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Do two climate wrongs make a right?

David Schimel[1] and Charles Miller[1]

[1] Jet Propulsion Lab
Pasadena, CA, 91101
dschimel@jpl.nasa.gov

Corresponding author:
David Schimel. dschimel@jpl.nasa.gov

Key Points:

- The global policy response to climate change has assumed that mitigation is expensive while adaptation is inexpensive.
- Recent data suggests both these assumptions are wrong, with the cost of damages moutning rapidly and the cost of green energy falling faster than projected.
- The widespread realization that wealth at risk could exceed the cost of mitigation could drive a tipping point in human behavior. Researchers need to substantiate this through empirical and modeling analyses.

Abstract

As the planet approaches local and global exceedance of the 1.5° C stabilization target, damages from climate change, mostly due to extremes, are growing, far faster than projected. At the same time, assessment models have projected high costs of mitigation, but the cost of energy is dropping faster than projected. Climate policy has assumed that damage costs are manageable while decarbonization is expensive. Both these assumptions are wrong. Damage costs are rising rapidly and green energy costs are dropping quickly. potentially leading to a tipping point in human behavior: scientists need to explore options better aligned with this emerging reality.

Plain Language Summary

The Earth is warming rapidly and global temperatures are increasingly causing local extremes that are expensive to respond to and difficult to adapt to. In parallel, the costs of green energy are falling faster than any projections. Climate policy has been based on the opposite paradigm, moderate damge costs and expensive mitigation. Widespread realization that the wealth at risk could be more than the cost of mitigation could be a tipping point for the managing climate change.

Commentary

Rockstrom et al's influential paper (Rockstrom et al 2009) laid out the concept of a safe operating space for humanity, in terms of a number of so-called planetary boundaries, environmental thresholds to be breached at our peril. They argued that for climate, the boundary lay at 2^{o}C global mean temperature above the pre-industrial value. Today, as the planet approaches local and soon global, exceedance of the 1.5^{o} C target, the world is experiencing rapidly growing damages from climate, primarily through the growing frequency and intensity of extremes, heat waveson land and in the ocean, droughts, severe storms and storm surge on the coasts, as well as cascading impacts such as wildfire, loss of river flows, and human migration. Climate models have done a very reasonable job of projecting the overall climate trend, but are neither intended to nor are they skillful at projecting changing extremes and their compound and cascading impacts.

Economic modeling of climate change likewise goes back decades, but has only recently begun to factor in the emergence of of extreme events. Early modeling and analyses found relatively modest economic impact from climate change, especially in the developed world. For example, in 1993, Nordhaus wrote "A preliminary reading is that other advanced industrial countries will experience modest impacts similar to those of the United States, and some may even have net economic benefits" while noting that "Small and poor countries, …, may be severely affected" (Norhaus 1993).

In that same paper, Nordhaus noted the high cost of mitigating greenhouse gas emissions, the primary anthropogenic driver of climate change, and concluded that "It would take a major misestimate of either the costs of emissions reductions or of climate-change damages to make the stabilization options economically advantageous". An IPCC analysis from the same era reached similar conclusions, that adaptation would limit the costs of climate impacts, while mitigation would have a significant impact on global wealth (Schimel et al 1997). These early conclusions have framed much of the debate, pitting equity, the health of natural systems and the precautionary principle against the view that mitigating climate change would damage the world's economy and perhaps endanger development in the developing world.

This world view began to change with the Stern report (Stern 2007), which argued that argued that postponing action would increase the eventual cost of mitigation, and stated there was still time to avoid the wost impacts of climate change, if strong action was taken soon. In contrast to Nordhaus' view, Stern argued that climate change was a market failure, where the negative consequences of climate change were not properly acconted for in near-term decision-making. Despite this view and strong advocacy from many sectors, most policy makers still saw climate change mitigation as too costly given the assumed modest impacts from climate change, their far off event horizon, and the sense of uncertainty that persisted, even as the science became more and more incontrovertible.

The scientific community, both climate scientists and economists, have been measured in their assessments of climate change costs as a function of scientific culture and a defensive reaction against accusations of alarmism coupled with pervasive skepticism and denial of climate change (Risby 2007). As a result, two crucial assumptions about climate change have been quantitatively in error, and, in fact, we made just the "major misestimate" about which Nordhaus wrote. Damages from climate change have accumulated faster than almost all scientists and models anticipated, and technology has advanced faster than projected. These two "misestimates" of the cost of impacts and the ease of adaptation on the one hand and the cost of mitigation on the other hand, create very different economic possibilities. Current commercial estimates of climate damges are far higher than early or even current model-based estimates: Swiss Re, a major reinsurer, estimates that 18% of global GDP could be lost to climate change by 2050 (Swiss re 2021).

