Forest Fires and Climate Change: Causes, Effects and Management

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Abstract

Life on Earth cannot exist without forests. Not only various species of plants and animals are found in forests, but they also supply critical natural resources including food, medicine, and timber. Forests also support and promote the well-being of nearby communities. Tropical rainforests are frequently referred to be the 'lungs of the planet' because they typically breathe oxygen in and carbon dioxide out. Despite the vital role played by the forests in the global ecosystem and economy, we are continuously losing them. Wildfires are one of the primary causes of deforestation, which resulted in the loss of more than 12 million hectares of forest cover on the tropics in 2020.

Although wildfires are a common occurrence in many places as a means of removing dead vegetation and replenishing nutrients, but now these fires have become more frequent and widespread. As per the data of centre for Research on the Epidemiology of Disasters, since 1911, there have been at least 470 wildfire disaster situations reported worldwide which have resulted in at least $120 billion in damages and at least 10 or more fatalities or 100 or more injured. In its annual Frontiers report, released on February 17, 2022, the United Nations Environment Programme (UNEP) cautioned that wildfires are expected to worsen over years to come.

Keywords: *Forests, Wildfires, Ecosystem and Climate change*

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1. Introduction

The importance of forests to life cannot be overstated. They prevent erosion, purify the air we breathe, clean the water we drink, and serve as a key barrier against climate change (WWF, 2022). We are losing these forests rapidly to forest fires across the globe. Annually around four million square kilometres (1.5 million sq miles) of land is affected by fire, as per the estimation carried by the European Space Agency. To put that in perspective, it should be noted that it is bigger than India and nearly four times the size of Nigeria (Hussein, 2021). More than 12 million hectares of tropical forest cover were lost in 2020 which is equivalent to almost 30 soccer fields' worth of trees every minute (WWF, 2022).

Inger Andersen, executive director of UNEP, stated in her preface that the trends towards increasing hazardous fire-weather conditions are growing as a result of rising atmospheric greenhouse gas concentrations and the associated escalation of wildfire risk factors.

According to the 6th IPCC Assessment Report, wildfire-prone weather (dry, hot and windy) has grown more common in some areas and will continue to rise with higher degrees of global warming, eventually resulting in the destruction of forests. The last five years have seen 13 of California's 20 most devastating wildfires. As per the estimate of National Aeronautics and Space Administration, in September 2021 these fires destroyed 40,000 homes, companies, and other infrastructure (Pandey, 2022). A vast cover of trees was lost in the year 2021 across the globe. The figure 1 below shows the nations with highest tree cover loss in 2021 due to fires.

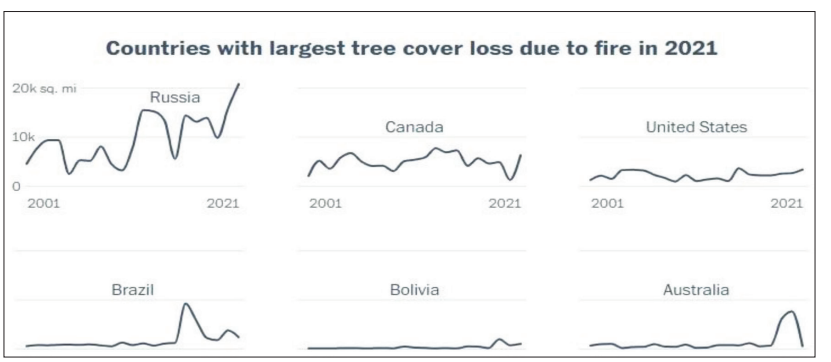


Figure 1 Source: (John Muyskens, 2022)

As mentioned earlier that in the recent past there has been an increase in wild fires across the globe which are having a serious effect on the environment. Some of these are mentioned below table:

