ENLIGHTENED ENVIRONMENTALISM

ENLIGHTENED ENVIRONMENTALISM

HOW WE GOT HERE AND HOW TO RESCUE OUR FUTURE

ANAND M. SAXENA, Ph.D.

Universal-Publishers
Irvine • Boca Raton

Enlightened Environmentalism:
How We Got Here and How to Rescue Our Future

Universal Publishers, Inc.
Irvine • Boca Raton
USA • 2021
www.Universal-Publishers.com

ISBN: 978-1-62734-356-5 (pbk.)
ISBN: 978-1-62734-357-2 (ebk.)

Typeset by Medlar Publishing Solutions Pvt Ltd, India
Cover design by Ivan Popov

Library of Congress Cataloging-in-Publication Data

Names: Saxena, Anand M., author.
Title: Enlightened environmentalism : How we got here and how to rescue our future / Anand M. Saxena.
Description: Irvine : Universal Publishers, [2021] | Includes bibliographical references.
Identifiers: LCCN 2021028946 (print) | LCCN 2021028947 (ebook) | ISBN 9781627343565 (paperback) | ISBN 9781627343572 (ebook)
Subjects: LCSH: Environmental degradation. | Conservation of natural resources. | Environmentalism.
Classification: LCC GE140 .S294 2021 (print) | LCC GE140 (ebook) | DDC 304.2/8--dc23
LC record available at https://lccn.loc.gov/2021028946
LC ebook record available at https://lccn.loc.gov/2021028947

I gratefully acknowledge the help given by my daughter Nalini in all phases of the development of my ideas into this book.

CONTENTS

INTRODUCTION

Technological progress and globalization have changed our lives by providing us with numerous comforts and conveniences. While factories keep churning out new gizmos at regular intervals that dazzle and delight us, we get objects of daily use, including clothing, furnishings, edible items, even fruits and flowers, from distant regions of the world. At the behest of industries, scientists and technologists keep creating objects with fascinating and amazing features. However, there are clouds on the horizon that clearly indicate that this era of profligate consumption has caused enormous harms to the ecosystem that may threaten our welfare, perhaps even survival.

Fossil fuels and their derivatives changed the lives of people almost everywhere. Personal transportation increased the range of human habitation, animal factories increased the production and consumption of meats and dairy, agriculture became highly dependent on chemical products, and electricity, mainly produced from fossil fuels, became an essential part of life. At the same time, products made with fossil fuels—from plastics to pharmaceuticals—filled our homes. The realization came later that a price had to be paid for these conveniences in terms of climate change and its deleterious effects that endanger human life and welfare. Events such as droughts, irregular rainfalls, forest fires, and intense hurricanes cause substantial damages, including loss of lives. Also, there are changes that are building up and will have serious consequences with the passage of time. Melting of glaciers and polar ice caps will accelerate and will have disastrous consequences in many parts of the world. Increasing acidity of oceans due to dissolved carbon dioxide from the atmosphere will have an adverse effect on marine life everywhere.

There are many other clouds on the horizon that threaten the welfare of humanity. We have lived with the implicit belief that the Earth is too large to be affected by human actions and has an unlimited capacity to provide us with resources and absorb the waste produced by our activities. With this mindset, oceans were freely used for dumping undesirable items, effluents from factories were only considered to be a temporary and local nuisance, and forests were razed whenever a more profitable use of the land was discovered. Agriculture was supposed to provide food items forever, albeit with some help from synthetic fertilizers and other chemicals. We have now come to realize that there are consequences of this lack of concern for the biosphere. Air and water pollution kill or shorten the lifespan of millions of people in all parts of the world, including the United States. Degradation of farmlands due to the loss of topsoil and the accumulation of chemicals is decreasing their productivity, while the population is increasing at a steady pace and the demand of agricultural products is increasing both for direct consumption by humans and also to feed the huge number of farm animals. A byproduct of our profligate lifestyle is that we are producing waste on a gargantuan scale that cannot be assimilated by the ecosystem. Ignorance of planetary limits and blind faith in technology are projected to adversely affect our welfare within the next few decades. Scientists and ecologists began to realize some time ago that this lifestyle is not sustainable, but the engines of industry were moving at full speed and reversing direction, or even slowing their growth, was considered to be suicidal by many of them. Continuously increasing consumption is maintained by inducements from businesses in the form of advertisements, easy credit, and rapidly changing features of consumer products. It is also encouraged by governments because personal consumption constitutes a major portion of the economy.