Figure 1 here

Climate policy is framed by these the opposing costs of damages in a warming world and the costs of decarbonizing the energy system. We now know the former question requires predicting future climate extremes, a formidable challenge, while the latter contrast a likely future without climate control against futures with varying levels of intervention, a complex and highly uncertain business. The impact of climate change on the world's wealth is "the *net* effect on gross world product, mitigation costs associated with decarbonizing the world's energy systems must be subtracted from the benefits of avoided damages" (Brown et al 2020)

The net cost of climate change, like other quantities critical to Earth System science, is the small difference between two large numbers and so vulnerable to large errors if even small errors are made in the gross values. Assumptions about the relative impacts of damages and mitigation following the above assumptions led to a sense that mitigation would decrease global wealth, requiring sacrifice and limiting resources available for economic progress in the developing world. Arguments for including natural capital, the world's ecosystems and natural resources, that could change this equation, have gained only limited traction.

Consider the alternative to the canonical view of expensive mitigation and modest damage costs. The pace of climate change, especially as manifest in extreme events, appears to have been underestimated, and many damages are hard or impossible to adapt to, including sea level rise, wildfire and regional drought (Boulton et al 2022). The rate of technological progress has been faster and the cost of alternative technologies declined faster than projections (Way et al 2021)

Climate model projections are most robust for large-scale patterns and broad patterns of warming, though their ability to forecast and project impacts through extremes is improving (Vitart and Robinson, 2018, Bador et al 2020). Scientists have long attempted to relate global changes, to for example mean annual temperature, to extremes, but in order to maximize the "signals", there analyses have often focused on changes at doubled CO_2 or in 2100, giving the impression that extreme changes were far off. This view is changing, due to both the rapid pace of climate-related disasters and improvements in both models and attribution techniques (Diffenbaugh 2020).

There is no evidence that models are intentionally biased toward catastrophic climate futures (Kemp et al 2022), so rather than being pessimistic, they are, at worst realistic in projecting global mean futures. Climate models, however, are not good at the more localized extremes and modes of variability that cause impacts like severe storms, drought, maritime storm surge, flooding, and icing. Based on the most recent data ana analyses, the Arctic Ocean is projected to be seasonally ice free as early as 2030 (Kim et al 2023) and sea level rise is projected at the high end of earlier estimates now that glaciologists realized that liquid meltwater percolating through ice sheets could greatly accelerate glacial mass loss (Noël et al 2019). These phenomena respond to a changing global climate by increasing frequency or intensity. Extreme weather damages have increased rapidly, partly due to societal vulnerability but mostly due to extremes (WMO 2023). High risk from climate change is an everyday reality.

Natural ecosystems and the benefits they provide to humanity also appear to be changing rapidly with climate. In the 1990s, George Woodwell and other ecologists (1995) argued that “warming might speed the warming” with higher temperatures from anthropogenic greenhouse gases leading to reduced uptake by the biosphere or even release of long-stored soil and biomass carbon. In 2000, an early model projected this could occur in South American forests by the 2050s (Cox et al 2000) , but recent studies suggest this transition to the balance between forest carbon uptake, release due to high temperature and drought stress, together with deforestation occurred not in the 2050s but in response to increasing drought frequency between 2010 and 2020 (Boulton et al 2022; Gatti et al 2021). In a similar vein, Wang and colleagues (2022) showed that, despite policies to promote forest carbon storage, California lost 5-10% of its forest cover over three decades. Warming and drying may speed the warming as Woodwell suggested three decades ago.

Climate also threatens agriculture more than expected in early assessments. World food security was long felt to be under only regional threat, but beginning with US assessments in the 2000s, evidence began to emerge of hard barriers to adaptation in both the biological flexibility of crops and livestock and in the cost and availability and of water and fertilizer to compensate for declining growing conditions, as well as emerging competition between food production and feedstock uses of crops (Backlund et al 2008). Gaupp et al (2020) also showed that even regional drought impacts have global food security consequences and climate shocks can be destabilizing. Agriculture is no longer viewed as adapting either easily or inexpensively to a changing climate and these impacts are now evident in global data.

What of the cost and difficulty of decarbonization? In a recent analysis, Way et al (2022) showed a pattern of consistently overestimated costs of decarbonization, comparing data to projections. They found that “IPCC conclusions thus appear to be based on an over-sampling of near worst-case scenarios regarding key green technology costs” and argue that for 40 years these overestimated costs have inhibited more aggressive action and that extrapolation of empirical data suggests the “green energy transition may be cheap”.

