**Managing the Risks of Climate Change and Terrorism**

by Eugene A. Rosa, Thomas Dietz, Richard H. Moss, Scott Atran, and Susanne Moser

**In Brief**

Society has difficult decisions to make about how best to allocate its resources to ensure future sustainability. Risk assessment can be a valuable tool: it has long been used to support decisions to address environmental problems. But in a time when the risks to sustainability range from climate change to terrorism, applying risk assessment to sustainability will require careful rethinking. For new threats, we will need a new approach to risk assessment.

**Key Concepts**

• The future is uncertain, and risk assessments are our way of navigating uncertainty. They can contribute to decision making about sustainability, especially by making comparisons across major domains of risk, like climate change and terrorism.

• Comparing one risk to another requires examining various driving factors, the ways the risk unfolds over time, and how it impacts affected groups.

• Traditional risk models are limited in their assessment of sustainability problems. Complex threats such as climate change and terrorism require a rethinking of the conventional risk assessment approach.

• Decisions about how to allocate resources to mitigate various risks will require both scientific understanding and a weighing of public values.

Albert Einstein, to his death, could never accept the probabilistic underpinnings and uncertainties of quantum mechanics. In a letter to Max Born in 1926 he wrote, “I am convinced that God does not play dice with the universe.” In the following year, at a physics conference, Niels Bohr admonished Einstein to stop telling God what to do.[1]

Even the world’s greatest minds struggle to cope with uncertainty. That’s why we have risk assessment: a method—comprising the identification, analysis, and management of risk—used worldwide for measuring risk and uncertainty. Risk assessment does for uncertainty what money does for valuing goods and services: it creates a common metric for comparing choices and making decisions. However, conventional risk assessment is being challenged by the rapid growth in risk domains—spheres of public decision making with high levels of uncertainty—that call for systematic assessments: toxins, bioengineering, climate change, rapid resource loss, and terrorism. Each of these represents a formidable challenge to a livable future, even if some are excluded from the conventional discourse on sustainability.

Consider, for example, two of today's most publicized and politicized threats to sustainability: climate change and terrorism. How much financial, intellectual, and policy capital should be spent on climate change, an indirect threat to sustainability, and how much on terrorism, a proximate threat to human lives? Though it is seldom done systematically, comparing different threats is essential because we are allocating scarce public and private resources to manage multiple risks to human safety and well-being. In addition, lessons from one risk domain can transfer to another and provide new insights.

To apply the logic of risk management to sustainability, we must change how we think about risk. Sustainability requires that we consider risks that cross many sectors of human activity (like climate change) and emergent risks (like concerns about the health risks posed by nanotechnology) and that we even consider the possibility that our current tools are not up to the challenge.

The standard risk model reduces the complexities of risk into three components: the context, the probability of occurrence, and the consequences of an unfavorable outcome. This approach assumes that decisions can be made based on measurable outcomes, such as the expected number of illnesses or deaths.[2] (For example, most toxic substances are regulated based on estimates of how many illnesses or deaths will result from their use.) Like all models, risk analysis is merely a crude rendition of the world it depicts. It imposes order on the world by ignoring many psychological and social dimensions of risk, such as dread, sense of personal control, equity, and justice, that could potentially affect our priorities and desires for managing risk.

What limitation does this modeling impose on our understanding of real threats? Ecologist Richard Levins provided one answer four decades ago.[3–5] Risk models seek to address three key criteria: realism, precision, and generality. By *realism*, he meant the extent to which the models omit artificial or simplified assumptions about a complex system. By *precision*, he meant the extent to which models make exacting predictions, such as accurate estimates of probabilities. By *generality*, he meant the extent to which models apply to multiple contexts and are, for instance, translatable between situations or locations. But as Levins convincingly showed, risk models cannot simultaneously maximize all three criteria. He noted three logical strategies for selecting the optimum model: (1) sacrifice generality to realism and precision, yielding a realistic model that can make precise predictions for a particular context (we will call this approach *iterative*); (2) sacrifice realism to generality and precision, for a model that can generate exacting (but not very realistic) predictions for a variety of situations or locations (the *conventional* approach); or (3) sacrifice precision to realism and generality, for a realistic model that can be used in different contexts but that does not yield precise predictions (we will call this last approach *adaptive*).