Table 1 Few Recent Wild Fires

Sr. No.	Name	Year	Country / Countrie's	Affected Area (km^2)
1	Russian Wild Fires	2021	Russia	200,000
2	California Wild Fires	2020	USA	18,000
3	Australian Bush Fires	2019-2020	Australia	338,000
4	Siberia Wild Fires	2019	Russia	43,000
5	Amazon Rainforest Wild Fires	2019	Peru, Brazil, Bolivia, Paraguay	9,000
6	British Columbia Wild Fires	2017	Canada	12,300
7	Russian Wild Fires	2015	Russia	11,000
8	Northwest Territories Fires	2014	Canada	34,000

Source: (Karl Hille, 2017), (Mohammed Haddad, 2021)

Recently, the Europe experienced an early fire season as a result of an extremely dry and hot spring that left the land parched and authorities say that climate change is to blame. They say that the flames are being fuelled by dry environment in some areas and earlier- than-usual hot temperatures. Experts on wildfires concur, noting that the dryness, extreme heat, and early fire season are all clearly signs of climate change (ED, 2022).

As per the report of European Forest Fire Information System (EFFIS), the second worst fire season for Europe since it began maintaining data of wildfires in 2000 was in 2021 (Shiel, 2022). A satellite-based analysis by the University of Maryland and Global Forest Watch says that, 2021 came up with more catastrophic losses for the forests across the globe. Last year, Earth's tree cover decreased by more than 97,500 square miles (John Muyskens, 2022).

The mix of heatwaves and droughts are causing wildfires to spread across Europe and making it challenging to put out the flames in some areas. Emergency services fought flames on July 20, 2022, while large areas of southern Europe were evacuated. According to the European Forest Fire Information System, 19 countries are currently in "severe danger" from wildfires, while France, Spain, and Portugal are in "very extreme danger." UK, Spain, France, Turkey, Greece, Italy and Portugal, all are experiencing wildfires (Aljazeera, 2022).

Spain: A fire that erupted in the province of Zamora last month (June, 2022) scorched at least 25,000 hectares as a result of a heat wave that broke records (61,000 acres). 32 local communities saw an evacuation of over 6,000 residents. Not only where the reports of critical injuries but two people also lost their lives

Portugal: On July 17, a wildfire in northern Portugal's Murca municipality began to move towards Carrazedo de Montenegro and Vila Pouca de Aguiar. As per the estimate carried out by the Copernicus Earth Observation Program of the European Union, around 14,800 acres (5,989 hectares) of land have been impacted by this fire. On July 7, a number of wildfires also erupted in the Ourem municipality's Leiria and Santarem districts. Strong winds not only helped the fire to spread rapidly but also made it more difficult for firemen to fight the flames. Thus, more than 7,413 hectares (18,318 acres) were burnt (Aljazeera, 2022).

Italy: On July 19 fire erupts close to the Tuscan town of Lucca which spread rapidly and about 650 hectares of tress were lost in no time.

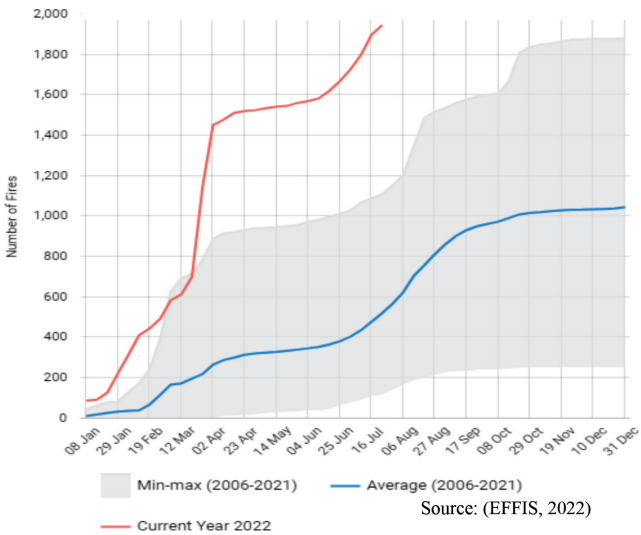
France: A fire since July 12 has scorched around 20,600 hectares and the firefighters in the southwest Gironde department are battling hard to tame it. There have been almost 37,000 residential evacuations. Compared to the same period last year, wildfires in France have burnt 25% more land this year (Aljazeera, 2022).

