ACADEMIA | Letters

Global Warming Potential: Causes and Consequences

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Abstract

This article briefly discusses the global warming potential (GWP) by shedding light on the leading causes and consequences, providing basic knowledge to non-technical readers. Human activities have been introduced as the main cause of GWP and presented in the burning of fossil fuels, deforestation and tree-clearing, and agricultural and farming activities. The main consequences of GWP, such as rising temperature, rising seawater level and heatwave risks, have been discussed briefly. Furthermore, a popular question of whether the sun is blamed for GWP has been raised and discussed in the last section. This article is believed to provide basic knowledge for non-technical readers to be aware of one of the most critical topics nowadays, like GW.

1. Introduction

Global warming potential (GWP) is the measure of different gases effect, known as Greenhouse Gases (GHGs), on heating the earth. The magnitude of GWP is measured as the amount of heat trapped by a specific gas mass relative to the amount of heat trapped by the same mass of carbon dioxide (CO2) during 20, 100 or 500 years. The CO2 was selected as a reference gas by the Intergovernmental Panel on Climate Change (IPCC) for its long lifetime, and its

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GWP was assumed to be 1. Therefore, the higher the GWP value of a specific gas, warming the earth more than the CO2 does.

Fig. 1 shows the leading gases that cause GWP, mainly are: CO2, water vapour (H2O), Methane (CH4), Nitrous oxide (N2O), Ozone (O3), Chlorofluorocarbons (CFCs) and Hydrofluorocarbons (F- gases), including both HCFCs and HFCs. GHGs play an essential role (at specific ratios) in maintaining the earth at a suitable temperature level, protecting it from harmful sun infrared radiation.

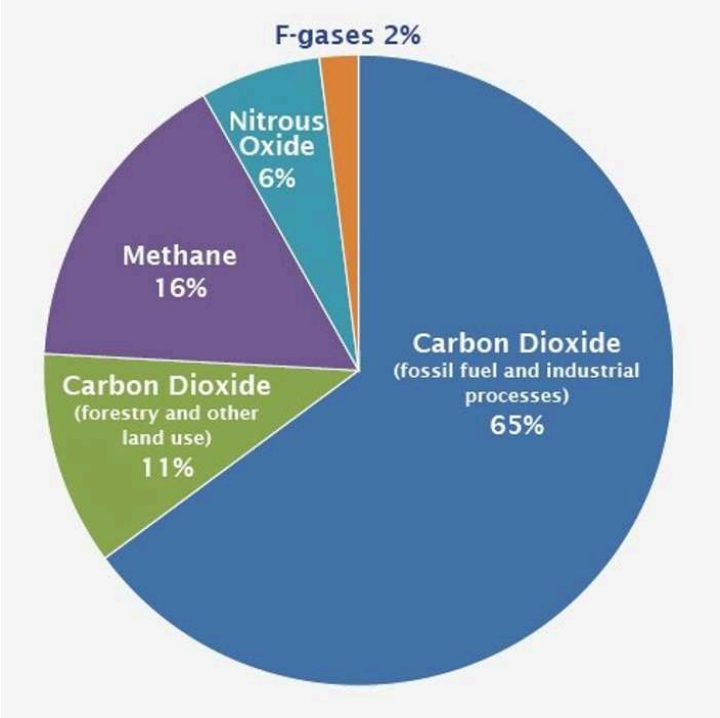

Fig. 1. Percentages of GHG emissions in the environment (IPCC, 2014)

In its fifth assessment report, IPCC reported that Methane has a lifetime of 12.4 years where its GWP equals 86 over 20 years and about 34 over 100 years, which means the GWP of Methane is decreasing by an approximate factor 2.5 (IPCC, 2014). Furthermore, F-gases (used mainly for cooling and air-conditioning processes) can destroy the stratospheric layer, shielding the earth from the harmful ultraviolet ray, causing ozone layer depletion. The latest report of IPCC provided new chances to limiting GWP to be close to 1.5°C or even 2°C by making rapid and large-scale reductions in GHG emissions. Meanwhile, the air quality improvement could be reached quickly. Further, the report also indicated that it might take

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20-80 years to reach a stable global air temperature (IPCC, 2021).

The International Energy Agency (IEA, 2016) reported the top 20 countries emitting CO2 emissions mainly from the conventional energy resources of oil, natural gas, coal, and other industrial waste and non-renewable resources, as shown in Fig. 2.

