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CLIMATE CHANGE: THE GREENHOUSE GASES CAUSING GLOBAL WARMING

Dr. Kumar Amit

Ph.D. (Science). VKSU. Ara. Bihar.

Corresponding Author: Dr. Kumar Amit

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Abstract:

Greenhouse gases act similarly to the glass in a greenhouse: they absorb the sun's heat that radiates from the Earth's surface, trap it in the atmosphere and prevent it from escaping into space. The greenhouse effect keeps the Earth's temperature warmer than it would otherwise be, supporting life on Earth The greenhouse effect is a natural process that warms the Earth's surface. When the Sun's energy reaches the Earth's atmosphere, some of it is reflected back to space and the rest is absorbed and re-radiated by greenhouse gases. Greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide, ozone and some artificial chemicals such as chlorofluorocarbons (CFCs). The absorbed energy warms the atmosphere and the surface of the Earth. This process maintains the Earth's temperature at around 33 degrees Celsius warmer than it would otherwise be, allowing life on Earth to exist. Earth's greenhouse gases trap heat in the atmosphere and warm the planet. The main gases responsible for the greenhouse effect include carbon dioxide, methane, nitrous oxide, and water vapor (which all occur naturally), and fluorinated gases (which are synthetic).

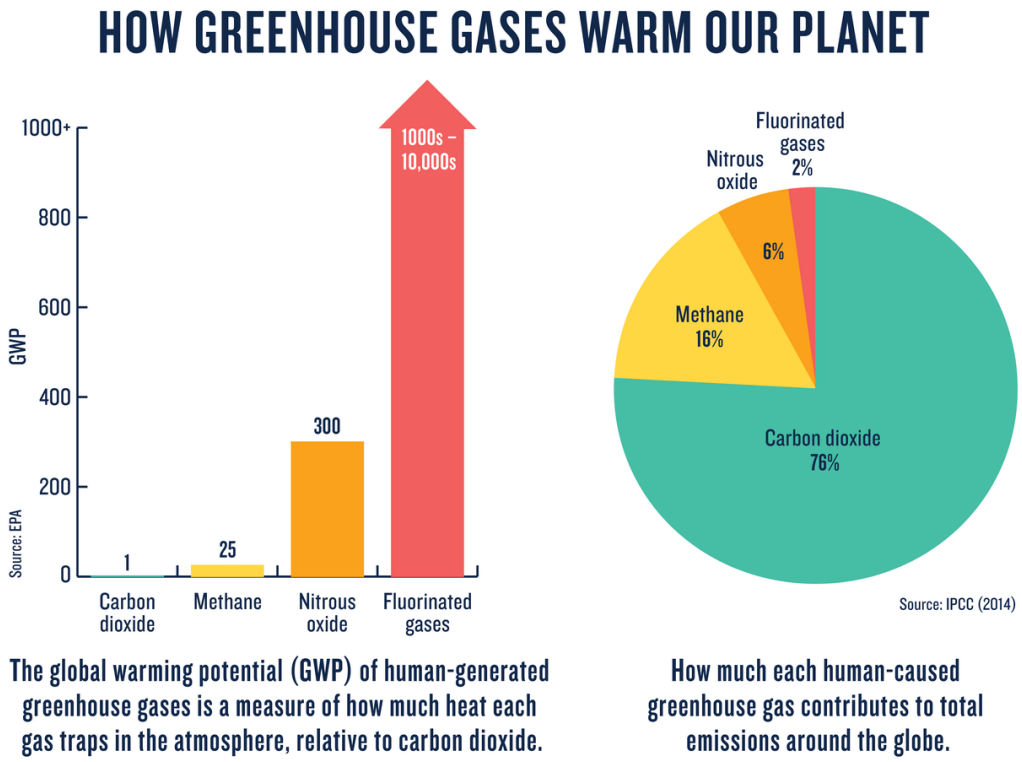
Keywords: Greenhouse Gases, Global Warming, Climate Change.

