Adaptation, mitigation, and their disharmonious discontents: An essay

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Abstract The frequently heard call to harmonize adaptation and mitigation policies is well intended and many opportunities exist to realize co-benefits by designing and implementing both in mutually supportive ways. But critical tradeoffs (inadequate conditions, competition among means for implementation, and negative consequences of pursuing both simultaneously) also exist, along with policy disconnects that are shaped by history, sequencing, scale, contextual variables, and controversial climate discourses in the public. To ignore these issues can be expected to undermine a more comprehensive, better integrated climate risk management portfolio. The paper discusses various implications of these tradeoffs between adaptation and mitigation for science and policy.

1 Introduction

A recent president of the American Association for the Advancement of Science, the world's largest international general scientific society, and currently U.S. President Barak Obama's Science Advisor, John Holdren, has famously and repeatedly said that the world has three choices in dealing with climate change: mitigation, adaptation, and suffering. The balance between the former two and the latter option is inversely related: The more we limit climate change and minimize its negative impacts, the less loss and disruption we will have to endure (Holdren 2008, p 431). A growing chorus of voices argues that, not only should we do much more in terms of mitigation and adaptation to reduce the penultimate suffering, but we should also seek out and prioritize those actions that accomplish mitigation and adaptation goals simultaneously. Researchers as well as advocates argue that there are many opportunities where adaptation could be harmonized with mitigation with obvious examples in the energy sector, transportation, and forest management with co-benefits for overall societal functioning through extreme events, economic development, human health, urban life quality, and environmental management (for additional examples see Table 1). This suggestion has been summarized and carefully assessed in the IPCC's Fourth Assessment Report (Klein et al. 2007b) and a number of other studies and reviews (e.g., Klein et al. 2007a; Wilbanks et al. 2003, 2007; Wilbanks 2005; Yohe and Strzepek 2007). Clearly, the truth about such opportunities for mutually beneficial integration, even if it were only a partial truth, is worth repeating: positive synergies and complementarities between mitigation and adaptation exist in virtually any sector because virtually all emit at least some greenhouse gases and all will be impacted to varying degrees by climate change. Moreover, the factors that enable society to mitigate and adapt are similar and often the same (Yohe 2001). And, of course, the intent behind the repeated call for integration is one that many would share: with multilateral climate negotiations continuing, albeit arguably with little real progress to show for, and global emissions continuing to rise, what can the science community possibly say that would make taking climate action more palatable? If the measured though increasingly alarming prose of the IPCC won't do, maybe the language of multiple benefits, cost-effectiveness, a vision of a better, greener, more resilient future, or even just plain optimism will.

[1] This paper has been revised again in minor ways after its initial online release.

Table 1 Examples of measures that enhance adaptation and mitigation goals simultaneously

Measure or option	Positive implications for mitigation	Positive implications for adaptation
Coastal wetland restoration	Increased carbon storage	Storm buffer, species habitat, fish nursery
Building insulation	Reduced energy consumption for heating and cooling	Protection from heat, human health benefits, comfort
Reforestation with native and diverse tree species	Carbon storage	Habitat and species protection, flood control, soil preservation
Reduction/cessation of off-shore oil production	Reduction in liquid fuel-related GHG emissions	Reduced risk of oil spills, reduction of multiple stresses on marine/ coastal ecosystems
Energy demand management	Reduced energy use and energy-related GHG emissions	Cost savings for energy user, system-wide lowered peak demands may avoid black-out
Soil conservation, e.g. through changed tillage or cover cropping practices	Potentially increased carbon storage and nitrogen fixation	Improved nutrient and water retention, increased soil biodiversity

Adapted from Bedsworth and Hanak (2008); Klein et al. (2007b); and additional refs in text

My intent in this paper is not to burst that bubble of optimism (as if we needed any more bad news!) but to show, as I do in the next section, why a range of "disharmonies" between adaptation and mitigation deserve an equal hearing. In particular, I will examine both the positive and negative interactions between adaptation and mitigation, and thereby surface important implications for policy and science so as to enable us to design a more promising package of climate risk management strategies.

