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Forest Fires Versus Other Disasters in India and A Comparison to that of World–An Analysis

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ABSTRACT

Forest fires pose global challenges, increasing intensity and intensity due to climate change. Forest fires and other disasters are detailed for 2021-2024 and compared with that of past 2-3 decades. High incidences in the Americas, Africa, Australia and Russia cause extensive destruction. Forest fires in India are primarily caused by droughts, heat waves, and human activities, but are also influenced by other natural disasters like earthquakes and cyclones. India's geography makes it more vulnerable to earthquakes, cyclones and floods and less to forest fires. Despite less frequent forest fires, the nation faces severe risk for natural disasters. Good strategy is crucial to mitigate their effects on communities and ecosystems.

Keywords: Wildfire, Forest fire, Disaster Cyclone, Flood, Earthquake, Tsunami, Drought.

INTRODUCTION

Forest fires and other natural disasters, encompassing a wide range of catastrophic events such as cyclones, floods, storms, earthquakes, tsunamis, landslides, cold waves, heat waves and droughts, have a significant impact on millions of individuals worldwide each year[1,2]. These events lead to widespread destruction, displacement, and loss of life, underscoring their potential to disrupt communities and economies. Despite the staggering nature of these incidents, it is important to recognize that humanity is not entirely defenseless against such calamities[3,4].

Over the years, advancements in disaster preparedness, response strategies, and early warning systems have contributed to a marked reduction in the global death toll associated with natural disasters, particularly in relation to droughts and floods. While it is true that natural disasters represent only a small fraction of total global mortality rates, their effects can be disproportionately severe, particularly for vulnerable populations residing in low-to-middle-income countries. These regions often grapple with inadequate infrastructure, limited resources, and insufficient emergency response capabilities, which exacerbate the consequences of natural disasters. In these contexts, even minor disasters can lead to catastrophic losses both in human lives and economic stability, highlighting the urgent need for targeted interventions and support[5,6].

As many millions of Indians use forest produce for their livelihoods, forest fires and its smokes kill or make sick 1-4 millions peoples every year. More population and low economy make this tragedy to rural Indians. Yet another evidence is recent landslides (year 2024) after heavy rain fall in the Wayanad region of Kerala, killing many thousands of people, damaging millions of dollar properties[7,8,9]. To effectively mitigate the risks posed by natural disasters, it is essential to deepen our understanding of their frequency, intensity, and overall impact. Comprehensive data analysis and research can reveal patterns and trends that inform disaster management policies. Enhanced knowledge in these areas will empower communities, governments, and organizations to develop more robust and proactive strategies aimed at improving preparedness, strengthening resilience, and ultimately safeguarding the lives and livelihoods of those at risk[10,11]. Examples of best disaster mitigation systems are Japan's earthquake monitoring system in stopping automatically the train, and North American (USA and Canada) Meso-scale forest fire monitoring and firefighting using chopper. By prioritizing such understanding, we can foster a more resilient world, capable of withstanding the challenges presented by natural disasters while ensuring that vulnerable populations receive the necessary protection and support[12,13]. This article briefly analysis the ever-increasing problems recently arising out of forest fires, climate change, extreme weather events and other disasters. It focuses mainly about these problems to India, and also makes a comparative account to those to the rest of the world.

MATERIALS AND METHODS

This review uses secondary data from open-access research articles and the data provided by Ministry of Environment, Forest and Climate Change, Government of India in its official open access website to assess the severity of forest fires and other disasters on forests and agriculture land, housing and buildings, crops and other properties, and human and animal life.

It provides a comparative analysis of the effects of forest fires, and natural and anthropogenic disasters, revealing adverse outcomes on a global scale with special attention on India. Understanding factors causing wildfires is crucial for predicting fire severity and implementing effective precautions. Advanced fire simulation models offer insights into fire behavior dynamics, aiding in strategic decision-making for wildfire management and emergency response initiatives.

A comparison of effect of forest fires and other disasters in India to the world is made. Comparing the size of forest fires of India with rest of the world, and effect of forest fires of India to other countries in the world is done. Comparing the effect of cyclones, earthquakes, flood, drought and other calamities of India to that of world is done.

This article compares the effect of Indian forest fires with other disasters from the data provided by Forest Survey of India and Centre for Science and Environment, New Delhi, India. From data provided by World Resources Institute, Washington, DC and NASA Earth Data, USA and International Disaster Database, Brussels, Belgium, a comparison of disaster problems of India to that of the world is made.

