ADAPTATION
FOR A HIGH-ENERGY PLANET

— A CLIMATE PRAGMATISM PROJECT —

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at Arizona State University

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BREAKTHROUGH INSTITUTE

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EXECUTIVE SUMMARY

Even as adaptation has more recently gained mainstream acceptance as an unavoidable response to rising global temperatures, it continues to be a sideshow to the main event of limiting greenhouse gas emissions through international climate negotiations. This misses enormous opportunities for effective action to reduce human suffering due to climate and weather disasters, and to lay a stable foundation for cooperative international efforts to address both climate adaptation and mitigation.

With global population growth, more accumulated wealth, and other socioeconomic changes, the number of people and amount of property exposed to and thus potentially vulnerable to climate risk will continue to increase, regardless of anthropogenic climate change and how well (or poorly) we address it. Societies can do a much better job in maximizing their resilience to climate-related risks.

With this in mind, we propose, as an animating goal for an adaptation agenda, the progressive and continual reduction of average number of deaths each year from natural disasters, including those disasters that will be exacerbated by a changing climate. With an agenda for action that is attentive to peoples' well-being, equity, and livelihoods, adaptation policies focus on opportunity rather than cost, promising benefits that are near-term and certain.

To bring adaptation to the fore, we emphasize two strategies. The first is to adopt progressive and decisive reductions in loss of life from disasters worldwide as a direct measure of adaptive success. The empowering lessons of regions as socioeconomically distinct as eastern India and the Netherlands show that such a goal can be within reach for all nations and people. The second strategy is to put adaptation at the center of the climate change policy agenda, along with energy access and innovation. "Low-regret" and "win-win" efforts to directly improve peoples' lives while supporting mitigation efforts offer attainable objectives for creating a more prosperous and resilient world that resonates with a diversity of values and worldviews.

Success in preserving human life in an often-capricious and frequently harsh environment is the result of innovative adaptations. Far from being a new activity undertaken in response to anthropogenic climate change, humans excel at the kinds of innovation-led adaptation which have lessened vulnerability to climatic and other challenges, and allowed humans to flourish in an incredibly diversity of climates.

We look at innovative adaptations that address challenges including food security, rising sea levels, and public health, in places as different as Nepal, the Netherlands, and inner-city Chicago. Two key lessons emerge from these examples:

1. **To adapt for rising exposure to climate change, innovate toward a range of possible futures:** Dealing with uncertainty requires flexibility and foresight to keep pathways open.

2. **High-energy adaptation means reduced vulnerability:** Reducing vulnerability to natural disasters depends on prioritizing socioeconomic development through modernized energy systems and other pragmatic initiatives. Successful adaptation will occur only on a high-energy planet.

In the following report, we evaluate opportunities to increase climate resilience through standard concepts used broadly to assess and mitigate risk; consider successful adaptations in a variety of different global contexts in search of key lessons for international climate adaptation; and consider what an alternative climate adaptation framework that takes adaptation as its primary objective might look like.

INTRODUCTION

For almost a generation, adaptation in response to a changing global climate has been the neglected stepchild of climate policy. In at least the first decade and a half after the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, adaptation was viewed negatively by many of the architects of the process, even as developing countries pushed for greater investment in adaptation efforts. Mitigating climate change through global greenhouse gas reductions was central to international efforts to address the challenge. Adaptation was perceived as a distraction to these efforts, since, as the UNFCCC asserts, "At the very heart of the response to climate change … lies the need to reduce emissions."[1]

Even as adaptation has more recently gained mainstream acceptance as an unavoidable response to rising global temperatures, it continues to be a sideshow to the main event in the international climate arena: efforts to establish limits on emissions. This single-minded approach has disappointed in myriad ways, as we detailed in the first two reports in this series, *Our High-Energy Planet* and *High-Energy Innovation*.[2] Climate policies with an overriding concern toward mitigation have tended to foster political gridlock, encourage alarmist rhetoric, and entrench inequities in, for example, access to modern energy.

A crowd calls for mitigation measures to deal with climate change near the Washington Monument on February 17, 2013. *Photo credit: Jmcdaid*

While demonstrably failing to achieve its mitigation targets, the UNFCCC has also constrained international adaptation efforts by narrowly defining adaptation in terms of responses to changes in climate that are attributable to human causes.[3] Such a definition effectively ignores the enormous vulnerability that much of the global population already faces to a naturally capricious climate, irrespective of any additional forcing attributable to anthropogenic greenhouse gas (GHG) emissions. At the same time, the UNFCCC's definition can in practice predicate adaptation action on the ability to distinguish climate impacts that result from human-caused global warming from those that do not—a near-absurd distinction.[4]

The present international framework for climate adaptation has been forced into the procrustean bed of climate change mitigation policy. Thus it has missed enormous opportunities for effective action to reduce human suffering due to climate variability and weather disasters, and to lay a stable foundation for cooperative international efforts to address *both* climate adaptation and mitigation. This foundation, we argue, would be greatly strengthened by refocusing attention on broad-based adaptation efforts—particularly those that

complement inclusive, low-carbon economic growth strategies. Now is the time to pragmatically rethink our approach to adaptation by connecting it to a diversity of values and aspirations—many of which have little connection to anthropogenic climate change.

