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THE HOTTEST YEAR RECORDED SINCE 1850 IS 2024: A BRIEF REVIEW

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ABSTRACT

The warmer air not only elevates the temperature but fasten up vaporization of water from oceans too, which led to increase in precipitation, sometimes creating strong storms, flood that bring hilarious destruction of population and nature. This warming was driven by record-high greenhouse gas concentrations, including carbon dioxide and methane, and contributed to extreme weather events worldwide. The persistent increase of greenhouse gas concentrations has co-occurred with a regular increase in world-wide temperatures, making the last ten years, the top ten hottest years on record.

It has been observed that temperature change is not consistent crosswise the earth, but more areas were found in hotter condition than in cooling. Also, the rate of warming has speeded up in last few decades. As per the Annual Climate Report of NOAA 2024, the temperature of land areas and water bodies both has raised up to 0.11 degrees Fahrenheit i.e. 0.06 degrees Celsius per decade since 1850. 2024 was confirmed as the hottest year on record globally by organizations like the World Meteorological Organization (WMO) and the National Oceanic and Atmospheric Administration (NOAA), surpassing the previous record set by 2023.

Keywords: *Greenhouse gases, carbon dioxide, methane, hottest year 2024, temperature, climate change etc.*

INTRODUCTION

The raise in temperature is direct outcome of warming of our earth, which is produced by the heat trapped by greenhouse gases present in the atmosphere. Which in turn, increases the temperature of Earth's surface, directing to bigger and hotter heatwaves.

Human activities like burning of fossil fuels, deforestation and farming release significant amounts of greenhouse gases consisting of Carbon dioxide and methane into the atmosphere, that traps heat and drives global warming and climate change. Industrial activities and waste disposal also contribute to increased greenhouse gas levels.

The IMD (Indian Meteorological Department) has confirmed that the hottest year since records began in 1980 is 2024, with intensified weather conditions worsen by climate change.

As per the IMD Director General, Mr. Mratunjay Mohapatra, "2024 was the hottest year recorded since 1901" with the yearly mean air temperature over land crosswise India being 0.65 degrees Celsius above the long term mean from 1991 to 2024.

Above information was based on the report published by United Nations. UN report foretold that 2024 would made a record of new world-wide temperature on a decade of increasing temperatures.

2024 was recorded as the hottest year globally by various renowned organizations like the National Oceanic and Atmospheric Administration (NOAA) and World Meteorological Organization (WMO) [24].

The factors responsible for this warmest year recorded were high concentrations of GHGs (Green House gases), with raised amounts of carbon dioxide and methane also.

REVIEW OF LITERATURE

As per the annual report published by NOAA (National Oceanic and Atmospheric Administration), National Centers for Environmental Information, 2024 was recorded as the hottest year since world-wide records started in 1850 [33].

Highlights of the report are as follows:

1. The **global average surface temperature** was found to be 2.32 Fahrenheit (1.29 degrees Celsius) above the 20th-century average (57.0 degrees Fahrenheit, or 13.9 degrees Celsius) and 2.63 degrees Fahrenheit (1.46 degrees Celsius) above the pre-industrial average (56.7 degrees Fahrenheit, or 13.7 degrees Celsius), which NOAA stated as the period from 1850-1900.
2. The 2024 **global temperature** was unexpected recorded 0.18 degrees F (0.10 degrees C) hotter than the earlier records [13].

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3. In the past 175-years historical records, all the warmest years, have recorded in the last decade i.e. 2015–2024.
4. Earth's temperature has raised by an average of 0.11° Fahrenheit (0.06° Celsius) per decade since 1850, or about 2° F in total.
5. The warming rate of our planet is found three times higher since 1982 i.e. 0.36° F (0.20° C) per decade.
6. Not only above these, the year 2024 was found to be the [28]

- warmest year for both the Earth's hemisphere (Northern and Southern) individually.
- warmest year for both terrestrial and aquatic regions individually.

Present and Past changes in global temperature:

Globally, the change in temperature has not recorded uniform throughout, rather more areas were found hotter. Also, the rate of heating has increased in past decades.

