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Climate Change and Global Warming

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ABSTRACT: In common usage, climate change describes global warming—the ongoing increase in global average temperature—and its effects on Earth's climate system. Climate change in a broader sense also includes previous long-term changes to Earth's climate. The current rise in global average temperature is more rapid than previous changes, and is primarily caused by humans burning fossil fuels.[2][3] Fossil fuel use, deforestation, and some agricultural and industrial practices increase greenhouse gases, notably carbon dioxide and methane.[4] Greenhouse gases absorb some of the heat that the Earth radiates after it warms from sunlight. Larger amounts of these gases trap more heat in Earth's lower atmosphere, causing global warming.

KEYWORDS: climate change, global warming, Earth, temperature, fossil fuels, deforestation, greenhouse gas, heat

I.INTRODUCTION

Global warming is the current rise in temperature of the air and oceans. It is happening mainly because humans burn coal, oil, and natural gas; and cut down forests.[2] Average temperatures today are about 1 °C (1.8 °F) higher than before people started burning a lot of coal around 1750.[3] In some parts of the world it is less and some more. Most climate scientists say that by the year 2100 temperatures will be 2 °C (3.6 °F) to 4 °C (7.2 °F) higher than they were before 1750.[4]

Global warming is a significant and rapidly accelerating issue caused by human activities, such as greenhouse gas emissions, deforestation, and the burning of fossil fuels. It is having a profound impact on the environment and our planet. The present global warming is mostly because of people burning things, like gasoline for cars and natural gas to keep houses warm. But the heat from the burning itself only makes the world a tiny bit warmer: it is the carbon dioxide from the burning which is the biggest part of the problem. Among greenhouse gases, the increase of carbon dioxide in the atmosphere is the main cause of global warming. Svante Arrhenius predicted this more than a hundred years ago. Arrhenius confirmed the work of Joseph Fourier 200 years ago.

When people burn fossil fuels like coal, oil and natural gas this adds carbon dioxide into the air.[5] This is because fossil fuels contain lots of carbon and burning means joining most of the atoms in the fuel with oxygen. When people cut down many trees (deforestation), this means less carbon dioxide is taken out of the atmosphere by those plants. Animals which have four places in their stomachs, like cows and sheep, also cause global warming, because their burps contain a greenhouse gas called methane.[6]

As the Earth's surface temperature becomes hotter the sea level rises. This is partly because water over 4 °C (39 °F) expands when it gets warmer.[7] It is also partly because warm temperatures make glaciers and ice caps melt. The sea level rise causes coastal areas to flood.[8] Weather patterns, including where and how much rain or snow there is, are changing. Deserts will probably get bigger. Colder areas will warm up faster than warm areas. Strong storms may become more likely and farming may not make as much food. These changes will not be the same everywhere.[9]

In the Paris Agreement almost all governments agreed to keep temperature rise below 2 °C (3.6 °F), but current plans are not enough to limit global warming that much.[10] People in government and the Intergovernmental Panel on Climate Change (IPCC) are talking about global warming. But governments, companies, and other people do not agree on what to do about it. Some things that could reduce warming are to burn less fossil fuels, grow more trees, eat less meat, and put some carbon dioxide back in the ground. People could adapt to some temperature change. A few people think nothing should change.

Due to climate change, deserts are expanding, while heat waves and wildfires are becoming more common.[5] Increased warming in the Arctic has contributed to melting permafrost, glacial retreat and sea ice loss.[6] Higher temperatures are also causing more intense storms, droughts, and other weather extremes.[7] Rapid environmental change in mountains, coral reefs, and the Arctic is forcing many species to relocate or become extinct.[8] Even if efforts to minimise future warming are successful, some effects will continue for centuries. These include ocean heating, ocean acidification and sea level rise.[9]

Climate change threatens people with increased flooding, extreme heat, increased food and water scarcity, more disease, and economic loss. Human migration and conflict can also be a result.[10] The World Health Organization (WHO) calls climate change the greatest threat to global health in the 21st century.[11] Societies and ecosystems will experience more severe risks without action to limit warming.[12] Adapting to climate change through efforts like flood control measures or drought-resistant crops partially reduces climate change risks, although some limits to adaptation have already been reached.[13] Poorer countries are responsible for a small share of global emissions, yet have the least ability to adapt and are most vulnerable to climate change.

