Global Warming, Climate Change, Energy and Mitigation

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Introduction

Global Warming

Global warming is the long-term warming of the Earth's surface observed since the pre-industrial era (between 1850 and 1900) due to human activities, primarily the burning of fossil fuels, increase the levels of greenhouse gases (GHGs) in the Earth's atmosphere that trap heat. Burning of fossil fuels for energy electricity, heat, industry, and transport; Deforestation; excessive use of chemical fertilizers; and industrial animal products all increase the concentration of greenhouse gases in the atmosphere.

Greenhouse gas concentrations in the atmosphere fluctuated slightly over millions of years before the industrial revolution. When humans began extracting and burning fossil fuels on a large scale, problems arose in releasing unprecedented amounts of CO_2 into the atmosphere. CO_2 concentrations have increased by about 50 percent since the industrial revolution. CO_2 is produced as a by-product from combustion processes that provide the major share of the energy production, driving our technical development and economic growth. "The energy sector is the source of around three-quarters of harmful global greenhouse gas emissions (WMO)". Data available at "Our World in Data" also proven that energy sector contributes nearly 75% from the total GHG emission. Following are the Global GHG emission by different sectors.

- Energy (electricity, heat and transport): 73.2%
- Direct Industrial Processes: 5.2%
- Waste: 3.2%
- Agriculture, Forestry and Land Use: 18.4%

Working Group III of Intergovernmental Panel on Climate Change (AR6) (IPCC AR6 WGIII), stated that, global net anthropogenic GHG emissions were 59 ± 6.6 GtCO2-eq in 2019, about 12% (6.5 $GtCO_2$-eq) higher than in 2010 and 54% (21 $GtCO_2$-eq) higher than in 1990. The annual average during the decade 2010–2019 was 56 ± 6.0 $GtCO_2$-eq, 9.1 $GtCO_2$-eq yr^{-1} higher than in 2000–2009. This is the highest increase in average decadal emissions on record. The average annual rate of growth slowed from 2.1% yr^{-1} between 2000 and 2009 to 1.3% yr^{-1} between 2010 and 2019 (high confidence).

IPCC AR6 WGIII, report also expressed that, in 2019, approximately 34% (20 $GtCO_2$-eq) of total net anthropogenic GHG emissions came from the energy supply sector, 24% (14 $GtCO_2$-eq) from industry, 22% (13 $GtCO_2$-eq) from agriculture, forestry and other land use (AFOLU), 15% (8.7 $GtCO_2$-eq) from transport and 6% (3.3 $GtCO_2$-eq) from buildings. If emissions from electricity and heat production are attributed to the sectors that use the final energy, 90% of these indirect emissions are allocated to the industry and buildings sectors, increasing their relative GHG emissions shares from 24% to 34%, and from 6% to 16%, respectively. After reallocating emissions from electricity and heat production, the energy supply sector accounts for 12% of global net anthropogenic GHG emissions (high confidence).

Emission of GHG and Global Warming

The greenhouse effect is a process that occurs when gases in Earth's atmosphere trap the Sun's heat by Greenhouse Gases. This process makes earth much warmer than it would be and it is called global warming.

Since the pre-industrial period, human activities are estimated to have increased Earth's global average temperature and according to Fifth Assessment Report on Inter Governmental Panel on Climate Change (IPCC AR5), the global temperature has increased by 0.850 (0.650-1.060) C for the period 1850-2012. Recent report, AR6 of IPCC indicated that each of the last four decades has been successively warmer than any decade that preceded it since 1850. IPCC AR6 pointed out that, global surface temperature in the first two decades of the 21st century (2001-2020) was 0.99 [0.84- 1.10] °C higher than 1850-1900. Global surface temperature was 1.09 [0.95 to 1.20] °C higher in 2011– 2020 than

1850–1900, with larger increases over land (1.59 [1.34 to 1.83] °C) than over the ocean (0.88 [0.68 to 1.01] °C). The current warming trend is unequivocally the result of human activity since the 1950s and is proceeding at an unprecedented rate over millennia (IPCC AR5).

Global Warming and Climate Change

Climate change is a long-term change in the average weather patterns that have come to define Earth's local, regional and global climates. These changes have a broad range of observed effects that are synonymous with the term. The terms "global warming" and "climate change" are sometimes used interchangeably, but "global warming" is only one aspect of climate change (NASA).

Warming Trend in Sri Lanka

Recent climate analysis in Sri Lanka indicates an increasing trend in both maximum and minimum temperature with higher increasing trend in minimum temperature leading to decreasing trend in Diurnal Temperature Change (DTR) (Shiromani *et.al.*, 2018). Temperature increase in Sri Lanka is almost similar to the global trend and the increasing trend is nearly 1.00 C for the last hundred years. With the increase of temperature, extreme climatic conditions (extreme weather includes unexpected, unusual, unpredictable severe or unseasonal weather; weather at the extremes of the historical distribution—the range that has been seen in the past) related to temperature and rainfall with high seasonal variability have been established in Sri Lanka.

