

Hot

**Living Through the Next Fifty
Years on Earth**

Mark Hertsgaard

Table of Contents

[Title Page](#)

[Table of Contents](#)

...

[Copyright](#)

[Dedication](#)

[Contents](#)

[Prologue: Growing Up Under Global Warming](#)

[1. Living Through the Storm](#)

[2. Three Feet of Water](#)

[3. My Daughter's Earth](#)

[4. Ask the Climate Question](#)

[5. The Two-Hundred-Year Plan](#)

[6. Do You Know What It Means to Miss New Orleans?](#)

[7. In Vino Veritas: The Business of Climate Adaptation](#)

[8. How Will We Feed Ourselves?](#)

[9. While the Rich Avert Their Eyes](#)

[10. "This Was a Crime"](#)

[Epilogue: Chiara in the Year 2020](#)

[Acknowledgments](#)

[Notes](#)

[Index](#)

[Footnotes](#)

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Dedication

For my daughter, Chiara, who has to live through this

Contents

Prologue: Growing Up Under Global Warming [\[>\]](#)

1. Living Through the Storm [\[>\]](#)
2. Three Feet of Water [\[>\]](#)
3. My Daughter's Earth [\[>\]](#)
4. Ask the Climate Question [\[>\]](#)
5. The Two-Hundred-Year Plan [\[>\]](#)
6. Do You Know What It Means to Miss New Orleans? [\[>\]](#)
7. *In Vino Veritas*: The Business of Climate Adaptation [\[>\]](#)
8. How Will We Feed Ourselves? [\[>\]](#)
9. While the Rich Avert Their Eyes [\[>\]](#)
10. "This Was a Crime" [\[>\]](#)

Epilogue: Chiara in the Year 2020 [\[>\]](#)

Acknowledgments [\[>\]](#)

Notes [\[>\]](#)

Index [\[>\]](#)

Prologue: Growing Up Under Global Warming

Working on climate change used to be about saving the world for future generations. Not anymore. Now it's not only your daughter who is at risk, it's probably you as well.

—MARTIN PARRY, co-chair of the *Fourth Assessment Report*,
Intergovernmental Panel on Climate Change

I covered the environmental beat for fifteen years before I became a father. Much of that time was spent overseas, where, like many other journalists, I saw more than my share of heartbreaking things happening to children. But they were always other people's children.

My first time was in the old Soviet Union, where I exposed a series of nuclear disasters that had been kept secret for decades by both the KGB and the CIA. One day, I visited the leukemia ward of the local children's hospital, where a dozen mothers and children had gathered to speak with me. Many of the kids were bald, thanks to the chemotherapy that was now being applied in a last-gasp attempt to save their stricken bodies. The mother of one heavysset girl could not stop sobbing. When her daughter stroked her arm to comfort her, the mother unleashed a deep, aching wail and fled the room. This woman, like the other mothers, knew what the children did not: the doctors expected 75 percent of these children to be dead within five years.

Soon after, I spent four months in the northeastern Horn of Africa, mainly covering drought and civil war. It was there, in a refugee camp in southern Sudan in 1992, that I first came face-to-face with starving children. In my mind's eye, I can still see the young mother as she entered the Red Cross compound, hoping to see a nurse. Unfolding the tattered cloth she had slung from her neck, the mother revealed a nine-month-old baby girl, a tiny creature with a grotesquely large skull and legs no thicker than my fingers. Like one of every eleven African children, this poor child would not live to see her first birthday.

Later still I visited China, where millions of children were breathing and drinking some of the most carcinogenic air and water on the planet. Crisscrossing the country in 1996 and 1997, I became the first writer to describe China's emergence as a climate change superpower, second only to the United States. To fuel its explosive economic growth and lift its people out of poverty, China was burning more coal than any other nation on earth, making its skies toxic and dark even on sunny afternoons. Some of the worst health effects were being measured in the northern industrial city of Shenyang. One afternoon I visited a heavy-machinery factory that ranked among the city's deadliest polluters. I arrived just in time to see the street fill with hundreds of children. Chattering and laughing, they walked in rows six abreast, returning home from school, inhaling poison with every breath.

In my journalism, I tried to draw the outside world's attention to the plight of all of these children, as well as to its causes and potential remedies. Emotionally, though, I could keep a distance. This was partly because, as I say, these were other people's children. But it was also, I now see, because I was not yet a parent myself. I did not really understand, viscerally, how it feels to see one's own child be sick, in danger, and perhaps facing death.

I found out soon enough.

My daughter was born in 2005, in San Francisco, at the end of a long and difficult labor. After many hours and much pushing and tugging, she finally emerged from her mother's body. By that time the urgency of the situation had drawn a dozen nurses into the room. As they attended to their various tasks—lifting the baby onto her mother's chest, administering her first bath—one nurse after another made the same observation.

"Wow, look how alert this baby is," the nurse in charge commented.

"I know," marveled a colleague. "Look at her eyes!"

Apparently, most newborns keep their eyes shut against the light of the new world. Not ours. Her blazing blue eyes were wide open. From the moment she got here, this little girl was awake on the planet.

When it came time to give her a name, her mother and I remembered these first moments of her life and decided to call her Chiara. In the Italian language of her ancestors, Chiara (pronounced with a hard *C*, *Key-AR-a*) means "clear and bright."

Everything seemed fine until two days later. We had taken Chiara home from the hospital. As scheduled, a nurse came to conduct a follow-up exam. A few hours later, a doctor called and told us to bring Chiara back to the hospital, to the intensive care unit, right away. The exam had found dangerous levels of bilirubin in her blood. Brain damage or worse could follow.

At the intensive care unit, Chiara was placed inside an incubator, a white gauze headband stretched around her little skull to protect her eyes. The nurses jokingly called it a raccoon mask. Day and night I sat beside the incubator, watching Chiara's yellowish body get drenched with vitamin D—laden light.

Yet as worried as I was, I also felt fortunate. Unlike the children I recalled in Russia, Africa, and China, Chiara had access to excellent medical care. Within three days, she had completely recovered with no lasting damage, and was sent back home.

Six months later, though, a different threat arose to my daughter's life, and this time no quick fix was available. During a reporting trip to London in October 2005, I learned that the global warming problem had undergone a momentous transformation. Humanity, it turned out, was in a very different fight than most people realized. Now, no matter what we did, Chiara and her generation were fated to inherit—indeed, spend most of their lives coping with—a climate that would be hotter than ever before in our civilization's history.