Here we propose as a concrete goal for adaptation policies the progressive and continual reduction of the human toll (measured as average number of deaths each year) from natural disasters, including those disasters that will be affected or worsened by a changing climate. Tangible and universally appealing, this goal offers the potential for leveraging actions whose benefits are measurable in the short term. It opens a tremendous number of options for action—humans are nothing if not ingenious in adapting to a dynamic and often hazardous environment[5]—and can provide a politically attractive and morally appealing vision for development initiatives such as the U.N.'s ambitious Millennium Development Goals and their successors, the Sustainable Development Goals.

In places like Ningbo, where three large rivers converge, China is undertaking substantial measures to reduce vulnerability to flash flooding. *Photo credit: Jiong Sheng*

We propose as a concrete goal for adaptation policies the progressive and continual reduction of the human toll from natural disasters, including those disasters that will be affected or worsened by a changing climate.

Progress toward systematically reducing deaths from natural disasters is measurable using the most tangible of yardsticks—the saving of lives—with direct payoffs in the present. The objective may seem formidable on a planet with a growing population, and requires shifting the conversation about climate adaptation to focus on peoples' well-being, equity, and livelihoods. But it is certainly no more ambitious than the radical economic and technological transformations required by drastic emissions reductions. And it is one that many societies in different parts of the world have actually succeeded at achieving.

Adoption of such a goal can open up climate policy to new, politically invigorating options and opportunities. Above all, unshackling adaptation from mitigation-centered institutions like the UNFCCC requires understanding adaptation as a central component of socioeconomic development. Shifting to adaptation-focused objectives for the many funding mechanisms, policy levers, and lending institutions that currently operate in poor countries under the rubric of climate mitigation—some which enable and some which inhibit truly sustainable development—can move these efforts in a more pragmatic and coherent direction, one that directly improves people's lives. Adaptation provides an agenda that policymakers can implement at the national and local level, shaping decisions about urban and community development, land use and resource management, hazard insurance, building codes, evacuation, and recovery efforts that impact how communities prepare for and experience crises.[6]

International adaptation efforts can also drive innovation in critical areas like food production, public health, and energy provision. Making societies more resilient increases their ability to innovate and mitigate around other challenges, notably the increasing concentration of greenhouse gases in the atmosphere. And since adaptation addresses universal concerns about safety and well-being, an agenda focused on improving adaptation to climate variability does not demand agreement on climate science or particular mitigation measures: it can embrace and benefit from a healthy political pluralism that is unavailable to

today's rigid mitigation-oriented policy structure—a lack of inclusiveness that has been, in part, responsible for its undoing.[7]

As a political matter, adaptation efforts as broadly conceived (essentially, "adaptation to climate" rather than "adaptation to climate *change*," although the latter may become more important in the future) reinforces a general political consensus over the responsibilities of government to provide the infrastructure, policies, and services necessary for thriving, and thus can counter the corrosive effect that climate change debates have sometimes had on democratic politics.[8] "Low-regret" and "win-win" efforts to directly improve and protect peoples' lives while supporting necessary mitigation efforts and other co-benefits offer attainable objectives for creating a more prosperous and resilient world that resonates with a diversity of values.

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In the sections that follow, we evaluate opportunities to increase climate resilience through standard concepts used broadly to assess and mitigate risk; consider successful adaptations in a variety of different global contexts in search of key lessons for international climate adaptation; and consider what an alternative framework that takes effective adaptation as its primary objective might look like.

Losses caused by disasters are the result of three factors: the hazard, exposure, and vulnerability.[9] The **hazard** is an extreme event such as a flood, hurricane, or drought. The origin, frequency, or severity of the hazard may have a human element that some risk-mitigation efforts attempt to reduce. Reforesting denuded hillsides, for example, can prevent landslides; dredging and widening river channels can help prevent floods. Similarly, mitigation-oriented climate policies are justified by the idea that a future of more intense or more frequent storms, droughts, and temperature extremes can be avoided through emissions reductions.

Exposure reflects the human development that is subject to the adverse effects of hazards. We live in a dynamic, unpredictable world, and there are few if any places in which we are not exposed to some natural disaster or other. Unfortunately, when it comes to climate risk, much of the world's wealth and population are concentrated in areas especially prone to the anticipated effects of climate change, such as coastal areas and flood plains. Some interventions can reduce or prevent exposure, like smart land-use planning or building codes.

Vulnerability describes the susceptibility of people, their livelihoods, or their property to suffer negative effects when exposed to a hazard. A complex set of factors plays a role in

whether or not people are vulnerable to climate hazards. Inadequate socioeconomic development is one of the most significant of these factors. Prosperous, well-governed, democratic communities have more resources and capacity to devote to protecting themselves from current hazards and adapting to deal with new ones.[10] This is why we tie our adaptation agenda so closely to development processes, such as improved energy access and greater innovation capacity. Without that development, poor communities can lack the capacity to manage their vulnerability to hazards, regardless of how well the world may progress in slowing climate change.

Much of the world's property and people are concentrated in places that are exposed to hazards like hurricanes, illustrated by the damage from Hurricane Sandy in Mantoloking, NJ. *Photo credit: Mark C. Olsen*

UNDERSTANDING THE CLIMATE HAZARD

The central tenet of climate change mitigation policies has been that reducing GHG emissions today will reduce the consequences of future climate hazards by preventing human-caused increases in the magnitude, frequency, or duration of hazards like hurricanes, floods, sea level rise, and droughts. The idea of reducing the hazards associated with anthropogenic climate change by preventing them in the first place may have made some notional sense as the UNFCCC was being formulated in the late 1980s and early 1990s. But the overwhelming evidence from two decades of peer-reviewed research since suggests that such hopes are an extraordinarily weak foundation for addressing the challenges of climate change that society will face this century.