Observed Rainfall trends in Sri Lanka

Previous studies indicated that no clear pattern or trend was observed in long term rainfall. Some studies identified that average rainfall is showing a decreasing trend while Nissanka *et.al.* 2011, observed that annual rainfall trend for the period 1961-2010 did not indicate significant trend. Analyzing fluctuations in rainfall associated with the four climatic seasons using rainfall data for nearly 130 years (1870-2000) 15 rainfall stations, Malmgren et al in2003 identified that decrease of rainfall in higher elevation areas and increase of rainfall in lowlands in the southwestern sector of Sri Lanka during southwest monsoon season. According to Shiromani *et.al*, 2018, the annual total precipitation has indicated a significant increasing trend during 1980-2015 and 65% of stations show significant increasing trend in annual total rainfall for the period 1980 to 2015.

It is clear that long-term rainfall trends show different patterns for different periods. It indicates the variability of rainfall rather than negative or positive trend. Recent analysis of rainfall variability pointed out that, it has increased, and the variability is high in the dry zone (Premalal, 2010). The high variability of rainfall explains the improper rainfall pattern and also more floods and more droughts.

A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of weather and climate extremes, and can result in unprecedented extremes increasing exposure of people and economic assets has been the major cause of long-term increases in economic losses from climate related disasters (IPCC SREX 2012).

Mitigation of Climate Change

The world will not be able cope with climate change without a global energy transition. The burning of fossil fuels for power generation is the single most important cause for global warming and climate change. At the same time, however, energy is the key foundation for economic and social development. A sustainable and needs-based energy supply for all must therefore be climate-neutral.

Reduction of emission of GHG is one of the important part to minimize the global warming. These emissions must be reduced dramatically, which can only be achieved by phasing out of fossil fuels. At the same time, developing and emerging countries need more and more energy. Primary energy demand worldwide could grow by one third by 2040. The energy sector is facing two challenges that have to be resolved by the middle of this century.

The United Nations Framework Convention on Climate Change (UNFCCC) was established at the United Nations Convention on Environment and Development with the purpose of uniting countries within the UN

to combat climate change via reduction in greenhouse gas emissions. The signatories of the UNFCCC meet annually at the Conference of the Parties (COP) to confer on further reductions of emissions and increase environmental protection. Through the UNFCCC there have been two agreements signed by nations in the UN to formally declare emission reduction goals. These are the Kyoto Protocol (1997) and the Paris Agreement (2015) (Care About Climate).

Kyoto Protocol	Paris Agreement
Created in 1997 and ratified in 2005. Had two periods from 1997-2020	Signed in November of 2016. New commitments are due every 5 years
Legally binding agreement to decrease GHG	Not legally binding commitment to reduce emissions, increase accountability
Original commitment to decrease overall emissions by 5% from 1990 levels	Overall goal to limit global temperatures to 1.5 degrees Celsius above pre-industrial levels
Only required developed nations to reduce emissions	Asked all nations to reduce emmissions
Targets are set but no determined time frame	New set of targets declared after 5 years

The Paris Agreement includes commitments from all countries to reduce their emissions and work together to adapt to the impacts of climate change and calls on countries to strengthen their commitments over time. The Agreement provides a pathway for developed nations to assist developing nations in their climate mitigation and adaptation efforts while creating a framework for the transparent monitoring and reporting of countries' climate goals.

The Paris Agreement provides a durable framework guiding the global effort for decades to come. It marks the beginning of a shift towards a net-zero emissions world. Implementation of the Agreement is also essential for the achievement of the Sustainable Development Goals.

How does it work?

The Paris Agreement works on a five- year cycle of increasingly ambitious climate action carried out by countries. Every five years, each country is expected to submit an updated national climate action plan - known as Nationally Determined Contribution, or NDC.

In their NDCs, countries communicate actions they will take to reduce their greenhouse gas emissions in order to reach the goals of the Paris Agreement. Countries also communicate in the NDCs actions they will take to build resilience to adapt to the impacts of rising temperatures.

To better frame the efforts towards the long-term goal, the Paris Agreement invites countries to formulate and submit long-term strategies. Unlike NDCs, they are not mandatory.

The operational details for the practical implementation of the Paris Agreement were agreed on at the UN Climate Change Conference (COP24) in Katowice, Poland, in December 2018, in what is colloquially called the Paris Rulebook, and finalized at COP26 in Glasgow, Scotland, in November 2021.

How Sri Lanka Contributes to mitigate GHG emission?