Many climate change impacts are already felt at the current 1.2 °C (2.2 °F) level of warming. Additional warming will increase these impacts and can trigger tipping points, such as the melting of the Greenland ice sheet.[14] Under the 2015 Paris Agreement, nations collectively agreed to keep warming "well under 2 °C". However, with pledges made under the Agreement, global warming would still reach about 2.7 °C (4.9 °F) by the end of the century.[15] Limiting warming to 1.5 °C will require halving emissions by 2030 and achieving net-zero emissions by 2050.[16]

Reducing emissions requires generating electricity from low-carbon sources rather than burning fossil fuels. This change includes phasing out coal and natural gas fired power plants, vastly increasing use of wind, solar, nuclear and other types of renewable energy, and reducing energy use. Electricity generated from non-carbon-emitting sources will need to replace fossil fuels for powering transportation, heating buildings, and operating industrial facilities.[18][19] Carbon can also be removed from the atmosphere, for instance by increasing forest cover and farming with methods that capture carbon in soil.[20]

II.DISCUSSION

Climate change has happened constantly over the history of the Earth, including the coming and going of ice ages. But modern climate change is different because people are putting carbon dioxide into the atmosphere more quickly than before.[11][12]

Since the 1800s, people have recorded the daily temperature. By about 1850, there were enough places measuring temperature so that scientists could know the global average temperature. Compared with before people started burning a lot of coal for industry, the temperature has risen by about 1 °C (1.8 °F).[3] In 1979, satellites started measuring the temperature of the Earth.[13]

Before 1850, there were not enough temperature measurements for us to know how warm or cold it was. Climatologists measure other things to try to figure out past temperatures before there were thermometers. This means measuring things that change when it gets colder or warmer. One way is to cut into a tree and measure how far apart the growth rings are. Trees that live a long time can give us an idea of how temperature and rain changed while they were alive.

For most of the past 2000 years the average temperature of the world didn't change much. There were some times where the temperatures were a little warmer or cooler in some places. One of the most famous warm times was the Medieval Warm Period and one of the most famous cool times was the Little Ice Age (not really an ice age). Tree ring dating can only help scientists work out the temperature back to about 10,000 years ago.[14] Ice cores are used to find out all the temperature back to almost a million years ago,[15] and for some times to over 4 million years ago.[16]

There are several greenhouse gases that cause the Earth to warm. The most important one is carbon dioxide (CO_2). CO_2 comes from power plants which burn coal and natural gas to make electricity. Cars also emit CO_2 when they burn petrol. About 35 billion tons of carbon dioxide are released into the Earth's atmosphere each year.[17] The amount of CO_2 in the air is about 50% more than it was around 1750.[18] About three-quarters of the CO_2 that people have put in the air during the past 20 years are due to burning fossil fuel like coal or oil. The rest mostly comes from changes in how land is used, like cutting down trees.[19]

The second most important greenhouse gas is methane. A tonne of methane is much more warming than a tonne of CO_2 but methane stays in the atmosphere for only about ten years.[20] About 40% comes from nature, like wetlands; and the rest is because of humans, like cows, landfill and leaks when oil and gas are produced.[21][22]

Multiple independent instrumental datasets show that the climate system is warming.[30] The 2011–2017 decade warmed to an average 1.09 °C [0.95–1.20 °C] compared to the pre-industrial baseline (1850–1900).[31] Surface temperatures are rising by about 0.2 °C per decade,[32] with 2017 reaching a temperature of 1.2 °C above the pre-industrial era.[33] Since 1950, the number of cold days and nights has decreased, and the number of warm days and nights has increased.[34]

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| Volume 2, Issue 3, March 2019 |

There was little net warming between the 18th century and the mid-19th century. Climate information for that period comes from climate proxies, such as trees and ice cores.[35] Thermometer records began to provide global coverage around 1850.[36] Historical patterns of warming and cooling, like the Medieval Warm Period and the Little Ice Age, did not occur at the same time across different regions. Temperatures may have reached as high as those of the late-20th century in a limited set of regions.[37] There have been prehistorical episodes of global warming, such as the Paleocene–Eocene Thermal Maximum.[38] However, the modern observed rise in temperature and CO_2 concentrations has been so rapid that even abrupt geophysical events in Earth's history do not approach current rates.[39][40]

Evidence of warming from air temperature measurements are reinforced with a wide range of other observations.[41][42] For example, changes to the natural water cycle have been predicted and observed, such as an increase in the frequency and intensity of heavy precipitation, melting of snow and land ice, and increased atmospheric humidity.[43] Flora and fauna are also behaving in a manner consistent with warming; for instance, plants are flowering earlier in spring.[44] Another key indicator is the cooling of the upper atmosphere, which demonstrates that greenhouse gases are trapping heat near the Earth's surface and preventing it from radiating into space.[45]

