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Wild Fires and Climate Change: Health, Air Quality, Wild Fires and Causes in India

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ABSTRACT

Wildfires are a serious problem that affects wildlife all over the world which is human beings together with nature, both play a fundamental role in the cause of wildfires. Wildfires may start quite inconspicuously, but can rapidly accelerate to become fierce and uncontrollable, at which point they also pose serious health problems to humankind. To clarify this problem descriptive method was applied which described the basic issue and explained all outcomes accurately and clearly. So, the review illustrates that from an anthropological perspective, greater numbers of people are now living closer to forests (and rural areas in general), which although seemingly satisfactory and beneficial to them, has also led to an increase in the destruction of forests, due to intentionally, and unintentionally generated fires. In addition to the human impact, climate change and other natural phenomena are also destroying the forests. This review indicates the connection between wildfires and climate change, it also studies the effects of wildfires on health and air quality, in addition, the paper highlights the particularly challenging situation in India, which, due to its substantial share of global forestland, is proportionately more impacted by these fires. Besides, the review mentioned the analytical method to predict fire propagation.

INTRODUCTION

Wildfires affect communities and the environment all over the world as they losses of properties and life. This, in turn, leads to changes in the composition of the vegetation and eliminates the soil properties for years ahead. In addition, wildfires remodel the hydrological systems (Penman et al., 2020; Qiao et al., 2018; Szpakowski & Jensen, 2019). On the whole, the ecological system is our main concern due to the turmoil resulting from fires that kill off all kinds of vegetation (Kanga & Singh, n.d., 2017; Pausas & Keeley, 2014).

Wildfires, also known as forest fires, vegetation fires, wildland fires, grass fires, and hill fires, have affected the earth's surface and atmosphere for more than 350 million years (Doerr & Santín, 2016). Moreover, they are as old as the forest itself. Frequently, these fires tend to be unrestrainable since they usually occur in wild, densely forested lands, and can rapidly spread to adjacent populated areas and agricultural resources, causing further ruin and destruction (Aponte C et al, 2016). They have the potential to impact the ecosystem in two quite disparate ways; either by changing and renewing it or by annihilating it and fatally injuring wildlife in the process. Beyond the obvious destruction they cause, these fires also pollute the air with toxic gases and can contaminate vast areas, which negatively impacts people, livestock, and wildlife.

The initial phase of forest fires starts with a 'surface fire', after which then spreads to ravage neighboring trees, with its flames rising increasingly higher to become an uncontrollable raging 'crown'. So, it is discernable that a small portion of the early fire grows to become huge wildfires. Thus, they cause gigantic damage during the fire season as fire spread depends on the topography of terrains and fuels (Alcasena et al., 2015). These fires can be extremely hazardous, especially in pine forests, where they burn more intensely due to the highly combustible resin content in the tree trunks (V.K Bahuguna and A. Upadhyay., 2002). This leads to deforestation and a substantial increase in Carbon Dioxide levels and other toxic gases being released into the atmosphere. This in turn affects the habitats and distribution of numerous different living organisms (Ajin et al., 2015). In addition to their obvious economic and destructive ramifications, these fires also detrimentally impact human health, psychological problems, and social situations, and they increase human fatality rates; resulting in tragic and long-lasting impacts (Doerr & Santín, 2016).

When all causes are considered, the key factors causing the occurrence of wildfires can be summarized as ignition factors, climatic conditions, human activities, and fuel availability in terms of its type, quantity, and degree of humidity. All these factors may also influence the behavior and frequency of forest fires (Boegelsack et al., 2018). A fire regime has six key recognized components which have been classified as the fire size, frequency, intensity, seasonality, type, and severity (Rudolph et al., 2016). Wildfire severity is a crucial factor in the fire regime. It has an essential role in defining the forest ecosystem's response to fire disorder.

In general, fire severity is recognized through the changes in the ecosystem's size caused by that former (Fang et al., 2018). The authors indicated that many agents affect fire severity such as fuel, meteorology, and topography (Alvarez et al., 2013). It is remarkable, fire regimes are determined by the climate, weather, fauna, and direct human influences. Therefore, the data available on fire regime parameters will assist administrators to reduce the severity of fires and preserve ecosystems (Molina-Terrén et al., 2016). However, the climate is considered to be a major factor in the occurrence of fire patterns globally (Aponte et al., 2016). Forest fires have various behavior based on their sources and other factors (Güngöroglu, n.d., 2018).