Environmental degradation and depletion of planetary resources may make life difficult, even impossible, for a large segment of the human population within a few decades unless drastic corrective actions are taken soon. The cost of mitigating steps will rapidly increase if actions are not taken expeditiously. Humans have proved numerous times that they are very resilient and can adapt to extreme changes when they perceive a threat to their existence. For example, the threat of COVID-19 has changed the behavior of people in all parts of the world. There is evidence that consciousness of the threat to human existence is developing now, and some people have started reducing their ecological footprint. The important thing is to increase the awareness of the present situation before it becomes too late to stop the progression of events. Steps taken

to ameliorate the development of dangerous events may require reducing consumption to sustainable levels, which will be vigorously opposed by people who control big businesses. Another problem is that many deleterious developments are not connected, in the common perception, with our profligate lifestyle and also there is the misplaced belief that science and technology will solve all problems in the course of time. Although technological developments can provide us with incredible gadgets for everyday use, the problems of decreasing productivity of farmlands, intense hurricanes and thunderstorms, droughts, rising sea levels, and the loss of biodiversity are global problems that need concerted actions by people everywhere.

The essays in this book develop an interrelationship between these developments with suggestions for making changes. The burden of humanity on the planetary ecosystem has increased at a very rapid rate during the last few decades, with the result that we are handing over a deeply flawed planetary system to the younger generation. Many young people in different parts of the world have come to the realization that they will have to face the consequences of the profligate lifestyle of previous generations. Millions of young people all over the world are demanding action from governments to fight global warming and environmental degradation. In September 2019, 4 million marchers in many countries demanded swift action from governments. Greta Thunberg, one of the leaders of the movement, addressed the United Nations General Assembly: "You have stolen my dreams. All you can talk about is money and fairy tales of eternal economic growth." Unfortunately, the epidemic of COVID-19 diverted the resources of people and governments to combating it, and the Green Agenda became of secondary importance. However, the environmental problems that have been building up for decades will not take a break and their effects will become even more calamitous due to lost time. It is up to us to save the planet from extreme events for our sake and for the sake of future generations. As an ancient Native American proverb says: "We do not inherit the Earth from our ancestors, we borrow it from our children."

ONE

CLIMATE CHANGE

Climate change is the greatest threat facing humanity because it endangers the welfare and lives of people everywhere in the world. Using satellites, weather balloons, floating buoys, and other instruments to monitor changes in temperature, scientists and engineers have carefully collected data over the last few decades in all parts of the world—from the depths of oceans to the top of the atmosphere. Their evidence is unequivocal: our planet is warming and the average global temperature breaks records almost every year. The initial consequences of global warming have already started affecting human lives while other consequences will endanger the lives and livelihoods of millions of people in the coming decades. Although a change in temperature by a degree or two may seem trivial, warming on a global scale will have drastic consequences. The number and severity of the adverse effects of global warming are increasing with each passing year. Extreme events such as floods, hurricanes, storms, forest fires, and droughts have become common in many parts of the world with devastating effects. Rising sea levels have swallowed a few islands and many coastal regions are in danger of being submerged. Droughts and higher temperatures have decreased the output of farms in many places. Increased acidity of oceans, disappearance of glaciers, and melting of ice on snow-covered peaks will cause death and destruction on a large scale.

Fossil Fuels

The main cause of global warming is the concentration of carbon dioxide in the atmosphere. A dynamic equilibrium between the sources and sinks of carbon dioxide maintained its atmospheric level within a narrow range for millennia.

This gas was primarily emitted from respiration by plants and animals, with some contribution from occasional forest fires, and was absorbed by plants during photosynthesis. The use of wood and charcoal by humans added to the burden of this gas in the atmosphere but it was not large enough to significantly disturb this equilibrium. The discovery and extensive use of fossil fuels upended this balance, resulting in far more carbon dioxide being produced than could be assimilated by natural systems.

Fossil fuels played a crucial role in ushering in the Industrial Revolution that began the process of transforming our lives. In the early stages of industrialization, the primary source of energy was coal, which had a much greater concentration of energy than wood. Coal is still widely used for the generation of electricity in power plants in almost all countries. The discovery of petroleum added another dimension to the use of fossil fuels because gasoline could be easily transported and ignited when needed, giving rise to motorized transportation. Fossil fuels—coal, natural gas, and petroleum—are still the major fuels to produce energy, both in the United States and around the world. In addition to providing a cheap and abundant source of energy, petroleum can also be used to manufacture a wide range of chemicals such as for plastics, fertilizers, pharmaceuticals, detergents, and perfumes. As technologists discovered more and more uses of fossil fuels and their derivatives, the public became fascinated with the products of this new source of energy and chemicals. Industries based on fossil fuels have provided us with resources and amenities that previous generations could not have imagined.