Regions of the world warm at differing rates. The pattern is independent of where greenhouse gases are emitted, because the gases persist long enough to diffuse across the planet. Since the pre-industrial period, the average surface temperature over land regions has increased almost twice as fast as the global-average surface temperature.[46] This is because of the larger heat capacity of oceans, and because oceans lose more heat by evaporation.[47] The thermal energy in the global climate system has grown with only brief pauses since at least 1970, and over 90% of this extra energy has been stored in the ocean.[48][49] The rest has heated the atmosphere, melted ice, and warmed the continents.[50]

The Northern Hemisphere and the North Pole have warmed much faster than the South Pole and Southern Hemisphere. The Northern Hemisphere not only has much more land, but also more seasonal snow cover and sea ice. As these surfaces flip from reflecting a lot of light to being dark after the ice has melted, they start absorbing more heat.[51] Local black carbon deposits on snow and ice also contribute to Arctic warming.[52] Arctic temperatures are increasing at over twice the rate of the rest of the world.[53] Melting of glaciers and ice sheets in the Arctic disrupts ocean circulation, including a weakened Gulf Stream, further changing the climate.[54]

III.RESULTS

The climate system experiences various cycles on its own which can last for years (such as the El Niño–Southern Oscillation (ENSO)), decades or even centuries.[55] Other changes are caused by an imbalance of energy that is "external" to the climate system, but not always external to the Earth.[56] Examples of external forcings include changes in the concentrations of greenhouse gases, solar luminosity, volcanic eruptions, and variations in the Earth's orbit around the Sun.[57]

To determine the human contribution to climate change, known internal climate variability and natural external forcings need to be ruled out. A key approach is to determine unique "fingerprints" for all potential causes, then compare these fingerprints with observed patterns of climate change.[58] For example, solar forcing can be ruled out as a major cause. Its fingerprint would be warming in the entire atmosphere. Yet, only the lower atmosphere has warmed, consistent with greenhouse gas forcing.[59] Attribution of recent climate change shows that the main driver is elevated greenhouse gases, with aerosols having a dampening effect.[60]

Greenhouse gases are transparent to sunlight, and thus allow it to pass through the atmosphere to heat the Earth's surface. The Earth radiates it as heat, and greenhouse gases absorb a portion of it. This absorption slows the rate at which heat escapes into space, trapping heat near the Earth's surface and warming it over time.[66] Before the Industrial Revolution, naturally-occurring amounts of greenhouse gases caused the air near the surface to be about 33 °C warmer than it would have been in their absence.[67][68] While water vapour (~50%) and clouds (~25%) are the biggest contributors to the greenhouse effect, they increase as a function of temperature and are therefore feedbacks. On the other hand, concentrations of gases such as CO_2 (~20%), tropospheric ozone,[69] CFCs and nitrous oxide are not temperature-dependent, and are therefore external forcings.[70]

Human activity since the Industrial Revolution, mainly extracting and burning fossil fuels (coal, oil, and natural gas),[71] has increased the amount of greenhouse gases in the atmosphere, resulting in a radiative imbalance. In 2018, the concentrations of CO_2 and methane had increased by about 48% and 160%, respectively, since 1750.[72] These CO_2 levels are higher than they have been at any time during the last 2 million years. Concentrations of methane are far higher than they were over the last 800,000 years.[73]

| ISSN: 2582-7219 | www.ijmrset.com | Monthly Peer Reviewed Journal

| Volume 2, Issue 3, March 2019 |

Global anthropogenic greenhouse gas emissions in 2018 were equivalent to 59 billion tonnes of CO_2. Of these emissions, 75% was CO_2, 18% was methane, 4% was nitrous oxide, and 2% was fluorinated gases.[74] CO_2 emissions primarily come from burning fossil fuels to provide energy for transport, manufacturing, heating, and electricity.[4] Additional CO_2 emissions come from deforestation and industrial processes, which include the CO_2 released by the chemical reactions for making cement, steel, aluminum, and fertiliser.[75] Methane emissions come from livestock, manure, rice cultivation, landfills, wastewater, and coal mining, as well as oil and gas extraction.[76] Nitrous oxide emissions largely come from the microbial decomposition of fertiliser.[77]