It seems clear that climate change is causing drier and hotter summers, and so unsurprisingly the world is therefore experiencing more frequent incidences of wildfires. Consequently, this is increasing the release of damaging particulates and gases into the atmosphere, which in turn are further exacerbating the climate change problem itself (Boegelsack et al., 2018; Rudolph et al., 2016). Increases in greenhouse gases caused by human activities (CO2, CH4, CO, etc.) have been detected in the atmosphere, which in turn are driving up ambient temperatures, and thereby further increasing the combustibility of forests (Flannigan et al., 2006).

Terrain can also be a very significant factor that impacts the degree of spread of fires. As an example, if there are natural firebreaks such as hills, lakes, and rivers, this can limit the extent to which fires spread. Furthermore, the direction and slope of the terrain will also have an impact. Weather conditions can be a critical ignition factor too. For example, lightning can ignite forest fires, and wind speed and direction may also substantially determine its severity.

Additionally, there is the human factor to consider. Various 'man-made' activities such as the expansion of agricultural land and urban expansion (Flannigan et al., 2006), as well as those human activities that result from inadvertence or accidents (Doerr & Santín, 2016), can also be major determining factors affecting fire regimes. In particular, the importance of changes in fuel flammability and fuel loading becomes even more critical in the context of climatic changes, however, this remains largely unexplored due to the limited available data (Turco et al., 2014).

There are also a variety of factors that determine the time a combusted area needs to recover, such as the depth of combustion in organic and mineral soils, the degree to which vegetation cover has been consumed, and the proportion of area that is less affected by fire (Doerr & Santín, 2016). This paper summarizes all facts about the causes and effects of wildfires. The concepts of analysis and best methods to decrease are elaborated.

MATERIALS AND METHODS

Since the study is based on secondary data, the data were collected from research articles and web-based information. Case studies, data analysis, and simulation methods have been applied in previous research to get the severity of wildfires and predict the occurrence of wildfires and reduce the negative effects of fires on the environment and humans. The study of factors that lead to the occurrence of wildfires helps in determining fire severity and behavior and assists our efforts to take precautions to preserve and protect natural sources and ourselves. Some of the factors rely on the fire station system to calculate the wind so that it helps in predicting the size and shape of the fire. Data analysis through the fire simulation model provides us with information about fire spreading speed.

RESULTS AND DISCUSSION

Wild Fires and Climate Change

Fires are labeled as devastating incidents that influence wildlife. Scientists anticipate an increase in wildfire actions due to climate change. This, consequently, leads to extreme weather conditions that would boost fire severity and frequency (Marino et al., 2014).

Considering the weather is the most changeable and great stimulus of a territorial burned area, wildfires take place when fuel, dry weather, and ignition source are available. High temperature (T), relative humidity (RH), wind (W), and rainfall affect wildland fire propagation averages and densities (Çolak & Sunar, 2020; Jolly et al., 2015; Parks et al., 2014). Authors suggested that global temperatures have raised by ~ 0.2°C per decade. Regional droughts are closely related to sea surface temperature variability, which demonstrates considerable attribution of burned area variations. Climate change is engaged in global fire varieties which lead to more rough fire seasons next decade (Jolly et al., 2015).

Climate change is increasing the severity, frequency, and duration of forest fires, and this is leading to longer seasons of fires, such as has recently been experienced in California. Here, the increased outbreak risks caused by faster-melting snow and rising temperatures are significantly exacerbating the incidence and severity of wildfires, while also causing greater quantities of greenhouse gases to be released into the atmosphere (Rudolph et al., 2016). Furthermore, this situation is driving change to other weather variables, such as the magnitudes of wind and wind speed since it is one of the key factors that influence fire propagation as well as precipitation levels, and cloud cover (Flannigan et al., 2006; Lopes et al., 2019).