The field of quantitative risk assessment, perhaps unknowingly, presupposes that sacrificing realism in the *conventional* approach is equally effective in assessing or comparing virtually all threats, even terrorism and climate change. (This approach estimates risks by multiplying the probability of an event times the exposure to risk.) However, with the rapid growth in threats and their complexity, an emphasis on generality and precision at the cost of realism is not always adequate or effective; indeed, the results may be misleading. So, while the *conventional* strategy has been the predominate strategy used in risk assessment, we believe *the iterative* and *adaptive* strategies may be more appropriate for certain complex risks to sustainability. For example, for climate change, the best approach may be to eschew precision in favor of realism and generality, using the *adaptive* approach ("adaptive" because it can be applied to different contexts). Terrorism risks, on the other hand, should take the *iterative* approach—repetitive reassessments capable of keeping up with changing terrorist strategies. The *iterative* model emphasizes appropriate precision and realism because generality can lead to over- (or under-) estimates of threat.

**Climate Change**

Standard risk analysis, while useful for understanding specific aspects of climate change, fails in assessing the problem's overall risk. This is due to the complexity and the intractable uncertainties of the climate system. Currently, it is simply not possible to establish precise, quantitative relationships between levels of climate change and impacts on human and ecological systems.[6] Indeed, the difficulty in developing a comprehensive "damage function" linking climate change to the harm it causes is often cited as a limit of using risk analysis in the climate context. To understand the influence of climate change on ecosystems, for example, we need to know not just how global average temperature will change but how climate change will drive the date of the last freezing temperatures and the first hard frosts, how it will change the amount of rainfall and its distribution across seasons, and how it will affect a variety of other drivers that are critical to ecosystem functioning but are hard to forecast at the local level.[6]

The UN Framework Convention on Climate Change defines its objective as "stabilization of greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system."[7] But what are "dangerous" levels of interference? Answering this question requires a more complete scientific understanding of how the climate system responds to abrupt change, how humans and ecosystems will respond to gradual or abrupt change, and the economic costs of prevention, mitigation, preparedness, and adaptation. In other words, the very definitional factors of risk (context, probability, and outcome) are the ones that currently elude us.

Given these uncertainties, we should develop new, more inclusive management strategies that involve scientists, policymakers, a wider public, and the private sector in something called *analytic-deliberative* (A-D) decision making.[8, 9–11] In the A-D approach, researchers and citizens interact to determine key issues and to ensure that the science is attentive to local conditions and public concern and that the public is informed by the best available science. The A-D approach is a sharp contrast to past practices where science proceeded without public discussion and where public discussion was decoupled from scientific understanding.

Public involvement should be focused on developing more effective communication strategies and tools for making decisions under conditions of deep complexity and uncertainty.[12] For example, coastal communities face diverse risks from climate change and sea level rise, with different community members bearing different risks and costs. In order to make sound decisions, those communities will need to understand the uncertainties inherent in current projections of sea level rise and to wrestle with the inevitable equity issues in responding to those risks. Processes, such as the A-D approach, that effectively meld scientific analysis with public deliberation seem the most appropriate way of approaching such challenges. Adopting this approach would mean abandoning the standard risk assessment model for one that emphasizes the *realism* and *generality* of the *adaptive* strategy in the management of climate risks. Here’s why: For coastal communities, the analysis must be *realistic* in capturing the details of threats to specific coastal areas, as those threats will depend on topography, ecology, population density, community makeup, and history. Since the effects of climate change and sea level rise cannot be predicted with great precision, the analysis must be *general* enough to be useful under a variety of possible scenarios. The analysis may not be very precise, but it could still give communities a better understanding of their options as they plan their responses to climate change.

**Terrorism**

In contrast to climate change, which is diffuse, cumulative, and systemic, terrorism is episodic, abrupt, and localized. It has been virtually ignored in the sustainability discourse to date, yet it clearly can have a degrading, if little analyzed, effect on any effort to move toward a livable, more secure future. Terrorism poses greater analytic challenges than virtually any other emerging risk. Not only are there deep uncertainties about the likelihood and final consequences of terrorist attacks, but there is even uncertainty about the context in which attacks may occur and, in contrast to climate change, very few efforts have been made by the appropriate sciences to understand terrorism. Indeed, the resultant inability to credibly predict attacks partly defines terrorism, and reinforcing these uncertainties is a terrorist strategy.