RESULTS AND DISCUSSION

Scourge of wildfires

In recent year, incidences of forest fires are more and often occur making the burning problem nearly two times forest area when compared to 20 years ago data[2]. Forest cover loss due to forest fires in 2022 is equal to total loss over the past decade. After year 2023, the world's forest fire activity is increasing more, and is showing high spread throughout the total world. In the year 2024, it started showing its devastating effect throughout the world. It is climate change problem that creates increasing forest fire. Spread of extreme heat waves triggers 5 times more likelihood for fire activity, in comparison to that was 150 years ago. Fire events are again occurring more frequent, as the planet is continually warming. Hot climate dries the landscape faster and creates a perfect environment for larger and more frequent fire seasons. After fire is ready, more carbon dioxide is emitted. This in turn creates hotter environment, further is aggrevating the climate for severe fire events. This is forest fire and climate feedback loop. This feedback loop and added human anthropogenic activity is driving much more fire activity that is seen today[2]. Fig. 1 shows forest fire alerts in India. After year 2021, its effect is low in India, but not very low. Forest fires are more in the Indian states of Goa, Uttarakhand, Himachal Pradesh, North East, Odisha, Madhya Pradesh and Gujarat. In the rest of the world, fire season increases steadily after year 2021. After year 2010, fire activity never drops in the world. It affects terribly Greece, Italy, Spain, France, Portugal, Algeria, Tunisia, Canada, USA, Australia, Russia and Indonesia, in very recent past years 2022-2024.

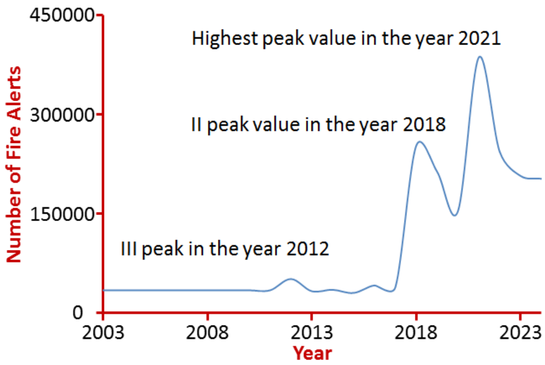

Fig. 1. Forest fire alerts in India from 2003 to 2024

In polar region, climate is becoming hot day by day leading to drier boreal forest regions, and thereby it is fueling severe fire seasons. Due to hot climate and forest fire, 70% of polar forests are lost over past two decades. Tree cover loss is estimated as 0.11 million hectares between 2001 and 2022. This loss is equal to 3% of total boreal forest. However, forest fire incidences are important to ecological functioning of boreal forests. Increased boreal fire activity is attributed mainly due to warming of northern pole high altitude forest regions. Nowadays, polar forest fires are showing longer fire seasons, more fire frequency, greater fire severity, and lead to larger burned areas. Russian forest fire in year 2021 has burned 5.4 million hectares. Loss of tree is highest over the last two decades. It is more severe and the loss is 31% more when compared to year 2020's fire season. This severity in fire event is possible only by human activity-induced cause of climate change triggering the forest fire. Recently in year 2023, Canada has burned record-breaking high fires in east and west provinces. It is fuelled by warmer and drier climate and prevailing drought in these provinces.

Unusually warm climate is more troublesome to boreal forests. Because these store 30-40% terrestrial carbon, that it is major carbon storage in the planet. Most of carbon in polar forests is in underground storage inside the soil. It includes permafrost. As climate becomes hotter day by day and fire seasons are more severe than ever before, permafrost is melting the soil carbon is vulnerable to forest fire. So, boreal carbon store has become carbon emission source[2].

Like Canada, forests of USA are also under severe forest fires. USA is in tropical dry climatic conditions and its forests are prone to more severe fires in nature. During year 2024, a total of 8,024 wildfires burned a cumulative 1,050, 012 acres (424, 925 ha) throughout the US state of California alone. The total number of wildfires was slightly higher than the five-year average, while the total number of acres burned was lower. In year 2020, fire events were also record-setting events in California. Over the course of the year, totally 8,648 fire events burned 4,304, 379 acres (1, 741, 920 ha), more than four percent of the state's roughly 100 million acres of land, making year 2020 the largest wildfire season recorded in California's modern history. However, it is roughly equivalent to the pre-1800 levels which averaged around 4.4 million acres yearly and up to 12 million in peak years. California's August 2020 Complex fire has been described as the first "gigafire", burning over 1 million acres across seven counties, an area larger than the state of Rhode Island. The fires destroyed over 10,000 structures and cost over $12.079 billion (2020 USD) in damages, including over $10 billion in property damage and $2.079 billion in fire suppression costs. The intensity of the fire season has been attributed to a combination of more than a century of poor forest management and higher temperatures resulting from climate change[14]. USA uses the Landsat satellite imagery of its forests affected by fires.. North American meso-scale forest management system monitors fire activity and takes immediate action to control fire events. Otherwise, fires may arise and affect under storey of forests that may affect soil structure and soil chemistry and in total the forest ecosystem. This method is highly useful for researchers providing 20 years data. It is helpful to forestry and agriculture. Again, forest degradation and deforestation are done due to agricultural expansion. From data analysis, it is very clear that tropical forests lost 36000 hectares due to forest fires. It is equal to 5% of forest cover loss. On contrary tropical forest cover shows an increase of 15% between 2001 and 2022. So, a 10% increase is noted during 2001-2022. But other than forest fires, deforestation for timber, and for shifting cultivation makes more forest fires due to human-induced climate alterations[2].