2 Adaptation–mitigation conflicts and disconnects

2.1 Unpacking tradeoffs

Making tradeoffs between mitigation and adaptation was defined by Klein et al. (2007b, p 749) as the "balancing of adaptation and mitigation when it is not possible to carry out both activities fully at the same time (e.g., due to financial or other constraints)." This definition is potentially very broad in that it could include a wide range of "other constraints." By virtue of its breadth and generality, it also obscures a critical distinction between two fundamentally different types of constraints. One type of constraint may prevent the full implementation of selected adaptation and mitigation measures because the *supporting means and conditions are not available*. Examples of this type of constraint include lack of sufficient financial or human resources, lack of information, inadequate political leadership, legal incompatibility, institutional obstacles, physical feasibility limits, or lack of social acceptability (Moser and Ekstrom 2010). In a slight variation on this theme, there may be sufficient political and social support for, say, the mitigation measure, but not for the proposed adaptation measure, or vice versa. Often this may be the case because of concerns over the second type of constraint. That type of constraint may prevent the full implementation of adaptation and mitigation measures because of concerns over *unwanted outcomes* such as negative environmental consequences, undesirable social implications, political repercussions, equity concerns such as distributional or intergenerational impacts, and so on.

The definition of tradeoffs offered by Klein et al. (2007a, b) also assumes that the constraints are known, can be reasonably expected, or are taken seriously, and that they actually have the power to influence the decision at hand. Unknown, unsuspected, or disregarded constraints do not impinge on the current capacity to carry out an activity to its full extent. Particularly powerful actors might stand to benefit from carrying out an action and thus may be inclined to dismiss uncertainties and unknowns about potential negative consequences or ignore legal or ethical constraints. And yet, there may well be tradeoffs for someone or something at some time whether or not these tradeoffs are understood or considered at the moment of decision-making. Well known challenges in this area include impacts on the voice-less (nature, marginalized or less valued segments of society, future generations) and the comparison of monetized and immaterial and/or non-market values. Table 2 lists examples of known tradeoffs where adaptation actions could have negative implications for mitigation goals, and Table 3 gives examples of known tradeoffs where mitigation measures could have negative implications for adaptation goals.

Table 2 Examples of adaptation measures that potentially undermine mitigation goals

Adaptation measure or option	Potential negative implications for mitigation
Desalinization, increased water reuse, groundwater banking and pumping, and inter-basin water transfers (if fossil fuel-based)	Higher ongoing energy consumption to fuel water pumping, storage and transfer processes, increase in GHG emissions
Increased use of air conditioning	Higher seasonal energy consumption, increase in GHG emissions depending on carbon content of fuel
Relocation of infrastructure and development out of floodplain	Increase in one-time GHG emissions due to rebuilding of structures; possible increase in sprawl and ongoing transportation-related emissions
Building of large dams or massive coastal protection structures	Increased (one-time) energy use and GHG emissions related to construction (cement)
Increased use of nitrogen fertilizers to offset potential yield losses	Increased emissions from agricultural sector

Adapted from Bedsworth and Hanak (2008); Klein et al. (2007b); and additional refs in text

Table 3 Examples of mitigation measures that potentially undermine adaptation goals

Mitigation measure or option	Potential negative implications for adaptation
Replacement of liquid fossil fuels with some biofuels	Biofuel production can replace more diverse ecosystems, potentially negative impacts on food production and security
Re- or afforestation with non-native and/or high water-demand species	Competition for water supplies, biodiversity loss, limited ecosystem services
Rapid switch to low- or no-GHG energy sources	Higher energy prices may slow economic development and disproportionately affect low-income populations, potentially increasing their vulnerability
Replacement of coal with lower carbon fuels	Reduced livelihoods for coal-mining communities, thus higher vulnerability
Hydropower and wet-season retention of water in reservoirs for hot, dry season	Potentially increased risk of spill and dam failure, reduced flood protection downstream of hydropower dam
Carbon capture and storage	Potentially increased use of and competition for water
More compact urban design	Potential increase in urban heat island, increased development in floodplains (if present)

