In any case, qualitative and quantitative analyses are typically used.

When analyzing options, financial and human losses and damages, including premature deaths and healthcare impacts, should be considered, with the method depending on the situation and type of analysis. Assessing the value of the lines of defense can be difficult because it often requires combining these costs, for example, property losses and morbidity. There are several ways to do this.[2] For costs and benefits involving an extended period, the choice of a discount rate is usually an important element.

Complicating such an analysis are the time lags between, for example, an extreme weather event and the ultimate losses and damage. For example, exposure to climate-related hazards such as wildfire smoke (particulate matter) or a heatwave can lead to or exacerbate cardiovascular, pulmonary, and communicable diseases weeks or even years after initial exposure. This contrasts with the usual distribution of causes of death or ill health from such an event, which typically includes only those reported in the few days after exposure. Because of these lags, the cost of climate-related risks is often underestimated.

To estimate expected losses and damage, a dynamic assessment is needed because both the climate and the underlying conditions change over time. Although I earlier indicated that overall climate risk is more important to consider in this estimation process, climate change projections can be significant for projecting future losses and damage, as the impacts of future warming scenarios are likely to worsen relative to current experience. Note that, depending on the effectiveness of the available and utilized lines of defense, the expected losses and damage may even be reduced.

Concentration risk for an insurer or a business can be significant. If a catastrophic event occurs, it is likely to affect many insured exposures. For instance, a storm, wildfire, or flood can severely damage the finances of a local government, business, or household, as well as an insurer without adequate capital or reinsurance. In addition, an existing health condition can be exacerbated by excessive heat. In any case, such an event can be catastrophic for a household.

Despite the challenges of developing a cost-benefit analysis of climate risk, these risks should be considered. During the risk management process, identifying, projecting, and reporting climate-related risks can be valuable. As part of this analysis, mitigation and adaptation options should be identified and their value evaluated.

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[2] Discussed in Gutterman, S. (2020). Social Discounting, Application to the Risk Management of Climate Change. *Society of Actuaries*. https://www.soa.org/globalassets/assets/files/resources/research-report/2020/social-discounting-climate-change.pdf

CONCLUSION

Climate risk should be considered in many risk management analyses and projects. A risk manager should follow traditional risk management practice: identify and analyze possible climate risk scenarios, including the expected effects of both the risk manager's and society's mitigation and adaptation actions. It is easy to conclude that climate risk is not significant to the entity being assessed. However, due to several factors discussed in this essay, including concentration risk and climate change, a risk manager should also consider whether investments in adaptation are warranted.

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Sam Gutterman, FSA, CERA, FCAS, MAAA, FCA, HonFIA is a consulting actuary. He can be reached at sam.gutterman1@gmail.com.