One reason is that losses from climate hazards have little to do with changes to the climate. The increased toll of human suffering, both in terms of casualties and property damages, from climate-related natural disasters over the past century is overwhelmingly a function of changes in exposure and vulnerability, not increasing hazards due to climate change.[11] The dramatic rise in disaster losses across the globe due to these other factors exceeds increases associated with hazard intensity by an order of magnitude. This contrast will likely continue to be the case for many decades, if not centuries, to come.

In the special report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX), the Intergovernmental Panel on Climate Change

(IPCC) observes that "[m]ost studies of long-term disaster loss records attribute these increases in losses to increasing exposure of people and assets in at-risk areas . . . and to underlying societal trends—demographic, economic, political, and social—that shape vulnerability to impacts."[12] Likewise, in the recent IPCC Fifth Assessment Report (AR5), the Second Working Group concludes: "Economic growth, including greater concentrations of people and wealth in periled areas and rising insurance penetration, is the most important driver of increasing losses."[13] The authors note that "the worldwide burden of human ill-health from climate change is relatively small compared with the effects of other stressors and is not well quantified."[14]

Two aerial views illustrating the development of Miami Beach, one from 1925 (left) and the other from 1978 (right), demonstrate the reason for increasing losses due to natural disasters. *Photo credit: Wendler Collection*

Another reason that mitigation policy can have little impact on climate hazards for the foreseeable future is that, even if wildly successful, the world is stuck with at least some warming and the consequent impacts. Even dramatic reductions in emissions today will not significantly manifest in terms of either global temperature trends or sea level rise until late this century or early in the next.[15] The IPCC estimates that even if emissions had stabilized in the year 2000, preceding emissions would have already "committed" the Earth to another half-degree Celsius of warming by 2100.[16] Other studies suggest that due to atmospheric-oceanic dynamics, surface temperature warming could continue for several centuries even if emissions stop today.[17] In addition, climate models predict little impact on sea level rise between radical emissions reductions and business-as-usual scenarios.[18]

These points do not minimize the importance of emissions reductions. Temperature increases of as much as 4 to 6 degrees Celsius over the next several centuries present unknowable and perhaps dire risks to human societies. We are not yet able to confidently predict the nature and scale of those risks, or the adaptive capacity of future human societies. Effective measures to reduce emissions in order to limit the magnitude of future climate change are hence warranted and valuable. But justifying those measures in terms of mitigating climate hazards now or in the near future is not only unwarranted, it has blinded climate policymakers and advocates to the opportunities for human development offered by innovation-focused strategies (particularly in energy), as we discussed in our first two reports.

Successfully working to reduce GHG emissions now may reduce the intensity and frequency of some climate hazards in the future. In the meantime, hurricanes and typhoons will ravage coastlines, severe droughts will imperil farmers and water supplies, and floods will regularly sweep away people, homes, and livelihoods. This is to say nothing of tropical diseases, wildlife habitat loss, the collapse of fisheries, soil degradation, air and water pollution, and the many other difficulties that currently confront populations worldwide.[19] Climate mitigation efforts alone can do little to reduce present vulnerability to these disasters, and can perversely expose fragile populations to greater risk. This is precisely what happens when the narrow objective of limiting carbon emissions takes precedence over socioeconomic development that is environmentally sound and socially just—as we have argued is the case with overly modest energy access targets for the world's poor.[20]