Energy consumption is a key differentiating factor between modern and pre-industrialization societies. Energy consumption generally determines the standard of living of a people. An average American consumes three times more energy than a Mexican, and seventeen times more energy than an African on a per capita basis.[1] Although fossil fuels are not the only available source of energy, other sources of energy have not played a significant role until recent times. The contribution of the alternative sources of energy is expected to grow with increasing awareness of the deleterious effects of fossil fuels.

All aspects of human existence today—food, shelter, transportation, furnishings, and a great variety of stuff that provides us with many types of creature comforts and with which we fill our homes—are either made directly from fossil fuels or by machines that operate by using these nonrenewable resources. Fossil fuels were formed from the organic remains of prehistoric plants and animals that have remained buried for millions of years. The Earth holds an

enormous amount of these sources of energy. The use of fossil fuels has been steadily increasing for almost a century. The average per capita consumption in the United States is about 2.7 gallons of oil-equivalent per day.[2] On a worldwide basis, humans use about 10 billion tons of oil-equivalent per year.[3]

Until a few decades ago, no serious consideration was given to the environmental effects of fossil fuels because it was believed that the Earth was too big to be affected by human activities. This line of thinking, and the easy availability of energy and chemicals from fossil fuels, prevented any serious considerations of their effects on the environment. When scientists concluded that the use of fossil fuels is damaging the planetary ecosystem, the engines of industry were moving with such speed that reversing direction, or even slowing the pace, would have been considered financial suicidal by many industries. Hence, the warnings from scientists were ignored and, to some extent, are being ignored even today.

Due to increasing concerns about the effect of burning fossil fuels, the Intergovernmental Panel on Climate Change (IPCC) was set up by the United Nations (UN) and the World Meteorological Organization in 1988. IPCC's objective is to assess the scientific, technical, and socioeconomic information relevant to understanding the risk of human-induced climate change, and to make recommendations to stabilize the concentration of greenhouse gases (GHG) at a level that will prevent dangerous interference with the global climate system. IPCC publishes the opinions of leading climate scientists and the consensus of participating governments. These reports assess the causes of climate change and their likely impact on the planet and have been emphasizing the gravity of the situation with pleas for immediate action to prevent extreme events. However, most nations have taken only faltering steps to decrease the emission of GHG. The longer the nations and people delay definitive actions, the more extreme will be the steps necessary to prevent disastrous events. With each passing year, the situation continues to worsen and the window of opportunity to prevent extreme changes in the environment may be about to close. The Fifth Assessment Report of IPCC warned that the world may be fast approaching a tipping point concerning climate change and suggested that the next few years will be crucial for reducing the amount of greenhouse gases.[4]

Since the use of fossil fuels is the main reason for the precarious situation in which we find ourselves, it is useful to understand the processes for extracting, purifying, and combusting them to produce energy. In addition to the accumulation of greenhouse gases, the very process of extracting them from the

ground has an adverse effect on the environment, the health of mineworkers, and people who live in the vicinity of mines. The processes involved and dangers associated with the extraction and purification of fossil fuels are discussed in an appendix.

