IN THIS CHAPTER

- Getting to know what global warming is all about
- Figuring out what started climate change in the first place
- Investigating the changes global warming might bring
- Examining the role governments can play in fighting global warming
- Finding solutions to the problem

Chapter 1
Covering the Basics of Climate Change

The phrase "global warming" has been in the news since the late 1980s, but climate change, as global warming is also known, has been around much longer. In fact, it has been a constant throughout history. Earth's climate today is very different from what it was 2 million years ago, let alone 10,000 years ago. Since the beginnings of the most primitive life forms, this planet has seen many different climates, from the hot, dry Jurassic period of the dinosaurs to the bleak, frozen landscapes of the ice ages.

Today, however, the planet is experiencing something new: Its climate is experiencing rapid and dangerous changes. Scientists are certain that these changes have been caused by emissions produced by human activities. By examining previous changes in the Earth's climate, using computer models, and measuring current changes in atmospheric chemistry, they can estimate what global warming might mean for the planet, and their projections are scary.

Fortunately, Earth isn't locked into the worst-case-scenario fate yet. By banding together, people can put the brakes on global warming. In 2009, when this book was first released, we had more time to apply the brakes than now. This chapter explains the essentials of global warming and what everyone can do to achieve a greener future.

Getting a Basic Overview — Global Warming 101

When "global warming" became a household phrase, greenhouse gases *(GHGs)*, which trap heat in the Earth's atmosphere, got a bad reputation. After all, those gases are to blame for heating up the planet. But, as we discuss in Chapter 2, GHGs in reasonable quantities aren't villains, they're heroes. They capture the sun's warmth and keep it around so that life as it's known is possible on Earth. The problem starts when the atmosphere contains too great an amount of GHGs. (In Chapter 3, we look at how scientists have determined the correlation between carbon dioxide in the atmosphere and temperature.)

Other factors, which we discuss briefly in the following sections, affect the Earth's climate. Some are short-term — mostly those are seen as variations in weather, like El Niño or El Niña. The ones that matter most, though, are those that have long-term effects on climate. When the overall temperature of the Earth and the oceans rise, that's not just a change in the weather. And it's not just a normal variation that might have been observed in the past. That's a change in the Earth's climate.

Heating things up with GHGs

Human activities — primarily, the burning of fossil fuels (which we look at in the section "Tapping the Roots of Global Warming," later in this chapter) — have resulted in growing concentrations of carbon dioxide and other GHGs in the atmosphere. As we explain in Chapter 2, these increasing quantities of GHGs are retaining more and more of the sun's heat. The heat trapped by the carbon dioxide blanket is raising temperatures all over the world — hence, *global warming.*

Since the beginning of the Industrial Revolution, Earth has seen a 1.4-degree Fahrenheit (1.1 degree Celsius) increase in global average temperature because of increased GHGs in the atmosphere. Temperatures in polar regions, such as the Arctic, are experiencing temperature rises that are three times the global average.

Investigating other causes of global warming

Global warming is a very complex issue that you can't totally understand without looking at the ifs, ands, or buts. Scientists have been certain for decades that the rapid changes to climate systems are due to the buildup of GHGs. With every new scientific report, they're more certain and more concerned that changes must be made to avoid the worst-case scenarios. Other elements play a role in shaping the planet's climate, however, including the following:

- **Cloud cover:** Clouds are connected to humidity, temperature, and rainfall. When temperatures change, so does the cloud cover — and vice versa.
- **Long-term climate trends:** The Earth has a history of going in and out of ice ages and warm periods. Scientific records of carbon dioxide levels in the atmosphere go back 800,000 years, but people can only give educated guesses about the climate earlier than that.
- **Solar cycles:** The sun goes through a cycle that brings it closer to or farther away from the Earth. This cycle ultimately affects the temperature of this planet and thus the climate. However, scientists have eliminated solar cycles as a factor in current warming.

We go over these other issues in greater detail in Chapter 3.

CLIMATE CHANGE — THE STORY IN A NUTSHELL

Earth has been around for about 5 billion years, starting as a ball of swirling gas and dust left over from the formation of the sun. In the first part of this very long time, the iron and silica that make up most of the planet separated — the hot heavy iron went down to the core and the lighter silicates came to the surface and cooled. Volcanoes belched material and gases up to the surface. Continents formed and move around on the surface of the planet. The Earth froze from pole to pole, heated, thawed, froze again. The mix of gases in the atmosphere changed as volcanoes and sun had their effects.