In Brazil, the forests face heavy deforestation by clearing trees and burning the more areas of Amazon rain forest for agriculture expansion. So, forest fire is an intentional burning that can sometimes spread and spark forest fires. It may be due to hot climate arising out of El Nino events. It is again possible due to nature's climate cycles recurring every 2-7 years. The El Nino seasons of 2015-16 is an example for heavy fire seasons and 10 fold tree loss in tropical rainforests of South East Asia and South America. Another El Nino event during June 2023-May 2024 is responsible for significant fire seasons in South and North Americas. After deforestation, the land is cleared using fire to make pasture land or agriculture field. This spreads to nearby forests, creating further fire seasons in the forest. Drought and hot climate in cleared land creates addition forest fires in nearby areas. So, fires in tropical areas are mainly by intentional and unintentional human-induced fire activity. Fire start by lightning strike and warmer and drier climate are also highly possible in tropical forests. Similar to boreal forests, Amazon tropical rain forest is also nearing tipping point for turning it to a net carbon source[2].

As far as risk of forest fire in temperate and subtropical forests are concerned, heat waves and shifting cultivation population is major contributors. In these forests, loss due to fire is less. It is 16% loss between 2001 and 2022. These forests store less carbon and face more fires. Forest fire is steadily increasing in this forest types. Climate change is mainly creating fire seasons. An evidence is Mediterranean basin forest fires. It occurs due to summer heat waves and droughts. Spain lost 0.07 million hectares of forest in the year 2022. It is the biggest fire event of Spain after year 2001. Similarly, Portugal lost 0.013 million hectares. It the worst fire faced by Portugal in 10 years. These fires activities were started by heat and drought. Excessive vegetation in abandoned agricultural land in Europe has created increased risk for wildfires. As more and more natural lands are converted into wild-urban interfaces, USA possesses more risk of of fire ignitions, and in turn damage and loss of lives. For example, California's fire and many other fires in the year 2022 created a loss of almost 1 million hectares of tree cover. Its loss is estimated to be roughly 3.2 billion dollars. It accounts for more death dolls and burned areas in recent years. It is a problem of Earth warming by human activity, and the loss is multi-billions of dollars. Fire alters geography of the forests completely. To stop these fire problems, we have to find solutions to reduce the emission of green house gases that is causing hot climate and in turn the forest fire[2].

Problems of other disasters

Disasters, encompassing a wide range of natural phenomena including earthquakes, storms, floods, and droughts, claim the lives of approximately 40,000 to 50,000 individuals annually[6]. This statistics represents a mean estimate derived from data collected over several decades, and is compared in detail for all countries (Fig. 2). While these numbers constitute a relatively minor proportion of global mortality rates, the ramifications of such disasters extend far beyond mere mortality, significantly affecting targeted populations. Certain catastrophic events have the potential to result in staggering loss of life, with some singular instances leading to the deaths of tens of thousands to even hundreds of thousands of people within a short duration. Historical data from the 20th century indicates that it was not uncommon for the annual death toll from natural disasters to surpass one million, underscoring the profound human cost associated with these events. Moreover, the impacts of disasters permeate various aspects of society and the economy. Each year, millions of individuals find themselves displaced due to the devastation brought by such calamities, with a considerable number rendered homeless. The economic repercussions of extreme weather events are similarly significant, frequently resulting in extensive financial losses that can be challenging to recover from. This situation is particularly direct in lower-income countries, where infrastructure and resources are often limited, exacerbating the difficulties faced in the aftermath of disasters. It is important to acknowledge that humanity is not entirely powerless in the face of such adversities. Over the past century, there has been a marked decline in disaster-related fatalities, attributable to several advancements. Innovations such as early warning systems, enhanced infrastructure, improved agricultural practices, and more effective coordinated responses have collectively contributed to the reduction of disaster-related deaths. However, the specter of climate change looms large, as it escalates the frequency and intensity of extreme events, thereby heightening the necessity for societies to bolster their resilience. It is imperative that efforts are made to protect the advancements achieved in disaster risk reduction, particularly in light of the evolving landscape of natural disasters. To effectively navigate this challenge, a comprehensive understanding of how disaster events are transforming, identification of the most vulnerable populations, and exploration of protective measures are crucial[6].

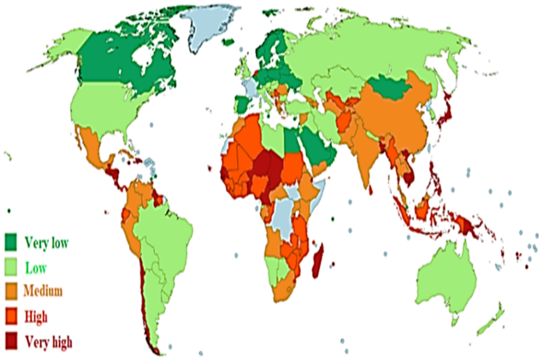

Fig. 2. Problems faced by all nations due to all disasters[5]