As per the Report 2024 of Annual Climate published by NOAA, the temperature of both surface areas and water bodies has increased at an average rate of 0.11 degrees Fahrenheit i.e. 0.06 degrees Celsius per decade. Also, this rate is observed three times more (0.36 degrees Fahrenheit, or 0.20 degrees Celsius) than rate of increase of temperature per last decades since 1975 [24].

Global surface temperature:

Global surface temperature refers to the average temperature of the Earth's surface, combining sea surface temperature and near surface air temperatures over land. This concept is very helpful in understanding climate change, as it reflects the overall warming or cooling trend of the planet. The global surface temperature is steadily increasing over the years, with 2024 being the warmest year on the last decades' records.

Global Average surface temperature:

Globally, Temperatures can vary from night to day, in between seasons and also in extremes in the Northern and Southern Hemispheres. Therefore, the concept of a global average temperature is laid down. It is found very convenient in detection and trailing of Earth's energy changes that can be calculated straightaway from space [25].

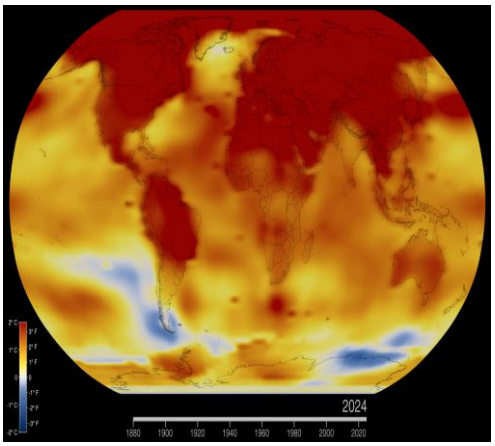
To know the exact status of the Earth's energy balance , one must be aware of global average surface temperature. It is nothing but is the amount of sunlight absorbs by the earth minus the amount of heat radiated back to space.

- When these quantities are identical, temperature of Earth′s average surface is steady-going.
- When these quantities are imbalanced or not same, the Earth either cool downs or warms up.

Earth's average surface temperature has been found increasing progressively. Although, the amount of increase might seem very small (approx 2 -degree Fahrenheit) but it is responsible for the above-mentioned significant increase in heat energies circulating throughout the Earth's various system like land, water bodies, frozen landscapes and even the atmosphere [24].

The increase in average earth's temperature year to year is due to the human beings only. As greenhouse gases, released by human beings are the main cause of Earth to absorb more and more energy, and in turn radiating (back to space) less heat.

WMO confirms 2024 as warmest year on record



Source: NASA Goddard's Scientific Visualization Studio: https://svs.gsfc.nasa.gov/5450.

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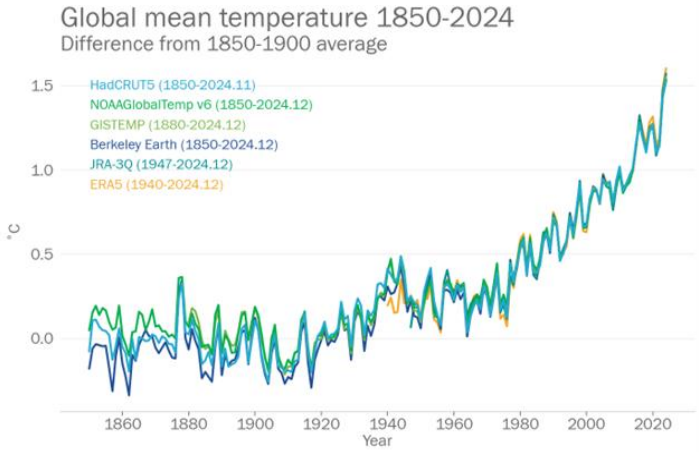
Above shown animated version of Earth's map of 2024 clearly indicates the irregularities in global surface temperature. White colour represents the Normal temperatures, while, red and orange the higher-than-normal temperatures, and blue the lower-than-normal temperatures [26].