Turkey: On July 13, a fire started in the Mugla region of the Aegean near the town of Marmaris and quickly spread over the forest. Approximately 17 homes and 728 hectares (1,800 acres) of land were completely destroyed. An evacuation of 3,530 individuals was carried out from 450 households.

Morocco: On July 13, a number of fires in the provinces of Larache, Ouezzane, and Tetouan began to flare up. The flames burned across almost 4,000 acres (or 1,618

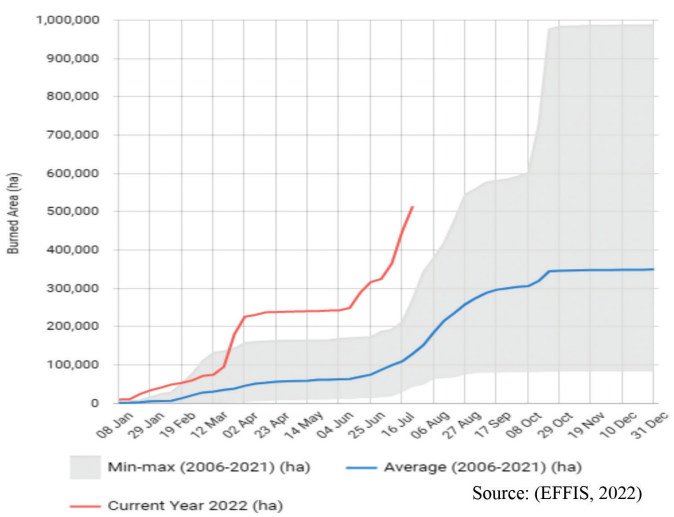
hectares) of forest (Aljazeera, 2022). The number of forest fires are on rise across the Europe as shown in the figure. The figure 2 shows how the number of fires incidents in this year are much higher than the average fire incidents from the year 2006-2021.

Figure 2 shows Weekly Cumulative Number of Fire Incidents



Source: (EFFIS, 2022)

Figure 3: Weekly Cumulative Burnt Areas



Source: (EFFIS, 2022)

The Figure 3 above shows the cumulative area burnt. We can clearly how the burnt area is much more than average years from 2006-2021.

Methodology

The aim of this work was to know in depth about forest fires, their alarmingly increasing numbers and their relation with climate change. An in-depth study about the fires in Europe and India was also carried out. Furthermore, focus was also given how to reduce carbon emissions which eventually will lead to decrease in the number and intensity of forest fires.

For this purpose, a thorough study of different publications, reports, articles and research papers was done. Various internet resources were also utilised for this purpose. Many websites like The Washington Post, Aljazeera, The Indian Express, Global Forest Watch, United States Environmental Protection Agency, National Geographic, The Print, BBC, UN Environment Programme, Forest Survey of India, IPCC, Centre for Climate and Energy Solutions, EFFIS etc. were accessed and lot of vital information and data was achieved from these sources. Information was also collected from various reports of IPCC and UN Environment Programme.

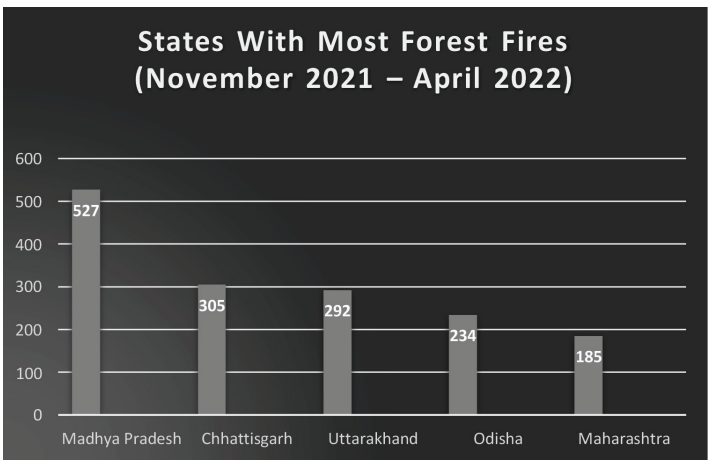
India and Wild Fires

Forest fire poses a threat to the forest wealth; and disturbs the bio-diversity, ecology and environment of the region. The last few summers have seen frequent forest fires in the Himalayas, most specifically in the Garhwal Himalayas. India's entire area covered by trees and forests is 80.9 million hectares, or 24.62 percent of the country's total area (FSI, 2022).