Global Warming Triggers Climate Change

The most important interview I did in London was with Sir David King, the chief science adviser to the British government. King received me at his office high above Victoria Street, a few blocks west of Parliament. When he stood up to shake hands, I could glimpse the spires of Westminster Abbey over his shoulder. Though not a tall man, King projected an unmistakable air of command as he

invited me to join him at a conference table. I was on assignment from *Vanity Fair* magazine, a fact that seemed to amuse King, who had chaired the chemistry department at Cambridge University for seven years before entering government. "That's one publication I never thought I'd appear in," he said, chuckling. "I guess climate change has finally made the mainstream in the United States."

Since becoming science adviser in 2000, David King had done as much to raise awareness of climate change as anyone except former U.S. vice president Al Gore. Among other accomplishments King had reportedly persuaded Prime Minister Tony Blair to make the issue a priority, and Blair in turn made climate change the lead topic at the 2005 summit of the Group of Eight, the world's richest economies. King also had a gift for attracting media coverage. In 2004, he called climate change "the most severe problem we are facing today—more serious even than the threat of terrorism." Coming barely two years after the September 11 terrorist attacks, the comment enraged right-wingers in Washington. But King told me he "absolutely" stood by it. "I think this is a massive test for our civilization," he said. "Our civilization has developed over the past eight thousand years during a period which has had remarkably constant weather conditions and remarkably constant ocean levels. What is happening now, through our use of fossil fuels, through our growing population, is that that stable period is under severe threat."

I had begun following the climate issue in 1989, the year I first interviewed James Hansen. As the chief climate scientist at the space agency NASA, Hansen had put climate change on the international agenda the year before when, in testimony to the U.S. Senate, he declared that man-made global warming had begun. Of course, *natural* global warming had been taking place for a very long time already. Building on the work of scientists going back to Joseph Fourier in 1824, the Nobel Prize-winning chemist Svante Arrhenius had published a theory of the greenhouse effect in 1896. The theory held that carbon dioxide and other gases in the atmosphere trap heat from the sun that otherwise would escape back into space, thus raising temperatures on earth. Indeed, without the greenhouse effect, Earth would be too cold to support human life. In his Senate testimony, Hansen argued that human activities—notably, the burning of oil, coal, and other carbon-based fuels—had now added excessive amounts of carbon dioxide to the atmosphere. This extra CO₂ was raising global temperatures, and they would rise significantly higher if emissions were not reduced. The higher temperatures in turn could trigger dangerous climate change, Hansen added.

A quick word here on definitions: although the terms *global warming* and *climate change* are often used interchangeably, a critical difference exists between them. In this book, *global warming* refers to the man-made rise in temperatures caused by excessive amounts of carbon dioxide, methane, and other greenhouse gases in the atmosphere. *Climate change*, on the other hand, refers to the effect these higher temperatures have on the earth's natural systems and the impacts that can result: stronger storms, deeper droughts, shifting seasons, sea level rise, and much else. To oversimplify slightly, think of global warming as the equivalent of a fever and climate change as the aches, chills, and vomiting the fever can cause.

It was partly Hansen's 1988 Senate testimony that led me to spend most of the 1990s traveling around the world, researching humanity's environmental future. I was also motivated by interviews I had done with Jimmy Carter, the former U.S. president; Jacques Cousteau, the French underwater explorer; Lester Brown, the founder of the Worldwatch Institute; and other leading environmental thinkers. Brown in particular had argued that problems such as global warming and population growth were cumulative in nature and thus presented a new kind of environmental challenge: if they were not

reversed within the next ten years, Brown said, they could acquire too much momentum to reverse at all. I wasn't necessarily convinced Brown was correct, but his assertion was a provocative hypothesis to explore as I set off around the world. My mission was to investigate whether our civilization's survival was indeed threatened by global warming, population growth, and related environmental hazards. And if the danger was real, I hoped to gauge whether human societies would act quickly and decisively enough to avoid environmental self-destruction.

Over the course of six years, I investigated conditions at ground level in sixteen countries in Asia, Africa, Europe, and North and South America to write the book *Earth Odyssey*. As part of my research, in 1992 I covered the UN "Earth Summit" in Brazil, where I watched the heads of state or government for most of the world's nations (including the United States, under the first President Bush) affix their signatures to the UN Framework Convention on Climate Change. This treaty remains in force today; the better-known Kyoto Protocol is an amendment to it. The treaty's key sentence affirmed the world's governments' pledge to keep atmospheric levels of greenhouse gases low enough to "prevent dangerous anthropogenic [man-made] interference with the climate system."

From the start, then, the goal of the international community was to stop global warming *before* it triggered dangerous climate change. As the 1990s wore on, more and more scientists came to agree with Hansen that average global temperatures were rising and that humanity's greenhouse gas emissions were the main reason why. But—and this is the key point—most scientists did not expect this global warming to trigger significant climate change for a long time to come: the year 2100 was the date usually referenced in scientists' studies of sea level rise, famine, and other possible impacts. Although 2100 was chosen partly because it was distant enough to enable more reliable computer modeling studies, the date had the practical effect of implying—especially to politicians, journalists, ordinary citizens, and non-scientists in general—that serious impacts were a century away. In short, climate change was regarded as a grave but remote future threat, and one that could still be averted if humanity reduced emissions in time.

Meanwhile, a tiny but well-funded minority had begun arguing that global warming was little more than a politically inspired hoax. Frederick Seitz, a former president of the U.S. National Academy of Sciences, was the highest-ranking scientist making this claim, but most of the argument was carried by spokespersons for the Global Climate Coalition, a pressure group created and funded by U.S.-based energy and auto companies. Notwithstanding its studiously neutral name, the coalition would spend millions of dollars in the 1990s on a public disinformation campaign whose strategy and tactics recalled the tobacco industry's earlier efforts to persuade people that smoking cigarettes does not cause cancer. Indeed, Seitz and organizations he directed were paid more than \$45 million for their work, first by tobacco and later by energy companies, as I'll describe later in this book.