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An overview of life on Earth

Life began and then ebbs and flows ensued:

- **3½ billion years ago:** Single-celled organisms and viruses appeared.
- **2½ billion years ago:** Photosynthesis began in bacteria; sunlight provided the energy to convert carbon to cellular growth and emit oxygen as waste.
- **900 million years ago:** The first multi-celled organisms appeared.
- **450 to 600 million years ago:** Life exploded, and plants and animals from the oceans began to colonize the land.
- **250 million years ago:** The first mass extinction happens — the survivors are the early dinosaurs and mammals.
- **200 million years ago:** Another mass extinction occurs — now the dinosaurs become dominant. At the same time, some little mammals become warm-blooded, with new abilities to live in varying climates.
- **150 to 100 million years ago:** The first birds and flowering plants appear; large dinosaurs coexist with four distinct groups of mammals.
- **66 million years ago:** An asteroid hits eastern Mexico, the cloud of dust and steam blocks the sun for years, plants die, and the dinosaurs (and all other animals weighing more than 55 pounds [25 kg]) go extinct.
- **55 million years ago:** Another mass extinction happens, this one perhaps caused by a rise in greenhouse gases, that make the atmosphere a more effective insulator and causes Earth to heat past the survival limits of many species. It's a tough place to live, Earth. Nothing is certain.
- **6 million years ago:** The first humans appear.

Human beings have been around in the same basic form for 6 million of the 5 billion years of Earth, one-eighth of one percent of all that time. During that (short) time, humans survived ice ages and developed tools, agriculture, writing, states and governments, music, and art. The human population grew constantly but slowly, held within the limits of what Earth and natural processes could provide, at about 0.04 percent per year, from 10,000 BC to 1700 AD. By 1700 about 600 million people lived on Earth, rising to about 1 billion by 1800.

But then things changed. Between 1800 and 1928, the human population doubled to 2 billion. From then on, the rate of increase rose rapidly until about 1968 — and

population went up to 2.5 billion, to 5 billion by 1987, and 7.7 billion by 2019. The rate of increase peaked in 1968 and has been decreasing ever since, but still the population is expected to rise to a maximum of about 11 billion by 2100.

So humans have come to dominate Earth as no other life form ever has. And it's not just people — the animals that humans keep are now by far the largest part of the world's total animal biomass (*biomass* is the total mass of living matter in a given area).

In addition to the rising population, humans learned in the early part of the 1800s how to use the energy stored in the Earth millions of years ago. It all came from those old plants that millions of years ago used energy from the sun to grow and make their carbon tissue. When the plants died, their tissues rotted and decomposed, and over millions of years were compressed into coal and oil.

Beginning to use fossil fuels

Black or brown coal, the compressed remains of ancient plants, is a wonderful source of high-density energy. It's sometimes easy to find on the surface of the Earth, so it has been used for thousands of years for fuel (and humans had learned to make a sort of coal equivalent, charcoal, by heating wood without enough oxygen to actually burn). But most of the coal in the world is underground, not so easy to pick up and take home to the fire. People dug shallow mines to get the coal out, but often water would flood in and prevent further digging.

And then came the revolution, the start of what this book is about.

In the late 1700s and early 1800s, a Scottish engineer named James Watt made the first steam engines with high enough efficiency to be used to reliably pump water out of coal mines. So the coal provided the fuel to heat the water to make the steam to drive the engine to work the pump to get rid of the water to get at the coal, and the Industrial Revolution was launched.

With abundant coal, industrial applications became possible all over England. Engines made by Watts and others drove all sorts of processes, factories of all sorts, wool and cotton spinning, steam looms, steel mills, railroads and steamships: Coal powered England to become the first great industrial empire. The technology was then exported around the world, to Europe and the new states in America, and industrial output exploded.

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With this new kind of industry, people began to be employed in large numbers in centralized locations. The move from the country to the cities accelerated. In the cities, coal was burned for heat, for hot water, and "coal gas" lit indoor and outdoor spaces. People worked longer hours of work and enjoyed evening entertainments in theaters and music halls.

But wait. There's still more.

The second Industrial Revolution begins

In 1859, oil was produced from a well in Pennsylvania, and the second Industrial Revolution began. Coal remained dominant for a long time, but the use of oil and its companion product methane gas (called *natural gas* to help with marketing) grew rapidly until the use of oil equaled coal by the 1950s and then displaced coal from most uses (except to make electricity and steel) by the 1970s. Oil is easier to handle than coal, produces more usable energy with less smoke and soot, and is just a better fuel source for railroads and ships, for industry, and for electrical generation. So King Coal lost its crown.

But humans were making more and more stuff and were still burning a lot of coal and now a lot of oil and gas as well. When that coal and oil was burned, humans got to use that ancient solar energy again to make things and move things and keep things warm. And all that carbon was released again, off into atmosphere as carbon dioxide and other gases called *greenhouse gases* because they act like the glass in a greenhouse to keep heat in. So, like any good greenhouse, the Earth became warmer. And it's still getting warmer today. And that's the problem to solve.