Source WMO site, press release, Jan.10,2025

"Climate history is playing out before our eyes. We've had not just one or two record-breaking years, but a full ten-year series. This has been accompanied by devastating and extreme weather, rising sea levels and melting ice, all powered by record-breaking greenhouse gas levels due to human activities," said WMO Secretary-General Celeste Saulo.

The World Meteorological Organization (WMO), a special administrative body of United nations, shows a important function in understanding the Earth's climate and atmosphere [40]. Its main aims are-

- Weather forecasting
- Climate monitoring
- Disaster Risk Reduction
- Global Cooperation

The WMO gives us important information of temperature assessment based on data collected by various sources like European Center for Medium range Weather Forecasts (ECMWF), National Oceanic and Administration (NOAA), Japan Meterological Agency (JMA), NASA, and many other sources [24].

Also, it collects information from various- weather stations, Satellites, radar, Buoys, Ships, Air-crafts, Weather Balloons [3].

"Once again, the temperature record has been shattered — 2024 was the hottest year since record keeping began in 1880," said NASA [29] Administrator Bill Nelson. "Between record breaking temperatures and wildfires currently threatening our centers and workforce in California, it has never been more important to understand our changing planet" [35].

NASA scientists had estimated that in 2024, Earth was approx 2.65 degrees Fahrenheit (1.47 degrees Celsius) warmer than the average of mid-19th century (1850-1900) [6].

For more than half months of the year 2024, the average earth' s temperature was found to be more than 1.5 degrees Celsius above the baseline (decided by Paris agreement). Also, the yearly mean temperature, with few numerical uncertainties, have surpassed the level for the first time.

Paris Agreement:

The Paris agreement is a world-wide written agreement by various countries on climate change that targets to set efforts to remain below 1.5 degrees Celsius over the long term. This treaty was signed by 195 countries at 2015 United Nations climate Conference in Paris, which entered into force on November 4, 2016.

The main objectives of the Paris agreement are-

- Mitigation: To reduce emission of GHGs (Green House Gases) to limit increase in global temperature.
- Adaptation: To deal with post impacts effects of climate change.
- Finance: To provide financial support for development and help in low release of greenhouse gases

Scientists have concluded that the warming pattern observed in recent decades is all due to excessive

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heat-trapping of carbon dioxide, methane, and other greenhouse gases led by various human activities like burning of fossil fuels, Deforestation and Farming [9].