It has also been noted that the effects of climate change on forest fires, such as rising temperature, will result in increases in evaporation and transpiration, thereby reducing humidity (Boegelsack et al., 2018), the authors also cited that there is a connection between wind velocity and large fires (Abatzoglou et al., 2018). This will inevitably cause longer dry periods and accordingly optimize conditions for ignition. These higher temperatures will usually increase the incidence of thunderstorms and lightning (Boegelsack et al., 2018), and, as mentioned before, lightning itself is one of the common causes of forest fire outbreaks (Aponte et al., 2016).

It is anticipated that in areas where climate change leads to drought, there will be new fire protocols (Aponte et al., 2016; Ex et al., 2019). The authors noted that a change in fire regime causes a change in the forest structure, which in turn affects the competence of forests to sequester carbon in the future (Aponte et al., 2016). Moreover, climate change also has indirect consequences concerning forest fires, which include its impact on tree distribution and human health. It has also been demonstrated that forest fires affect fuel moisture and pest population, which may also have critical impacts (Boegelsack et al., 2018).

Forests in humid ecosystems with little seasonal rainfall are burned owing to extreme weather conditions which means that fire is no longer a progressive pressure (Pausas, 2015). The Intergovernmental Panel on Climate Change (IPCC, 2014) has offered in its fifth report screenplays of raising an average over a hundred years. Hence, this climatic change is expected to have specific outcomes of piecemeal change in ecosystems, and that affects the allocation and nature of the constative ecosystem's species which causes changes in ecosystem performance (Garbolino et al., 2015).

Wild Fires and Health

The forest is an oxygen factory on Earth that clears the air by purifying it of pollutants (Frantzana, 2021). The effects of forest fires are not only limited to the ecosystem but can also adversely impact humans and their health. Such effects may be immediate, short-term, or long-term (Frantzana, 2021; Rudolph et al., 2016). Human injuries related to wildfires are labeled in three forms:

1. Toxic gases inhale
2. Hot gases inhale
3. Skin thermal injury (Butler, 2104)

The inhalation of smoke and other toxic gases such as Carbon Monoxide (CO), can be particularly damaging to those who are more vulnerable, such as children, the elderly, pregnant women, and people suffering from heart diseases, respiratory illnesses, and cancers. Symptoms can range from fainting to dizziness, and even suffocation. Forest fire smoke can travel considerable distances, and even affect the quality of air inside homes, leading to inhalation of forest fire particulates (Rudolph et al., 2016).

As wildfires are the main source of particulate matter (PM), particularly during the hot season. (PM) increase the danger of respiratory disease, asthma, and lung cancer. (PM) is also linked with increasing precocious death (Wildfire Climate Change and Health, n.d., 2016). In addition, it is also worth mentioning that there can be psychological and mental health consequences, such as concentration problems, sleeping difficulties, anxiety, fear of death phobias, and depression (Rudolph et al., 2016; P. Bo Xu et al., 2013).

The Effects of Wild Fires on Air Quality

Forest fires cause air quality to be 5-15 times worse than on ‘normal’ days. Moreover, the degree of proximity to residential areas, and the size of the fire will both determine the degree of this poor air quality (Kenward et al., 2013). The smoke from these fires reduces the visibility in the proximity of the forest fires, and destroys the oxygen in the atmosphere, leading to serious health crises, due to the increased levels of carbon dioxide and greenhouse gases. Volcanoes are another natural cause of forest fires and can be an even larger source of pollution due to the enormous volumes of particles and gases released into the atmosphere, e.g., Sulphur and Carbon Dioxide emissions (Ladrach, 2009).

Wildfires are normally accompanied by a huge amount of pollutants such as ozone, carbon monoxide, and particulate matter are emitted as well (R. Xu et al., 2020). See Table 1. The authors mentioned that carbon monoxide encloses damaged areas by fires, while particulate matter and ozone spread over long distances (R. Xu et al., 2020). The essential products of wildfires are water and carbon dioxide with a minimum amount of hydrocarbons and carbon monoxide in Table 1 (Ladrach, 2009).

Table 1. Emissions from forest fires

Material	Percent
Carbon Dioxide (CO2)	67
Water Vapor (H2O)	25
Carbon Monoxide (CO)	6
Particulate Matters (Soot, Ash)	1

Source: (Ladrach, 2009)

Accurate emission figures for other chemicals such as Sulphur Dioxide (SO2), Nitrates (NO3), Nitrogen Oxides (NOx), and Hydrocarbons (HC) have also been quantified, although are not stated here (Ladrach, n.d., 2009).