Tapping into The Roots of Global Warming

Just what are humans doing to release all those GHGs into the atmosphere? You can pin the blame on two main offenses, which we discuss in the following sections: burning fossil fuels and deforestation.

Fueling global warming

When you burn *fossil fuels*, such as coal and oil (named fossil fuels because they're composed of ancient plant and animal material), they release vast amounts of GHGs (largely, but not exclusively, carbon dioxide), which trap heat in the atmosphere. Fossil fuels are also a limited resource — meaning that humanity can't count on them over the long term because eventually they'll just run out.

The fossil fuel that produces the most GHG emissions is coal, and burning coal to produce electricity is the major source of coal-related GHGs. The second-worst offender is using gasoline and diesel for transportation, followed by burning oil to generate heat and electricity. In fact, if people could replace the coal-fired power plants around the world and switch away from the internal combustion engine, humanity would have most of the problem licked. This switch is happening now, more and more quickly, but industries that have been built on the fossil fuel bonanza, and their supportive governments and bankers, continue to delay the inevitable progress. (Check out Chapter 4 for more fossil fuel info, Chapter 13 for the scoop on energy alternatives, and Chapter 17 for an introduction to the disruption expected and feared by those industries.)

Heating up over deforestation

Forests, conserved land, and natural habitats aren't important just for the sake of saving trees and animals. Forests and all greenery are important players in keeping the climate in check. Plants take in the carbon that's in the atmosphere and give back oxygen, and older trees hold on to that carbon, storing it for the duration of their lives. By taking in carbon dioxide, they're significantly reducing the greenhouse effect. (See Chapter 2 for more about how plants help the Earth keep atmospheric carbon at a reasonable level.)

Unfortunately, much of the world's forests have been cut down to make way for farmland, highways, and cities. Deforestation is responsible for about a quarter of GHG emissions. Rainforests and mangrove forests (very productive forests that grow in wetlands) are especially good at soaking up carbon dioxide because they breathe all year round. Temperate forests, on the other hand, don't absorb much carbon dioxide over the winter, practically going into hibernation. (Chapter 5 has more about deforestation.)

Examining the Effects of Global Warming around the World

This book could easily be called *Climate Emergency For Dummies.* Although "global warming" is the common term for the climate changes that the planet's experiencing (and scientists agree that average global temperature is increasing with the buildup of GHGs), the term doesn't tell the whole story. The Earth's average surface temperature is certainly going up. But while the average keeps rising, the variations around the average are also getting larger and larger. So some areas of the planet may actually get colder or experience more extreme bouts of rain, snow,

or ice build-up. Consequently, most scientists prefer the term "climate change." In the following sections, we look at how different places around the world will experience climate change.

WARNING

Much of this section is pretty depressing. But nothing is exaggerated — the information here is all based on peer-reviewed scientific reports. Just how serious could the global impact of climate change be? The first global comprehensive scientific conference, which was held in Toronto, Canada, in 1988, described the potential effects of climate change this way: "Humanity is conducting an unintended, uncontrolled, globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war."

Of course, different parts of Earth have very different climates now, and climate change won't affect every part of the planet in the same way. The following sections explain in general terms how some parts of the world are being affected by climate change.

The United States and Canada

In the United States and Canada, average temperatures have been rising because of climate change. As a result, the growing season has lengthened; trees have been sucking in more carbon, and for a while, farms were more productive. The recent years have had far more severe wet years followed by extreme drought. The 2021 drought had negative and long-term impact on wheat, corn, and other crops, according to *Forbes.*

Many plants and animals are spreading farther north to adapt to climate changes, affecting the existing species in the areas to which they're moving. Increased temperatures have already been a factor in more forest fires and wildfires and damage by forest insects, such as the pine beetle epidemic in the interior of British Columbia, Canada. (See Chapter 8 for more information about how global warming will affect animals and forests.)

Scientists project that the United States and Canada will feel the effects of climate change more adversely in the coming years. Here are some of the problems, anticipated to only get worse if civilization doesn't dramatically reduce GHG emissions:

- **Droughts and heat domes:** Rising temperatures are increasing droughts in areas that are already arid, putting even larger pressure on scarce water sources in areas such as the U.S. Southwest. In Canada, 600 people died from extreme heat in 2021 as a *heat dome* (happens when the atmosphere traps hot ocean air) formed over the west and drove temperatures to record levels.

Some areas of British Columbia experienced temperatures of 122 degrees Fahrenheit (50 degrees Celsius).