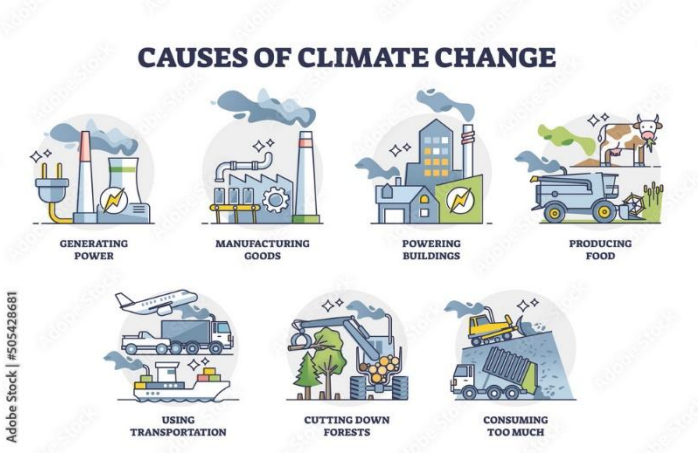

Fig.1: Source: www. Depositphotos.com

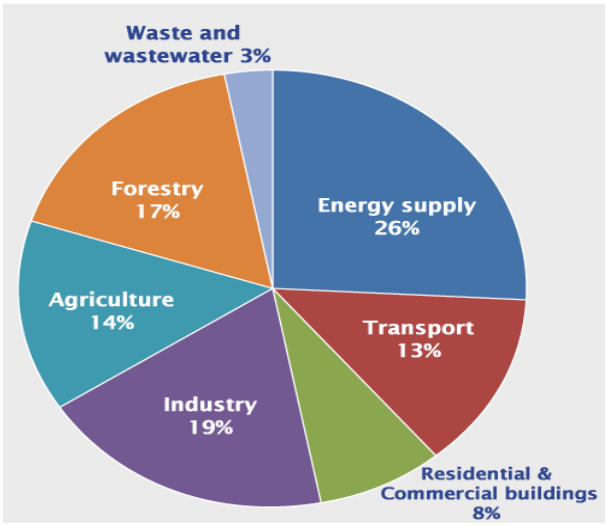

Fig. 2: Source: slides.com

How these human activities increase temperature

1. Burning of fossil fuels:

The burning of fossil fuels produces high quantities of carbon dioxide and other greenhouse gases into the atmosphere which traps the heat of sun causing increase in earth's temperature. These trapped gases in turn acts likes a blanket around the earth. Ultimately, leading to global warming by intensifying the greenhouse effect. This, global warming is responsible for the melting of icebergs, change in weather patterns and other environmental changes.

Fossil fuel combustion
↓
Green House gas Release
↓
Greenhouse effect (Trap of GHGs increase heat)
↓
Global warming

Fossil fuels are major source of human produced greenhouse gas emissions. These fossil fuels on burning, produces 75% of global GHG emissions and approx 90% of total CO_2 emission.

2. Deforestation:

Deforestation is another major contributor of increase in global temperature. Numerous vulnerable

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forests are being cut down for timber, spaces for big industries, and other human greeds.

Forest acts as carbon sinks by absorbing carbon dioxide from the atmosphere. Trees absorb and store carbon dioxide, and when forests are cut or burned, stored carbon dioxide is returned back into the atmosphere. Hence, produces large amounts of greenhouse gases. Deforestation leads to intense global warming due to both release of CO_2 and biophysical effects. Forests, covering over 30% of the world's land area, are important in combating global warming. To reduce, or slow down the climate change important steps must be taken strictly-

- Protecting forests
- Reforestation and afforestation

3. **Farming:**

To create farmland, big areas of forests are either burned or cut, producing the loss of biodiversity and excessive release of stored carbon dioxide [4].

Shifting agriculture, also known as slash and burn agriculture or swidden agriculture is a traditional farming practice which includes rotating land use to maintain fertility of soil.

These farming practices lead to excessive emissions of Greenhouse gases, especially methane from livestock, nitrous oxide from fertilizers. Not only this, the cleared forest land, frequently loses the capacity to store carbon effectively. Hence, it can be said that this type of practices is very significant contributor to green House gas emissions [5].

Continuous clearing of forest can lead to soil erosion and also to the loss of biodiversity by destroying their habitats. Soil erosion also decreases the fertility of the soil which further enhances the more use of fertilizers to the agricultural land, ultimately increasing the more emission of nitrous oxide to the atmosphere.

It not only stops here; the demolition of habitats is a threat to loss to many species. Some species had already become extinct and some are categorized under endangered species. The ecological balance is disturbed.

4. **Animal husbandry/ livestock production:**

Animal husbandry, also called as livestock production is another part of agriculture which provides very essential daily life products like milk meat, eggs, silk and wool.

All ruminant animals, like cattle and sheep produces quite good amount of methane through the digestives processes. As a part of digestion in these animals, alimentary tract fermentation takes place which releases methane as a by-product.

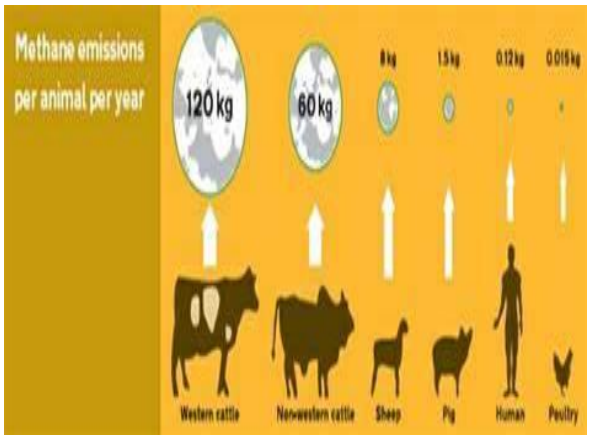

Fig. 3: Source: agri.group4.wordpress.com

The high supply of meat and dairy products in turn has made a road for expansion of livestock farming, which in turn is increasing methane emissions.