In terms of its geographical positioning, the Earth is situated at an elevation of 4,850 feet above sea level, which places it in a unique context relative to the various environmental factors that influence its weather patterns and susceptibility to natural phenomena. Over an extensive period of 54 billion years, this particular region has endured a multitude of natural disasters, each with varying degrees of intensity and impact on both the local ecology and human infrastructure. Among the various types of natural disasters that occur, floods have emerged as the most prevalent (Fig. 3), leading to deaths and severe property loss. Statistical evidence underscores this trend, particularly within the USA and in India, where official declarations indicate that over 90% of all recognized natural disasters are attributable to flooding events. These floods can arise from a range of causative factors, including but not limited to excessive rainfall, rapid snowmelt, and storm surges, which collectively contribute to significant alterations in the landscape and pose risks to human safety and property. Moreover, the economic implications of natural disasters are substantial and multifaceted. Between the years 2000-2024, the impact of such events on a global scale resulted in an outstanding financial burden, totaling many trillion dollars in damages. This figure highlights not only the immediate costs associated with disaster response and recovery but also the long-term economic disruptions that can ensue from widespread destruction of infrastructure, loss of livelihoods, and heightened insurance premiums. Thus, the repercussions of natural disasters extend far beyond their immediate effects, necessitating comprehensive strategies for disaster management and mitigation in order to safeguard both human lives and economic stability[5].

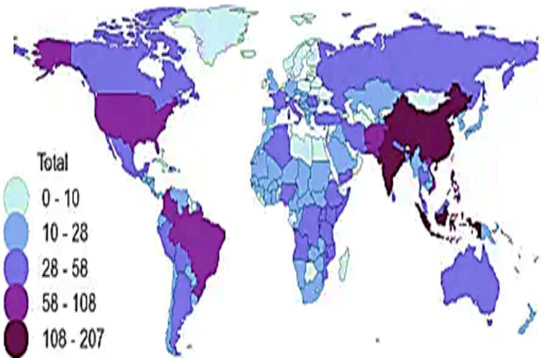

Fig. 3. Occurrence of floods during 2000-2022: only major events[9]

Table 1 gives some of the major disastrous events world faced in the past three decades. The The International Disaster Database, commonly referred to as EM-DAT, shows that approximately two-thirds of all recorded disasters stem from human activities.

Table 1: Major disasters occurred in past three decades in the world[9]

Calamity/Disaster Event Name	Total Number of Occurences	Agency inventorying disasters, and recording criteria
Flood	>5750	International Disaster Database, Brussels
Storm	> 4580	Belgium. It is an Inventory for hazards and
Earthquake	>1570	disasters from 1988
Drought	>790	Criteria for classifying a calamity into disaster
Landslide	>790	· (1) 10 fatalities
Extreme Temperature	>600	· (2) 100 affected people
Wildfire	>450	· (3) A declaration of state of emergency
Volcanic	>270	· (4) A call for international assistance

This statistic highlights the significant role that human behavior plays in not only causing disasters but also influencing their frequency and severity across the globe. EM-DAT is a crucial tool for researchers, policymakers, and community leaders. It provides comprehensive information about various disasters that impact different countries and regions over time. By analyzing this wealth of data, we can better understand the reasons behind these disasters and their effects on affected communities. The insights garnered from EM-DAT are critical for strengthening disaster preparedness. Identifying the trends and causes of these disasters allows for the development of effective strategies aimed at minimizing their adverse impacts. This includes not only better planning but also the efficient distribution of resources and increasing awareness among vulnerable populations. Being informed about the patterns of disasters leads to practical measures that can reduce damage and save lives in times of crisis. By focusing on the findings and analysis from EM-DAT, we can enhance our support for community safety efforts. The knowledge gained from this database enables us to foster a safer environment for everyone, ultimately protecting lives and property when disasters strike. Prioritizing data-driven strategies ensures that communities can withstand and recover from catastrophic events more effectively[5].

Remote sensing of wildfires

Remote sensing technology plays a critical role in fire management and ecology by enabling the prediction of fire risk, the early detection of fires, and the monitoring of their spread[3,4]. Through the use of satellite imagery and aerial surveillance, remote sensing allows for the assessment of environmental conditions that contribute to fire susceptibility, such as vegetation type, moisture levels, and recent weather patterns. This predictive capability is essential for proactive fire management strategies, allowing for timely interventions that can mitigate the likelihood of catastrophic wildfires. When a wildfire occurs, the significance of remote sensing continues, as it facilitates the early detection of active fires. This capability is vital for ensuring rapid response by firefighting teams, thereby increasing the chances of controlling fires before they can escalate. Furthermore, remote sensing aids in monitoring the trajectory of wildfires, providing real-time information on their spread and intensity, which enhances situational awareness for emergency responders. Once a wildfire has been extinguished, remote sensing techniques are employed to analyze the post-fire landscape and evaluate the ecological impact of the fire. These analyses are crucial for guiding sustainable restoration efforts, as they provide insights into the extent of the burn, the severity of the damage, and the condition of the affected ecosystems. By utilizing remote sensing data, land managers and ecologists can design effective rehabilitation strategies that promote the recovery of native vegetation and the overall health of the ecosystem. Remote sensing methods are adept at generating biophysical measurements that characterize ground conditions both before and after a wildfire event. These measurements have proven invaluable in various applications related to fire risk management. For instance, they contribute to fire risk mapping, which identifies areas susceptible to future wildfires, and fuel mapping, which assesses available combustible materials that could potentially exacerbate a fire. Additionally, remote sensing allows for accurate active fire detection, burned area estimates, and assessments of burn severity, all of which are essential for understanding the full impact of wildfires. Moreover, remote sensing plays a pivotal role in monitoring vegetation recovery in the aftermath of wildfires. By providing ongoing assessments of the regrowth and recovery of plant life, remote sensing enables researchers and land managers to track the resilience of ecosystems to fire disturbance. This data is critical for informing long-term land management practices and ensuring that restoration efforts align with ecological recovery processes. In summary, remote sensing serves as an indispensable tool in the comprehensive management of wildfire risks, enhancing both immediate response capabilities and long-term ecological recovery strategies[3].