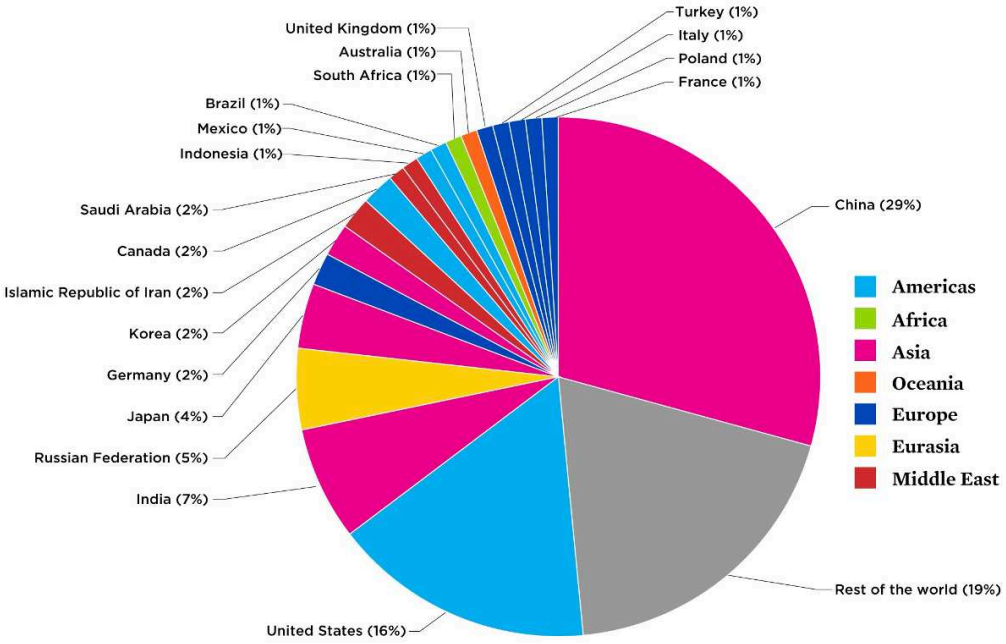

Fig. 2. Top 20 highest emitters of cumulative CO2 (IEA, 2016)

CFCs were used in the industries extensively, and their ability of stratospheric ozone depletion has noted later. Therefore, they have been banned under Montreal Protocol in 1987 and proposed to be replaced by HCFCs and hydrofluorocarbons (HFCs) in the 1980s. HCFCs were also later noted to cause ozone layer depletion and bear high global warming potential. Therefore, Kyoto Protocol 1997 has scheduled a phase-out of HCFCs by 2020–2030 and HFCs by 2025–2040.

After the end of the Kyoto Protocol's first commitment, Doha Amendment was organised in December 2012 in Qatar. In this event, Nitrogen trifluoride has been added to the list of emission gases indicated in the Kyoto protocol with other commitments for 2013-2020 (Gregor Erbach, 2015). The Doha amendment lived for a short period wherein 2015; the Paris Climate Agreement was introduced. The primary goals of the Paris agreement were

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keeping global temperature below 2 oC this century, increasing the ability to deal with climate change impacts and dealing with greenhouse gas emissions mitigation, adaptation and finance (UNFCCC, 2019).

This short discussion provides a brief understanding of GWP by shedding light on its leading causes and consequences. Moreover, whether the sun is responsible for GWP or not has been raised and discussed at the end of this paper to correct such globally misunderstood facts. This article also leaves a hidden curious question, directing the reader to seek the necessary acts and solutions to minimise the GWP.

2. Causes of GWP and climate change

The leading causes of GWP are related to human activities. IPCC stated that about 95% of human activities had warmed the planet during the past 50 years (IPCC, 2014). These activities are mainly associated with burning fossil fuels, deforestation and tree-clearing, and agricultural and farming activities.

2.1. Burning of fossil fuels

The burn of fossil fuels, such as coal, oil, gas, etc., for generating electricity, powering transportations and operating different energy sectors is the leading cause of GWP due to the release of GHGs (CO2 in particular) with high ratios. In this regard, Fig. 3 shows the Keeling curve that shows the daily CO2 emissions maintained by Scripps institution of oceanography at UC San Diego.