In our country, forest fires are a common occurrence that are frequently seen in the summer. In the period from November 2020 to June 2021, there were 52,785 forest fires discovered by the MODIS (Moderate Resolution Imaging Spectro-radiometer) sensor and 3,45,989 by the SNPP-VIIRS (Suomi-National Polar-orbiting Partnership - Visible Infrared Imaging Radiometer Suite). Numerous forest types, especially dry deciduous forests, experience severe fires; however, evergreen, semi-evergreen, and highland temperate forests are comparably less vulnerable. According to estimates, more than 36 percent of the country's forestland is at risk of regular forest fires. Approximately

4 percent of the nation's forest cover is deemed to be highly fire prone, while 6 percent is considered to be very highly fire prone (Bhaduri, 2022). Every year, fires of various size and ferocity spread across wide areas of woodlands. According to forest inventory records, there are occasional fires in 54.40 percent of India's forests, moderately regular fires in 7.49 percent, and high incidence levels fires in 2.40 percent of the country's forests (Forest Fire Activities, 2022).

According to a new study, the frequency of severe forest fires has increased ten-fold in India over the past two decades, which is a disturbing sign of climate change. The Global Climate Risk Index placed India 7th among the nations most affected by climate change in 2019. The Council on Energy, Environment and Water (CEEW) recently conducted research and discovered that India's forests had suffered significantly. According to this research, 36% of India's forest cover is located in areas that are susceptible to severe forest fires. According to the study, between 2000 and 2019, there was a consistent rise in the occurrence and intensity of these fires (SIRUR, 2022). According to the data, whereas there were 3,082 forest fires recorded across all states in 2000, there was a steep rise in the forest fire incidents and the number went up to approximately 30,947 in 2019. Additionally, air quality declined as a result of forest fires. The study found the worst-affected districts were located in almost all North-eastern states, Andhra Pradesh, Maharashtra, Odisha, Chhattisgarh, Madhya Pradesh and Uttarakhand (SIRUR, 2022). The top five states with most forest fire incidents reported are shown below.



Source: (Dubey, 2022)

Eighty-nine percent of the 192 districts in India that are at risk for severe forest fires are in areas that are prone to drought or exhibit what is known as a "swapping trend," in which historically prone areas to flooding become more prone to drought. This demonstrates that drought-like conditions are characterised by more frequent dry spells, which, according to the study, incite forest fires. According to Abinash Mohanty, Program Director at the Council on Energy, Environment, and Water, with the rise in global temperatures, the number of severe forest fires have skyrocketed worldwide, especially in places with dry weather (SIRUR, 2022) (Bhaduri, 2022).

From November 2020 to June 2021 around 21,142 significant forest fires were recorded. Among these, 149 large forest fires burned nonstop for a week, 275 large forest fires burned for six days, 399 fires burned for five days, and 666 burned for four days. There were two fires that raged for 14 days and 24 major forest fires that burned for 10 days (Jha, 2022).