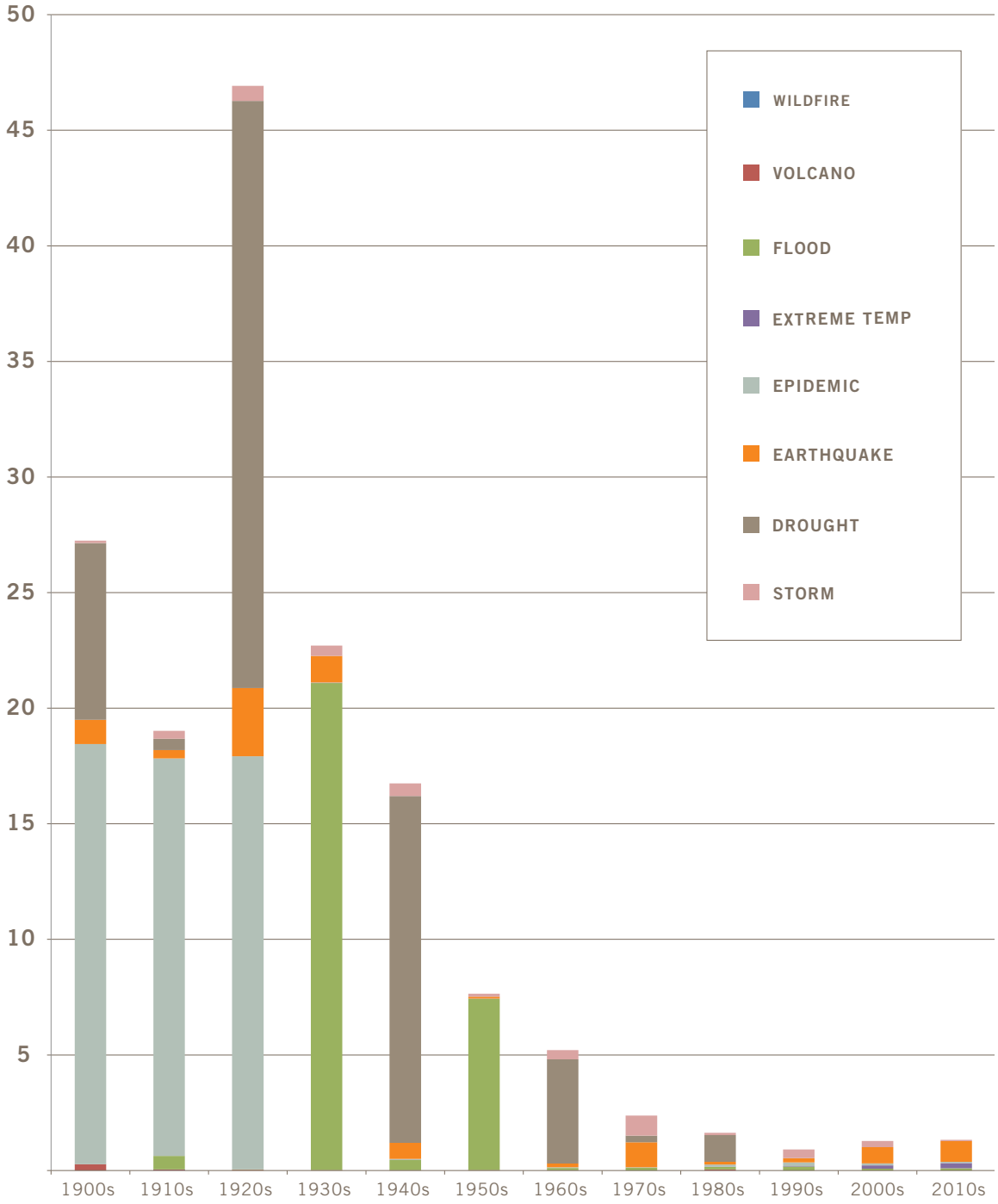
Improving global resilience to climate variability and hazards will require international efforts to reduce exposure and vulnerability through broad-based adaptation, shifting focus away from whatever small role anthropogenic climate change presently plays in those hazards.

ADAPTING TO INCREASED EXPOSURE THROUGH INNOVATION

With global population growth, more accumulated wealth, and other socioeconomic changes, the number of people and amount of property exposed to and thus potentially vulnerable to climate risk will continue to increase, regardless of anthropogenic climate change.[21] Societies can do a better or worse job in maximizing their resilience to climate-related risks. We think a much better job is possible, and history shows this to be the case. Over at least the past century, humanity as a whole has dramatically reduced mortality from natural catastrophes. This success in preserving human life in an often-capricious and frequently harsh environment is the result of innovative adaptations.

Following the IPCC, we define adaptation as adjusting to or preparing for the current or anticipated climate (not just the human-caused *change*) and its impacts, with the intention of both reducing vulnerability to harm and taking advantage of opportunities. Reducing vulnerability (or, alternatively, improving resilience—not quite the same, but adequate as synonyms for our purposes) is the ability of coupled human and natural systems and their constituent parts "to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner."[22] These may be sudden and relatively unpredictable events, like tsunamis or cyclones, or slow-onset changes, as with atmospheric warming or changes in rainfall patterns. Effective adaptation efforts intervene in human and natural systems to manage exposure and reduce vulnerability to hazards. Adaptation can be pursued at all levels of governance and scales of action.

ANNUAL GLOBAL DEATH RATE (PER 100,000) PER DECADE FROM NATURAL CATASTROPHES, 1900–2013



Infographic credit: Max Roser (OurWorldInData.org)

How is adaptation accomplished? There are lessons from around the world that governments and civil society can learn from.

CASE STUDIES IN ADAPTATION

1. ADAPTATION AS INSTITUTIONAL INNOVATION: CROP DEVELOPMENT IN NEPAL

This plant breeder works with farmers in Nepal to produce hardier crops for cultivation. *Photo credit: Netra Chhetri*

Nepal provides a good example of a novel multilevel institutional partnership that supports adaptation—in this case alleviating the country's food security challenge. The collaboration among farmers, non-governmental organizations, and the government of Nepal that works at all stages of technological innovation in agriculture. This includes goal-setting, sharing knowledge with various stakeholders, and developing farmer-preferred technologies suitable to the local environment.[23]

The partnership has been enhanced over the last two decades through an approach called Participatory Technology Development (PTD). While forging dialogue among farmers, researchers, and agricultural policymakers, this collaboration has been vital in setting a research agenda and developing locally appropriate technologies. This novel institutional

arrangement has worked to everyone's advantage: it has been cost-effective, location-specific, and met the needs of both farmers and researchers.

The outcome of the PTD approach has been the development of hardy rice varieties in a region of Nepal that suffers perennially from poor production due to variable climatic conditions. Institutional and technological innovations of this kind contribute not only to food security but also to climate adaptation. The partnership has enhanced the institutional and technological skills of farmers and communities in plant breeding, seed production, and marketing.[24] This kind of collaboration, facilitated by community-based institutions, allows knowledge to flow between key groups—breeders gain information about the farmers' preferences for specific traits, and farmers learn about and experiment with improved rice varieties.[25]

Innovative institutional arrangements like the PTD program develop new information and technology aimed at improving resilience; coordinate with social groups and individuals; and can provide financial and leadership support that strengthens local institutional capacities.[26] And today, these arrangements are crucial contributors to Nepal's capacity to recover from the tremendous destruction of the 2015 earthquakes.