Introduction:

Since the start of the Industrial Revolution and the advent of coal-powered steam engines, human activities have vastly increased the volume of greenhouse gases emitted into the atmosphere. It is estimated that between 1750 and 2011, atmospheric concentrations of carbon dioxide increased by 40 percent, methane by 150 percent, and nitrous oxide by 20 percent. In the late 1920s, we started adding man-made fluorinated gases like chlorofluorocarbons, or CFCs, to the mix. In recent decades we've only picked up the pace. Of all the man-made emissions of carbon dioxide—the most abundant greenhouse gas released by human activities, and one of the longest-lasting—from 1750 to 2010, approximately half were generated in the last 40 years alone, in large part due to fossil fuel combustion and industrial processes. And while global greenhouse gas emissions have occasionally plateaued or dropped from year to year

(most recently between 2014 and 2016), they're accelerating once again. In 2017, carbon emissions rose by 1.6 percent; in 2018 they increased by an estimated 2.7 percent.

Discussion:



The global warming potential (GWP) of human-generated greenhouse gases is a measure of how much heat each gas traps in the atmosphere, relative to carbon dioxide.

How much each human-caused greenhouse gas contributes to total emissions around the globe.

Five Major Greenhouse Gases:

The most significant gases that cause global warming via the greenhouse effect are the following:

Carbon Dioxide:

Accounting for about 76 percent of global human-caused emissions, carbon dioxide (CO2) sticks around for quite a while. Once it's emitted into the atmosphere, 40 percent still remains after 100 years, 20 percent after 1,000 years, and 10 percent as long as 10,000 years later.

Methane:

Although methane (CH4) persists in the atmosphere for far less time than carbon dioxide (about a decade), it is much more potent in terms of the greenhouse effect. In fact, pound for pound, its global warming impact is 25 times greater than that of carbon dioxide over a 100-year period. Globally it accounts for approximately 16 percent of human-generated greenhouse gas emissions.

Nitrous Oxide:

Nitrous oxide (N2O) is a powerful greenhouse gas: It has a GWP 300 times that of carbon dioxide on a

100-year time scale, and it remains in the atmosphere, on average, a little more than a century. It accounts for about 6 percent of human-caused greenhouse gas emissions worldwide.

Fluorinated Gases:

Emitted from a variety of manufacturing and industrial processes, fluorinated gases are man-made. There are four main categories: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF6), and nitrogen trifluoride (NF3).

Although fluorinated gases are emitted in smaller quantities than other greenhouse gases (they account for just 2 percent of man-made global greenhouse gas emissions), they trap substantially more heat. Indeed, the GWP for these gases can be in the thousands to tens of thousands, and they have long atmospheric lifetimes, in some cases lasting tens of thousands of years.

HFCs are used as a replacement for ozone-depleting chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), usually in air conditioners and refrigerators, but some are being phased out because of their high GWP. Replacing these HFCs and properly disposing of them is considered to be one of the most important climate actions the world can take.

Water Vapor:

The most abundant greenhouse gas overall, water vapor differs from other greenhouse gases in that changes in its atmospheric concentrations are linked not to human activities directly, but rather to the warming that results from the other greenhouse gases we emit. Warmer air holds more water. And since water vapor is a greenhouse gas, more water absorbs more heat, inducing even greater warming and perpetuating a positive feedback loop. (It's worth noting, however, that the net impact of this feedback loop is still uncertain, as increased water vapor also increases cloud cover that reflects the sun's energy away from the earth.)

Big Bend Power Station, a coal-fired power plant in Tampa, Florida

Results:

Population size, economic activity, lifestyle, energy use, land use patterns, technology, and climate policy: According to the Intergovernmental Panel on Climate Change (IPCC), these are the broad forcings that drive nearly all human-caused greenhouse gas

emissions. Here's a closer look at greenhouse gas emissions by source. Electricity and Heat Production the burning of coal, oil, and natural gas to produce electricity and heat accounts for one-quarter of worldwide human-driven emissions, making it the largest single source. In the United States it's the second-largest (behind transportation), responsible for about 27.5 percent of U.S. emissions in 2017, with carbon dioxide the primary gas released (along with small amounts of methane and nitrous oxide), mainly from coal combustion.