Remote sensing is used to predict fire risk, detect fires early, and monitor their spread. After a wildfire is extinguished, remote sensing is used to analyze the impact of a fire and to guide sustainable restoration efforts. Remote sensing techniques are capable of producing biophysical measurements of ground conditions both pre-fire and post-fire, which have been used to assist in fire risk mapping, fuel mapping, active fire detection, burned area estimates, assessments of burn severity, and for monitoring vegetation recovery.

Wildfires represent a natural phenomenon that plays a vital role in the health and stability of our ecosystems. Through the process of burning, wildfires recycle essential soil nutrients, thereby facilitating the rejuvenation of healthy forests and sustaining biodiversity. In the vast wilderness of Alaska, it is reported that approximately one million acres (or 4,000 square kilometers) of land succumb to flames each year. In particularly severe fire seasons, this figure can escalate dramatically, with records indicating that as much as six million acres may be engulfed by wildfire. While many of these fires are permitted to spread unimpeded as part of natural ecological processes, the occurrence of wildfires in proximity to populated areas poses significant hazards. Such instances can threaten not only the safety of communities but also the overall well-being of residents in those regions. Recent (year 2022) catastrophic fire seasons in Alaska, California, and Australia have underscored the escalating risks faced by communities situated within what is known as the Wildland Urban Interface (WUI). This term refers to areas where urban development meets undeveloped wildland or vegetative fuels. The increasing incidence and intensity of wildfires can be largely attributed to the hotter and drier summer conditions driven by climate change, which further exacerbates the vulnerability of these communities. In response to this pressing challenge, the integration of remote sensing technology has emerged as a critical tool in efforts to safeguard these at-risk populations. Wildfire analysts harness advanced satellite imagery and sophisticated computer algorithms to assess fire risk, detect wildfires at their incipient stages, and monitor the progression of flames through various environments. This technological approach significantly enhances the capacity for early intervention, helping to mitigate the devastating impacts of wildfires on both human life and property. Furthermore, once a wildfire event has concluded, remote sensing continues to play an essential role. It facilitates in-depth analyses of the fire's impact on the landscape and the surrounding ecological systems, guiding effective and sustainable restoration efforts aimed at rehabilitating the affected areas[3].

These satellite-maps are indispensable for supporting firefighting strategies on the ground, ultimately contributing to more informed and effective responses to wildfire incidents. Changes in temperature, precipitation patterns, wind speed, and relative humidity as a result of climate change are poised to significantly impact the fire regimes across various forest ecosystems. To assess these changes, we conducted a comprehensive analysis of their effects on fire weather conditions within Indian forests. This was achieved by utilizing a fire weather index in conjunction with high-resolution downscaled climate projections that reflect anticipated future climate scenarios. Contrary to the prevailing assumption that rising temperatures will invariably lead to increased fire weather indices across the board, our findings reveal a more nuanced reality. Specifically, this relationship holds true primarily for dry forest ecosystems, where heightened temperatures correspond with a marked increase in fire risk. In stark contrast, humid forests are expected to experience a decrease in their fire weather indices despite the overarching trend of global warming. This phenomenon can be attributed to projected future increases in precipitation and relative humidity, which collectively exert a dampening effect on fire risk. The implications of these findings are significant. In dry forest regions, the frequency of days classified as having severe fire weather danger is forecasted to escalate by as much as 60%. Conversely, humid forest areas are anticipated to see a reduction of up to 40% in such severe fire weather days. Furthermore, it is projected that the overall fire season will extend by an additional 3 to 61 days across various regions of the country. Notably, the pre-monsoon fire season is predicted to intensify in over 55% of India's forests, raising concerns about the increasing vulnerability of these ecosystems. Given the complexity and diversity of India's forest landscapes, which are characterized by fragmented habitats and varying ecological climates, our study underscores the urgent need for policymakers and conservationists to develop standards and mitigation strategies that are tailored to regional contexts rather than relying on broad national approaches. This targeted strategy will be crucial for effectively addressing the unique challenges posed by evolving fire regimes in response to climate change[4].

Disaster management in India

It is based on a near real-time monitoring using ArcGIS and Python programming for updates on active wildfires (Fig. 4). This capability will enable them to stay informed about ongoing wildfire incidents and facilitate timely decision-making processes. In addition to accessing web resources, it gives the ability to navigate sophisticated databases that house remote sensing imagery and data, thereby enhancing their ability to understand and interpret complex spatial information. Moreover, it gives geospatial data proficiently, enabling to detect fire hot spots, map burn areas, and assess the severity of wildfires with precision. This analytical skill set is crucial for understanding the dynamics of wildfire behaviour and its impacts on the environment.