Greenhouse Gases and Their Global Warming Potential

Greenhouse gases trap heat in the atmosphere, resulting in warming of the Earth. The extent to which a gas is effective in global warming depends on a number of factors, including the concentration of the gas in air, the period for which it stays in the atmosphere, and its capacity to absorb the radiant heat emanating from the Earth. Although carbon dioxide is the primary greenhouse gas, methane, nitrous oxide, and fluorinated gases also make significant contributions to global warming. The capacity of a gas to trap heat in the atmosphere is called its Global Warming Potential (GWP). Carbon dioxide is assigned a GWP of one, and the effectiveness other gases is measured in terms of "carbon dioxide equivalent." Since the period for which a gas stays in the atmosphere varies considerably, the GWP of a gas will also depend on the duration for which its effectiveness is being considered. It is common to consider a time frame of 20 years when comparing the effects of greenhouse gases. Methane (CH_4) stays in the atmosphere for about 12 years and has a GWP of 84 to 87 for this period.[5] This means that this gas is about 85 times more effective in its warming potential than carbon dioxide. Nitrous oxide stays in the atmosphere for about 120 years and has a GWP of 280. Several hydrofluorocarbons (HFCs) are also produced during the combustion of fossil fuels. In general, they are good absorbers of thermal radiation, and their lifetimes range from one year to many centuries, hence their GWPs can be very large. As an example, the GWP of CFC-11 (CCl_3F) is 6,730 for a 20- year time horizon. Consideration of the lifetime of greenhouse gases becomes important when the objective is to determine the long-term effect of gases already in the atmosphere.[6] In 2014, the total GHG emission in the United States was 6,870 million tons of carbon dioxide equivalent.[7] Total emission of greenhouse gases in the world is estimated to be 53,526 million metric tons of CO_2 equivalent per year.[8]

While carbon dioxide is produced in copious amounts during the combustion of fossil fuels, particularly in motor vehicles, other greenhouse gases are released in the atmosphere during various uses of petrochemicals. Human activities that release methane in the atmosphere include livestock farming and

leakages in the production, transportation, and use of natural gas. Fracking, the process of injecting highly pressurized liquid into rocks with the goal of extracting oil or gas, is increasing in popularity and leads to the release of large amounts of methane. Other sources of methane include landfills, organic waste, biomass burning, and rice agriculture. Some nitrous oxide is usually produced during the combustion of almost all fossil fuels. This gas is also released from the decomposition of synthetic fertilizers containing ammonia or nitrates in the soil. HFCs are used in refrigerators, air conditioners, foams, and aerosol cans. They frequently leak during the manufacture of these products and continue to leak throughout the product's life. Hydrofluorocarbons are produced by human activities mainly in the industrial processes that use fossil fuels; there is no natural source of these gases.

Global Temperature and Carbon Dioxide

Many natural processes release carbon dioxide in the atmosphere; these include soil decomposition, ocean-atmosphere exchange, volcanic eruptions, and respiration from plants and animals. Plants, however, also absorb carbon dioxide in the presence of sunlight and stabilize it in the form of organic matter in their leaves, stems, roots, and other components. On average, plants absorb much more carbon dioxide by photosynthesis than they release during respiration. For thousands of years—until the mass-scale use of fossil fuels—sources and sinks kept the level of carbon dioxide within a narrow range in a dynamic equilibrium.

Scientists and engineers have explored the link between the concentration of carbon dioxide in the atmosphere and global temperature by drilling into ice sheets that cover Antarctica and Greenland, where thousands of years of snow has compressed into thick slabs of ice. These ice layers also trap bubbles from the ancient atmosphere, thus allowing a direct measurement of the level of CO_2 and other gases in the atmosphere in the years when the ice was formed. While the level of CO_2 is measured directly from the bubbles trapped in ice, the temperature at different periods is inferred from the concentrations of isotopes of oxygen. By determining the ratio of the heavy isotope of oxygen (^{18}O) to the light isotope (^{16}O) in marine sediments, ice cores, and fossils, scientists can determine changes in the atmospheric temperature at the time these objects were formed.[9] These observations show a tight correlation between global temperature and the level of carbon dioxide during the last 800,000 years, as shown in Figure 1.