- **Evaporating lakes:** The cities in the great heartland of the Great Lakes Basin will face retreating shorelines when the water levels of the Great Lakes drop because of increased evaporation. Lower water levels will also affect ship and barge traffic along the Mississippi, St. Lawrence, and other major rivers.
- **Floods:** Warmer air contains more moisture, and North Americans are already experiencing more sudden deluge events, causing washed out roads and bridges, and flooded basements and even Manhattan's subways. In British Columbia in 2021, a form of rainstorm so extreme it's called an *atmospheric river* caused massive flooding. The estimated damage to farms and transportation infrastructure was about $5.9 billion US, $7.5 billion Canadian. Bridges and other sections of roads and highways were washed away, isolating coastal areas from the rest of Canada for weeks.
- **Major storms:** Warming oceans increase the risk of extreme weather that will plague coastal cities. Think of Hurricane Katrina, arguably the most devastating weather event ever to hit a North American city, as a precursor of storms like Superstorm Sandy. Katrina was whipped into a hurricane with a massive punch from the super-heated waters of the Gulf of Mexico in 2005. In 2021 a devastating series of tornadoes, way outside the "normal" tornado season, clobbered the southern and central United States, killing almost 100 people and causing millions in damage.

REMEMBER

Not all extreme weather events are hurricanes. Global warming is expected to increase ice storms in some areas and thunderstorms in others.

- **Melting glaciers:** Glaciers from the Rockies to Greenland, are in rapid retreat, according to the National Snow and Ice Data Center. Glacier National Park could someday be a park where the only glacier is in the name. When glaciers go, so does the spring recharge that flows down into the valleys, increasing the pressure on the remaining water supplies. People who depend on drinking water from rivers or lakes that are fed by mountain glaciers will also be vulnerable.
- **Rising sea levels:** Water expands when it gets warmer, so as global average temperatures rise, warmer air warms the ocean. Oceans are expanding, and sea levels are rising around the world, threatening coastal cities — many of which are in the United States and Canada. This sea level rise will be far more devastating if ice sheets in Greenland and Antarctica collapse.

Changes across northern Canada and Alaska are more profound than in the south. We discuss these impacts in the section "Polar regions," later in this chapter.

On average, North Americans have many resources, in comparison to developing regions of the world, to help them adapt to climate change. The Intergovernmental Panel on Climate Change (IPCC) says Canada and the United States can take steps to avoid many of the costs of climate change, to better absorb the effects, and to avoid the loss of human lives. For example, North America could establish better storm warning systems and community support to make sure that poor people in inner cities have some hope of relief during more frequent killer heat waves. (See Chapter 10 for more information about what governments can do to help their countries adapt to the effects of climate change.)

Latin America

South America has seen some strange weather in the past few years. Drought hit the Amazon in 2005, Bolivia had hail storms in 2002, and the torrential rainfalls lashed Venezuela in 1999 and 2005. In 2003, for the first time ever, a hurricane hit Brazil. More recently, the World Meteorological Association says:

> "Latin America and the Caribbean (LAC) is among the regions most challenged by extreme hydro-meteorological events. This was highlighted in 2020 by the death and devastation from Hurricane Eta and Iota in Guatemala, Honduras, Nicaragua, and Costa Rica, and the intense drought and unusual fire season in the Pantanal region of Brazil, Bolivia, Paraguay, and Argentina. Notable impacts included water and energy-related shortages, agricultural losses, displacement and compromised health and safety, all compounding challenges from the COVID-19 pandemic."

Other changes in Latin America may be attributable to global warming. Rain patterns have been changing significantly. More rain is falling in some places, such as Brazil, and less in others, such as southern Peru. Glaciers in the Andes Mountains and across the continent are melting. This glacier loss is a particular problem in Bolivia, Ecuador, and Peru, where many people depend on glacier-fed streams and rivers for drinking water and electricity from small-scale hydroelectric plants. (See Chapter 9 for more about how global warming will affect humans.)

Scientists project that the worst is yet to come. The IPCC models anticipate that about half of the farmland in South America could become more desert-like or suffer saltwater intrusions. If sea levels continue to rise at a rate of 0.08 to 0.12 inches (2 to 3 millimeters) per year, it could affect drinking water on the west coast of Costa Rica, shoreline tourism in Mexico, and mangroves in Brazil.

The threat to the Amazonian rainforest from logging and burning has attracted the concern of celebrities such as Sting and Leonardo DiCaprio. But human-caused global warming could potentially do more damage than loggers. By mid-century, the IPCC predicts that parts of the Amazon could change from wet forest to dry

grassland, and that reduction in rainfall during dry months will reduce agricultural yields. Recent scientific reports confirm even a 2 degree C temperature increase could wipe out the Amazon. (We cover how ecosystems will be affected by climate change in Chapter 8.)