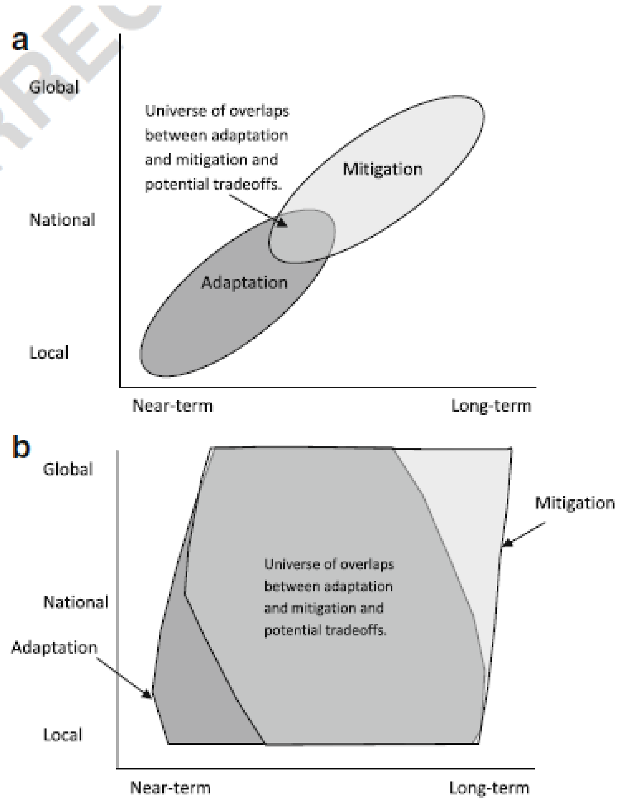
Adapted from Bedsworth and Hanak (2008); Klein et al. (2007b); and additional refs in text

In principle and practice, the notion of tradeoffs also applies to climate policy measures of any variety vis-à-vis other non-climate policy goals. For example, efforts to stimulate regional economic growth in a rural area or development in a less developed country may enhance some factors underlying adaptive capacity or reduce vulnerabilities for all or some communities and economic sectors in that region, but could also create new vulnerabilities or potentially increase energy consumption and consequently greenhouse gas (GHG) emissions. Investments to pursue a particular policy goal, such as efforts to enhance the attractiveness of a region as a tourist destination, or to address a structural debt problem, or any other competing policy goal may reduce the resources and options available to limit GHG emissions and reduce vulnerabilities. Yet Klein et al. (2007a, b, p 755) acknowledge that, "The competition of adaptation measures, mitigation measures and non-climate policies for a finite budget has not been studied in much detail." While specific empirical or modeling studies may be lacking, the all-too-real experience with myopic decision making at the individual, household, local, national and international levels where immediate concerns and threats receive more ready political and policy attention than long-term threats (even if they are potentially more severe) is well established (see review in National Research Council 2010b).

Importantly, tradeoffs may be direct and immediate (i.e., actions taken locally have undesirable, yet clearly identifiable consequences for others locally), or indirect and delayed (i.e., actions taken in one location may negatively affect others elsewhere or in the future through obvious or less obvious "tele-connections"). This feature of tradeoffs can result in, and may be the consequence of, temporal and spatial (or jurisdictional) disconnects between decision-makers (Moser and Ekstrom 2010). Actions in the past and/or at remote locations may affect the action space of actors here and now; actions taken at higher levels of governance may affect the action space of actors at lower jurisdictions, and so on (e.g., Cash et al. 2006).

The temporal and spatial cross-scale interactions between adaptation and mitigation measures and policies deserve more specific attention here. Adaptation options tend to be discussed as efforts focused mainly on the relatively near-term (i.e., with immediate effectiveness) and on local scales. By contrast, mitigation options, especially with an eye to the global impact they need to have to affect atmospheric GHG concentrations, tend to be viewed as long-term solutions and involving primarily higher (national and international) scales of governance. If this were so (or in the cases when this is so), the direct overlap of adaptation and mitigation is constrained to a fairly limited set of options, thus also constraining the universe of tradeoffs one would need to be concerned about (Fig. 1a). However, reality is far more complex and demands a long-term, life-cycle, and systems perspective to appreciate that in most instances, adaptation and mitigation—regardless of the level at which they are initiated—will interact with each other for the duration and wherever they are implemented (Fig. 1b). Just a few examples to illustrate this complexity: a country adopts a national policy to foster renewable energy (e.g., wind, solar, hydro, geothermal or tidal power) to permanently shift its energy mix and reduce its contributions to global GHG emissions. One may be tempted to argue it is only at this level that tradeoffs with nationally instituted adaptation policies (e.g., insurance schemes or construction standards) need to be examined. But such a perspective would ignore that the actual renewable energy producing facilities will be placed somewhere, that is: in real places, locally. At that local level, such national policies interface with local ecosystems and species that need to adapt to rapid climate change (e.g., Venema and Rehman 2007). A similar scenario with international ramification could be drawn, where one country decides to increase its nuclear power generation, but does not itself have the uranium resources to feed its power plants. Uranium mining in source countries will affect the local ecology, local to national economy, regional water resource use and so on, all critical in that country's and region's adaptive capacity. Ongoing debates about the interaction between biofuels and food production with implications for global GHG emissions and international food security reflect different specifics but similar patterns of interaction between mitigation and adaptation across temporal and spatial scales (e.g., Naylor et al. 2007; Escobar et al. 2009; Tilman et al. 2009).