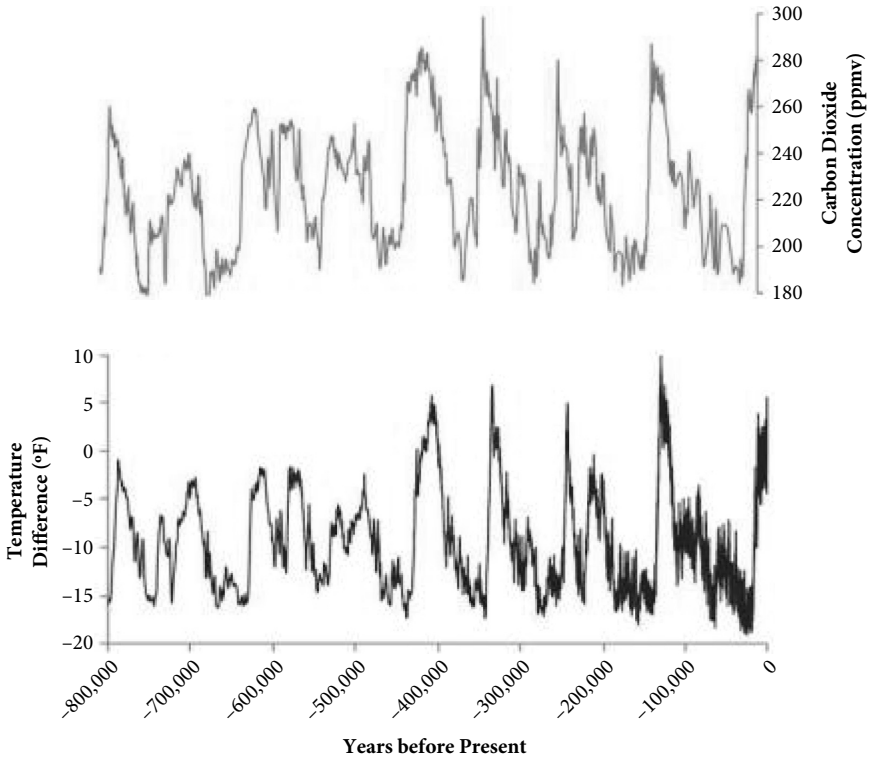

Figure 1 Correlation between CO_2 Level and Temperature over 800,000 years.[10]

The plots show that during the last 800,000 years, there have been seven cycles of significant variation in the amount of carbon dioxide in the atmosphere. During these cycles, the concentration of CO_2 in the atmosphere varied between 180 and 300 parts per million (ppm). This variation is caused by natural events such as volcanic eruptions, ocean-atmospheric exchange, and the formation and dissolution of microscopic forms of life on a global scale.

Since the mid-20th century, humans have been adding huge quantities of CO_2 to the atmosphere by the combustion of fossil fuels. The level of carbon dioxide in the atmosphere is now at unprecedented high levels. Its concentration since 1960 has been determined at the Mauna Loa Observatory on the island of Hawaii. The isolation of this place allows a record of the concentration of this gas that is unperturbed by industrial activities. It shows a continuous increase from 1960 at the rate of 2 ppm per year in recent decades, reaching a level of 410.27 ppm in November 2019. The data obtained from the observatory since 1960 is shown in Figure 2.

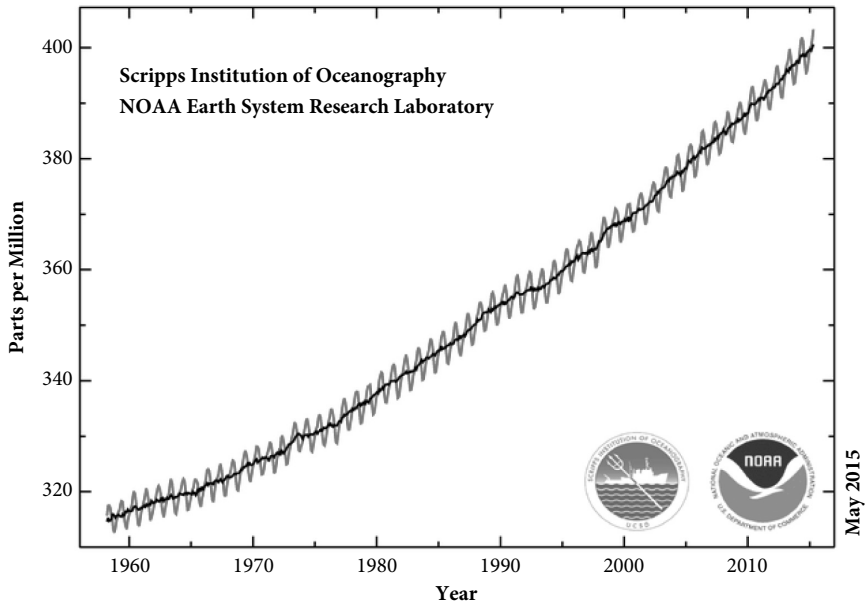

Figure 2 Atmospheric CO_2 at Mauna Loa Observatory.
Source: NOAA.