More effort has been made to decrease the reliance on fossil fuels and seek environmentally friendly alternatives with no GHGs emissions in the last few years. Renewable energy sources, such as solar, wind, biomass, etc., have been a good alternative showed outstanding performance in many energy sectors. However, nuclear power generation has also been introduced as an essential energy source to minimise GHGs. Despite the essential role of renewable technologies, they are still not fast-growing and cannot overcome worldwide economic expansion and population growth. According to IEA, today's world still heavily uses fossil fuels, and they will remain that way for a long time, as indicated in Fig. 4 (IEA, 2019). Moreover, the IEA stated that renewables would provide 50% of energy demand by 2040, led by solar energy technologies.

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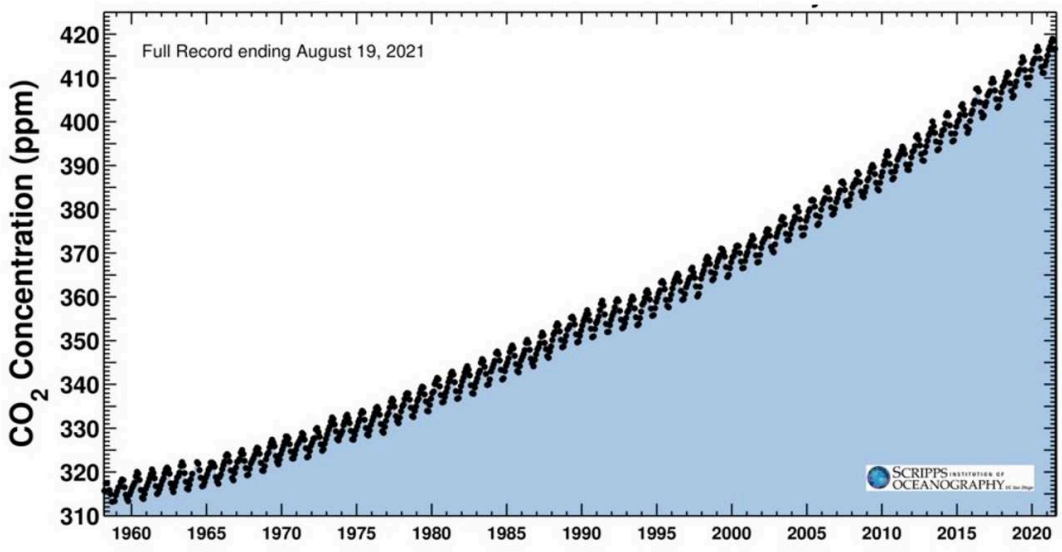

Fig. 3. CO2 concentrations from 1960 up to date (Keeling curve) (UC San Diego, 2021)

2.2. Deforestation and tree-clearing

It is well known that forests and trees absorb CO2 from the air, store the carbon (C) and release the Oxygen (O2) during the photosynthesis process, which plays a significant role to balance the climate. Deforestation and other clearing activities against the trees represent a serious contributor to the increase of GHGs by releasing the C as a CO2 back to the air, increasing the GWP eventually. According to the Food and Agriculture Organization of the United Nations (FAO, 2006), deforestation releases between 25–30% of GHGs annually, which increase the GWP accordingly.

2.3. Agriculture and farming

The agricultural sector is responsible for about 20-30% of emitted GHGs to the air (Vermeulen SJ et al., 2012) and the most contributor of N2O (59%), which has the destruction ability to the stratospheric ozone layer and other health issues (Ciais P et al., 2013). Agricultural fertilisers are the primary source of N2O emissions that are increase by 50% from 2000 to 2050 (Alexandratos and Bruinsma, 2012). Methane, CH4, from the other side is produced from livestock (cows, sheep, and cattle) and rice production. Livestock is responsible for 12% of CH4 emissions and contributes significantly to GWP (Petr Havlík et al., 2014) through digesting their food by enteric fermentation. On the other hand, Rice paddy fields release the