Fig. 1 Overlap of Adaptation and Mitigation and the Universe of Potential Tradeoffs. **a** Common range of spatial and temporal scales of adaptation and mitigation options: If and when there is only limited overlap, the universe of potential tradeoffs is relatively constrained. **b** Common range of spatial and temporal scales of adaptation and mitigation options: Over the full lifecycle of a policy option the overlaps are significant and the universe of potential tradeoffs vast



Another example makes the cross-sectoral dimension apparent: a nation may set new building codes to improve the energy efficiency of houses—at first glance a positively synergistic measure that will reduce household energy use and ultimately national GHG emissions in warmer winters and hotter summers (mitigation), while better protecting its local inhabitants from the dangers of extreme heat (adaptation). And yet, as experts in the UK have argued, greater home insulation is considered a maladaptation with regard to flooding, as the cost of repair to flood-damaged houses is significantly higher than that for less insulated houses (Walsh and Hall 2008). Finally, a regional water district may determine that it cannot meet the water demands of its growing population against a backdrop of projections of a drier climate and is faced with tough long-term choices: while water conservation measures effectively implemented in the near-term may buy time (and save energy in the process) as scientific projections improve and financial resources are ascertained, the longer term outlook requires either the building of a local desalinization plant (a long-term, expensive, energy-intensive commitment with impacts ultimately on global GHG emissions), water imports and trading across regions (also a costly, energy-intensive proposition), or the unsustainable (and energy intensive) exhaustion of groundwater resources.

Warren (2011) convincingly argues that most assessments continue to ignore such interactions, including how climate change itself causes direct loss of ecosystem services (e.g., of particular relevance in the agricultural and forest sectors) that would make it extremely difficult to assume similar (much less improved) levels of vulnerability and adaptive capacity or similar future roles these systems could play in absorbing carbon (see also Parry 2009). In short, the examples illustrate clearly that any adaptation and mitigation measure must be examined from a systems perspective, for the length of the measure's lifecycle and its impacts on natural and human systems (Biesbroek et al. 2009). This is not to stymie action for fear of system interactions across scales, but to take seriously the ramifications of our further interference in the coupled human-natural systems in which we exist and on which we depend (NRC 2010b).

2.2 History, sequence and context matters

The typical calls to harmonize adaptation and mitigation are neither concerned with the scientific exploration nor with the *real politik* of tradeoffs. And much of the available science that has examined them is based on either modeling studies or a very limited set of empirical examples. Yet it is precisely this realism that may affect our understanding and interpretation of them. Thus, it is not just the competition for the necessary means, including staff time, the wrangling for a place on the policy agenda, and concerns over undesirable consequences (common issues in the broader literature on policy windows, e.g., Kingdon 2002) that describe the challenges associated with implementing a full portfolio of adaptation and mitigation actions. History, timing and context also matter—at least in practice.

While there is a long and diverse scientific interest in adaptation, arguably as long as in climate science, much of that interest has been disconnected from the modern day climate change debate, in general is less well established than our understanding of climate science and probably less well understood than mitigation. Whatever understanding of climate change adaptation we do have (and the limitations in that knowledge) have risen to attention only recently. In particular, policy-relevant, actionable, and place-based scientific knowledge on adaptation is relatively sparse, although that knowledge base varies across countries (National Research Council 2010a). This relative lack in scientific understanding is (maybe surprisingly) particularly acute in the US, where it has come into focus as adaptation has risen sharply on the federal, state, and local policy agendas (Moser 2009; National Research Council 2010a; Brody et al. 2010). The UK and Australia, by contrast, are perceived to be further along in providing scientific information to support adaptation policies and decisions (Rayner and Jordan 2010; Neufeldt et al. 2010; Australian Department of Climate Change 2010; Gardner et al. 2010). In the context of limited usable knowledge, however, the quest for harmonizing adaptation and mitigation must proceed without equal and balanced input on both aspects of an integrated climate risk management portfolio.