2. ADAPTATION AS MANAGEMENT STRATEGY: STAYING DRY IN THE NETHERLANDS

The Dutch live with the constant threat of inundation, and have been engaged with an ongoing process of adaptation for more than a thousand years. They have essentially carved their country out of the North Sea through engineering prowess, innovative institutions, and collective action.[27] Future challenges for the country include rising sea levels, sinking land, and changing precipitation patterns.[28] But these risks are well understood, and the country has the adaptive capacity to deal with them for the foreseeable future.

What is more uncertain is Dutch social and economic development, which can change exposure to risk in the long term and which is hard to predict. As in many other affluent countries, the dangers stem not only from the sea or climatic variability, but also from economic changes, demographic shifts, and land-use policies.[29] Recognizing the hazard is not enough: understanding how to address exposure and vulnerability to these hazards is needed for adaptation, and Dutch policymaking and governance has excelled at this.[30]

The Dutch have used their considerable financial resources to reduce the danger posed by flooding, storms, and the ongoing concentration of wealth in vulnerable areas. The Dutch Delta Programme, which addresses these challenges, has its own government commissioner, its own legal basis in the Delta Act, and a budget of one billion euro per year. Much of the protection against flooding involves a capital-intensive system of dikes, dams, seawalls, and other protective infrastructure. But reclaiming and protecting land from the sea also necessitates investment in technological and institutional innovation. Local water boards were organized as long ago as the 13th century as a form of democratic governance that allows citizens to make decisions about how best to confront collective risks.[31] These institutions improve not just the capacity to deal with water, but also inspire other government agencies to decide on adaptive practices, such as how to increase the already extraordinary reliability of the Netherlands' power grid.[32]

One of the ways the Dutch build flexibility into their policies and infrastructure is to focus on current or near-term needs but with, when feasible, the option to adapt their protections to future conditions if needed. Thus, for example, levees are constructed or strengthened to withstand existing flood predictions, but are also designed to be heightened in the future, as increasing risks or higher safety standards might necessitate. This strategy is complemented with a systematic lowering of river levels, for instance by means of creating bypasses, or "room for the river." For Dutch water managers and the public, this kind of flexibility is predicated both on the likelihood of a warmer future and the need to deal with the complexities of a highly unpredictable world.

3. ADAPTATION AS DISASTER RESPONSE: LEARNING FROM CYCLONES IN INDIA

A super cyclone slammed into the northeast coast of India in October 1999. Accompanied by tidal surges and days of torrential rain, the eye of Cyclone 05B made landfall in the state of Odisha.[33] Neither officials nor citizens in the storm's path took warnings about the impending storm seriously.[34] In the hardest-hit areas, coastal deforestation to make room for prawn fisheries and migrant housing meant there was little to hinder winds with top speeds of 160 miles per hour and tidal surges of 26 feet.[35] The devastation caused by the super cyclone is difficult to comprehend. Official estimates place the death toll at nearly 10,000 people, with millions made homeless; crops and livestock over a wide swath

of the state were destroyed, along with the livelihoods they supported.[36] Essential infrastructure like roads and bridges lay in ruins. Relief workers pulled bodies from the mud for weeks afterward.

A multipurpose shelter like this one protected citizens of Odisha from the worst effects of Cyclone Phailin in 2013. *Photo credit: ADRA India*

In 2013, another massive cyclone developed off the east coast of India, in the Bay of Bengal. Cyclone Phailin had worryingly similar characteristics to the 1999 storm: the day before it made landfall, the cyclone had sustained winds of 160 miles per hour, and it smashed into Odisha only slightly further south than the previous storm. Tidal surges destroyed fishing boats and heavy rains caused extensive flooding inland. The high winds swept away houses, uprooted trees, and wrecked power grids throughout the state.[37] But remarkably, of the 13 million people affected by the cyclone, only 44 died: 21 from the cyclone itself (mostly from falling branches), and 23 killed in flash flooding in the storm's aftermath.[38]

Why did vastly fewer people die during Cyclone Phailin than Cyclone 05B—or, for that matter, from other notable storms like Typhoon Haiyan (with more than 6,300 deaths), Hurricane Katrina (more than 1,700 people), and Hurricane Sandy (285 fatalities)? The most important answer is that in the years after the devastation of 1999, the state of Odisha and its coastal communities resolved that storm casualties were unacceptable. This provided a powerful motivation for effective protection measures, and was the inspiration for the adaptation goal proposed in this report.

In cooperation with the Indian central government and donors like the World Bank, they put tremendous effort into reducing their vulnerability to another super cyclone. Adaptation initiatives included building cyclone shelters as multi-purpose structures that house schools when not being put to emergency use (ensuring their upkeep); developing contingency plans for evacuating and housing hundreds of thousands of coastal residents; and improving the Indian Meteorological Department's storm tracking and predictions to enable accurate early warnings.[39] Similar examples of responsive governance leading to fewer deaths from storms can be found in other parts of South Asia.[40]

The conceptual drawing for an elevated Tsunami Evacuation Park (TEP) in Padang, Indonesia. *Image credit: Kornberg Associates*