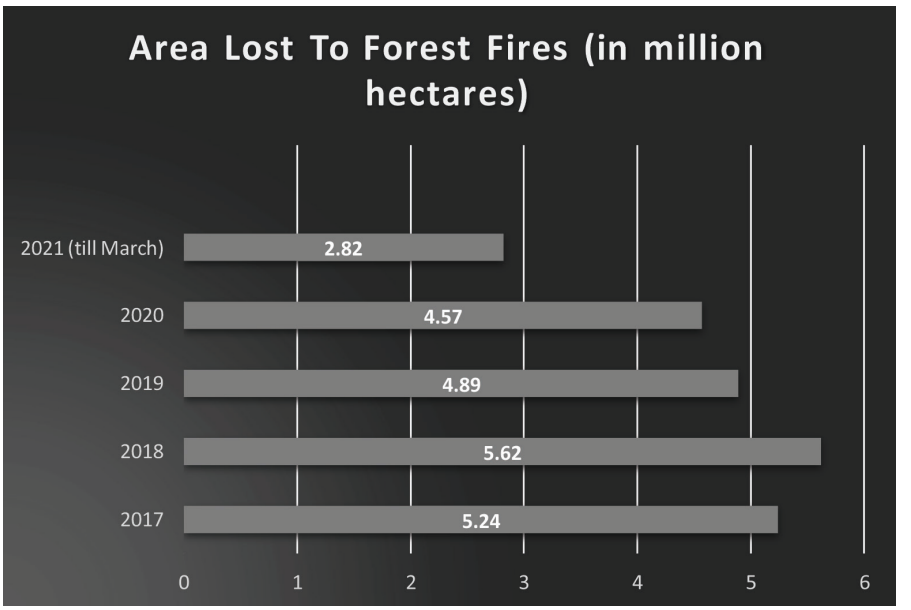
Before the end of March 2022, fires occurred in the Ladkui Jungles in Madhya Pradesh's Sehore district, the Perimalmalai Peak close to the Kodaikanal Hills in Tamil Nadu's Dindigul district, the Similipal Wildlife Sanctuary in Odisha, the Sariska Tiger Reserve in Rajasthan and the Majhgawan region of Satna district's forests (Bhalla, 2021). According to the Forest Survey of India, there were about 340 fire incidents on the last day of March, and 1,141 major forest fires had been burning for more than one week. Between January 1 and March 31, 2022, the country had 136,604 fire points (Jha, 2022).

The main fire season in India usually begins in the last days of February and continues for around 13 weeks. Between July 26, 2021, and July 18, 2022, there were 20,175 VIIRS fire alarms of high confidence registered. Comparing this to the sum from years prior to 2001, it is extremely high. 2012 has 6.0Mha of the total number of fires ever recorded (Watch, 2022).

The data of Forest Survey of India on forest fires between March 1 and April 30, 2022, clearly demonstrates an increase in events that coincided with intensifying hot conditions. Over the four weeks of March, there were an increase in forest fire points from 8,735 to 42,486 (Manraj Grewal Sharma, 2022). Himachal Pradesh has the largest area of burned land during the recent four weeks of data, with 1.59 kha of area destroyed. This is significantly more than the same time starting in 2001. In April, there were around 750 fires reported in Himachal. In the woods of Chamba, Hamirpur,

Shimla, Rampur, Nahan, Bilaspur, Kullu Mandi, Dharamshala, and the Great Himalayan National Park at Shamshi in the Kullu region, these fires have destroyed around 5,662 hectares. This represents a significant increase from the state's reported 1,045 forest fire incidences over the full summer of 2020–2021. The state had last seen such destructive fires in 2018– 2019, when a total number of 2,544 fires were reported (Khadka, 2021) (Manraj Grewal Sharma, 2022).

Over the past five years, there has been a steady increase in both the number of fire alarms and the affected areas. According to data from the Global Forest Watch, Punjab has been the most-affected state in terms of the amount of land that has burned down due to forest fires over the last year. 2.01 million hectares have been destroyed. The figure below shows the area of forest lost to fires.



Source: (Dubey, 2022)

An examination of data from the Forest Survey of India's State of Forest Reports, between 2013 and 2021, India's total forest cover expanded by 0.48 percent, but the number of forest fires identified increased by 186 percent. According to scientists, several areas of northern India and neighbouring Nepal have been experiencing the most intense forest fires in the previous 15 years. According to the Copernicus Atmospheric Monitoring

Service (CAMS) of the European Union, the forest fires in Uttarakhand in the last month released a record amount of carbon dioxide (0.2 mega tonnes). This is the highest amount of carbon emissions since 2003. Based on the study of satellite images, Nepal is believed to have released about 18 mega tonnes of carbon during the same time period, which is the most since it released 27 mega tonnes of carbon in 2016. This

illustrates how fiercely the wildfires are raging in the area, which is very concerning (Khadka, 2021).