Aside from the science-policy history, policy history also has implications for attempts to harmonize adaptation and mitigation. Deliberate attempts to plan and prepare for the impacts of anthropogenic climate change, much less to make any specific policy or management changes on the ground have begun to emerge only relatively recently (e.g., Martens and Chang 2010; Tompkins et al. 2010; Preston et al. 2011) The overarching insight in the IPCC's Fourth Assessment was that while recognition of the need for adaptation was on the rise and planning activities were underway in many locations, few of these activities had reached the point of implementation (Adger et al. 2007). By contrast, there are many more practical experiences with making emission reduction efforts—in industry, private businesses, government operations at all levels of governance, at the household level, and through mandatory, regulatory, and market-based or voluntary approaches with or without explicit incentives (e.g., National Research Council 2010c; Bulkeley and Betsill 2005).

In places where regulation of greenhouse gas emissions is already on the books (e.g., the State of California), or where a price on carbon has been set and carbon trading schemes have been established (e.g., the European Union or Alberta, Canada), adaptation planning and actions typically fall into an uneven policy landscape: for those charged with implementing climate risk management strategies, mandates or price signals for mitigation are far more compelling—especially when financial, technical, and human resources are constrained—than voluntary measures or plans and general guidance documents. Until both mitigation and adaptation are set on an equal footing, i.e., on legally and/or economically equally compelling grounds, it is difficult to see how adaptation and mitigation can be harmonized effectively. Short of mandates to consider both mitigation and adaptation at the same time, the most cost-effective and most likely opportunities for "voluntary harmonization" are during regularly scheduled policy, planning, or maintenance intervals (e.g., general plan overhauls, infrastructure replacement), or in the aftermath of particular events (e.g., the rebuilding of communities and infrastructure after a climatic or non-climatic disaster such as a typhoon or an earthquake).

A final disconnect arises from the history (and legacy) of the climate change debate. Over the past 20 years, a deeply divisive public debate about climate science and the need for and nature of mitigation policy, have made "climate change" a red flag in many political contexts. The US and Australia are good examples. Widely (though not uniformly) documented declines in public belief in the reality of climate change, the solidity of climate science, and the need for action (e.g., evident in polls from the UK and the US, see Leiserowitz et al. 2010; Webster and Riddell 2009) not only undermine constructive debate over mitigation policies, but provide the context and political atmosphere for the now-emerging discussions about adaptation. Even in Europe, where climate change—generally speaking—has been discussed in less adversarial terms, the discourse historically was dominated by mitigation, whilst adaptation has entered the public and policy agendas only more recently, and public perceptions of the urgency for action vary with current weather events, economic concern, and other events competing for attention (Moser 2010b). Adaptation thus does not begin on a level playing field, but follows on a history of sometimes "disharmonious" or at least one-sided discussions of climate change to date. Much less is actually known about how the public thinks about local impacts and the need and of options for adaptation (Leiserowitz 2005; Moser 2009, 2010a), but practical experience shows that the pervasive skepticism leveraged against climate science and mitigation in some instances also shapes initial reactions to, and perceptions about the need for, adaptation to climate change impacts (Binder 2009; Bowman 2009; Kahan 2010; Kahan and Braman 2006). There is considerable communication yet to be done to challenge and replace old attitudes and perspectives which view mitigation and adaptation as alternatives, rather than as complementary and necessary approaches to managing climate risks. Resistance to tackling adaptation is still often based in the belief that talking about adaptation is a form of capitulation on mitigation (Moser 2009). Clearly, it is encouraging to see local communities and national-level agencies realize that because some climate change impacts are already occurring now and will continue to unfold for decades, even if global emissions could be completely stopped immediately, policies for mitigation *and* adaptation are needed (e.g., Council on Environmental Quality 2010; Australian Department of Climate Change 2010). That opens the door for harmonizing adaptation and mitigation, but neither the science, nor the policy landscape, nor the public debate will make this happen easily.