The goal of the disinformation campaign was to "reposition global warming as theory rather than fact," according to an internal strategy memo unearthed by journalist Ross Gelbspan, who exposed the campaign in his 1997 book *The Heat Is On*. Despite such revelations, the deniers had considerable influence over the public debate, at least in the United States. Fortified by corporate contributions and bipartisan support in the U.S. Congress, deniers turned global warming into a political rather than a scientific dispute, blaming a supposed conspiracy by Gore and other "liberals" to advance a radical environmental agenda. James Inhofe, a Republican senator from the oil-rich state of Oklahoma, led the charge, calling global warming "the greatest hoax ever perpetrated on the American people." But Inhofe, Seitz, and other deniers could never have fooled the public and stalled political progress

without the help of the mainstream media. In the name of providing journalistic balance, U.S. news stories routinely gave as much prominence to deniers of man-made global warming as they did to affirmers of it, even though the deniers amounted to a tiny fraction of the scientific community and often, as in Seitz's case, were in the pay of fossil fuel companies.

The upshot was that public discussion of global warming from the 1990s onward was framed as an if-then formulation: *if* global warming is real, and *if* greenhouse gas emissions are not reduced, then humanity *might* face problems in the far-off future.

In our London interview, David King shattered this framing. Climate change, the science adviser told me, was no longer a distant hypothetical threat: it had already begun. What's more, climate change was guaranteed to get worse, perhaps a lot worse, before it got better.

No comparably prominent scientist in the United States was saying this sort of thing publicly in 2005. In particular, King's assertions went beyond the findings of the Intergovernmental Panel on Climate Change (IPCC), an international group of scientists and experts the UN had created in 1988 to advise the world's governments on global warming. The IPCC had issued three major reports on climate change by the time I interviewed King. Its *First Assessment Report* appeared in 1990, its *Second Assessment Report* in 1995, and its *Third Assessment Report* in 2001. Only in its *Fourth Assessment Report*, released in 2007, eighteen months after our interview, did the IPCC declare that the scientific evidence for man-made global warming was "unequivocal" and that long-term sea level rise and other impacts of climate change had become inevitable. If King was ahead of the curve, it was partly because, as the British government's chief science adviser, he kept a close eye on what his country's scientists were doing. Indeed, he told me, a group of British scientists had recently detected the so-called climate signal; that is, the scientists had demonstrated that global warming had already exerted an impact on the earth's climate that stood out from the statistical noise of the historical record.

The scientific rule of thumb had always been that no single weather event could be linked to global warming. After all, extreme weather events were a recurring fact of history; how could one know whether a given event was caused by global warming, not by something else? But Britain, King claimed, had some of the best weather scientists in the world, a legacy of the nation's past as a maritime empire. Now, three of those scientists—Peter A. Stott, D. A. Stone, and M. R. Allen—had produced a breakthrough of epochal significance.

Their research, published in the scientific journal *Nature*, focused on the summer of 2003, when Europe experienced a brutal heat wave. Public health systems were overwhelmed. By mid-August, corpses were piling up outside morgues in Paris. The summer of 2003 was not only "the hottest ... on record," King told me, it was also "the deadliest disaster in modern European history." It left 31,000 people dead, he added—a death toll twenty times higher than that of Hurricane Katrina, which had struck six weeks before our interview.

"Now," said King, "if we treat that hot summer as a single extreme event, the conclusion is that it's a 1-in-800-year event—quite a highly unlikely event." But the science adviser pointed out that over the past fifty years global warming had created "a rising baseline" of higher temperatures, which was heating up Europe's weather in both normal and abnormal years. Thus Europe's average summer temperature in 2005 was the same as it had been in the hottest summer of the twentieth century, in 1947. When an extreme event like the 2003 summer came along, the rising baseline made it even

hotter. The conclusion, said King, was that "about half" of the excessive heat Europeans endured in 2003 was due to the rising baseline—that is, to global warming.

King then recalled the single harshest truth about climate change: we can't turn it off, at least not anytime soon. Once global warming has triggered it, climate change continues for a very long time. The reason? The laws of physics and chemistry—what King called "the inertia of the climate system." Carbon dioxide, the most plentiful greenhouse gas, stays in the atmosphere for as long as hundreds of years; oceans absorb the heat created by global warming and release it back to the atmosphere over the course of centuries. As a result, there is a lag effect, a delay, between the time greenhouse gas emissions may be reduced and the time global temperatures may begin to fall. The lag effect meant that Europe was already locked in to more frequent heat waves in the years ahead. Because of the rising baseline of temperatures, the science adviser told me, by 2050 Europe was projected to experience heat waves like that of 2003 once every two years.

King summarized the dilemma by offering a hypothetical case: even if our civilization stopped emitting all carbon dioxide overnight, he said, "temperatures will keep rising and all the impacts [storms, drought, sea level rise, and so on] will keep changing for about twenty-five years."

I asked if that meant it was "too late to save humanity, if that's not being too dramatic."

"No, no, it's not too late," King hurried to reply. "And saving humanity, I think, is not being too dramatic." Because we had waited so long to reduce emissions, we now had no choice but "to adapt to the impacts that are in the pipeline," King said. At the same time, the longer we wait to cut emissions, the greater the impacts will be. "So let's never give up on this," he said.

I had a six-month-old daughter, I replied, so giving up was not an option.

"Right," he said, flashing a quick smile. "My kids know who I'm battling for."

"Chiara Has to Live Through This"

After leaving King's office, I needed time to absorb all I had heard, so I headed down Victoria Street to walk along the river Thames. The weather was sunny, pleasant, a stark contrast to King's dire pronouncements. In effect, the science adviser had told me that climate change had already arrived, a hundred years ahead of schedule. If he was right, the debate over global warming was forever altered.

If climate change had indeed already begun, the inertia of the climate system ensured that the planet was locked in to at least twenty-five more years of rising temperatures no matter what—no matter how many solar panels people bought, no matter how soon the United States and China might limit their emissions, no matter what treaties the world's governments might one day agree upon. And as temperatures continued rising, this additional global warming would drive additional climate change: harsher hurricanes, deadlier wildfires, more epidemics.

By now I was passing Parliament, threading my way through crowds of tourists and office workers dashing out to lunch. King had said we were locked in to twenty-five more years of warming, but fifty years seemed more plausible. The reason was partly that, as I learned later in my reporting, other scientific analyses indicated that the climate system's inertia would keep temperatures rising

after a global emissions halt for thirty to forty more years, not the twenty-five years King had cited. A second reason was that halting carbon dioxide emissions overnight is impossible: it would mean turning off most of the world's power stations, factories, vehicles, and other essential infrastructure—a recipe for chaos and suffering. Like it or not, fossil fuels were essential to our current social organization; it would take time to shift to alternatives. Historically, such shifts—from wood to coal in the nineteenth century, from coal to oil in the twentieth—had taken about fifty years. Even if we managed the task in half the time, we still faced at least fifty more years of intensifying summer heat, dwindling water supplies, and persistent droughts like the one then fueling civil war in Darfur. Lester Brown's warning back in 1990—that if we didn't reverse global warming within the next ten years, it could become irreversible—began to look disturbingly prescient.