Climate Change and Forest Fires

A forest fire may start due to carelessness on the part of humans or by natural causes such extended hot, dry weather or lightning strikes. Wildfires can be put out when at least one of the three "fire triangle" component is eliminated, which they need for growth and spread: fuel, oxygen, and heat. (Shiel, 2022). In other words, the forest fire requires three things: the ideal environment and weather, a lot of fuel that can burn, and a spark. Over the past few decades, it has become increasingly clear that climate change has a huge impact on the first two components (heat and fuel) of the fire and in some cases on the third component (oxygen) also. According to Jennifer Balch, a fire ecologist at the University of Colorado, Boulder, "people are affecting all three of things." Although, there are other issues at play, climate change is a significant and main part of this issue. Ignitions induced by humans account for a major portion of the risk: In research that Balch co-authored, it was discovered that, between 1992 and 2015, humans were to blame for 97 percent of the ignitions that led to fires that later threatened residences in the wildland-urban interface. 2020 (BORUNDA, 2020).

While forests can reduce and even reverse the effects of climate change, it is undeniable that climate-proofing forests is urgently required. Temperature increases mostly cause an extended dry spells and dry season, which turns the soil and land drier and more vulnerable to forest fires (SIRUR, 2022). Heatwaves have increased in frequency, intensity, and duration due to human-induced climate change. This has been attributed by the UN report to both human activity and climate change. Climate change exacerbates those elements which create perfect fire conditions. Lower precipitation, topography, vegetation, surface deposits, human activities and warmer air temperatures dry the forests. Forest fire poses a threat to the forest wealth; and disturbs the bio-diversity, ecology and environment of the region.

The risk and size of wildfires have grown in the Western United States as a result of climate change. Temperature, soil moisture, and the availability of trees, bushes, and other possible fuel sources are those factors which influence wildfires. All of these elements are strongly related to climatic variability and climate change, either directly or indirectly. In the western United States, the number of big fires increased by twofold between 1984 and 2015 due to climate change, which accelerates the drying of organic matter in forests (the substance that ignites and spreads wildfire) (Solutions, 2022).

Climate change has been causing more and more erratic weather events, such as droughts and floods, throughout the country. According to a press release by the Indian Meteorological Department in April 2022, the 50-year annual rainfall normal in India has come down by 16.8 mm in the past 10 years. The southwest monsoon is passing through a dry epoch that started in the 1980s, according to the report. The spike in forest fires in India can so be seen as a manifestation of climate change.

Estimates show that heat waves today are 5 to 10 times stronger than they were a century ago due to climate change. Extreme weather events including rain, hotter temperatures, floods, droughts and famines are being caused by human induced global warming, which is disrupting natural weather cycles. This year's initial heatwave in Europe reached temperatures beyond 40 degrees Celsius, a level that is often only reached in July or August. In May 2022, the Earth's atmosphere had its highest recorded concentration of carbon dioxide, which was at 420 ppm (parts per million). Such high levels had not been seen in 4 million years. Heat is trapped by carbon dioxide, which leads to heat waves, fires and droughts. Heat waves and low humidity brought on by climate change have all been linked to the flames in Europe including Greece, Spain, and Germany (Shiel, 2022).

Where we can Improve

Wildfires across the world are becoming bigger and more frequent. Experts say that the approach has to change from firefighting to mitigation of factors that lead to extreme fire events. The United Nations Environment Programme (UNEP) stated in its annual Frontier report this year: "The trends towards increasingly hazardous fire-weather conditions are projected to intensify due to rising concentrations of atmospheric greenhouse gases and the resulting escalation of wildfire risk factors" (Pandey, 2022).

a. Community Participation

While it is true that there have been more dry spells, it is crucial to keep in mind that most fires in India are ignited by humans, not by natural causes. In order to reduce forest fires, local communities must feel a renewed sense of ownership over their forests, according to Dr. Vishal Singh, senior fellow at the Centre for Ecology Development and Research (SIRUR, 2022).