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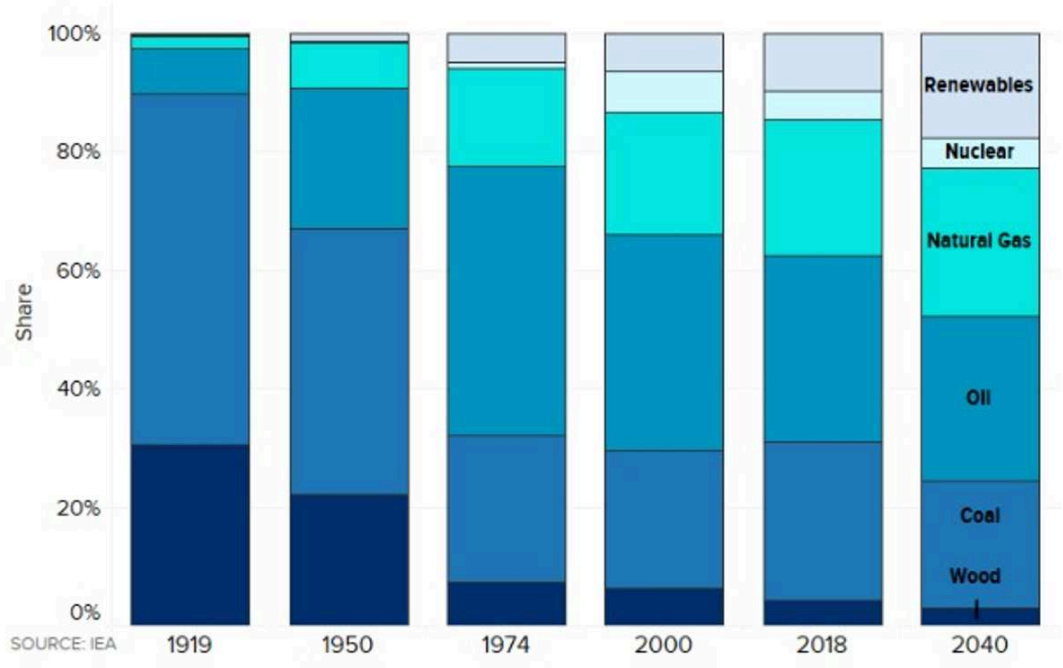

Fig. 4. Global energy dependency from 1919 to 2040 (IEA, 2019)

CH4 gas emissions in permanently flooded fields with a high ratio and contribute to the GWP (Lagomarsino A. et al., 2016).

Many other human activities cause the GWP, such as methane contributions from landfills, natural gas, different petroleum industries, the refrigerants used for refrigeration and industrial processes, etc.

3. Consequences of GWP

GWP became an urgent issue in today's life, and many impacts have appeared which danger humanity. Some of these consequences are:

3.1. Rising temperature

The increase of CO2 emissions in the air creates a blanket surrounding the earth and prevents the heat from escape. The weather became hotter than before, and IPCC, in its fifth report, stated that "*each of the last three decades has been successively warmer at the Earth's surface*

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than any preceding decade since 1850" (IPCC, 2014). Scientists and measured data also show that, globally, the last decade was the warmest ever and 2016 was the hottest than 2015 by more than 1 oC (UOCS, 2016).

3.2. Rising seawater level

Globally, it became the fact that the sea water level has risen than before due to GWP. Raising seawater levels occurs due to the melting of ice sheets glaciers and the expansion of seawater due to warming (as indicated in Fig. 5). Moreover, melted ice sheets reduce albedo (reflection of sun rays) when ice sheets disappear, which contributes significantly to GWP.

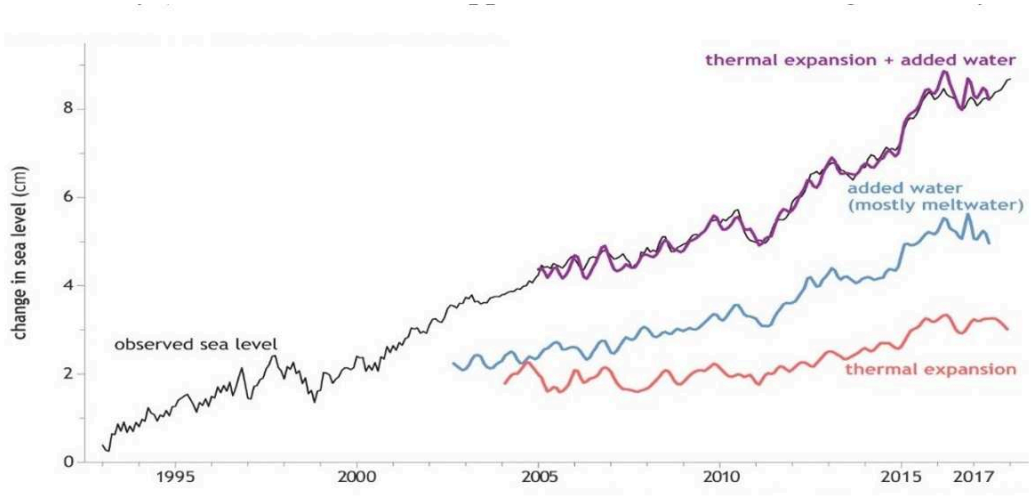

Fig. 5. Global sea-level change from 1993 to 2017 (Thompson P.R. et al., 2018)

The American Meteorological Society (AMS) report, state of the climate in 2017, stated that the sea level rose by about 77 millimetres in 2017 compared to 1993, which is a consequence of GWP (Thompson P.R. et al., 2018).