Figure 3 shows the average global temperature from 1880 to present. The undulations represent the annual mean, and the solid line displays the five-year mean. The average global temperature has been steadily rising since 1970, setting records almost every year. Earth's average temperature has increased by 1.6°F (0.9°C) since 1910 with the major part of that increase occurring during the last three decades. According to the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA), 2016 and 2020 were the warmest years since records were first kept in 1880. The five warmest years have all occurred since 2010.[11]

Since the mid-20th century, the combustion of fossil fuels has released large amounts of CO_2 in the atmosphere. Table 1 shows the amount of carbon dioxide emitted by the combustion of wood and various fossil fuels.[12] The number is highest for wood because it is less dense in energy than fossil fuels. The amount of carbon is not the same in different types of coal, as indicated by the range given in the table. Anthracite coal has the greatest concentration of carbon and is the most efficient producer of energy. Lignite has the least carbon with bituminous coal somewhere in between.

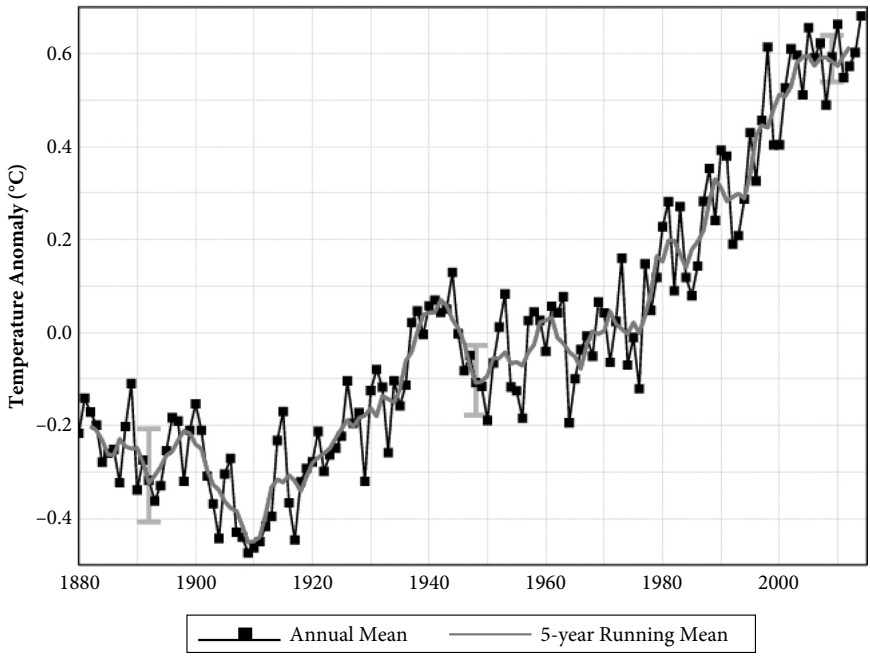

Figure 3 Global Land–Ocean Temperature Index.
Source: NASA.[13]

Table 1 Emission of CO_2.

Fossil Fuel	Emissions in $KgCO_2/GJ$
Wood	109.6
Coal	101.2–94.6*
Fuel Oil	77.4
Diesel	74.1
Crude Oil	73.3
Kerosene	71.5
Gasoline	69.3
Natural Gas	56.1

Note: *depending on the type.

In June 2015, the National Oceanic and Atmospheric Administration released the temperature data obtained from numerous observation stations, buoys, commercial ships, and weather stations. An analysis shows that the temperature of the Earth has been rising continuously for the last fifty years. Although an increase in temperature by a degree or two may be considered trivial because the temperature at most places fluctuates by many degrees during the year, an increase in the average temperature at the global scale will have serious consequences. The close correlation between the level of carbon dioxide in the atmosphere and the global temperature clearly indicates that this warming is related to the level of CO_2 in the atmosphere caused by the combustion of fossil fuels.

Methane and Other Greenhouse Gases

Methane is the second-most-common greenhouse gas. Since it is about eighty-five times more effective than carbon dioxide in trapping the radiant heat emanating from the Earth, it makes a much greater contribution to global warming than its concentration in the atmosphere. The level of methane in the atmosphere has been rising since 2007. Methane leaks at almost every point in the supply chain—at drilling sites, compression stations, and from the network of pipes that deliver natural gas to homes. The complexity of these sources makes it difficult to quantify the amount of methane released in the atmosphere. In 2016, the Environmental Protection Agency (EPA) estimated that the amount of methane released is about 9.3 million metric tons per year, 27 percent higher than the previous estimate. Over a twenty-year timeframe, these emissions have the same impact on the climate as 200 coal-fired power plants. Methane gas leaked from the supply chain is estimated to be worth $1.4 billion at 2015 prices.[14]