To these challenges we can add an even more fundamental, paradigmatic one, namely a challenge to the “rational actor” presupposition of Western thought that underlies risk management in the *conventional* risk assessment strategy.[2] The rational actor perspective presupposes that self-interested individuals purposively choose the course of action that is the most efficient or that most optimally achieves their desired ends. Current risk management approaches for countering terrorism presume that terrorists are making rational choices. Instrumental rationality—the pursuit of the most cost-effective means to achieve a desired end—too, is falsely presumed to be employed across belief systems. It is this thinking embedded in the *conventional* strategy that engenders the dangerously false assumption that terrorists offer their lives in martyrdom for seventy-two virgins waiting in heaven—that a terrorist's choice reflects a cost-benefit decision, with the benefits in paradise. As an approach to analyzing terrorism, conventional risk assessment is grossly misleading.

Empirical evidence contradicts the rational actor expectation. Interviews with jihadi terrorists and their loved ones show that individuals who join the jihad, especially would-be "martyrs" (e.g., suicide bombers), are often motivated by values that stem from small-group dynamics, that is, from peer groups.[13] These values trump the rational self-interest that is presumed in the conventional risk assessment approach. The following is a revealing illustration of the difference between the instrumental rationality of the rational actor perspective in the West and the moral rationality of the jihadi warriors (mujahedin). One of the fundamental tenets of instrumental rationality is the principle of transitivity. That is, if A is preferred to B and B is preferred to C, then A must be preferred to C.

Scott Atran[13] administered the following questionnaire to Indonesian mujahedin:

> Question 1: Would you give up a roadside bombing (B) if it meant you could make the only pilgrimage to Mecca (A)? (Most answered yes).
>
> Question 2: Would you give up a suicide bombing (C) to instead carry out a roadside bombing (B) if it is possible? (Most answered yes).
>
> Question 3: Could you give up a suicide bombing (C) if it meant you could make the only pilgrimage to Mecca (A) in your lifetime? (Most answered no).

This set of responses—where A>B, and B>C, but C>A—violates the transitivity principal and, therefore, the expectations of instrumental rationality.

Furthermore, our belief in the universality of instrumental rationality can cause our efforts to diffuse or avoid conflict to backfire.[14] For example, both Palestinian Hamas militants and Israeli settlers report feeling disgusted by material incentives offered by the other side. In one scenario, Israeli settlers were offered a deal to give up the West Bank to Palestinians in return for peace and an American subsidy to Israel of $1 billion a year for 100 years. This offer was acceptable to settlers who had chosen to live in the Occupied Territories for economic reasons or to improve their quality of life (for them, the land was not sacred). But once material incentives were introduced, settlers who believed the Occupied Territories to be God's ancient trust to them reported feeling angry and disgusted by the offer and said that they would be more willing to use violence to oppose it.

This means that our standard calculations of how to defeat or deter an enemy—by providing material incentives to defect (instrumental benefits) or by threatening massive retaliation (costs) against supporting populations, for example—are misaligned with the moral logic of terrorists and might backfire. Instead, we believe the most appropriate approach to understanding terrorism risk would be based on the *iterative* strategy, which emphasizes *realism* and *precision* at the cost of generality (for terrorism, as we have just shown, a one-size-fits-all approach would be misleading). For terrorism risk, the analysis must be *realistic*, taking account of complex and changing situational factors that shape potential terrorist actions and vulnerabilities. What motivates one aggrieved group, whether it is Al Qaeda, the Taliban, or more localized cells, to embrace terrorism as a tactic may not produce the same results in a different group. Atran summarizes the point: "The growth and development of terrorist networks is largely a decentralized and evolutionary process, based upon contingent adaptations to unpredictable events and improbable opportunities, more the result of localized tinkering (of fragmentary connections between semi-autonomous parts) than intelligent design (hierarchical command and control)."[13]

While risk estimates may never be numerically precise, the iterative strategy embraces *precision* by being specific to the context of each potentially threatening situation and by attending to the cultural and political dynamics that can exacerbate or diffuse the risk.

**How to Make Better Decisions in the Face of Multiple Risks**

When establishing risk management priorities, three groups—experts, decision makers, and the public—must be at the table. Stakeholder groups must be matched by relevance to, and expertise about, the domains to be assessed. While analytic-deliberative processes have not been applied to all risk domains relevant to sustainability, there is a wealth of experience in melding scientific analysis and public deliberation across a wide variety of environmental and natural-resource issues, such as management of toxic sites or the use of fisheries, that can provide guidance for designing processes for new risk domains.[9,10]