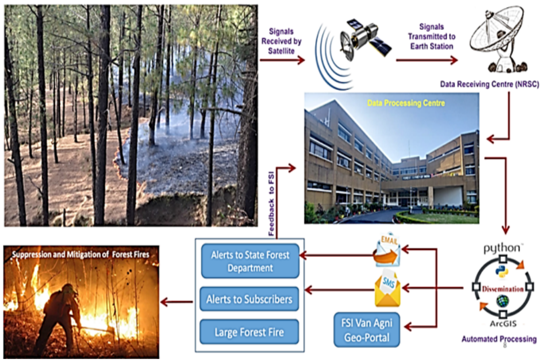

Fig. 4. Near real time forest fire monitoring of Indian forestry[3,4]

A key component of the analysis involves the processing of image and Geographic Information System (GIS) data using ArcGIS Pro, a powerful software application that supports various functionalities essential for geospatial analysis. ArcGIS Pro is an advanced, full-featured desktop GIS application developed by ESRI, renowned for its robust capabilities in managing and analysing spatial information. Utilising ArcGIS Pro, users can engage in a range of operations including, but not limited to, exploring spatial data through interactive viewing, creating detailed 2D maps and visually immersive 3D scenes, and performing advanced data analysis to draw meaningful insights. The platform also provides functionalities to edit and manage maps and associated data, ensuring users can maintain accuracy and up-to-date information. This powerful application not only supports the analysis of 2D data but also allows for the exploration of 3D and even 4D datasets through its intuitive user interface, making it an indispensable tool for professionals in the field. It is an excellent method in the application of geospatial technology for wildfire management and analysis[3,4].

In near real time forest fire monitoring system of India, data is obtained using MODIS and SNPP-VIIRS of NASA. This is crucial for saving lives and minimizing damage. Here are some methods and tools that are in use:

(a). **Google Earth Pro:** While Google Earth Pro provides imagery that is usually less than a year old, it's not the best for detecting active forest fires directly. However, you can download the latest active fire data from NASA and overlay it in Google Earth Pro. Additionally, you can use Landsat imagery to verify the fire's location. Landsat scenes from the USGS Earth Explorer can help you see snapshots of forest fires. Simply select your area and time frame, choose Landsat-8, and download the relevant image. Drag and drop the Landsat image into Google Earth Pro to visualize the fire's extent.

(b). **NASA's Worldview and FIRMS:** NASA Worldview provides both active fire maps and live imagery. You can view forest fires as they happen in near real-time. To see fires in Worldview, click "Add Layers" and explore the wildfire data category. Fire Information for Resource Management System, shortly known as FIRMS, offers an interactive fire map with daily global fire locations. It uses data from MODIS (Moderate Resolution Imaging Spectroradiometer) and VIIRS satellites.

(c). **ArcGIS Pro:** ArcGIS Pro is a powerful GIS software that allows you to create custom workflows for fire risk mapping. You can use various spatial data layers (such as slope, elevation, aspect, and land use) to assess wildfire risk. By analyzing these layers, you can identify areas prone to fires and implement proactive safety measures. Remember that combining satellite data, GIS tools, and Python scripts can enhance your forest fire monitoring capabilities.

In India, the management of various disasters falls under the responsibility of two primary organizations: the Indian Meteorological Department (IMD) and the Disaster Mitigation Authority (DMA). The IMD plays a crucial role in monitoring weather conditions and issuing timely warnings for natural disasters such as cyclones, floods, and heat waves. This department gathers and analyzes data on meteorological phenomena, which aids in forecasting and risk assessment. It collaborates with state governments to ensure that communities are prepared and informed about potential threats. On the other hand, the DMA focuses on reducing the impact of disasters through effective planning and response strategies. This authority develops guidelines and frameworks aimed at improving disaster preparedness at all levels of government and local communities. It conducts training programs and support initiatives to enhance the capabilities of responders and volunteers. Together, the IMD and the DMA work to create a comprehensive approach to disaster management. They not only respond to emergencies but also strive to prevent disasters from causing harm whenever possible. Their combined efforts contribute to building safer and more resilient communities across the country[3,4].

Wildfire versus other disasters

In India, extreme weather events trouble more than forest fires. In the recent past years, these are record-breaking highest. India is driest and hottest in year 2024. It is higher than that in record in year 1901 (earlier driest and hottest). Floods are heavy and are mostly arising out of cyclones and storms. Table 2 lists the major disasters that shook the world with death of lives, heavy crop damage, housing and other building damage6. From Table 2, it is observed that annual loss of lives in India was around 120,000 peoples per year by respiratory and cardiovascular diseases due to air pollution and forest fires. In another estimate, air pollution is created 51% by industries, 27% by vehicles, 17% by crop burning, and 5% by other sources. Even if we consider 5% air pollution related deaths, it is only 6000 peoples die per year due to forest fires. In India, 5000 peoples are directly killed by forest fire every year. Also, 100 firefighters die annually in India by direct fire incidences. These are evidenced from the data provided by Forest Survey of India, Ministry of Environment, Forest and Climate Change, Government of India. Indian forests account for only 2% of world forests. As far as fire seasons and events are concerned, 54.4% of forests face occasional fire events, 7.49% forests are prone to moderately frequent fires, and it is only 2.4% forests are exposed to frequent fires in India[14].