Soon I had crossed the Westminster Bridge and begun heading down the far bank of the Thames. A large Ferris wheel, known as the London Eye, stood just ahead. I heard children laughing and shouting as they waited for the Eye's mechanical arms to lift and wheel them high above the bustling city. I was still a new father at that point, and it took these children's cries to remind me that I had a child of my own now. The words burst from my mouth before I knew it: "Chiara has to live through this."

It was a staggering realization. My infant daughter did not know how to walk or talk yet, but some fundamental facts about her future seemed already determined. Twenty years from now, when I hoped Chiara would be finishing college and preparing to make her way in the world, average global temperatures would still be rising, unleashing yet more powerful impacts. And temperatures and impacts were bound to keep increasing until at least 2050, when Chiara would be almost as old as I was now.

True, higher temperatures will have positive as well as negative effects. For example, as climate contrarians such as Danish statistician Bjørn Lomborg like to emphasize, fewer people figure to die from winter cold. But such positive effects will be dwarfed by negative ones, according to the vast majority of scientific analyses, including the IPCC's reports. It is also true that there is considerable uncertainty about the scope and timing of climate change impacts. Scientists find it especially difficult to determine the probability of the most extreme scenarios, such as the total melting of the massive Greenland and West Antarctic ice sheets or the shutdown of the Atlantic Ocean's thermohaline circulation—popularly known as the Gulf Stream—whose warm currents give Europe its temperate climate. But the practical consequences of such extreme events—an estimated forty feet of sea level rise if those ice sheets melt, a near-polar chill descending on Europe if the Gulf Stream shuts down—a re so grave that they command concern. "The odds of some of the extreme scenarios may be only 10 to 20 percent, we're not sure," said Stephen Schneider, a professor of biology at Stanford University who was one of the first scientists to raise concerns about global warming in the 1970s. "But it's crazy to run those kinds of risks. The odds of your house catching fire are a lot less than 10 percent, but you wouldn't think of going without fire insurance."

The fundamental point is that my infant daughter would be growing up under global warming for the rest of her childhood and coping with climate change for the rest of her life. Under the circumstances, it wasn't just Chiara's physical safety I worried about; her emotional well-being was also at risk. As she got older, how would she cope with knowing that the climate around her would become less and less hospitable over time? How would that make her feel about her future, about perhaps having kids herself someday?

Staring down at the Thames, I felt stunned, heartbroken, but also deeply angry. Of course Chiara was not the only one at risk; every child on earth faced a version of the same fate. My fear mingled with a sense of personal failure, for my daughter and her generation were locked in to the very future that I and many other people had spent years trying to prevent. Now, it seemed, time had run out on a lot of us who had tried to halt global warming before it did serious damage.

But there was more to it than that. True, the premature arrival of climate change was partly a matter of bad luck. Even scientists as outspoken as Hansen were surprised by its speed. "The impacts we're seeing today weren't expected until late in this century," he later told me. Nevertheless, humans had played a decisive role.

Our collective failure to take action against global warming had been a conscious decision, a result of countless official debates where the case for reducing greenhouse gas emissions was exhaustively considered and deliberately rejected. Voices of caution had repeatedly been overpowered within the halls of government, in the media, and in the business world. Bankrolled by the carbon lobby, to borrow author Jeremy Leggett's term—the energy and auto companies that profited from carbon emissions—opponents of taking action had confused the public, politicians, and the media with false or misleading information while also pressuring governments not to act.

Covering the climate story during the 1990s, I had often wondered about the deniers' motivation. Did they sincerely doubt the scientific case for man-made global warming? Or were their attacks rooted in an allegiance to continued burning of fossil fuels? Years later, an answer emerged after a lawsuit pried loose internal documents of the Global Climate Coalition. It turned out that the coalition's own scientific advisers had informed its leadership in 1995—two years before the carbon lobby led the fight against the Kyoto Protocol—that the science behind man-made global warming was "well established and cannot be denied." The coalition's board of directors responded by ordering their scientists' judgment removed from the coalition's public statements.

In short, the carbon lobby knew perfectly well that global warming posed real dangers, but it chose to deny those dangers and disparage anyone who sought to bring them to public attention. The lobby put its immediate economic interests ahead of humanity's future well-being. By devoting enormous financial resources and political muscle to blocking limits on greenhouse gas emissions, the carbon lobby in effect insisted that humanity bet its survival on the possibility that David King, James Hansen, and hundreds of other scientists were either lying or wrong about the dangers of climate change. Now, in October 2005, it was becoming clear that scientists had actually underestimated the danger. Humanity had lost the bet. Climate change had arrived a century sooner than expected, and future generations were no longer the only victims. My daughter and her peers around the world were now at grave risk as well.

As a father, I rebelled at what all this implied for my little Chiara's future. So there beneath the London Eye, I made a silent vow: to find a way, if one existed, for Chiara and her generation to survive the challenges ahead. Using my journalistic skills, I would investigate how bad things were likely to get, how soon. What would Chiara's community in northern California look like after ten, twenty, fifty more years of climate change? What were our civilization's chances and options for reversing global warming? Could we do so soon enough to avert what the IPCC had delicately called "the worst scenarios" of climate change, including an eventual sea level rise of eighty feet—enough to put most of civilization underwater? I also hoped to discover ways to cope with the heat waves,

droughts, sea level rise, and other impacts that were now locked in over the coming decades. Could sufficient protections against these impacts be put into place? Above all, what steps were needed to turn these twin imperatives—to reverse but also to survive climate change—into practical realities? In short, what had to happen for my daughter and her generation to live through the storm of climate change?

1. Living Through the Storm

The first thing that struck me ... was the magnitude of the risks and the potentially devastating effects on the lives of people across the world. We were gambling the planet.