According to experts, local communities that live in or close to forests may significantly contribute to putting out fires, but this is not occurring. That is because there is a serious trust deficit between these people and the state-run forest authorities. There are conflicts between indigenous communities and administrations because these communities want their rights, including access to forest resources, to be recognised and respected. This conflict has undoubtedly hampered efforts to fight forest fires. If this problem can is fixed, it will greatly aid in preventing forest fires and minimising the damage (Khadka, 2021).

To decrease the likelihood and impact of wildfires, all the stakeholders—including towns, builders, homeowners, and forest managers—must cooperate and work together for this cause. This can be achieved by the following measures:

- Incorporating fire-resistant design features and materials while making any construction.
- The sources of fuel like dead plants and trees should be removed from those forests which are at risk.
- Developmental and construction works should be discouraged through smart zoning rules around fire-prone forests.
- The space between structures and trees in the vicinity should be increased and the same should be done for clearing space between neighbouring houses.
- Proper recovery plans should be formulated and developed well in advance. Such plans should be followed in no time in case a fire erupts to minimise the loss.
- Increasing resources allocated to firefighting and fire prevention (Solutions, 2022).

Programs which foster community resilience must be strengthened. Engaging vulnerable groups can help reduce wildfires and loss of life, therefore we must take a proactive strategy rather than a reactive one (Pandey, 2022).

b. Capacity Building

In the past, the NDMA had called attention to severe flaws in the nation's fire services based on the findings of the Standing Fire Advisory Committee. The committee discovered that the number of fire services personnel in the country was 96% below the necessary level, and that there were more than 80% less fire-fighting and rescue vehicles than what was needed (Bhalla, 2021). Although we have come a long way since those discoveries, we still need to accomplish much more in these difficult times. Aniruddh Jadeja, an environmental activist in Uttarakhand's Kumaon district, claimed that the administration is not preparing to deal with the fires which are getting more intense. Despite the vast size of our forests, government forest departments have fairly less personnel. So, when there is a large forest fire, they are hardly able to do anything (Khadka, 2021).

We should use indigenous firefighting methods and concentrate on long-range weather predictions and forecasting. Additionally, we should put more emphasis on data handling and remote sensing technologies like satellites, ground-based radar, and lightning detection (Pandey, 2022).

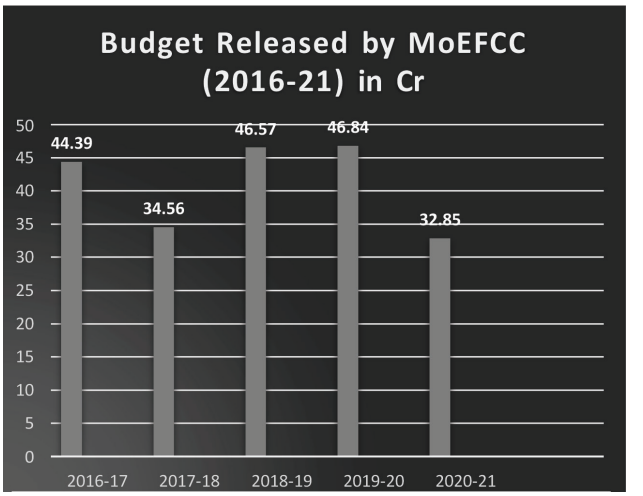
c. Policy Improvement

Improved planning, policies and regulations, and practises are required for the effective management and prevention of wildfires. Under the National Disaster Management Act, forest fires ought to be categorised as a specific disaster. This would improve the National Plan on Forest Fires' financial allocation and establish a cadre of trained forest firefighters (Bhaduri, 2022).

d. Adequate allocation of budget

To tackle the rising forest fires and to enhance fire-fighting capabilities, it is important to have adequate financial resources. In this regard, the Ministry of Environment, Forests and Climate Change supports states and Union Territories with funds under the Forest Fire Management and Prevention Scheme. Very recently the revised Budget of 2021 was about Rs approximately 33 crore, down from Rs 47 crore the previous year as shown in the figure above. Despite the rise in forest fires across the country in recent years, the assistance budget released by the Ministry of Environment, Forest and Climate Change

saw a decrease of nearly 26% from 2016 to 2021 which is shown in the figure.