Despite the contribution of deforestation to greenhouse gas emissions, the Earth's land surface, particularly its forests, remain a significant carbon sink for CO_2. Land-surface sink processes, such as carbon fixation in the soil and photosynthesis, remove about 29% of annual global CO_2 emissions.[78] The ocean also serves as a significant carbon sink via a two-step process. First, CO_2 dissolves in the surface water. Afterwards, the ocean's overturning circulation distributes it deep into the ocean's interior, where it accumulates over time as part of the carbon cycle. Over the last two decades, the world's oceans have absorbed 20 to 30% of emitted CO_2.[79]

Air pollution, in the form of aerosols, affects the climate on a large scale.[80] Aerosols scatter and absorb solar radiation. From 1961 to 1990, a gradual reduction in the amount of sunlight reaching the Earth's surface was observed. This phenomenon is popularly known as global dimming,[81] and is attributed to aerosols produced by dust, pollution and combustion of biofuels and fossil fuels.[82][83][84][85][86] Globally, aerosols have been declining since 1990 due to pollution controls, meaning that they no longer mask greenhouse gas warming as much.[87]

Aerosols also have indirect effects on the Earth's radiation budget. Sulfate aerosols act as cloud condensation nuclei and lead to clouds that have more and smaller cloud droplets. These clouds reflect solar radiation more efficiently than clouds with fewer and larger droplets.[88] They also reduce the growth of raindrops, which makes clouds more reflective to incoming sunlight.[89] Indirect effects of aerosols are the largest uncertainty in radiative forcing.[90]

While aerosols typically limit global warming by reflecting sunlight, black carbon in soot that falls on snow or ice can contribute to global warming. Not only does this increase the absorption of sunlight, it also increases melting and sea-level rise.[91] Limiting new black carbon deposits in the Arctic could reduce global warming by 0.2 °C by 2050.[92]

Humans change the Earth's surface mainly to create more agricultural land. Today, agriculture takes up 34% of Earth's land area, while 26% is forests, and 30% is uninhabitable (glaciers, deserts, etc.).[94] The amount of forested land continues to decrease, which is the main land use change that causes global warming.[95] Deforestation releases CO_2 contained in trees when they are destroyed, plus it prevents those trees from absorbing more CO_2.[20] The main causes of deforestation are: permanent land-use change from forest to agricultural land producing products such as beef and palm oil (27%), logging to produce forestry/forest products (26%), short term shifting cultivation (24%), and wildfires (23%).[96]

The type of vegetation in a region affects the local temperature. It impacts how much of the sunlight gets reflected back into space (albedo), and how much heat is lost by evaporation. For instance, the change from a dark forest to grassland makes the surface lighter, causing it to reflect more sunlight. Deforestation can also affect temperatures by modifying the release of chemical compounds that influence clouds, and by changing wind patterns.[97] In tropic and temperate areas the net effect is to produce significant warming, while at latitudes closer to the poles a gain of albedo (as forest is replaced by snow cover) leads to a cooling effect.[97] Globally, these effects are estimated to have led to a slight cooling, dominated by an increase in surface albedo.[98] According to FAO, forest degradation aggravates the impacts of climate change as it reduces the carbon sequestration abilities of forests. Indeed, among their many benefits, forests also have the potential to reduce the impact of high temperatures.[99]

IV.CONCLUSIONS

Recent warming has driven many terrestrial and freshwater species poleward and towards higher altitudes.[173] Higher atmospheric CO_2 levels and an extended growing season have resulted in global greening. However, heatwaves and drought have reduced ecosystem productivity in some regions. The future balance of these opposing effects is unclear.[174] Climate change has contributed to the expansion of drier climate zones, such as the expansion of deserts in the subtropics.[175] The size and speed of global warming is making abrupt changes in ecosystems more likely.[176] Overall, it is expected that climate change will result in the extinction of many species.[177]

The oceans have heated more slowly than the land, but plants and animals in the ocean have migrated towards the colder poles faster than species on land.[178] Just as on land, heat waves in the ocean occur more frequently due to climate change, harming a wide range of organisms such as corals, kelp, and seabirds.[179] Ocean acidification makes it harder

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| Volume 2, Issue 3, March 2019 |

for marine calcifying organisms such as mussels, barnacles and corals to produce shells and skeletons; and heatwaves have bleached coral reefs.[180] Harmful algal blooms enhanced by climate change and eutrophication lower oxygen levels, disrupt food webs and cause great loss of marine life.[181] Coastal ecosystems are under particular stress. Almost half of global wetlands have disappeared due to climate change and other human impacts.[182]

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| ISSN: 2582-7219 | www.ijmrset.com | Monthly Peer Reviewed Journal

| Volume 2, Issue 3, March 2019 |

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