Agriculture and Land Use Changes:

About another quarter of global greenhouse gas emissions stem from agriculture and other land-use activities (such as deforestation). In the United States, agricultural activities—primarily the raising of livestock and crops for food—accounted for 8.4 percent of greenhouse gas emissions in 2017. Of those, the vast majority were methane (which is produced as manure decomposes and as beef and dairy cows belch and pass gas) and nitrous oxide (often released with the use of nitrogen-heavy fertilizers). Trees, plants, and soil absorb carbon dioxide from the air. The plants and trees do it via photosynthesis (a process by which they turn carbon dioxide into glucose); the soil houses microbes that carbon binds to. So nonagricultural land-use changes such as deforestation, reforestation (replanting in existing forested areas), and afforestation (creating new forested areas) can either increase the amount of carbon in the atmosphere (as in the case of deforestation) or decrease it via absorption, removing more carbon dioxide from the air than they emit. (When trees or plants are cut down, they no longer absorb carbon dioxide, and when they are burned or decompose, they release carbon dioxide back into the atmosphere.) In the United States, land-use activities currently represent a net carbon sink, absorbing more carbon dioxide from the air than they emit.

Industry:

About one-fifth of global human-driven emissions come from the industrial sector, which includes the manufacturing of goods and raw materials (like cement and steel), food processing, and construction. In 2017, industry accounted for 22.4 percent of U.S. man-made emissions, of which the majority was carbon dioxide, though methane, nitrous oxide, and fluorinated gases were also released.

Jingying Zhao/Getty

Transportation:

The burning of petroleum-based fuels, namely gasoline and diesel, to power the world's transportation systems accounts for 14 percent of global greenhouse gas emissions. In the United States, with Americans buying larger cars and taking more flights and with low gas prices encouraging drivers to use their cars more, transportation is the largest contributor of greenhouse gases. (It accounted for 28.7 percent of U.S. emissions in 2017.) Carbon dioxide is the primary gas emitted, though fuel combustion also releases small amounts of methane and nitrous oxide, and vehicle air conditioning and refrigerated transport release fluorinated gases too.

Buildings:

Operating buildings around the world generates 6.4 percent of global greenhouse gases. In the United States, homes and businesses accounted for about 11 percent of warming emissions. These emissions, made up mostly of carbon dioxide and methane, stem primarily from burning natural gas and oil for heating and cooking, though other sources include managing waste and wastewater and leaking refrigerants from air-conditioning and refrigeration systems.

Conclusion:

Other Sources:

This category includes emissions from energy-related activities other than fossil fuel combustion, such as the extraction, refining, processing, and transportation of oil, gas, and coal. Globally, this sector accounts for 9.6 percent of emissions.

Greenhouse Gas Emissions by Country:

Since the start of the Industrial Revolution, more than 2,000 billion tons of carbon dioxide have been released into the atmosphere by human activities, according to the Global Carbon Project. North America and Europe are responsible for approximately half of that total, while the emerging economies of China and India have contributed another 14 percent. For the remainder, 150-plus countries share responsibility. An analysis of carbon dioxide emissions by country today shows that China now leads the pack, responsible for 27 percent of all emissions. Next comes the United States (15 percent), the European Union's 28 member states including the United Kingdom (10 percent), and India (7 percent) next. Together, these global powers account for almost 60 percent of all emissions.