Livestock wastes which further works as manure when either stored or treated under anaerobic conditions, in lagoons or in high holding tanks, produces additional methane emissions. The food in use for livestock production also show a part in methane production. Grain-based food for cattle, instead of natural grazing on grasslands, also increases emission of methane gas, due to improper digestion [8].

The grass lands are becoming less, so the cattle had to depend more and more on grain-based food. Their production and transportation further produce greenhouse gases. Moreover, the livestock production is many-sided contributor in production of methane and other GHGs leading to climate change.

5. Rice Cultivation

It's very interesting to know that rice cultivation is also known for methane production as one of its by product. Paddy fields, where rice is grown is kept always full with water. This flooded condition makes the environment anaerobic, where methane is produced as a by-product of decomposition of organic matters (weeds).

The flooding rice paddies is a very old or can be said as traditional practice used for sufficient supply of water to sapling and also to control the weeds present in paddy fields.

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Today, large portion of the world population is feeding on rice and its products. Therefore, large areas are used for rice cultivation, favoring notable quantity of methane production by decomposing of organic matters by large anaerobic environments. The emission of methane gas from these flooded rice fields are major contributor of agricultural Green House Gases.

6. Synthetic Fertilizers

To make more money, or better livelihood, farmers are more dependent of synthetic fertilizers to enhance their crop production. Synthetic fertilizers are constitutes of high quantity of nitrates. These nitrates can transform into nitrous oxide, which has high capacity to remain in atmosphere for long time and has thus good impact on global warming comparing to other greenhouse gases, especially carbon dioxide [21].

The excess application of these fertilizers leads to overflow into water system contaminating the either the ground-water or the surface water bodies further producing many diseases. The excessive usage of synthetic or NPK (Nitrogen, Phosphorous, Potassium) fertilizers tends Nitrogen to accumulates in the soil further leading to many chemical reactions like nitrification and de-nitrification releasing nitrous oxide as by-product into the atmosphere.

Hence it can be said that, the utilization of synthetic fertilizers is another agriculture-based technique that contributes parallel to climate change through nitrous oxide emissions like another Green House Gases.

7. **Industrial Emission**

It's obvious that Industrial emissions have high impact on global warming as well as on climate change, as only this sector is responsible for producing approx 20% of world-wide Carbon dioxide gas constituting one of the major parts of Green House Gases. These industrial gaseous releases are very hard to destroy since they are originated not only from energy usage but also directly from the industrial processes concerned [3].

These industrial waste gaseous releases can degrade the plant employees and surrounding residents' health safety and behaviour by spreading unpleasant odour, loud noises black smokes [(2)].

The manufacturing industries especially, IRON, STEEL and CEMENT industries contributes significantly to world-wide air pollution, releasing many harmful waste vapours which is proven serious threat to human health as well as the environment. [(39)]

Many industries, like oil and gas industries, chemical and petrochemical based industries, food and beverage industries, pharmaceutical plants, biogas plants, packaging industries, flex and graphic printing presses, , and many others, are creating global warming by releasing **volatile organic compounds (VOCs)** [17].

8. Transportation

Transportation also somewhere contributes to global warming and climate change.

The transportation sector is major source of emission of carbon dioxide due to burning of petrol, diesel, gasoline and jet-fuels. It has been observed that approx 16% of all greenhouse gases is released by road vehicles like car truck buses. Ships, trucks, and airplanes, the primary modes of transport in global supply chains, are to a great extent dependent on fossil fuels [19].