4. ADAPTATION AS SHARING KNOWLEDGE: PREPARING FOR TSUNAMIS

Effective adaptation, like other innovation processes, requires learning from past experience, experimenting with novel practices and technologies, and participating in a network of people who can share and evaluate new practices that emerge from particular contexts. During the 2004 Indian Ocean tsunami, for example, which killed nearly 230,000 people, inhabitants of Simeulue Island in Indonesia knew to head into the mountains when they saw the ocean retreating, through knowledge passed down from the generation that had experienced a deadly tsunami in 1907. They survived in much greater numbers than other places in Indonesia, whose inhabitants may not have had that knowledge. Several programs since then have sought to educate coastal communities about what to do for the next tsunami, using social networks and institutions to provide information, rather than high-tech measures that fail to reach everyone and have proven to be unreliable.[41]

It may be impossible for coastal communities, particularly in densely populated cities, to reach higher ground even if adequately warned of an approaching tsunami. In a neat reversal of traditional evacuation plans, one innovative approach seeks to bring higher ground to low-lying communities in the form of elevated parks. A half-dozen elevated parks in the Indonesian city of Padang could save as many as 100,000 people from the threat of inundation. Simple, relatively inexpensive, and reassuring to the city's inhabitants, this innovation depends more on knowledge of a particular social and institutional context than of the science of tsunamis or complex models of how they work.[42]

LESSON: TO ADAPT FOR RISING EXPOSURE TO CLIMATE CHANGE, INNOVATE TOWARD A RANGE OF POSSIBLE FUTURES

The one sure thing about the future is that the unexpected will occur. Dealing with uncertainty requires flexibility and foresight to keep pathways open.

An adaptation agenda, with the ambitious goal of minimizing harm from natural disasters, means setting goals with concrete benefits now—but keeping an eye toward a variety of potential futures. The pathways for achieving the goals that communities want and need for adaptation are varied. For example, increasing risks of flooding due to sea level rise or

higher peak river discharges can be approached with elaborate infrastructure, by retreating from vulnerable areas, by improving evacuation procedures, by flood-proofing buildings and infrastructure, and through democratic participation in a process that decides how the country will develop socioeconomically. All of these methods have been adopted as strategies in the Netherlands.

Even as nations develop economic and infrastructural resilience to extreme events, there are better and worse approaches to adaptation. The above case studies demonstrate smart, forward-looking, flexible policies to increase resilience even where significant capital and human life are exposed.

PROTECTING THE MOST VULNERABLE

Vulnerability to climate extremes is not equitably distributed. Reduced vulnerability is highly correlated with both individual and societal wealth. Wealthy societies can afford infrastructure and institutions, from sea walls, flood channels, and evacuation shelters to emergency response systems, building codes, and the capacity for implementation that poor societies often cannot. With higher incomes come air conditioning, refrigeration, and communication technologies that help individuals navigate both immediate crises and chronic long-term shifts in the natural environment.[43] Prosperous societies are able to invest in institutions and decision-making processes that embody principles of good governance, providing a solid foundation for identifying adaptation priorities, making fair trade-offs, and building resilience.[44]

Therefore the most effective way to expand options for dealing with both expected and—often more importantly—unexpected changes is through socioeconomic development. In general, economically distressed and disenfranchised communities are fragile and vulnerable to hazards, with few resources to invest in protection or recovery from extreme events. In terms of governance and institutions, the weaker and less democratic they are, the more citizens suffer when natural disasters occur. Economic development and responsive governance provide a strong foundation for dealing with all kinds of unpredictability, from epidemics to storms to economic recessions.[45] Poor populations are mainly not more vulnerable to climate risk than rich countries because of their geographies, but because they have not yet acquired the resilience underpinned by socioeconomic development processes.

CASE STUDIES IN VULNERABILITY REDUCTION

1. ADAPTATION AS DRIVER OF DEVELOPMENT: ENERGY ACCESS IN SUB-SAHARAN AFRICA

The Katse Dam in Lesotho is an important source of water and energy. *Photo credit: Christian Wörtz*

The conspicuous lack of access to modern energy sources in sub-Saharan countries has resulted in a staggering 80% of urban households using charcoal for cooking and heating. Charcoal production to meet this need has created swathes of deforested land around cities like Addis Ababa, Lusaka, and Kampala.[46] Deforestation has a number of negative consequences, ranging from soil erosion (which can exacerbate flooding and landslides), to poor agriculture (and food insecurity), to increased risk of wildfire (because secondary growth forests are more susceptible to fire). It also destroys an important source of atmospheric carbon sequestration. In addition to these regional impacts, charcoal's use indoors causes considerable health problems at the household level.

Access to reliable modern energy services can reduce vulnerability to these hazards: powered irrigation systems make farmers less reliant on unpredictable rainfall; effective healthcare depends on energy services like electricity and fuel for refrigeration, transportation, and device operation; and abundant energy drives industrial expansion, urbanization, and job growth. Equitable access to reliable and abundant energy also reverses the enormous environmental despoliation created by the subsistence living of hundreds of millions of poor people—despoliation that itself greatly magnifies the risk of natural disasters, such as mudslides and floods caused by deforestation of mountainous regions.

Without reliable, modern forms of energy like electricity and natural gas, many communities in sub-Saharan Africa are deprived of the opportunities for socioeconomic advancement presented by energy access. Forced to meet cooking and heating needs with fuels like charcoal, energy poverty exacerbates inequality—particularly for the women and children who spend a considerable amount of their time finding fuel and cooking indoors—and vulnerability to many hazards. The minimal or nonexistent energy access in developing countries becomes an example of maladaptation not just to future challenges, but current conditions as well.