Europe

Recent findings have shown that climate change is already well under way in Europe. Years ago, the IPCC projected the changes that the continent is experiencing today: rising temperatures, devastating floods, increased intensity and frequency of heat waves, and increased glacier melt.

As for what's in store for Europe, the IPCC reports a 99-percent chance that Europe will experience other unfavorable climate changes. Changes experienced so far include the following:

- **More flash floods and loss of life in inland areas:** In 2021, floods in Germany and Belgium killed more than 200 people and caused billions in damage — experts agree that such previously called "once in 400-year" floods are much more likely because of climate change.
- **More heat waves, forest fires and droughts in central, eastern, and southern Europe:** These events significantly impacted health and tourism in southern Europe in particular. The worst year on record for forest fires was 2019, until 2021 burned 1.2 million acres (half a million hectares). Much of the forest burned was in southern Europe, but fires are having increasing effects in the north as well.
- **Rising sea levels, which will increase erosion:** These rising sea levels, coupled with storm surges, will also cause coastal flooding. The Netherlands and Venice are experiencing greater impacts than other areas in Europe dealing with the rising sea level. Venice, a 1,600-year-old Italian city that is one of the world's greatest heritage sites, is built on log piles (which are gradually sinking) among canals, and so is particularly vulnerable to climate change. Rising sea levels are increasing the frequency of high tides that inundate the city.

  A report published by the U.S. National Academy of Science says that loss of up to 50 percent of Europe's native species of plants and animals may be likely if climate change isn't arrested. Fisheries will also be stressed.

These impacts are all serious, but none of them represents the worst-case scenario — the Gulf Stream stalling. The results of this (stopping of a major ocean current) would be disastrous for Europe. (We look at the Gulf Stream Ocean current issue in Chapter 7.)

Africa

On a per-person basis, Africans have contributed the very least to global warming because of overall low levels of industrial development. Just look at a composite photo of the planet at night: The United States, southern Canada, and Europe are lit up like Christmas trees, burning energy that results in GHG emissions. Africa, on the other hand, shows very few lights: some offshore oil rigs twinkle, and a few cities shine, but the continent is mostly dark.

Despite contributing very little to the source of the problem, many countries in Africa are already experiencing effects of global warming. East Africa Hazards Watch says

> "Major cities in East Africa have witnessed an increase in temperatures that almost doubles the 1.1 degrees C warming that the globe has experienced since pre-industrial times. Since 1860 Addis Ababa (Ethiopia) has warmed by 2.2 degrees C, Khartoum (Sudan) by 2.09 degrees C, Dar es Salaam (Tanzania) by 1.9 degrees C, Mogadishu (Somalia) by 1.9 degrees C, and Nairobi (Kenya) by 1.9 degrees C."

Global warming is expected to melt most of Africa's glaciers within the next few decades, which will reduce the already critically low amount of water available for farming. Long periods of drought followed by deluge rainfall have had devastating impacts in places such as Mozambique. Coastal areas in East Africa have suffered damage from storm surges and rising sea levels. The World Bank projects that by 2050 86 million people could be displaced by climate-related changes.

WARNING

Unfortunately, because of pervasive poverty and the historic scourge of HIV/AIDS and now of COVID, many areas of Africa lack the necessary resources to help people living there cope with climate change. And the effects of global warming may act as a barrier to development and aggravate existing problems. At present, as many as 400 million (or 33 percent of the continent's population) lack drinkable water, according to the World Resources Institute. The IPCC projects that some countries could see a 50-percent drop in crop yields over the same period and a 90-percent drop in revenue from farming by the year 2100. (We look at how developing nations are affected by and are addressing global warming in Chapter 12.)

Asia

More people call Asia home than any other continent — 4.7 billion in all. This high population, combined with the fact that most of Asia's countries are developing, means that a lot of people won't be able to sufficiently adapt to climate change impacts. As in Africa, climate change will bring pressures to the continent that will slow down development.

Here are some impending concerns for many parts of the continent:

- **Future availability of drinkable water:** This has been and continues to be a major problem because of population growth, pollution, and low or no sanitation. The IPCC projects that anywhere from 120 million to 1.2 billion people may find themselves without enough drinkable water within the next 42 years, depending on the severity of climate change. Already, rising temperatures are causing glaciers in the Himalayas to melt. These disappearing glaciers, which are the water supply to 2 billion people, are also contributing to increased avalanches and flooding.
- **Rising sea levels for coastal Asia:** The IPCC reports that mangroves, coral reefs, and wetlands will be harmed by higher sea levels and warming water temperatures. Unfortunately, this slightly salty water won't be good for freshwater organisms, as a whole. (See Chapter 8 for more about the impact global warming will have on the oceans.)
- **Illnesses:** They're also expected to rise because of global warming. Warmer seawater temperatures could also mean more, and more intense, cases of cholera. Scientists project that people in South and Southeast Asia will experience more cases of diarrheal disease, which can be fatal. (Chapter 9 offers more information about how global warming might increase the environmental conditions that promote the spread of diseases.)