9. **Wastes**

Wastes in any form is directly responsible for global warming and climate change. The most contiguous impact of waste is mainly from its decomposition in landfills and incineration processes. All organic wastes, like food remains, field's wastes, paper etc. decomposes under anaerobic conditions and produces lots of **methane and** carbon dioxide **which** traps heat and raises the earth's temperature. At the same time, decomposition of inorganic wastes and materials releases **carbon dioxide (CO_2)** and other greenhouse gasses [12].

Electronic devices which are of no use now or out dated are cited as E-waste, like computers, televisions, and many other electronic devices. Inappropriate disposal of e-wastes also creates many environmental issues, like pollution and contamination of air, land and water, and destruction of habitats.

10. **Natural disasters**

The concentration of Green House Gases is directly proportional to Global surface temperature. These days all land and water areas are recorded with increased surface temperature. High surface temperatures are not only observed due to raise in GHGs concentration by human activities to but also due some of the natural calamities like forest fires and

volcanic eruptions. When temperature rises, forest fire arises and spread more easily which in turn also raises global temperature and Carbon dioxide production in massive quantity [14]. So somewhere, not only human activities but also natural calamities are found responsible for global temperature and climate change.

Why was year 2024 so Hot:

WMD and other worldwide agencies, indicated that the continuation of rise in temperature in 2024 is due to the increased atmospheric concentration of carbon dioxide from around 278 ppm in 1750 to 420 ppm in 2023.An increase of approx 51% is observed which itself is a big record of temperature [23]. The increase in CO_2 concentration had trapped more heat and as a result more temperature was recorded globally.

According to the latest data obtained from NASA and WMO [24, 40], the list of the last hottest years, (in descending order of hotness) 2024, 2023, 2016, 2020, 2019, 2017, 2022, 2015, 2021, and 2018.