Methane is also released in the atmosphere during the hydraulic fracturing process. Shale gas, essentially the same as natural gas, is tightly held in shale formations and is extracted by high-precision horizontal drilling and hydraulic fracturing (fracking). A large amount of methane is emitted during the extraction process, which almost completely negates the advantage of shale gas over coal in its impact on climate change.[15] Methane is also released in the atmosphere in oil and gas operations. Satellite observations of oil and gas basins in Texas and North Dakota show that substantial amounts of methane are leaked into the atmosphere from these facilities. Other sources of methane include decaying organic matter in landfills, rice agriculture, and the digestion of food in the stomachs of ruminants (cows, goats, and sheep). When these

animals ingest food, it is fermented in the first division of the stomach—known as the rumen—as part of the digestive process that releases methane. It is estimated that about a quarter of the methane in the atmosphere has its origin in enteric fermentation of food in the stomachs of farm animals. Since humans raise livestock for food, this methane emission is related to the consumption of meat and dairy. When all sources of methane emission are considered, natural gas may be just as damaging for the environment as coal or oil.[16] The EPA estimated that 8 million tons of methane leaks into the atmosphere per year in the U.S. However, the Environmental Defense Fund (EDF) estimated that the leakage rate of methane is much higher at 13 million tons per year.

The atmospheric concentration of greenhouse gases has been increasing steadily since the beginning of the Industrial Revolution, mainly from the use of fossil fuels by individuals, businesses, and industries. The worldwide emission of greenhouse gases increased by 35 percent during the twenty-year period from 1990 to 2010. Carbon dioxide accounted for three-fourths of this total; its concentration in the atmosphere increased by 42 percent during this period. Dr. James Hansen, former head of the Goddard Institute for Space Studies, made the following statement: "If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimatic evidence and ongoing climate change suggest that CO_2 will need to be reduced from current levels to below 350 ppm."[17] This statement has led to a movement known as 350.org. Since the last recorded level of carbon dioxide was 412.89 ppm in November 2020, the goal of this eminently sensible movement is not only to stop the growth of greenhouse gases in the atmosphere but also to reduce their concentrations to what the levels were in the year 1990.

Scientific Consensus

There is overwhelming scientific consensus that global warming is indeed happening and is caused by the release of greenhouse gases from human activities. In fact, almost the entire concentration of greenhouse gases during the last few decades is attributable to human activities.[18] Eighteen leading American and international scientific societies have joined together to make the following statement, supported by NASA: "Observations throughout the world make it clear that climate change is occurring, and rigorous scientific research demonstrates that the greenhouse gases emitted by human activities are the primary driver."[19] An examination of 11,944 scientific papers on climate change

published from 1991 to 2011 showed that 97.1 percent endorsed the consensus position that humans are causing global warming.[20] The few papers that do not support anthropogenic climate change have been shown to have methodological flaws, in that they ignored information that does not fit their conclusions or used inappropriate statistical methods.[21] A more recent analysis of 24,210 peer reviewed papers by 69,406 authors shows that only four authors reject human-caused global warming, which means that the consensus of climate scientist on this topic is 99.99 percent.[22] More than 200 worldwide scientific organizations hold the position that climate change is caused by greenhouse gas emissions from the burning of fossil fuels.

Consequences of Climate Change

Although climate hazards are natural events in the weather cycle, the scale of destruction and devastation caused by extreme climatic events in recent decades is new and terrifying. The frequency of such events is increasing with each passing year, endangering the lives and livelihoods of millions of people in almost all parts of the world. A striking, visible effect of global warming is the melting of ice and snow that cover high mountains. Glaciers, which help maintain the flow of rivers throughout the year, are shrinking in size around the world and most of them are projected to disappear within the next few decades. The areas covered by ice sheets in the Arctic and Greenland have been decreasing each year, and Kilimanjaro, the highest mountain in Africa, has lost 80 percent of its snow cover.

The average global temperature breaks records almost every year. Even a small increase in temperature on the global scale will have many consequences, some of which will affect the lives and livelihoods of millions of people right now, while others will slowly degrade the planetary ecosystem in ways that will have far-reaching effects on the welfare of humanity. Evidence of changes in climate and weather patterns throughout the world has been accumulating for the last few decades. Extreme events, such as high category hurricanes, typhoons, periods of excessive or inopportune rainfalls, forest fires, and droughts have become more frequent with devastating effects on communities around the world. The slow but persistent events that are bound to have profound consequences include rise in sea levels, acidification of oceans, and changes in the flow of rivers caused by irregular rainfalls and the melting of ice caps on mountain peaks.