Australia and New Zealand

If you ask an Australian or a Kiwi about global warming, you probably won't get any argument about its negative effects. According to the World Wildlife Fund (WWF), Australia has experienced increased extreme and deadly bush fires, heat waves, less snow, and changes in rainfall. Extreme drought conditions persisted from 2003 to 2012 and from 2017 to today. This heat and lack of precipitation will likely worsen while global warming's effects intensify.

REMEMBER

The ozone layer in the Earth's atmosphere is sort of like sunscreen for the planet — *ozone* intercepts some of the ultraviolet radiation that causes sunburn and skin cancer. The use of chlorofluorocarbons for refrigerants and other purposes caused the ozone layer to get thinner, resulting in an ozone hole over Australia and New Zealand. Partly as a result, Australians have the highest incidence of skin cancer on Earth. In 1987, the nations of the world came together to regulate the use of these chemicals, and their concentration in the atmosphere continues to decrease and the ozone layer is making a comeback. But now, increasing average temperatures in Australia and New Zealand are compounding these effects — one problem reduced by international cooperation is still affected by the lack of international cooperation on another.

Climate change has also strongly affected the ocean. Sea levels have already risen 2.8 inches (70 millimeters) in Australia since the 1950s, and increasing ocean temperatures threaten the Great Barrier Reef. The reef is at risk of bleaching, half its coral has disappeared since 1995 and the possibility that it may be lost altogether is becoming more real. (See Chapter 8 for details.)

Small islands

You probably aren't surprised to hear that when it comes to climate change, rising sea levels and more extreme storms create an enormous risk for small islands everywhere, such as the South Pacific island of Tuvalu. Some islands will simply disappear due to rising sea levels if global efforts to limit global warming aren't successful. Here are other climate-related concerns for small island nations:

- **Forests vulnerable to major storms:** Storms can easily topple island forests because a forest's small area doesn't provide much of a buffer and the root systems of trees are generally quite shallow on islands.
- **Limited resources:** Some islands can't adapt physically and/or financially.
- **Proximity of population to the ocean:** At least 50 percent of island populations live within a mile (1.5 kilometers) of water, and these populations are threatened by rising sea levels. Tsunamis (they used to be called *tidal waves*) caused by earthquakes and volcanoes, and storm surges from hurricanes and typhoons do much more damage when the ordinary level of the sea surrounding an island is even a little higher than it used to be.
- **Risks to drinkable water:** The intrusion of ocean saltwater because of rising sea levels could contaminate islands' drinkable water, which is already limited on most islands.
- **Reliance on tourism:** Beach erosion and coral reef damage, two possible effects of climate change, would undermine tourism, which many islands rely on for their source of income.
- **Vulnerable agriculture:** Island agriculture, often a key part of the local economy, is extremely susceptible to harmful saltwater intrusions, as well as floods and droughts.

Polar regions

The planet's polar regions are feeling climate change's effects more intensely than anywhere else in the world. Warming temperatures are melting the ice and thawing the *permafrost* (the permanently frozen layer of earth in northern regions of Alaska, Canada, and Siberia) that used to be solid ground.

The Arctic is home to many changes brought on by global warming, including the following:

- **Lost traditions:** Some indigenous people who make their homes in the Arctic are having to abandon their traditional ways of life. The Arctic ice and ecosystem are both core to many of these people's cultures and livelihoods. For more on this issue, flip ahead to Chapter 9.
- **Melting ice:** The Greenland ice sheet is melting, adding to sea level rise. Arctic ice is also steadily losing ice volume. All of this melting is diluting ocean waters and affecting ocean currents.
- **New plant life:** Greenery and new plants have been appearing in the Arctic in recent years. The *tree line* (where tree growth use to end and tundra began) is shifting farther north, but the soil isn't there to support a forest. Soils and ecosystems take thousands of years to develop — the changes happening now are rapid and unpredictable.

GOOD NEWS

Some people look forward to the changes that the Arctic is experiencing. Now that so much sea ice has melted, ships can navigate the Arctic Ocean more efficiently, taking shorter routes. Without any sense of irony, oil companies now keenly anticipate being able to reach more fossil fuels below what used to be unreachable areas because of ice cover. Communities in the Arctic may be able to harness river flows that have been boosted or created by ice melt to run hydroelectric power. But these short-term economic developments can't outweigh the negative planetary impacts.