3.3. Risks of heatwaves

The consequence of heatwaves can be represented into two impacts; wildfires and health issues.

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3.3.1. *Wildfires*

GWP increase the possibility of wildfires due to heatwaves as the high temperature dries the groundwater and green vegetation, which acts as a fuel that accelerates the combustion (Rossiello M. R. and Anthony Szema, 2019).

3.3.2. *Health issues*

The heatwaves caused by GWP increase the mortality rate and hospitalisation, especially in the areas with the typical cold climate where the people are not adapted to the intense heat. Rossati reviewed the health impacts of GWP and reported that the mortality rate has increased when the temperature is above and below optimum values (Antonella Rossati, 2017). The study indicated that the heat waves in Europe during August 2003 resulted in 14800 deaths. Moreover, people with chronic conditions like hypertension, heart disease and diabetes were highly influenced by the heat waves and risk of complications.

4. Does the sun blamed for GWP?

Many people consider that the earth is wormed as heat from the sun, the primary energy source, contributes to GWP. Several studies showed an opposite trend revealing that if the GWP occurred due to solar radiation, the temperature increment should appear in all atmosphere layers. Instead, the scientists noticed that the upper atmosphere layers are colder than the lower ones, influenced by the trapped heat by GHGs. Moreover, satellite tools used to measure the energy output from the sun indicated that the solar radiation had dropped slightly since 1978, which means that the earth does not receive high energy from the sun to be warmed (as illustrated in Fig. 6). Therefore, it can be concluded that the sun is irresponsible for the GWP (NASA, 2019).

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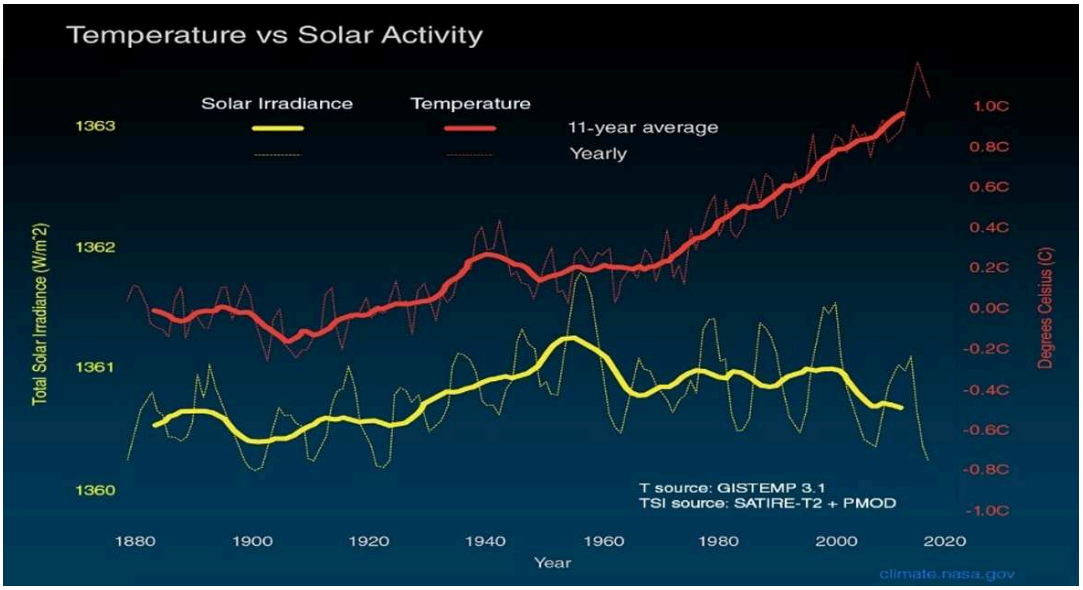

Fig. 6. Global surface temperature versus sun's energy on earth (NASA, 2019)

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