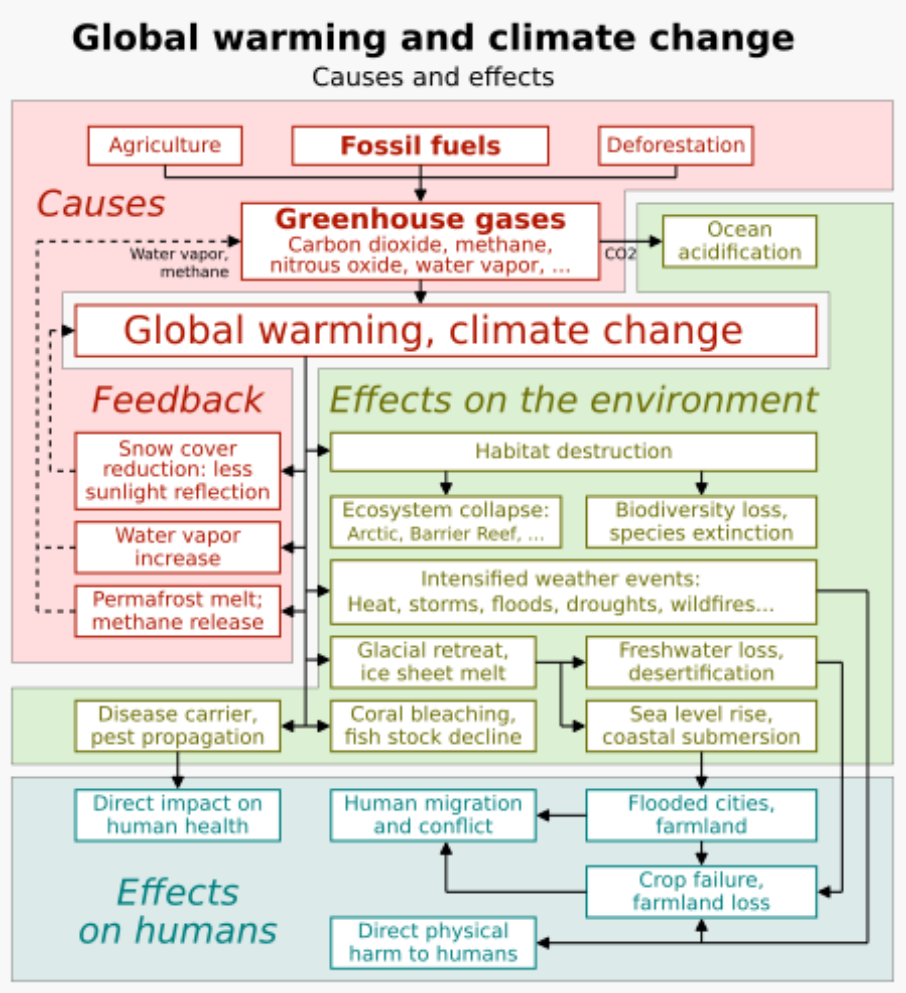

Fig. 4 Source: kids.kiddle.com

Impact of Heat waves in Year 2024 in India

Occurrence

The heat waves had taken place in India in the dry season, from March to July, showing highest temperatures in months April and May [20, 31].

Highest Temperature recorded

Churu , Sirsa and Phalodi districts in Rajasthan was recorded with peak temperature as 50.5 °C (May month), the highest recorded among last 10 years [34], and districts Mungeshpur, Narela and Nazafgarh of Delhi had also reached near 50°C (May month) [18]. As per IMD data, Delhi has recorded its hottest night ever at minimum temperature of 35.2 °C [36].

Casualities reported

Indian government had reported above 40,000 cases of heatstroke through the country during the heat wave [37].

In India, there were total 219 casualties found from the heat wave [7] and approx 25,000 others suffered from heatstroke [28].

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Later on, 147 deaths were also reported in Odisha, and 12 more in Rajasthan [28].

Impact

Increased water consumption and high surface temperature had lowered level of water bodies. Many states had suffered with severe water crisis, so their daily necessities were fulfilled by adequate supply of water by water tankers [4].

Many manufacturing industries and even corporate sectors had reduced their working hours following the government orders which were given by authorities for the sake of employees health and safety [15].

All India Power Engineers Federation has advised of high loss and blacAZkouts of power. This was all due to the very high usage of electric power used for cooling [1].

CONCLUSION

UN Secretary-General António Guterres, in his address to the world in New Year message, said that human race is on a "road to ruin" and had "no time to lose." “Today I can officially report that we have just endured a decade of deadly heat," he said. "In 2025, countries must put the world on a safer path by dramatically slashing emissions, and supporting the transition to a renewable future.”

The Green House Gases (GHGs) traps the heat energy present in the atmosphere leading to the raise in Earth's surface temperature which indirectly is responsible for the longer and hotter heat waves. More the GHGs emission, more will be heat trapped and more will be the global temperature [16].

To fight with this increased global warming and climate change, a combined effort to be made by all environmentalists, scientists and policy makers. This journey needs the balanced and hand to hand act of meeting human consumption demands giving priority to environmental health. With these initiatives of mitigating efforts and guide we can give our children a sustainable and lively future.

- Farming techniques, such as regenerative agriculture and increasing use of compost and green manure instead of synthetic fertilizers can help in reducing carbon dioxide emissions with improving soil health.
- Forestry methods, like reforestation and afforestation can help in reducing CO_2 emissions with enhancing biodiversity and habitats, directly the ecosystem.
- Promoting climate education awareness can help in tackling the impacts climate change and also will inspire individuals and communities to act for its prevention [34]
- Transitioning of industries from traditional fuels to its alternatives like solar power, wind energy and tidal energy [10].
- Emphasizing more on electric vehicles, car-free days and no-go zones can help in improving air quality.
- Companies can focus more on energy efficient techniques like updated and automotive tools to reduce energy consumption [30].
- Such policies should be made which can help in reducing waste by re-using, re-purposing and re-cycling. This can help in minimizing the demand for raw materials indirectly reducing the environmental pollution produced during their extraction and processing.
- Emphasizing on biodegradable rather than non-biodegradable by opting Eco-friendly materials

The future of our Earth and children depends on how much carbon dioxide and methane with other greenhouse gases we release in our next upcoming decades.

SAVE NATURE, SAVE FUTURE

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