The list of extreme climatic events that have occurred in the last few years is growing on a continual basis. These events cause economic loss, hardship, and loss of lives in different parts of the world. The frequency and severity of these events is increasing with the passage of time. Data about major disasters in each of the last four decades in the United States is given in the following table.[23]

Decade	Number of Billion-Dollar Disasters	Associated Cost (billions)	Associated Fatalities
1980–1989	28	$127.78	281
1990–1999	52	$269.68	217
2000–2009	59	$510.38	305
2010–2019	119	$802.08	521

This table shows that the number of events that caused an economic loss of more than 100 billion dollars, the total associated cost in inflation-adjusted dollars, and the number of fatalities is rapidly increasing with each passing decade. There have been numerous devastating events in all regions of the world. Some of them are listed below.

Drought in Southwest U.S.: A severe drought occurred in the Western United States during 2012–2016. This record drought, the worst since record-keeping began, caused a shortage of water in most of California and created a parched landscape in many regions. A study established that anthropogenic GHG emissions increase the probability that higher temperatures will be accompanied by low precipitation—a combination that created this drought.[24] California's Central Valley, which extends for 450 miles from Sierra Nevada to the Pacific Coast, is the single most productive tract of land in the world. A large proportion of fruits, vegetables, nuts, and rice are grown in this region. Since California provides both a substantial amount of agricultural output to the rest of the country and also 15 percent of the agricultural exports from the United States to other nations, a drought in California has a serious impact on the availability of food in the domestic and international markets. This drought caused an estimated loss of $1.5 billion in revenue and of 17,000 jobs. Scientists from NASA, Columbia University, and Cornell University estimated that the chance of a thirty-five-year or longer "megadrought" striking the Southwest and Central Great Plains is over 80 percent if the world stays on its current trajectory of greenhouse gas emissions.[25] Although rainfall in 2017 brought some

relief, climatologists fear that low snowfall in the Sierra Nevada mountains may produce another shortage of water in coming years.[26]

High-Intensity Hurricanes: While hurricanes occur in the North Atlantic every year, they have been particularly destructive during the last few years due to strong winds, ocean surges, and enormous rainfalls. Eight of the ten costliest hurricanes on record in the United States have occurred since 2014. As temperatures rise, more water vapor evaporates into the atmosphere, acting as fuel for the storms. Any storm that develops has a greater potential to turn into a hurricane. Modeling predicts a 45 to 81 percent increase in the frequency of Category 4 and 5 hurricanes in the Atlantic coast of North America in coming years.[27] A higher temperature of seawater provides more energy to the storms, thus fueling their intensity. The recorded maximum speed of most powerful hurricanes has also been increasing since 1981.

The 2017 hurricane season was extremely active and deadly. Hurricanes Harvey, Irma, and Maria destroyed thousands of structures and many people were displaced, injured, or killed. Hurricane Harvey dumped 40 inches of rain on Houston, America's fourth-largest city, and displaced 13 million people in Texas, Louisiana, Mississippi, Tennessee, and Kentucky. The damage caused by this hurricane was estimated to be $125 billion by the National Hurricane Center. Irma, a Category 5 hurricane, was one of the most powerful hurricanes in recorded history. The winds blew with a speed of 137 miles per hour for thirty-seven continuous hours and the coastal storm surges were 20 feet above the normal tide levels. It caused the deaths of 102 people, including seventy-five in Florida. The damage caused by Hurricane Maria was estimated to be around $65 billion, a staggering cost for Puerto Rico's ailing economy. Residents had to live without proper food, water, and fuel for many months. Although the official death toll following the hurricane was only sixty-four, researchers from Harvard University estimate that at least 4,645 deaths occurred during the storm and in the following weeks.[28]

Typhoon Haiyan: Typhoon Haiyan, one of the strongest tropical cyclones ever recorded, devastated some regions of Southeast Asia in November 2013. It caused maximum damage in the Philippines, which was hit with sustained winds with speeds up to146 miles per hour. Haiyan caused immense destruction in the country. More than 6,000 people were killed and thousands of homes were destroyed. Over 14 million residents, including nearly 6 million children, were displaced by the typhoon. The financial cost of the damage to the Philippines' economy was estimated to be $14 billion.