Table 2: Comparison of forest fires and other disasters of World and India

Sr. No	Parameters	World	India	% of India to World
1	Land Area	13.393 billiion Ha	328.7 million Ha	2.4%
2	Forest Cover	4.06 billion Ha	80.9 million Ha	2%
3	Economic Loss of Disasters	$350 billion/year	$7 billion/year	2%
4	Loss due to Forest Fires	35 million Ha/year	3500 Ha/year	0.01%
5	Economic loss due to extreme weather events	$300 billion/year	$ 1 billion/year	0.33%
6	Loss of lives due to forest fires	0.33 million peoples/year	0.12 million peoples/year	35%
7	Loss of lives due to extreme weather events	50,000 peoples/year	3000 peoples/year	6%

In general, throughout the world, climate is warmer than earlier by 1.5°C. Due to dry and hot climate, in Himalayan mountain, drought tolerant fir grows well compared to birch. In the world, 1500km^2 forest lost without any explanation. For sustainable future, properly maintaining water, energy and climate is essential. An estimate says 25-58% rise in energy requirements is possible due to cooling load increase to withstand hotter climate. Adopting the water efficient technology is required. Switching over to 90% photo-voltaic is preferred choice. This ever-increasing climate change affects child health in the form of heat waves. Hot climates created more malaria in the world. It created 5, 97,000 deaths, and 76% children deaths in Africa. Rising seas and oceans and submerging low lying land is sever in the past 150 years. For example, sea level rise was 20 cm in year 1880 from preindustrial era. But, it is 1.2m in year 2024. India contains 7,500 km coast and the challenges are increasing day by day in the form of cyclones and tsunamis. Airlines contribute 4% to green house gases' emission. So, fuel efficient aircrafts are required from now onwards. It may lead to hike in airfares. Heat waves affect marine life. For example, humpback whales population dropped by 20% in pacific ocean, and cod population dropped by 80% in the pacific ocean. In year 2022, 150+ million peoples in Arab countries could not get healthy diet. In recent years (2021 onwards), water problems are arising in many parts of the world. If water is <1700m^3, it is called water crisis. If water is <1000m^3, it is called water scarcity. For example, Indian state of Rajasthan, water available is 1450m3 now, and it may drop to 1300m^3 by year 2030 due to ever increasing dry climate[6].

Effect of disasters in India in year 2024 is more when compared to previous year 2023. After year 2010, danger of disasters increased tremendously. In 2024, 6 major types of disasters such cold waves, cyclones, lightning, heavy rains, floods and landslides devastated the India, in terms of both deaths and loss of property. Destructive effect of disasters are >3200 deaths, >3.2 Million hectares crop damages, >0.2 Million house demages, and >9000 livestock demages. But in 2023, these are >2900 deaths, >1.8 Million Hectares crop damages, >80,000 Million house demages, and >92,000 animal deaths. Total number of extreme weather events is highest in Madhya Pradesh, and total number fatalities are more in Kerala. Year 2021 is driest and hottest in Indian history. Similar hot seasons noted in year 1901, that was 120 years back. Vulnerable population was in relentless cycle of loss and damage during the recent past year (2024). In each state of India, one or more disasters lead to more damages. In year 2024, Kerala faced highest fatalities of 550 deaths, Andhra Pradesh faced highest building damages of 85,806 homes, and Madhya Pradesh faced heavy crop damages of 25,170 Hectares. Worst affected states are Karnataka, Kerala, Uttar Pradesh and Tamil Nadu by heavy floods. India is larges country and is affected by flood caused by excess rain as well as drought arising out of low rain (Figure 5).

Natural disasters are characterized as unanticipated and extreme phenomena that inflict considerable damage not only on human populations but also on plant and animal life. These events disrupt the natural order, often leading to catastrophic consequences that can last for years. Natural disasters can be classified into three main sub-categories: sudden impact disasters, slow-onset disasters, and epidemic diseases. Sudden impact disasters encompass a range of violent occurrences such as floods, earthquakes, landslides, storms, and volcanic eruptions, each capable of causing profound destruction in a matter of moments. In contrast, slow-onset disasters, including droughts, famine, deforestation, and desertification, develop gradually over time, eroding communities and ecosystems in a more insidious manner. Epidemic diseases, which pose a significant threat to public health, encompass illnesses such as cholera, malaria, and swine flu, as well as global crises like the recent pandemic instigated by the outbreak of COVID-19, which has profoundly affected societies worldwide[6,9].

Fig. 5. Effect of extreme weather events (Flood to Drought)[6,9]

The North-East Region of India is particularly vulnerable to various natural disasters, including earthquakes, floods, erosion, landslides, cyclones, and occasionally droughts (Fig. 6). Although earthquakes occur with infrequency, their potential for destruction cannot be understated. Flooding, exacerbated by erosion, constitutes a chronic crisis in this region, often worsened by human activities that interfere with natural processes. The two primary rivers, the Brahmaputra and the Barak, along with their numerous tributaries, frequently unleash catastrophic floods in Assam, leading to widespread devastation[9].