Meanwhile, appropriate tools and methods needed to assess and compare risks across domains are currently not available—at least none have been developed specifically for cross-domain comparisons. But there are many tools available that can be applied within domains: game theory, scenario development, policy planning and gaming exercises, computer simulations, and integrated assessments, to name a few.[15] Perhaps the most promising and innovative approach is domain-specific integrated assessments, conducted by the Intergovernmental Panel on Climate Change (IPCC)[16] (for the domain of climate change) and by the Millennium Ecosystem Assessment (MEA) (for the domain of global biodiversity).[17] In principle, the procedures applied in these assessments could be translated to the cross-domain challenge and expanded to consider the broad set of challenges to sustainability.[18] Two features would be of obvious value. First, the IPCC and MEA charged authors with assessing both the strength of evidence and the degree of certainty behind each of their conclusions.[19] This distinction between the two is crucial but not always given adequate attention in risk characterizations. For example, it is possible to have a substantial body of evidence regarding environmental stressors, such as greenhouse gases or biodiversity loss, but still have considerable uncertainty about their proximate or distal impacts. Using this approach consistently across domains could help calibrate a cross-domain assessment of risk.

Second, both the IPCC and MEA developed scenarios about the future of the global economy, which were then used to ground projections of environmental stressors.[20–23] These integrated scenarios offer three immediate advantages. First, they provide transparency by making explicit the assumptions about future expectations and how alternative assumptions affect risks. Second, the use of common scenarios across domains facilitates risk comparisons across assessments. Third, open discussion of the scenarios reveals underlying presuppositions about individual and organizational behavior that are a part of all risk assessments but that often remain unrecognized and unexamined.[2]

One promising direction for threat comparison might be to abandon the conventional risk assessment model in favor of a “risk governance” paradigm.[24] Arguably, risk governance—simultaneously analyzing risks while developing policies and programs to mitigate and manage these risks—is better suited for risk contexts with deep uncertainty, complexity, and ambiguity. In these situations, uncertainty is not an excuse for inaction, though care must be taken to preserve flexibility so that we can adjust policies as the effects of, say, climate change actually unfold. This would allow governments to better manage allocation of resources among multiple threats over time, which is the ultimate goal.

While the analytic challenges are formidable, there are tractable first steps. We can press risk analysts in all domains to use consistent language about uncertainty and to be clear about the scenarios that underpin their analyses, following the lead of global change assessments, such as those of the MEA and IPCC. We can initiate cross-domain comparisons, starting with sketches as simple as Table 1 but moving to more systematic comparisons. Finally, we can acknowledge that decisions about allocating resources across domains involve weighing hard facts, expert judgments, and public values and thus must involve both scientific analysis and public deliberation.

**Table 1. Dimensions of Climate Change and Terrorist Risks**

Table 1 compares the key risk characteristics of climate change and terrorism.[25–29]

| | **Climate Change** | **Terrorism** |
|---|---|---|
| **System Dimensions** | | |
| Causal processes | Systemic and cumulative changes in the earth system | Global network of perpetrators |
| Change in system over time* | Some aspects change slowly, some quickly | Some aspects change slowly, some quickly |
| Sources of uncertainty | Stochastic physical processes, limited understanding of complex feedbacks and nonlinearities, limited understanding of ecosystem and societal trajectories and responses | Nonlinear, strategically anticipatory processes |
| What is at risk? | Climate and earth systems, all populations | Geopolitical security |
| Quantitative accuracy | Imprecise | Very imprecise |
| Differential vulnerability: Who is at risk? | All populations, with variation in consequences among specific populations | Targeted populations, with circumscribed consequences |
| Speed of consequences | Delayed | Immediate |
| Immediate range of consequences if risk is realized | Global (diffuse) to local (specific) | Local (specific) |
| **Human Dimensions** | | |
| Public level of awareness | High | Very high |
| Perceived public dread | Low | Very high |
| Sense of control by affected individuals | Low | Low |
| Extent of synthesis of scientific knowledge | High | Low |
| Understanding of underlying causes by public | Low | Low |
| Is the threat new or old? | Modern era | Very old |
| Number of people affected | Very high | Low |

| | | |
|---|---|---|
| **Mitigation and Management** | | |
| Assessment strategy | *Adaptive* strategy: Realism and generality | *Iterative* strategy: Realism and precision |

* The interaction of variables that have relatively slow rates of change with those that change quickly can lead to very complex and sometimes highly unstable dynamics in complex systems.