In the Antarctic, some scientists project major change because of global warming, thinking there's a chance that the western Antarctic ice sheet might collapse by the end of the 21st century. The western Antarctic ice sheet is simply enormous. It contains about 768,000 cubic miles (3.2 million cubic kilometers) of ice, about 10 percent of the world's total ice. It appears to be weakening because warmer water is eroding its base. For the first time in the 2021 Sixth Assessment Report, IPCC scientists accepted as plausible, but not likely, that the entire sheet could melt. The Greenland ice sheet is also melting — quickly. Both the western Antarctic and Greenland ice sheets are adding to sea level rise.

The melting polar ice is also endangering many species, such as polar bears and penguins, which rely on the ice as a hunting ground. (Chapter 8 offers more information about the ways the polar animals are being affected by global warming.)

Positive Politics: Governments and Global Warming

Governments are often the first institutions that the public looks to for big solutions. Governments represent the people of a region, after all, and are expected to make decisions for the good of the public. So, governments need to be able to respond to global warming effectively. Climate change is a very big problem for which no one has all the answers. Despite this challenge, governments around the world are willing to play their part — and it's an important one.

Governments need to take the lead. The next sections lay out some of the necessary actions at all levels from your local water authority to the international institutions.

Making a difference from city hall to the nation's capital

All levels of government, from cities and towns, to states and provinces, to countries, have the ability to affect taxes and laws that can help in the fight against climate change:

- **Local governments:** Can implement and enforce city building codes, improve public transit systems, and implement full garbage, recycling, and composting programs.
- **Regional governments:** Can set fuel efficiency standards, establish taxes on carbon dioxide emissions, and set efficient building codes.
- **Federal governments:** Can lead on the largest of issues, such as subsidizing renewable energy sources, removing subsidies from fossil-fuel energy sources, taxing carbon, and developing national programs for individuals who want to build low-emission housing. Federal governments can also set standards and mandatory targets for GHG reductions for industry, provinces, and states to follow.

The most effective governments work with each other — partnerships between cities, states, and countries exist around the world, supporting one another while they work on the same projects. To read more about what governments can do and are already doing, check out Chapter 10.

Working with a global government

Countries must work together through global agreements to deal with, and conquer, a problem as urgent, complex, and wide-sweeping as climate change. Global agreements create a common level of understanding and allow countries to create collaborative goals, share resources, and work with each other towards global warming solutions. No one country can solve climate change on its own, just like no one country created global warming in the first place.

The core international law around climate change is the 1992 UN Framework Convention on Climate Change (UNFCCC) and a series of subsequent agreements, from the 1997 Kyoto Protocol to the current 2015 Paris Agreement. Countries have agreed that globally they will hold to as far below 2 degrees C as possible and preferably to no more than 1.5 degrees. But, collectively, despite marked progress in some nations, particularly within the European Union, the world's countries aren't on track to deliver on these goals.

The international discussions are ongoing; government representatives meet on an annual basis for the United Nations Climate Change Conference. These targets we re-affirmed at the last such meeting in Glasgow, Scotland in 2021. We discuss just what goes on at those meetings in Chapter 11.

Helping developing countries

The effects of climate change are taking a particularly heavy toll on the populations of *developing countries* — countries with little or no industry development and a weak or unstable economy. These countries, which are primarily located in Latin America, Asia, and Africa, have fewer financial resources to recover from events such as flooding, major storm damage, and crop failures. Money that these nations have to spend paying for the effects of global warming is money that they can't spend building their economies.

Developing countries have little or no major industry development, for the most part (although China has overtaken the United States as the world's largest polluter), so they don't add many GHG emissions to the atmosphere. Even China, with its growing industry, lags far behind the emissions of industrialized nations on a per-person basis. Because industrialized countries have been the primary GHG emitters, they have the main responsibility for reducing emissions, and they can also play a role in helping developing countries shift to renewable energy sources and adapt to climate impacts. For more about how developing nations are addressing climate change, see Chapter 12.

Solving the Problem

Everyone can play a part in slowing down global warming, and humanity doesn't have time to start small. Solving climate change requires a major commitment from everyone — from big business and industry to everyday people. Combined, the following changes can make the necessary difference.

Changing to alternative energies

Fossil fuels (see Chapter 4) are the primary source of the human-produced GHGs causing global warming. Although they've fueled more than a century of human progress, it's time to leave them with the dinosaurs. Fortunately, a wide array of energies is waiting to take the place of oil, coal, and gas.