Yet, as we explored in our two previous reports, this kind of energy sector development—one that underpins prosperous and resilient societies—lies outside, and in many ways directly contradicts, the framework within which energy, development, and climate change are typically linked. Reorienting that framework toward the imperative of improving access to abundant, affordable, and increasingly clean energy provides a much sturdier foundation for development, resiliency, and environmental protection. This should be the "win-win" priority for organizations and governments that seek to foster sustainable development.

2. ADAPTATION AS GREATER EQUALITY: PUBLIC HEALTH AND EXTREME HEAT

The individuals most vulnerable to a range of hazards tend to be those with the weakest social networks within their communities—the old, very young, infirm, poor, or otherwise marginalized.[47] Advance warning of dangers do little to help these individuals, and they often lack the ability to access even basic services (like transportation, healthcare, public shelters, or even information about natural disasters) that can help them cope with extreme events.

The deadly 1995 heat wave in Chicago, Illinois provided ample evidence of this kind of vulnerability. A disproportionate number of the 739 people who died from the heat were elderly and African American, living alone in poor, violent, segregated neighborhoods. But not all communities with these characteristics suffered equally. In demographically similar neighborhoods, but ones where businesses had not fled and community organizations remained active, people survived the heat wave at rates comparable to or exceeding more affluent areas of the city. Churches, block clubs, and especially commercial activity, provided an informal social support network that ensured many fewer people died during the city's worst natural disaster.[48] A similar story played out in Europe during its deadly heat wave in 2003.

Improved social bonds can help communities deal with hazards like heatwaves. *Photo credit: Vasilios Sfinarolakis*

Poor and marginalized individuals may remain isolated and alone during other crises, such as flooding, hurricanes, earthquakes, or influenza outbreaks.[49] Improving social bonds among these individuals and with the broader community thus offers a powerful form of resiliency that improves the overall health of individuals and communities and their development prospects. The benefits of strong social capital, underpinned in part by a vibrant commercial sector, range from reduced obesity and diabetes rates,[50] to lower levels of crime,[51] to longer life spans.[52] With these impacts in mind, over the past fifteen years the

Centers for Disease Control and Prevention has launched community engagement programs in various U.S. cities to build and strengthen the kinds of local social infrastructure that help vulnerable communities deal with hazards and address public health concerns like smoking, cancer, and heart disease.[53]

LESSON: HIGH-ENERGY ADAPTATION MEANS REDUCED VULNERABILITY

Reducing vulnerability to natural disasters depends on prioritizing social and economic development. Adaptive capacity requires more energy for climate control in buildings, high-tech crops and energy-intensive fertilizers, levies and sea walls, and the kinds of commercial activities that improve social bonds. Successful adaptation will occur only on a high-energy planet.

While the correlation between socioeconomic development and climate resilience is strong, it is important to recognize that causation runs both ways. Improved adaptation to climate extremes and natural disasters brings greater socioeconomic development, even as that development improves resilience. Air conditioning in tropical countries, for instance, not only makes the population less vulnerable to heat waves, but also dramatically increases labor productivity year round.[54]

How best to accelerate socioeconomic development remains a vexed and controversial topic. We simply argue that fostering development prospects and decreasing disaster vulnerability are synergistic. Ambitious adaptation objectives—as India's declaration to eliminate deaths from cyclones demonstrates—can be powerful drivers of these development processes, even in countries that are not yet affluent.

Prioritizing human development as an adaptation strategy requires actions and investments that are most appropriate within that development context, rather than the conventional mitigation focus of climate policy. For example, achieving more access to modern energy for more people, which is a problem from the mitigation perspective, is a solution pathway from an adaptation perspective. A good first step to improving adaptation in developing countries would therefore be to address the vast inequities in access to modern energy. In our previous reports we explained how a focus on energy access and modernizing energy production and distribution systems can accelerate technological innovation that leads to cleaner, cheaper energy. Here we emphasize that energy access also helps build resilience into all societies—an approach in which mitigation and adaptation are complementary.

AN ALTERNATIVE ADAPTATION FRAMEWORK

As described above, we propose as an animating goal for an adaptation agenda the progressive and continual reduction of average number of deaths each year from natural disasters, including those disasters that will be exacerbated by a changing climate. With an agenda for action that is attentive to peoples' well-being, equity, and livelihoods, adaptation policies focus on opportunity rather than cost, promising benefits that are near-term and certain rather than long-term and uncertain. And as the examples discussed here illustrate, reduced disaster vulnerability is something societies have succeeded at achieving.

Adaptation activities neither preclude nor discourage—and in fact should complement—action on the critical task of reducing GHG emissions. As we discussed in our two previous reports, socioeconomic development and energy innovation open new opportunities for stabilizing atmospheric greenhouse gas concentrations. Energy innovation is also a broadly adaptive process because the prosperous modern societies enabled by improved energy access and innovation capacity are better able to deal with hazards, for reasons ranging from better infrastructure to more effective public institutions.[55] Localized adaptations also support mitigation efforts. One example is urban planning that prioritizes high-density, mixed-income neighborhoods, mass transit, and infrastructure produces urban communities that are both climate resilient and lower-emission on a per capita basis.[56]

Social institutions are a critical component of climate adaptation.[57] Nepal's farmer-managed irrigation systems, for example, perform a range of activities, including pooling resources for maintaining irrigation waterways, regulating water distribution and allocation, monitoring rule violation, and arbitrating and negotiating conflict. These local institutions have historically been instrumental in safeguarding resources, including the protection of forests and watersheds. In recent decades, these institutions have played an important role in bridging the gap between researchers, development workers, and the lay community. Such local institutions are vital in facilitating climate adaptation processes, whether in the foothills of the Himalayas or inner-city Chicago. Yet, as we are seeing in the aftermath of Nepal's recent earthquakes, they can be threatened by—and thus must be resilient to—a range of hazards, not just those related to climate.