**References**

1. Rosenthal, JS. *Struck by Lightening: The Curious World of Probabilities* (Joseph Henry Press, Washington, DC, 2006).

2. Jaeger, C, Renn, O, Rosa, EA & Webler, T. *Risk, Uncertainly and Rational Action* (Earthscan, London, 2001).

3. Levins, R. The Strategy of Model Building in Population Biology. *American Scientist* 54, 421–431 (1966).

4. Orzack, SH & Sober, E. A critical assessment of Levins's *The Strategy of Model Buildin*g (1966). *Quarterly Review of Biology* 68, 534–546 (1993).

5. Levins, R. A response to Orzack and Sober: formal analysis and fluidity of science. *Quarterly Review of Biology* 68, 547–555 (1993).

6. U.S. National Academies of Science Committee on Stabilization Targets for Atmospheric Greenhouse Gas Concentrations. *Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia* (National Academies Press, Washington, DC, 2010).

7. Article 2 of the UN Framework Convention on Climate Change [online]. http://unfcc.int/essential_background/convention/background/items/1353.php.

8. U.S. National Academies of Science Panel on Advancing the Science of Climate Change. *Advancing the Science of Climate Change* (National Academies Press, Washington, DC, 2010).

9. Stern, PC & Fineberg, H eds. *Understanding Risk: Informing Decisions in a Democratic Society* (National Academies Press, Washington, DC, 1996).

10. U.S. National Academies of Science Panel on Public Participation in Environmental Assessment and Decision Making (2008).

11. U.S. National Academies of Science Panel on Informing an Effective Response to Climate Change. *Informing an Effective Response to Climate Change* (National Academies Press, Washington, DC, 2010).

12. Moser, SC & Dilling, L, eds. *Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change* (Cambridge University Press, Cambridge, 2006).

13. Atran, S. *Talking to the Enemy: Faith, Brotherhood, and the (Un)making of Terrorists* (Harper Collins, New York, 2010).

14. Ginges, J, Atran, S, Medin, D & Shikaki, K. Sacred bounds on rational resolution of violent political conflict. *Proceedings of the National Academy of Sciences, USA* 104, 7357–7360 (2007).

15. Brewer, GD. Inventing the future: scenarios, imagination, mastery and control. *Sustainability Science* 2, 159–177 (2007).

16. Intergovernmental Panel on Climate Change. *Climate Change 2007: Synthesis Report; Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Intergovernmental Panel on Climate Change, Geneva, 2007).

17. Reid, WV et al. *Ecosystems and Human Well-Being: Synthesis* (Island Press, Washington, DC, 2005).

18. U.S. National Research Council. *Our Common Journey: A Transition toward Sustainability* (National Academies Press, Washington, DC, 1999).

19. Moss, R & Schneider, SH in *Guidance Papers on the Cross-Cutting Issues of the Third Assessment Report of the IPCC* (Pachauri, R, Taniguchi, T & Tanaka, K, eds), Uncertainties in the IPCC TAR: recommendations to lead authors for more consistent assessment and reporting, 33–51 (World Meteorological Organization, Geneva, 2000).

20. Moss, R. Reducing doubt about uncertainty: Guidance for IPCC's third assessment. *Climatic Change* 108(4), 641–658 (2011).

21. Carpenter, SR, Pingali, PL, Bennett, EM & Zurek, MB, eds. *Ecosystems and Human Well-Being: Scenarios*, Vol 56 (Island Press, Washington, DC, 2005).

22. Intergovernmental Panel on Climate Change. *Emissions Scenarios* (Cambridge University Press, Cambridge, 2000).

23. U.S. Climate Change Science Program. *Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations (Part A) and Review of Integrated Scenario Development and Application (Part B)* (Department of Energy, Office of Biological and Environmental Research, Washington, DC, 2007).

24. Renn, O. *Risk Governance: Coping with Uncertainty in a Complex World*. (Earthscan, London, 2008).

25. U.S. National Research Council. *Decision Making for the Environment: Social and Behavioral Science Research Priorities* (National Academies Press, Washington, DC, 2005).

26. U.S. National Research Council. *Public Participation in Environmental Assessment and Decision Making* (National Academies Press, Washington, DC, 2005).

27. Slovic, P. Perception of risk. *Science* 236, 280–285 (1987).

28. Rosa, EA, Matsuda, N, & Kleinhesselink, RR. in *Comparative Risk Perception* (Renn, O & Rohrmann, B, eds), The cognitive architecture of risk: pancultural unity or cultural shaping? 185–210 (Kluwer, Dordrecht, the Netherlands, 2000).

29. Lorenzoni, I, Pidgeon, NF & O'Connor, RE. Dangerous climate change: the role of risk research. *Risk Analysis* 25, 1387–1398 (2005).