—SIR NICHOLAS STERN, British economist, House of Lords

CHIARA AND I BEGAN reading fairy tales together long before she could understand the words or even focus her eyes on the pages. She was a week old, just released from her ordeal in intensive care, and normal things felt almost magical. It was bliss to sit in a rocking chair, cradle her tiny body against mine, and lull her to sleep with *The Three Billy-Goats Gruff*, *The Adventures of Peter Pan*, or *The Hobbit*. And so began our ritual. Chiara and I would read books together every night before bed and again the first thing the next morning, when we slipped downstairs early to give her mother some much-needed extra rest. We read fairy tales, nursery rhymes, picture books, Italian books, even adult nonfiction (the words didn't matter to Chiara at that point; it was enough for her to hear my voice). As the days became weeks and months, Chiara grew to adore books and the stories they contained. And her father came to understand that fairy tales offer valuable lessons to children and adults alike in the face of global warming.

Found in almost every culture, fairy tales are some of the oldest, best-loved stories on earth. They are passed down through generations not only because they amuse children (and help parents get them to sleep) but because they offer comfort and inspiration. In *The Uses of Enchantment*, psychoanalyst Bruno Bettelheim argued that fairy tales enable children to make sense of the world around them and to face the fact that "a struggle against severe difficulties in life is unavoidable, is an intrinsic part of human existence." But, Bettelheim continues, "if one does not shy away, but steadfastly meets unexpected and often unjust hardships, one masters all obstacles and at the end emerges victorious."

The first fairy tale Chiara fell in love with was *The Nutcracker*. She was about eighteen months old when she developed an obsession (and believe me, *obsession* is the word) with Tchaikovsky's magnificent score of E. T. A. Hoffmann's Christmas tale. Though she had only just begun to talk in full sentences, she insisted on hearing the story and music again and again. The plot is simple: At a Christmas party, Clara is given a nutcracker by her godfather, an inventor with a hint of magic about him. Clara falls asleep under the Christmas tree, clutching the toy. She awakens at midnight to see the nutcracker, now grown as large as she, has come under attack from an army of giant mice, led by a king with seven heads. Just as the king is about to slay the nutcracker, Clara leaps into the fray and kills the mouse with a well-aimed hurl of her shoe. Her gesture transforms the nutcracker into a handsome prince, who shows his gratitude by inviting her to his kingdom, the Land of Sweets, where they live happily ever after.

After seeing *The Nutcracker* ballet onstage, Chiara began acting out the story at home. She invariably cast herself as Clara; her mother or I was assigned to play the godfather, the prince, or both. One day, after she and I had played the game for about the three hundredth time, I got distracted. To my half-listening ears, the music seemed to indicate the start of the battle scene, so as the prince I began to brandish my sword. A puzzled look appeared on Chiara's face. It took her a moment to realize that her father was confused. She looked up and carefully explained, "No, Daddy. It is still the

party. The danger is not here yet."

The party, so long and pleasurable, that gave rise to global warming is indeed still under way. Despite years of warnings about overheating the atmosphere, we humans are still merrily riding in cars and airplanes, building pipelines and power plants, gobbling meat, clearing forests, expanding our houses and suburbs, and doing a thousand other things that emit the greenhouse gases that cause the problem. There has been a lot of talk about going green, but the economies of most nations are still based on burning oil, coal, and other carbon-based fuels, so emissions continue to increase. Meanwhile, the party gets more crowded and raucous by the day, as global population swells, the wealthy pursue ever more luxurious lifestyles, and the poor yearn for their own taste of the comforts fossil fuels can provide.

If most of us nevertheless seem in no hurry for the party to stop, the second half of Chiara's statement suggests why: the danger is not here yet, at least for most of us. The majority of the world's people have not been hit by climate change yet; it has not cost us a house, a livelihood, or a loved one. Sure, we may feel nervous about the recent erratic weather, we may feel disturbed by news reports of distant tragedies, but our daily lives continue pretty much as before. And so the party continues.

For millions of less fortunate people, however, indifference to climate change has become an unaffordable luxury. For them, the danger is now.

While visiting Bangladesh for this book, I met a little girl who was almost exactly Chiara's age. Her name was Sadia, and her father was the unofficial mayor of a village that was literally disappearing beneath his feet. The village, Antarpara, used to straddle the mighty Brahmaputra River. Like most of the rivers that course through Bangladesh, the Brahmaputra originates in the snowpack of the Himalayan mountains. But rising temperatures were now melting the snow faster and, along with stronger monsoon rains, boosting the river's volume. No one could say for sure that the excessive flooding was caused by global warming—after all, Bangladesh has a long history of flooding. But the flooding of Antarpara was certainly consistent with what scientists projected as global warming unfolded: faster glacial melting and more volatile monsoon rains.

"You cannot definitively attribute any single extreme event to climate change, but the overall pattern is clear," said Saleemul Huq, a Bangladeshi biologist who directed the climate change program at the Institute for International Economics and Development in London and who had invited me to his native country. "In Bangladesh, we know very well what a 1-in-20-years-size flood looks like. We've had them for centuries. But in the last twenty years, we've had four floods of that magnitude: in 1987, 1988, 1995, and 2005. This suggests we have entered a new pattern where we get a 1-in-20-year event about every 10 years. This is something we have to worry about now, not in the future."

Anisur Rahman, the mayor of Antarpara, was a broad-shouldered man who wore a dirty blue shirt and tattered rubber sandals. As we stood by the bank of the Brahmaputra, gazing out at the sluggish, silver-white current, he told me, "This river comes from India. For some reason, the water in India is increasing, so the floods here are bigger. They are sweeping away our houses, even the land beneath them. There were 239 families in this village before. Now we are 38 families."

Clustered around the mayor as we talked were dozens of villagers, mainly women in cheap bright saris—lime green, sky blue, scarlet—with skinny children clinging to their necks. "I have had to move my house seven times in the last twenty-eight years," said Charna, a haggard mother of two. "I used to

live over there," she said, gesturing toward the middle of the river, "but floods washed the land away and I had to move here."

Later, when I bade the mayor goodbye, he was holding his daughter in his arms. Sadia was a pretty, solemn little girl, about eighteen months old. She was the mayor's first child, and he definitely wanted her to go to school one day, but it would not be in Antarpara. "By the time she is old enough," he explained, "this village won't be here."

There is a terrible injustice at the heart of the climate problem: climate change punishes the world's poor first and worst, even though they did almost nothing to bring it on. After all, they cannot afford to drive gasoline vehicles, fly in airplanes, eat much meat, or inhabit the climate-controlled buildings that are the principal contributors to global warming. "Eighty percent of global greenhouse gas emissions come from the richest 20 percent of the world's people," said Saleemul Huq. "The poorest 20 percent of the world's people are responsible for less than 1 percent of emissions. But because of their lack of resources, they will probably account for 90 percent of the deaths those emissions cause. This means that climate change is no longer just an environmental or energy or economic problem. It is also a justice problem."