Adaptation activities neither preclude nor discourage—and in fact should complement—action on the critical task of reducing GHG emissions.

These and the other adaptations are not necessarily cutting edge, nor are they directed only at the anticipated impacts of a warming climate, and that is our point. What these adaptations have in common is that they build on a long history of adjusting to dynamic environments and improving well-being in the context of current and expected challenges. They do not depend, as action under the UNFCCC does, on determining which phenomena are the result of "dangerous anthropogenic interference with the climate system." They do not even depend on prioritizing climate change as the core issue, although this may be an effective entry point for addressing problems such as sea level rise.

Crises—and the increased possibility of crises—offer opportunities for increasing resilience. Because of their immediacy, they can unite communities around the need for resilience in ways that abstract or future-oriented climate predictions cannot. In addition, the impact of extreme events offers metrics for evaluating adaptation efforts: Did a community's adaptations produce resiliency when tested by events? Conversely, reduced vulnerability provides longer-term benefits beyond disasters themselves. The initiatives described in Odisha and the Indian Ocean communities have the potential to create positive feedbacks of

effective governance, democratic participation, and increased adaptation, as the public demands an end to avoidable deaths and the government implements programs to realize that goal.

The options offered by an adaptation agenda are also necessary from a political perspective: unlike mitigation's gridlock and divisiveness, adaptation empowers decision makers to act on a variety of important issues in ways that resonate with their constituencies. In some contexts, that will mean explicitly connecting policies to addressing climate change; in other cases, action can be premised on concerns like raising living standards for those in poverty or protecting lives and property against natural hazards of all causes. The politics of adaptation align with the values of virtually all citizens.

CONCLUSION

Climate policy writ large, and international climate negotiations in particular, have prioritized emissions reduction and put adaptation on the back burner. In our view, hanging the long-term "solutions" for everything from food security to public health to economic growth on how well the world can reduce its greenhouse emissions is untenable and ineffective. Such an approach makes it difficult to see the advantages of dealing pragmatically with impacts of climate in the present, through adaptive strategies that can deliver near- and medium-term benefits that justify the political and economic costs of taking action.

Politically, the mitigation approach has framed climate change as a narrow problem with a linear relation between action and impact. *Reduce greenhouse gas emissions to avert catastrophe!* is a simple formula that translates nicely into bumper stickers such as "Save the Planet" or "Stop Global Warming." It defines all action that connects to reduced emissions as desirable, and all others as bad. It specifies goals mainly in terms like parts per million of atmospheric carbon dioxide and its benefits reside in an unknowable future. In the real world, GHG concentrations are but one abstract manifestation of the complex sociotechnical systems on which humans depend for their well-being. And despite the enormous efforts expended to create a global greenhouse gas mitigation regime, the result has mostly been political divisiveness—and, so far, ever-rising emissions.

In stark contrast, adaptation to the current and anticipated climate (and not just its human-caused changes) is a process of identifying multiple pathways for achieving concrete goals like reduced deaths and economic losses from disasters, more equitably distributed prosperity, stronger communities, better public health, and more access to modern energy systems.

The National Center for Research on Earthquake Engineering in Taipei, Taiwan can perform full-scale testing of earthquake-resistant building designs. *Photo credit: Gatutigern*

An adaptation agenda includes an array of activities beneath its broad umbrella, but central to it is creating options and opportunities for achieving desirable outcomes under a range of possible futures.[58] Determining which outcomes are desirable and what futures are possible is the messy task of our democratic institutions; achieving this adaptability through continual learning is the responsibility of our communities and organizations. Positive, pragmatic adaptive action—difficult and incremental as it may sometimes be—is a powerful

force for protecting human dignity, livelihoods, and prospects in the face of a dynamic climate and rapidly evolving societies. It is pluralistic and inclusive, it promises near-term benefits for near-term costs, and it offers broad opportunities for political support. Nearly everyone can see themselves as a potential "winner" in some aspect of an effective adaptation agenda.

Innovation, a process through which new (or improved) technologies and institutions are developed and brought into widespread use, has always been an integral part of the social response to the multiple stresses from the natural world. Far from being a new activity undertaken in response to anthropogenic climate change, humans excel at the kinds of innovation-led adaptation which have lessened vulnerability to climatic and other challenges, and allowed humans to flourish in an incredibly diversity of climates.[59] Technological examples include food preservation techniques to overcome the problem of seasonal shortages; aluminum and other structural materials that resist environmental deterioration; antifreeze to safeguard internal combustion engines in the winter; and weather and earth resource satellites for analysis of weather and climate. Other adaptations include vaccine development, property insurance, disaster preparedness, forest management, and biodiversity conservation—the list is nearly endless.

To unleash this force we emphasize in particular two focusing strategies. The first is to adopt progressive and decisive reductions in loss of life from disasters worldwide as a direct measure of adaptive success. The empowering lessons of two regions as socioeconomically distinct as Odisha and the Netherlands show that such a goal can be within reach for all nations and people. The second strategy is to put improved adaptation to climate at the center of the international policy agenda, along with energy access and innovation. This new, pragmatic focus can create a multitude of political opportunities and policy pathways for emerging from a quarter century of climate change gridlock into an era of enhanced human thriving and improved capacity to manage the natural systems that sustain us.

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