Sri Lanka is a low carbon emitting country with per capita emissions of around 1.02 tons/per person, and its development pathway has remained low-carbon-intensive. A recent analysis of the interplay between per capita emissions and human development, picks out Sri Lanka as a rare example of a country that has achieved both high human development and managed to keep CO_2 emissions well below the long-term average needed to contain global warming targets of the Paris Agreement.

Despite the low carbon footprint and high vulnerability to climate change, Sri Lanka commits to reducing its GHG emissions. In these NDCs, the country presents an enhanced ambition which include 4% unconditional and 10.5% conditional emission reduction commitments with respective to Business-As-Usual (BAU) scenario. This document is organized sector-wise detailing Sri Lanka's climate change mitigation commitments and adaptation needs, loss and damage, and means of implementation. It sets out the process

and institutional architecture for implementation; and discusses the critical need for external support with financial, technology transfer and capacity development provision to fully realize these commitments. With such timely support, Sri Lanka is positioned to demonstrate a development pathway that successfully de-couples human development and economic prosperity from carbon-intensive consumption and production.

Despite this low carbon footprint and highly vulnerable status, Sri Lanka commits to increase 32% forest cover by 2030 and reduce greenhouse emissions by 14.5% for the period of 2021-2030 from Power (electricity generation), Transport, Industry, Waste, Forestry, and Agriculture in order to realize this ambitious target, Sri Lanka further commits;

- To achieve 70% renewable energy in electricity generation by 2030
- To achieve Carbon Neutrality by 2050 in electricity generation
- No capacity addition of Coal power plants Sri Lanka has already launched following major initiatives.
- Adopting 'Colombo Declaration on Sustainable Nitrogen Management' with an ambition to halve nitrogen waste by 2030
- Banning agro-chemicals and chemical fertilizer
- Promoting organic fertilizer and farming
- Banning single-use plastics
- Promoting E-mobility
- Promoting circular economy
- Sri Lanka expects to achieve its Carbon Neutrality by 2060

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Our World in Data

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IPCC AR6, 2022, Intergovernmental Panel on Climate Change

IPCC SREX 2012

NASA

Updated Nationally Determined Contribution, 2021, Ministry of Environment

WMO

Related URLs

https://www.careaboutclimate.org/blog/paris-agreement-vs-kyoto-protocol-comparison-chart

https://www.un.org/en/climatechange/paris-agreement

Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change

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Can Nuclear Power be Adopted to Sri Lanka as a Solution to the Energy Crisis?

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In the light of recent events, Sri Lanka has turned its focus on alternative electricity sources as the existing power sources such as hydro, fossil fuel and biomass systems have proved insufficient to accommodate the increasing electricity demand in the country. Hence, Sri Lanka may consider adopting nuclear power as an effective solution for the future power crisis.

Nuclear power generates electricity using nuclear fuel as the power generation source. Even though nuclear power generates electricity in a similar mechanism to thermal power, it does not involve any fuel burning.

Fission reactions

Fissionable uranium, that is ^{235}U isotope, which is the most popular nuclear fuel, can produce very high thermal energy when it undergoes fission reactions with neutrons in a nuclear reactor. In fission reactions, ^{235}U splits into two smaller elements and neutrons as given in the following few examples.

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}Ba + {}^{92}Kr + 3\,{}^{1}_{0}n$$

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{137}Cs + {}^{92}Rb + 3\,{}^{1}_{0}n$$

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{1461}La + {}^{87}Br + 3\,{}^{1}_{0}n$$

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{144}Xe + {}^{90}Sr + 2\,{}^{1}_{0}n$$

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{137}Te + {}^{97}Zr + 2\,{}^{1}_{0}n$$

As given in the above examples of fission reactions, neutrons continuously get regenerated from the fission reactions itself and therefore only the initial neutron supply is sufficient to maintain fission reactions in a nuclear fuel reactor. Each fission reaction heat is generated as a biproduct. With millions of such reactions can undergo in a nuclear reactor that would lead to generate massive heat energy.

The heat generated from these fission reactions is transferred to the reactor fluid inside the reactor. This absorbed heat by the reactor fluid is then converted to steam that drives to operate the steam turbines, like any other thermal power station.

Fusion reaction

Alternative to fission reactions nuclear energy can be produced using fusion reactions. However, fusion reactions are still under experimental state. In fusion reactions two or more smaller mass elements fused together produces larger element.

$$^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$$

Unlike fission reactions, fusion reactions produce no radioactive by products. However, fusion reaction to initiate need the particles to be energized to overcome the Coulombic barrier. This occurs only when the reactants are in plasma state at very high temperature as 15 000 000 K. Naturally fusion reactions occur in stars under such high temperature. Even though this sounds quite unrealistic to have such vigorous reaction under laboratory conditions, scientists are successfully experimenting on nuclear fusion. One good example was the recent breakthrough showcased from US National Ignition Facility in California demonstrating fusion reactions exceeding high powered lasers under laboratory conditions.