"You'll Remember How Nice Summers Used to Be"

Even for the rich, climate change is now a matter of self-interest. "I attended a conference recently and found myself talking with an executive of DuPont, the chemical company," said Chris West, the director of the UK Climate Impacts Programme, a British government agency that educates local governments, businesses, and individuals on how to manage the impacts of climate change. "[This executive] told me about all the green initiatives that DuPont had launched—shrinking its carbon footprint, reducing its toxic emissions, just treating the environment better in general. 'Jolly good,' I said. 'But is DuPont also prepared for how the environment might treat you?' He didn't know what I was talking about. I asked how many facilities his company had around the world. 'About three hundred,' he said. I asked how many of them were located in floodplains. He didn't know. I said, 'Don't you think you should?'"

As we begin the second decade of the twenty-first century, every person on earth finds himself or herself in the same boat as that DuPont executive. Like the executive, we are largely unaware of what is about to hit us, even as we congratulate ourselves on our blossoming environmental awareness. Many of us have heard about global warming and want action taken against it. But few of us have reckoned with the inconvenient truth that climate change is going to keep coming at us no matter what for a long time. We do not realize that serious climate impacts are inevitable in the years immediately ahead. We have not considered how harsher heat waves, melting snowpacks, and other inevitable climate impacts will affect our work, homes, children, and communities; much less have we taken steps to reduce our vulnerability.

Don't you think we should?

"The point we have to get across to people is that the future is not going to be like the past. It's human nature to assume it will be, but with climate change that's no longer true," said Kris Ebi, an independent scientist who began analyzing global warming while working for the U.S. electric utility industry and later coauthored a chapter of the *Fourth Assessment Report* about health impacts. "I do a

lot of speaking at colleges and universities, and even there this message hasn't gotten through," added Ebi, who has two adult daughters. "I told one class, 'When you're my age, you'll think back to how nice summers used to be. Summers in the future will be a lot less comfortable than today.'"

How did the students respond? I asked.

"They didn't say much, but their eyes got very big," Ebi replied.

Fear of climate change is only natural, and it is perhaps inevitable that some people take refuge in denial. One father I met in San Francisco, a city proud of its green consciousness, told me that he deliberately avoided news about climate change—it was too depressing, especially when he thought about the implications for his kids, aged seven and four. "I think people my age will be all right," he said. "Things will be tolerable for the next twenty years or so. But our kids are screwed."

Avoiding unwelcome truths may be standard procedure for human beings, but it isn't much of a survival strategy. If there is even a slight possibility of improving our children's chances of coping with what lies in store, how can we choose denial? We wouldn't do that if our child were diagnosed with a life-threatening illness; we would face the awful facts, find the best doctors we could, and pursue every possible treatment option. When Lisa Bennett, a Bay Area mother of two young boys, awoke to the dangers of climate change, she felt compelled to take action. She later explained, "I began to think it a bit crazy that I attended to every bump and scrape on my children's little bodies and budding egos but largely ignored the threat likely to put sizable areas of the world, including parts of the coastal city where we live, underwater within their lifetime."

To borrow again from fairy tales, it is facing the dragon, as scary as that may be, that calls forth the heroes who deliver victories. "The baby has known the dragon intimately ever since he had an imagination," observed the writer G. K. Chesterton. "What the fairy tale provides for him is a St. George to kill the dragon." Often the heroes who kill dragons are ordinary people, as frightened as anyone but impelled to do the right thing. In *The Nutcracker*, Clara must attack the seven-headed mouse king in order to save her beloved nutcracker. In *The Wizard of Oz*, Dorothy and her companions must bring back the broomstick of the Wicked Witch of the West before their wishes are granted. In the Harry Potter series, the young hero must confront and defeat his parents' murderer. Now, in the struggle against climate change, we need thousands of ordinary heroes to step forward and fight for our future.

Happily, there are genuine reasons for hope. Not only do we know what it will take to stop global warming, but most of the necessary technologies and practices are already in hand. Best of all, putting these tools to work could actually strengthen our economy, improve our quality of life, and make money, lots of it.

Ironically, one of the biggest profitmakers is a company that later caused the largest environmental disaster in U.S. history, the BP oil gusher that fouled the Gulf of Mexico in 2010. But in 1999, under different leadership, BP had invested in energy efficiency, which is by far the quickest most lucrative way to reduce greenhouse gas emissions. BP invested \$20 million to install more efficient light bulbs, motors, and operating schedules in the company's refineries, offices, and workplaces. Over the next three years, those efficiency improvements lowered BP's energy bills by \$650 million. Thus the company's original \$20 million investment yielded a profit of \$630 million—stunning thirty-two-fold return on investment. Even organized crime doesn't enjoy those kinds of

profit margins.

Plenty of other corporations are following the same path, and so are forward-thinking governments. In Germany, Chancellor Angela Merkel's conservative government has subsidized energy efficiency investments that were initially devised by the left-of-center Green Party. Every year the German government funds the renovation of 5 percent of the nation's pre-1978 housing stock, covering the up-front costs of installing more efficient insulation, heating, and electrical systems. The program is widely regarded as a win-win-win. The annual 1.5 billion Euros in subsidies are recouped through lower energy costs. Greenhouse gas emissions are reduced. And perhaps most important for a nation struggling with high unemployment rates, the program generates thousands of jobs for construction workers, jobs that by their nature cannot be sent abroad.

In the United States, the state of California boasts comparable achievements. Under the leadership of Governor Jerry Brown in the 1970s, California launched a sustained effort to improve energy efficiency, especially regarding electricity use. We'll discuss specifics in a later chapter, but the results have been remarkable. California's electricity consumption today is roughly the same as thirty years ago, even as the state's population and economy have grown tremendously.

California, Germany, and BP are but three examples of the larger truth: if we're smart, the fight against climate change can repair, not ruin, our economies. Renovating our homes, workplaces, farm transportation, and other systems to run on low-carbon energy sources will cost money up front, but it will create jobs, spur innovation, and boost profits over the long term. Installing the protections needed against heat waves, sea level rise, and other future climate impacts could likewise stimulate enormous amounts of economic activity, especially for the construction industry and other labor-intensive sectors. Indeed, the green economy is shaping up as the largest growth field of the twenty-first century; a 2009 study by the HSBC Bank calculated that the global green economy will grow from a \$500 billion market today to a \$2 trillion market by 2020. Germany and China, the world's two leading export powers, clearly recognize this opportunity and are moving quickly to seize it; the jury is still out on the United States.