The penetration of electric vehicles has exceeded expectations, and the cost of renewable energy, rather than being higher than backstop fossil technologies, is now close or competitive, though storage and grid challenges remain. In 2017, the solar industry achieved SunShot’s original 2020 cost target of $0.06 per kilowatt-hour for utility-scale photovoltaic (PV) solar power three years ahead of schedule, dropping from about $0.28 to $0.06 per kilowatt-hour (kWh) between 2010 and 2017. Cost targets for residential- and commercial-scale solar have dropped from $0.52 to $0.16 and from $0.40 to $0.11 per kWh respectively, during that same period. Similar gains may be realized in storage and smart grid technologies. Increasing regional instability adds a national security dimension motivating decarbonization, and aviation is increasingly experimenting with biofuel and hydrogen energy sources.

The carbon-climate change equation is changing, from the 1990s Kyoto's challenge of "preventing dangerous interference" in the climate system to the far more concrete targets of the Paris Agreement. As the damages accrue and the availability and cost of alternative technologies decline, the framing of mitigation as a risk to global economic growth is less certain, and the possibility that effective mitigation could be inexpensive or a net benefit increases. There remains ethical and equity complexities to mitigation choices, but the economic tools available change as we see larger damages accruing rapidly and cheaper energy alternatives. While climate change mitigation is often seen as being in opposition to free markets (Küppers et al 2022), this emerging new equation suggests the contrary.

As noted in a recent New York Times article (NYT 2022), the high risk/lower cost scenario motivates changes to investment, both in R&D and in securities that are leaders in reducing their climate risk and carbon footprints. The increasing impacts of climate on the world economy and on human welfare leads to an increasing and perhaps very high social cost of carbon, while unexpectedly rapid progress in decarbonization may be further accelerated by investment and the removal of barriers and perverse incentives, for example, by the recent US climate action. Two wrongs, an incorrect estimate of climate impacts (Yale, 2011) and overestimated costs of mitigation – could lead to a right, the effective mitigation of climate change at a globally affordable cost. Indeed, a world with an efficient transition to green energy may be not only more verdant but wealthier than the unmitigated world, as damages mount and mitigation costs drop. As the private sector realizes the wealth at risk to climate could be more than the cost of mitigation, a tipping point in human behavior could occur, unleashing the creativity and capital needed to decarbonize the energy system.

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Open Research

This paper includes no new data.

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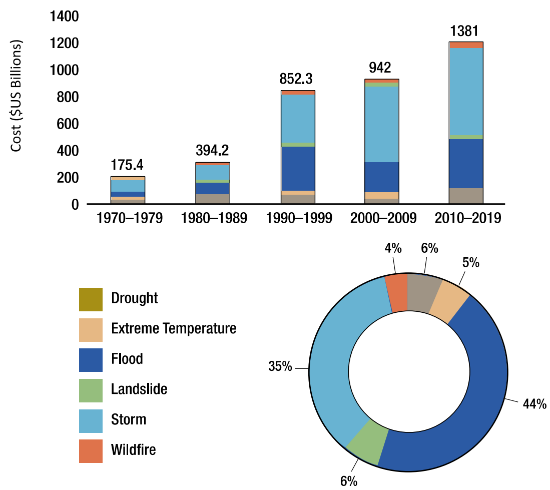
FIGURES

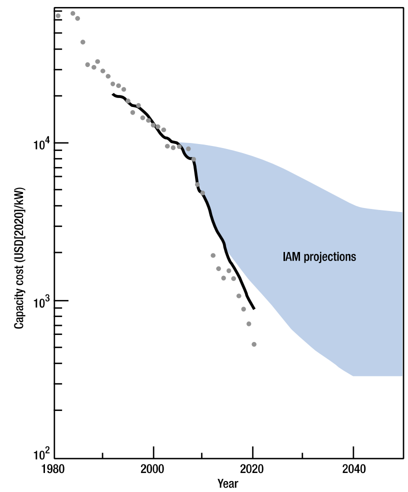
Figure 1. Two faces of the problem: Changing costs of damage and mitigation. A) Damages reported by the World Meteorological Organization for a range of climate-related events, showing costs of 6 types of climate related damage (WMO 2023). B) The falling costs of solar energy. Data and empirical projections show projections have been consistently too conservative, leading to overestimated mitigation costs. (Way 2022) Note, PV module costs are re-scaled by 2.5 to match axes.

Rapidly Growing Damages



The cost of climate damage is rising rapidly
(Data from World Meteorological Organization)
https://library.wmo.int/doc_num.php?explnum_id=10989

Rapidly Falling Costs



The price of renewables are dropping far faster than all projections
(Blue shade, model projections, dots, observed PV module cost, solid line, observed average investment in solar)
Way R, et al.Joule. 2022 Sep 21;6(9):2057-82.