REMEMBER

Here's a list of *renewable resources* — energy that doesn't run out, unlike fossil fuels, and doesn't pump more carbon into the atmosphere:

- **Geothermal:** Jules Verne was wrong; the center of the planet doesn't contain another world, but it does have plenty of heat. People can use that heat to boil water to produce steam that propels turbines and generates electricity. Even areas without geo-heat sources to boil water can heat homes through *geothermal* energy (the warmth of the earth).
- **Hydro:** People can harness *hydropower,* or water power, to turn turbines and create electricity.
- **Solar:** Humanity can use the sun's warmth in a few ways. Solar cells, like you see on some roofs, can convert sunlight to electricity. People can also heat buildings and water with the sun's direct heat.
- **Waste:** Garbage is more than just trash. It offers astounding possibilities. People can harness the methane emitted from dumps, burn the byproducts of agriculture as fuel, and even use old frying oil as a type of diesel.
- **Wind:** Remember that pinwheel you had as a kid? Giant versions of those wheels are popping up all over the world as wind turbines, generating clean electricity for homes, businesses, and entire energy grids.

Feeling charged up? Check out Chapter 13 to further explore the renewable-energy possibilities, and Chapter 17 to see how rapidly some of these changes are happening already.

Getting down to business

Big industry is the largest contributor to GHG emissions, and it can make the biggest contributions to the fight against global warming. Although some of the changes that businesses can make may have an initial impact on the businesses' pocketbooks, many of these changes may even save businesses money in the long run.

Industrial-strength solutions

The greatest immediate change businesses and industries can make is to improve their efficiency. Companies waste a lot of energy powering antiquated equipment, heating poorly insulated buildings, and throwing out materials that they could recycle. Chapter 14 details some of the ways that companies can pull up their socks and make smarter use of energy, and it also shares some impressive success stories.

Ideally, renewable energy will ultimately power industry. Industry dependence on fossil fuels must rapidly decrease. Currently, some scientists and industries are trying to store carbon emissions underground. This solution is controversial, however. We consider the issue in Chapter 13.

Green fixes for forestry and farming

The forestry and agriculture industries can do more than just cut back on their GHG emissions; they can actually increase the amount of carbon that's absorbed from the planet's atmosphere. (See Chapter 2 to take a ride on the carbon cycle and understand the critical role that plants play in keeping Earth livable.)

REMEMBER

Around the world, forests are being cut down, removing valuable *carbon sinks*, which absorb carbon from the atmosphere. Where they harvest trees, logging companies need to explore methods other than clear-cutting; selectively harvesting trees enables forests to continue to thrive. In other countries, particularly in South America, people are clearing forests for farmland. Losing those forests is particularly costly for the atmosphere because, unlike forests in more temperate climates, these rainforests absorb carbon year-round. Deforestation methods have to change.

Farming's solution for global warming is dirty — or how dirt is treated. Believe it or not, a simple action like excessively tilling the land causes carbon to be released into the atmosphere. And when farmers add GHG-laden fertilizers to the soil, they release even more emissions. By cutting back on tilling the land and using less fertilizer, farmers can be a potent part of the solution to climate change. *Regenerative agriculture* (an approach to farming that works to rebuild topsoil) can play a big part in avoiding climate disaster.

Making it personal

You're a vital part of the climate change solution, too. As a citizen, you can ensure that governments recognize the importance of global warming and follow through on their promises. As a consumer, you can support companies that are making the biggest strides in fighting climate change and encourage other companies to make reducing GHGs a priority. If you're really passionate about having your voice heard, you might even want to consider joining a group dedicated to spreading the word about global warming. We tell you how you can get involved in Chapter 15.

TIP

You can also make many changes in your daily life — some that seem small, some less so — that cut back on the carbon emissions for which you're responsible. You're probably already familiar with many of the little steps you can take to be more climate friendly:

- **Making your home more energy efficient:** Better insulate your roof, basement, and walls; seal your windows; and replace your old light bulbs with LEDs.
- **Reducing the amount of garbage you produce:** Take a reusable bag with you when you shop, buy unpackaged goods, and recycle and reuse materials.
- **Using energy wisely:** Turn off lights and appliances when you're not using them, use the air conditioner less in the summer, and turn down the heat in the winter.

Did you know that many of your appliances are gobbling electricity, causing the emission of GHGs, even when those appliances are turned off? Or that putting a lid on pots on your stove makes your food cook more efficiently?.

Not every action that you can take to cut back on your GHG emissions is manageable — not everyone can yet buy a hybrid or electric car or build a home that doesn't rely on major power producers for energy. But, hopefully, we suggest some options in this book that fit your situation and can help you to make a difference.

Global warming affects everyone, and everyone can play an important role in stopping it. Balance the doom and gloom and — start thinking about the exciting opportunities you have to make a change.