Energy efficiency is not a silver bullet, nor can it forever neutralize the effects of billions of people consuming more and more all the time. If the consumerism of the rich, the population increase of humanity as a whole, and the ceaseless growth imperative of modern capitalism continue unchecked, their impacts will cancel out the gains of even the most ambitious efficiency programs. Nevertheless, improving efficiency is a crucial first step. Because it is so profitable, it can generate funds to develop and deploy the solar panels, carbon-neutral buildings, protective seawalls, and countless other technologies that are needed both to reduce emissions and to cope with the unavoidable impacts of those emissions. And because it is fast-acting, energy efficiency can buy us time to deploy these technologies while we wrestle with the deeper challenges of taming consumerism, limiting population growth, and reorienting our economies from material growth toward alternative measures of well-being.

Another piece of good news: climate change does not necessarily doom the poor. The most hopeful story I uncovered while researching this book was in Africa, the continent scientists say will be hit hardest by climate change. In the sun-baked Sahel, I talked with illiterate farmers who did not know the term *climate change* but were adapting to it nonetheless. To capture rainfall and rejuvenate soil fertility, the farmers were growing trees amid their fields of millet and sorghum. With little

outside funding, their techniques had spread from village to village across vast areas of Niger, Burkina Faso, and Mali, with remarkable results: despite enduring some of the hottest, driest weather on earth, greenery has returned to more than 12.5 million acres of land. Underground water tables have risen. Crop yields have doubled and tripled. To be sure, life is still hard in the Sahel, and it is bound to get harder still as temperatures rise further in the years ahead. But the region's farmers are by no means surrendering in the face of climate change, and they may yet survive it if the outside world does its part and slashes greenhouse gas emissions.

Global warming is not the only reason our civilization must shift to low-carbon energy sources: there is also the threat of "peak oil." As recently as five years ago, the theory of peak oil—which holds that humanity has already consumed half of the oil on the planet—was derided as nonsense from the fringe. No longer. As stalwart a member of the energy establishment as James Schlesinger, a former director of the CIA and secretary of the U.S. Departments of Energy and Defense, said in 2007, "The debate is over—the peakists have won." There is still lots of oil to be had on this planet, but it "will get harder and costlier to find," Ronald Oxburgh, the former chairman of the British arm of Royal Dutch Shell oil, told me. (Peak oil is one reason BP was drilling so deeply in the Gulf of Mexico in the first place.) Meanwhile, global demand for petroleum continues to climb. If and when global demand outstrips supply, analysts warn, the imbalance could bring debilitating shortages, soaring prices, crashing economies, resource wars, and social breakdown. The car-dependent lifestyle that millions of Americans (and growing numbers elsewhere) take for granted will become impossible. Fatih Birol, the chief economist of the International Energy Agency, is another insider worried by the approach of peak oil. "We should leave oil before it leaves us," Birol wrote in 2008.

Make no mistake: going green at the speed and scale needed to defuse global warming and escape peak oil will not be easy. We will have to abandon old ways of thinking, confront powerful interests, spend large amounts of money, adjust our material appetites, and stay focused on the mission for many years to come. But there are unsung heroes all over the world who are already working to make these changes a reality; you will meet some of them in this book. They deserve our help.

The Double Imperative of the Climate Fight

Chiara happened to be born at a momentous turning point in human history. What I call the first era of global warming began on June 23, 1988—the day NASA's James Hansen told the U.S. Senate that man-made global warming had begun. Although a handful of insiders were worried before then, it was Hansen's testimony—and the attention it received after the editors of the *New York Times* ran the story on [\[>\]](#)—that put the world on notice that civilization's future is at risk. Global warming quickly became a common phrase in news bureaus, government ministries, and living rooms around the world. When a top scientist at the agency that put a man on the moon warns that trouble is brewing, attention must be paid.

As emissions kept growing, climate change went from being a distant theoretical danger to a punishing current reality. This shift took place sometime around the turn of the twenty-first century (scientists are still determining the exact date), inaugurating the second era of global warming. The battle to prevent dangerous climate change was now over; the race to survive it had begun. If humanity is to win this race, the essential first step is to change the way we think about climate change. The climate problem has undergone a paradigm shift; we humans must now make a paradigm

shift of our own.

To day, in the second era of global warming, humanity faces a double imperative. On the one hand, we must reverse global warming, and quickly—before the climate system passes tipping points that could trigger irreversible warming. "We're about ten years from a point of no return," Al Gore told me in 2006. "But we still have time to slow the rate of warming and thereby buy time for the introduction of revolutionary technologies and practices that could reduce emissions enough to avoid the worst impacts of climate change." Yet even as we strive to lower the global thermostat, we must also go beyond this traditional definition of climate action. We must take steps as well to prepare our societies for the serious climate impacts that are already in the pipeline. In short, we have to live through global warming even as we halt and reverse it.

At present, this double imperative remains unrecognized by many of us, whether we are individuals, communities, businesses, or governments. Over the past few years there has been an explosion of concern about global warming. But if awareness is high, understanding remains low, in rich and poor countries alike, among both the general public and policymakers. To hear most politicians, corporate advertisements, media reports, and even environmental groups tell it, fighting climate change is all about shifting to cleaner energy sources (and—a distant second—changing farming and forestry practices). If we switch to solar, wind, and other low-carbon energy sources, we can "Stop Global Warming," to quote one oft-heard slogan, in the same way we turn off a car engine. But few people seem to recognize how quickly this shift must be made, or grasp how substantial the impacts will be in any case. A better analogy is to imagine that our civilization is traveling in a train, heading downhill, picking up speed, and approaching a landscape obscured by storm clouds. We can hit the brakes by reducing greenhouse gas emissions, and we must. But the train's momentum ensures that it will be a long time before we actually come to a halt, and before we do, we will cross a great deal of unknown territory.