When the forest fires are increasing at a fast speed, we need to have proper financial resources to utilize them for preventing such fires and minimizing the loss. So, the need of hour is to have an adequate amount of finance allocated while preparing a budget.

e. Cutting down the carbon emission

As we know the global temperatures are rising which leads to dry periods, low humidity and weather that is conducive to fires. Heatwaves are increasing across the globe leading to increased number of fires. The temperature is rising due to carbon emissions and the need of hour is reduce them drastically.

According to the Emissions Gap Report 2021, the world is on track to experience a 2.7°C increase in global temperature by the end of the century. That is much higher to the agreement of Paris climate and it would have catastrophic effects on the climate of earth. In order to achieve the Paris Agreement's aspirational target of keeping global warming below 1.5°C this century, annual greenhouse gas emissions must be cut in half during the next eight years (UNEP-CCC, 2021).

Major changes in the sector of energy are necessary to reduce global warming. This will necessitate a significant decrease in the use of fossil fuels, widespread electrification, increased energy efficiency, and the use of alternative fuels like hydrogen. By 2050, greenhouse gas emissions might be reduced by 40 to 70 percent if the correct laws, technology and infrastructure are in place to support changes in our lifestyles and behaviour. This has a lot of untapped potential, according to Priyadarshi Shukla, co-chair of IPCC Working Group III (IPCC, 2022).

Results

The study reveals that both directly and indirectly, climate change has raised the risk of fires. Even if an ignition occurs naturally, there is a considerably greater probability than there would be if climate change didn't exist that it will start a large fire. Due to climate change the dry seasons get prolonged and the rising temperature make the conditions favourable for fires. Heatwaves have increased in frequency, intensity, and duration due to human-induced climate change. The spike in forest fires in India and across globe can be seen as a manifestation of climate change.

Discussion

It is obvious that climate change is bringing on dry periods, low humidity, and weather that is conducive to fires. Globally, the forests are burning rapidly at an alarming rate. Across the world, the flames are being fuelled by dry environment in some areas and earlier-than-usual hot temperatures. Experts on wildfires concur, noting that the dryness, extreme heat, and early fire season are all clearly signs of climate change. While forests can reduce and even reverse the effects of climate change, it is undeniable that climate- proofing forests is urgently required.

We already know that both directly and indirectly, climate change has raised the risk of fires. Even if an ignition occurs naturally, there is a considerably greater probability than there would be if climate change didn't exist that it will start a large fire. Globally, the average annual area burned has increased by five times during the past few decades. According to several studies, today's flames are both alarming and completely predictable. The challenging aspect of fires is that they are caused by a number of puzzle pieces coming together, rather than by a single factor. It takes prompt, firm action from numerous perspectives to learn to adjust to the new reality and reduce dangers (BORUNDA, 2020).

India has committed to planting enough trees and creating enough forest cover by 2030 to absorb 2.5 to 3 billion tonnes of co2. By the same year, it has also committed to restoring 26 million hectares of degraded forests. Unless forest fires are effectively controlled, these commitments are unlikely to be kept.

Conclusion

It is obvious that climate change is bringing on dry periods, low humidity, and weather that is conducive to fires. Past few years are showing us that the nature of fires is changing, and changing really fast across the globe. The high temperatures across the globe are becoming new normal and are contributing immensely to forest fires. In India we are also witnessing that not only the fire incidents are increasing but these fires are getting more devastating. So, the need of the time is that government should take all the necessary proactive measures to minimise these fire incidents and reduce the loss. Since the beginning of the industrial age, the planet has already warmed by around 1.1C, and temperatures will continue to rise unless governments drastically reduce the carbon emissions worldwide. Together we can do it, so globally all the countries need to put efforts and take measures collectively while as at country level the administration should take steps to bring all the stakeholders together to fight collectively for this cause. It is only through the collective efforts that we can reduce the carbon emissions and minimising the forest fires and the loss.

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