The Consequences of the Greenhouse Effect:

Today's human-caused greenhouse gas emissions are higher than ever, the concentration of greenhouse gases in the atmosphere is rising rapidly, and according to the IPCC, the planet is heating up. Between preindustrial times and now, the earth's

average temperature has increased 1.8 degrees Fahrenheit (1.0 degrees Celsius), with approximately two-thirds of that warming occurring in the last handful of decades alone. According to the IPCC, 1983 to 2012 was likely the warmest 30-year period of the last 1,400 years (in the Northern Hemisphere, where assessment is possible). And all five of the years from 2014 to 2018 were the hottest on record globally. If warming trends continue at the current rate, it's estimated global warming will reach 2.7 degrees Fahrenheit (1.5 degrees Celsius) above preindustrial levels between 2030 and 2052. Fueled by man-made greenhouse gas emissions, global warming is altering the earth's climate systems in many ways. It is:

- Causing more frequent and/or intense extreme weather events, including heat waves, hurricanes, droughts, and floods.
- Exacerbating precipitation extremes, making wet regions wetter and dry regions drier.
- Raising sea levels due to melting glaciers and sea ice and an increase in ocean temperatures (warmer water expands, which can contribute to sea level rise).
- Altering ecosystems and natural habitat, shifting the geographic ranges, seasonal activities, migration patterns, and abundance of land, freshwater, and marine species.

These changes pose threats not only to plants and wildlife, but directly to people. Warmer temperatures mean insects that spread diseases like dengue fever and Zika can thrive—and heat waves are getting hotter and more lethal to humans. People could go hungry when our food supply is diminished thanks to droughts and floods—a 2011 National Research Council study found that for every degree Celsius that the planet heats up, crop yields will go down 5 to 15 percent. Food insecurity can lead to mass human migration and political instability. And in January 2019, the Department of Defense released a report that described the threats to U.S. military installations and operations around the world due to flooding, droughts, and other impacts of climate change.

A solar array and wind turbine at the National Wind Technology Center in Jefferson County, Colorado Dennis Schroeder/NREL

The Greenhouse Effect Solution:

The earth has always experienced warm and cool phases, with natural forces—from the sun's intensity, volcanic eruptions, and natural changes in greenhouse gas concentrations—affecting how much energy from the sun our planet absorbs. Scientists say that as recently as a couple of centuries ago, the planet underwent a "Little Ice Age," caused by a decrease in solar activity and an increase in volcanic activity. But today's climatic warming—particularly the increase in temperatures since the mid-20th century—is occurring at a pace that can't be explained by natural causes alone. According to NASA, "natural causes are still in play today, but their influence is too small or they occur too slowly to explain the rapid warming seen in recent decades." In other words, humans are the problem. But we may also be the solution. We have the ability to rein in greenhouse gas emissions, though doing so certainly won't be easy. Overhauling our energy systems will require transformative, aggressive global action—and now. According to the IPCC, we must decrease greenhouse gas pollution by 45 percent from 2010 levels by 2030 and reach net zero emissions by 2050. To allow global warming to exceed 1.5 degrees Celsius (which the IPCC has identified as the threshold for avoiding climate change's worst impacts) would mean more intense drought, extreme heat, flooding, and poverty, the decline of species (including a mass die-off of the world's coral reefs), and the worsening of food shortages and wildfires. Reducing our greenhouse gas emissions will require significant effort at the international, national, and local levels. First and foremost, we must slash fossil fuel production, consumption, and pollution by ramping up our use of clean, renewable energy and energy-efficient technologies and by investing in fuel-efficient and electric vehicles. We must end fossil fuel subsidies and better leverage "cap and invest" programs, carbon pricing, and carbon capture, storage, and utilization technologies (which catch the carbon dioxide from emissions sources like power plants or directly from the air and permanently bury it underground or convert it into other materials). We must protect our carbon-storing forests and reduce food waste and the emissions that go with it. And as individuals, we must commit to taking carbon-cutting actions in our daily lives. Currently the United States faces the additional hurdle of an administration doubling down on fossil fuel use by rolling back standards aimed at reducing emissions from dirty power plants and cars and trucks (in other words, from the electricity and transportation sectors, the nation's two largest sources of greenhouse gas emissions). President Trump is also working to withdraw the nation from

the landmark 2015 Paris climate agreement even though nearly two-thirds of Americans believe we should do more to tackle climate change, not less. Still, decision makers, companies, leaders, and activists across the country and around the world staunchly believe we must act on climate change. For just as the emissions of man-made greenhouse gases long ago are inducing the climate change, we see now, the emissions we release today will impact us long into the future.

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