In triggering climate change, humanity has unwittingly launched an unprecedented planetary experiment. Because this experiment has never been run before, and because it involves extremely complicated systems, knowing exactly how it will turn out is impossible. What we do know is, we are pushing the earth's climate system well beyond its normal limits. The past 250 years of industrialization have increased the amount of carbon dioxide in the atmosphere to 390 parts per million—the highest level in the last 800,000 years, and probably in the last 20 million years. We know further that this increase has not only caused global warming but contributed to concrete examples of climate change, such as the 2003 heat wave in Europe, and that such impacts will intensify in the future. Nevertheless, there are many specifics we do not know. For example, the years ahead are expected to bring an increase in the frequency of extra-strong hurricanes. But exactly when and where they will strike, no one knows.

This lack of scientific certainty is no cause for reassurance. From the beginning of the climate debate in the early 1990s, those opposed to taking action have used the lack of certainty to argue against reducing greenhouse gas emissions. Why damage the economy, they asked, unless we are sure such reductions are required? The developments of the last ten years reveal the recklessness of that argument. Opponents ignored that scientific uncertainty can cut both ways—yes, things can turn out better than expected, but they can also turn out worse.

That simple piece of common sense is the basis of the precautionary principle. A cornerstone of

modern environmentalism, the precautionary principle holds that policymakers should err on the side of caution when making a decision that carries apparent but uncertain risks. Put differently, the absence of definitive proof that a given activity is dangerous does not prove it is safe. But the precautionary principle has been ignored in the battles over climate policy. Alas, real-world experience and additional scientific observation and analysis have now demonstrated the folly of this course. The climate system has turned out to be much more sensitive to global warming, much more prone to human disruption, than anticipated.

"In the last few years, we've gotten strong hints that we've underestimated this problem, not overestimated it," said Peter Gleick, founder of the Pacific Institute in Oakland, California, and one of the world's leading experts on water policy and climate change. "Scientists can be conservative when it comes to drawing controversial conclusions, especially when they know they will be attacked for them. In the water area, we're seeing many developments consistent with the worst scenarios projected for future climate change. For example, we're in the middle of a very extreme drought in the southwest and the southeast of the United States. We're not certain yet that climate change is causing these extremes—history shows that the hydrological cycle is characterized by extremes—but it is entirely possible."

Sir Nicholas Stern famously remarked in his 2006 study of the economics of climate change that climate change represented "the greatest and widest-ranging market failure ever seen." Prices, government regulations, and other market forces had not only failed to prevent climate change, Stern pointed out, they had encouraged greenhouse gas emissions to grow and grow. Now, we can say that climate change also represents the greatest and widest-ranging failure of the precautionary principle ever seen. In the face of uncertain but potentially catastrophic consequences from increasing emissions, our economic and political leaders chose to pursue business as usual, presuming that the risks would turn out to be manageable. The coming years will instruct us about how manageable they actually are.

It is often supposed that rich societies and individuals will find it relatively easy to adapt to climate change; their money and technological prowess, goes the argument, will enable them to counter harsher heat waves with more air conditioning and stronger storms with sturdier seawalls. Leave aside for the moment the fact that this assumption ignores the plight of the world's poor, who amount to roughly half the people on earth. My research for this book has convinced me that even wealthy, technologically advanced societies will find it enormously challenging to defend themselves. The climate impacts that are already in place are so large, pervasive, and interlocking that they will tax our adaptive capacity to the maximum, especially because we will be confronting them at the very time we are grappling with peak oil and global economic disorder, not to mention the necessity of reversing global warming before its impacts increase from the "merely" grave to the outright apocalyptic.

Over the next fifty years, climate change will transform our world in ways we have only begun to imagine. Humans have changed the weather on this planet, and that will change everything: from how we grow food and obtain water to how we construct buildings and fight disease; from how we organize economies and control borders to how we manage transportation systems and deploy armies; from how we write insurance and produce wine to how we talk with our children and plan for the future.

By no means is climate change the only threat to our civilization's future, but it tends to intensify

other outstanding threats, whether military, economic, or environmental. Military experts call climate change "a threat multiplier," to quote a 2008 report by the European Union's two top foreign policy officials. Climate change will worsen existing conflicts over water supplies, energy sources, and weather-induced migration, the report warned, potentially "overburden[ing] states and regions which are already fragile..." Economic prosperity is also endangered. Approximately 25 percent of the gross national product of the United States is at risk from extreme weather events, according to the American Meteorological Society and the American Geophysical Union.

Global warming and climate change also undermine the ecosystems that make human life possible on this planet, ecosystems that our civilization has already placed under extreme stress. In particular, global warming and climate change hasten the loss of plant and animal species, which is arguably the single most worrisome global environmental trend after climate change itself. Already, temperatures and climates are shifting too fast for many species to adapt, especially in the face of rapid habitat loss, which has been the primary cause of species loss to date. Writing in *Nature* in 2009, nineteen of the world's leading biodiversity scientists warned that climate change alone could lead to the extinction of between 15 and 37 percent of all species by 2100. Need one add that such a massive loss of other species raises the odds that humans will also go extinct sooner rather than later?

Indeed, over the course of writing this book, I have come to see the climate crisis as a major evolutionary test for our civilization and perhaps our species. Like all such tests in the long, long history of evolution, it will be the individuals who can adapt to the new conditions best who will survive and prosper. Those who cannot adapt, meanwhile, will perish, perhaps not immediately but before very long.

The Third Era of Global Warming

The inevitability of fifty more years of rising temperatures and their associated impacts is the great unfolding story of our time. The implications haven't sunk in yet to most people, but it won't be long. Reality is a powerful teacher.

Yet reality is also a work in progress. Temperature rise and the physical effects it causes may be inevitable, but how humans react is up to us. There is still time, if we hurry, to enlarge our vision of how to cope with climate change—to recognize that we must not only reverse it but also adapt to it. Only such a shift in thinking and action can give our children, future generations, and the natural world we all depend upon a fair chance of living through the gathering storm of climate change.

With Chiara, Sadia, and the rest of their generation foremost in mind, I aim in this book to call attention to the new realities of climate change; to provide a hopeful but realistic picture of the changes that lie in store over the next fifty years and beyond; and to identify the best steps to both reverse global warming and adapt to its impacts. Some of these steps you can take as an individual. Others can be taken only by governments. Still others fall to the private and civil sectors. Individuals can plant trees, conserve water, and do a thousand other valuable things, but it is governments that must build seawalls and set overall energy and economic policies. It is corporations that must quit dirty fuel sources like coal and embrace alternatives like efficiency and solar.

Chiara, Sadia, and their peers belong to what I call the climate change generation: the nearly 2 billion people who have been born since the first era of global warming began in 1988. In the years

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