3 Science and policy implications

The disconnects and conflicts described above have far more direct and maybe more useful implications for science and policy than the partial, presumed and sometimes wishful, harmonies between mitigation and adaptation. Several pragmatic suggestions are offered in conclusion here.

First, there is a general and a more specific implication for advancing our scientific understanding to support better integration of adaptation and mitigation policies and actions. Because adaptation science is significantly behind climate science in general and in many instances even mitigation science, the climate change research enterprise must rapidly expand its understanding and knowledge base on adaptation (e.g., Adger et al. 2007; National Research Council 2010a, b). Only if we better understand the options, barriers and implications of various adaptation options in different sectors, regions, at and across different scales can we begin to make reasonably informed suggestions on how to effectively integrate them with mitigation strategies. More specifically, focused scientific effort must be expended at researching the potential positive synergies and the tradeoffs between them (including incompatibilities, competitions, and negative consequences), as well as assessments of the implications of policy timing and sequencing (Klein et al. 2007b; National Research Council 2010b). Such compatibilities and tradeoffs should be investigated under different degrees of warming (i.e., assuming some degree of failure to mitigate substantial further climate change) or any other variation in contextual variables (e.g., economically good vs. worse times) to assess how the options and challenges change under different circumstances and with different degrees of uncertainty (e.g., Kwadijk et al. 2010; Smith et al. 2011). Better quantification of costs and benefits of harmonization vs. independent implementation, efficiency gains due to integration, improved assessment of negative consequences of independent or joint implementation, more systematic identification of barriers to adaptation and mitigation, and improved monitoring and periodic evaluation of outcomes (generally more challenging for adaptation than for mitigation) are some of the more prominent examples of needed research in this arena (Wilbanks 2005; Wilbanks et al. 2007; Yohe and Strzepek 2007). In particular, the question of what would constitute “success” of a comprehensive, integrated portfolio of risk management strategies—reminiscent of the question of “what is dangerous interference in the climate system?—is in great need of both scientific and normative examination. To be practically relevant, such work must eventually also inform the development of user-friendly decision support tools that decision-makers at various levels can employ as they face the challenges of harmonizing climate policies.

In policy and practice, as progress is being made in developing and implementing mitigation and adaptation strategies and actions, evaluation of each policy’s implications on the potential action space for enacting complementary climate policies should become standard practice. Common policy tools available to assess such compatibilities include legal assessments and environmental impacts statements. Where they do not yet include consideration of emissions or robustness under different climate change scenarios, there are obvious (if difficult) opportunities to simultaneously advance adaptation and mitigation agendas. Where no climate policies have been developed or enacted yet, parallel development of mitigation and adaptation policies—with frequent interaction among the relevant staff—may be challenging, but could ultimately result in more efficient climate policy than piecemeal policy development and implementation. Overarching policy mechanisms (such as environmental impacts statements for major developments or plans), crosscutting changes in the kind of information being used to make decisions (e.g., no longer historical climate information but forward looking climate projections), and one-by-one reviews of smaller decisions and actions will be needed.

Important also will be the identification of adaptation or mitigation actions that have no or very limited impacts on the complementary climate policy or unrelated policy goals. Not every adaptation policy will have a mitigation component and vice versa. There is a risk in the desire to harmonize climate policies to disfavor stand-alone policies.[2] Differently put, the temptation should be resisted to prioritize only those measures that will create “win-wins” or positive synergies between adaptation and mitigation measures, while neglecting measures that are well indicated and demonstrably useful but don’t also produce co-benefits (e.g., certain land use restrictions).

[2] The author thanks an anonymous reviewer for pointing out this potential challenge.

Such changes in approach, rules and regulation, as a result of careful integration of climate policies, supported by adequate scientific input to assess tradeoffs and implications, will require high-level support and leadership from decision-makers at any level of governance involved in climate-sensitive decisions. Such visible leadership will send an important message to the public and thus help change the public debate. But public support for an integrated approach to managing climate risks will not come about easily or on its own, and instead require sustained education, communication, and meaningful dialogue where all involved learn about each others' concerns, values, needs and knowledge. Neglecting any side of the challenge of integrating mitigation and adaptation—the science, the policy landscape and history, and those who will need to support and be affected by climate policy—is bound to lead to further delays, tradeoffs, and ultimately, as John Holdren would say, greater suffering.

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