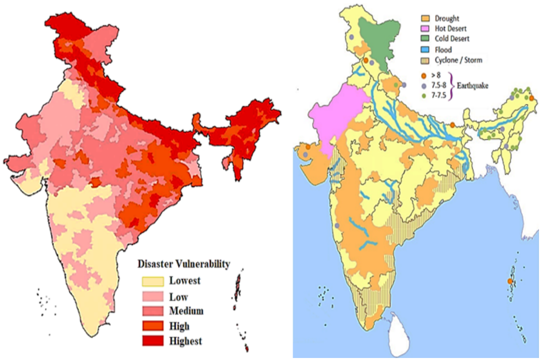

Fig. 6. Disaster vulnerability of various Indian states (Severity and Type)[2,3]

The earthquake that struck in the year 1950 was a pivotal event, resulting in significant loss of life and property, and altering the hydrological landscape by changing the course and morphology of many rivers, including the Brahmaputra. Flooding predominantly occurs during the monsoon season, from May to September, and manifests in multiple detrimental ways. Floods wreak havoc by destroying homes, impacting wildlife sanctuaries, ruining crops, causing soil erosion, breaching embankments, washing away livestock, and uprooting trees. The Brahmaputra River, one of Asia's longest rivers measuring approximately 2,906 km, flows through the

Tibet region of China for 1,625 km, continues through India for 918 km, and finally traverses 363 km in Bangladesh before reaching the Bay of Bengal[8].

Over the years, the scale and intensity of floods, landslides, and riverbank erosion have grown markedly, leading to an increasing number of affected areas and individuals. The situation for those suffering from erosion is often more dire compared to those impacted by flooding, as riverbank erosion has obliterated nearly 4,500 square kilometres of land, devastates more than 4,000 villages, and displaces over five million people in Assam[8].

Natural disasters, including floods, earthquakes, and tsunamis, cannot be entirely averted; however, their adverse effects can be significantly mitigated through the development and implementation of comprehensive disaster response plans. There is an urgent need for rigorous scientific research combined with a strategic long-term approach to effectively manage the recurrent issues of flooding and erosion. This paper aims to illuminate the consequences and underlying causes of natural disasters, with a particular focus on the floods and erosion that have afflicted Assam annually since 2015. Furthermore, it seeks to examine the impacts of the most recent COVID-19 outbreak in the North-East, assessing the region's preparedness and response strategies for disaster mitigation[8].

In recent years 2021-2024, many countries in the world faced severe forest fire problems. In year 2024, forest fire attacked many countries, viz, Greece, Italy, Spain, Portugal, Algeria, Tunisia, Canada, Australia, Bolivia, Canada, Australia, and USA. In 2023, Europe, Middle East and Africa collectively experienced their worst wildfires since 2000 and lost 5,00,000 Hectares forest land. In year 2023, 12 million Hectares forest land burned. Canada alone burned 7.8 million Hectares, ie, 65%. It emitted 3 billion tons of CO_2 gas. It creates climate change. It is 5 times higher than it was 150 years ago. In year 2021, 5.4 million Hectares of Russia's forests burned. It is the worst fire incident in 23 years. In year 2022, >70,000 Hectares of Spain's forest burned. It is the greatest fire incident after year 2001. In USA, 1 million Hectares of forest land burned. During 2021-23, most of Eucalyptus forest of Greece came under fire risk. Boreal forests are under risk due to climate change. During 2001-2023, around 1,38,000 Hectares of boreal forests burned[2].

Forest fires in India is mainly (95%) caused by human activities. It is Himachal Pradesh state that faces severe fire challenges all time. In the year 2024 alone, Himachal faces 1,684 fire incidences, destroying 17,471 Hectares forest land. On an average, 36% of forests in Himachal is fire prone forests. In year 2021, forest fire attacked Uttarakhand, Himachal, Nagaland-Manipur border, Odisha, Madhya Pradeh and Gujarat. In India, loss of life and property due to forest fires is very low when compared to world average. 54.4% of Indian forests are exposed to occasional fires, 7.49% to moderately frequent fires, and 2.4% to high incidence levels. But, in USA, 50% of population is vulnerable to forest fire related risks. Russia has highest annual tree cover loss 2.5 million hectares per anuum since year 2001. Africa is known as continent of fire. Eastern Australia is often exposed to forest fires[1].

CONCLUSION

Wildfires in India significantly impact forest reserves, affecting the livelihoods of communities relying on them for sustenance and economic activities. These disastrous events have profound social and economic implications. However, the direct consequences of forest fires are minimal compared to the broader spectrum of natural disasters in India. Other include famines, floods, earthquakes, and tsunamis. However, forest fires affect boreal, temperate and tropical forests spread over Americas, Africa, Australia and Russia. The multifaceted nature of natural disasters in India necessitates a comprehensive understanding of their impact on the environment and human populations. The complex challenges faced in disaster preparedness and mitigation highlight the need for comprehensive disaster management strategies. Forest fires are controlled using NASA's MODIS and VIIRS satellites imagery and ArcGIS software and Python program based near real time monitoring system.

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Conflict of interest

There is no conflict of interests in this work.

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