Causes of Wildfires

Wildfires are not ordinary incidents, they also cause critical damage and can lead to deaths (Jazebi et al., 2020) causing loss in economic and social life, poor air quality degradation, and an increase in landslides (Mangiameli et al., 2021; Zigner et al., 2020). Official reports have shown that approximately 85%-90% of forest fires are caused by equipment failure or by human errors or interventions, such as the careless throwing away of cigarettes, burning of debris, unorganized camp fires arson, and use of equipment that ultimately malfunctions. There are also many other causes, such as the burning of dry grass, fireworks, and electrical system faults (Jazebi et al., 2020).

In addition to that, the process of clearing cultivation leftovers (Kumar, 2020) due to neglected land by farmers (Mahfoud, 2020) can also play a primary role in forest fires, in addition to burning the detritus by population in some areas (Kumar, 2020). The authors noted that the populations have a key role in world fire activity (Coogan et al., 2019). The impacts of the growing world population and climate change on future fire systems are still now under argumentation. The relationship between wildfires and the human population is complicated due to anthropogenic ignitions, fuel production, fuel crash, and cultural attitudes (Balch et al., 2017; Coogan et al., 2019). Furthermore, abandoned uncultivated agricultural land has been expanding widely, which leads to randomly unwanted vegetation growth and so accelerates fire risk caused by fuel accumulation in the forests (Moreira & Pe’er, 2018).

Speaking of natural causes of wildfires, volcanic eruptions, thunderstorms, and lightning (Jazebi et al., 2020), it’s worth mentioning that the prospect of fire spread relies on topography (slope, elevation, and aspects), vegetation type, fuel moisture content, and wind speed and tendency (Trucchia et al., 2020). The authors pointed out that naturally-caused forest fires are an important reason to reduce the forest area and can negatively remodel the environment (Kukhar et al., 2020). It is explicit that the recently experienced extreme climate changes are playing a fundamental part in this respect, as mentioned above (Jazebi et al., 2020). The authors showed that moisture content, wind speed, fuel load, and slope are major components in fire spreading (Burrows et al., 2018).

Wild Fires in India

India's geographical area is estimated at 328 million hectares, of which approximately 80 million hectares are covered by forest or tree cover, and there are four principal types of forest. Tropical forests represent 80% of the forested area, and the tropical wet and dry forests are particularly vulnerable, representing 64% of the total forested areas. It is worth mentioning that bushlands, desert lands, and vegetation land with eminent shrubs, encompass an important component of the vegetation of temperate and subtropical climates (Anderson et al., 2015).

According to the Ministry of Environment and Forests and the Government of India, 3.73 million hectares of forests in India are affected annually by fires, and about 90% of these fires are caused either by man-made activities, human error, or neglect, e.g., grazing, agricultural shifting, cultivation, the collection of small forest products and nectar, nature trips and camping (Boegelsack et al., 2018; Rudolph et al., 2016).

The risk of forest fires is proportionately higher where the density of human and livestock population is greater, and is further adversely affected by the increase in demand for forest products. Broadly we can classify the causes of these fires into two categories: natural causes and human causes.

Natural causes are those that are related to extreme weather conditions, such as the aforementioned high temperatures, humidity, speed and direction of winds, and long periods of drought. While human causes are usually due to forest management methods, and other human-initiated intentional or unintentional fires. As an example, villagers sometimes set fires to keep wild animals away, and, inadvertently. These can become uncontrollable (P. Bo Xu et al., 2013). Whether of natural or human origin, forest fires can cause catastrophic destruction over a relatively short time. They lead to the decline and destruction of organisms, as well as soil erosion, due to the lack of bonding that would otherwise come from natural weed and bush growth (Ajin et al., 2015).

Since Indian forests are rich in environmental resources, representing 60-70% of global biodiversity, from a broader perspective, these fires are having a devastating impact on the Earth's overall biodiversity. Moreover, the renewal of economic plant species has also slowed down due to the recently-experienced increased incidence of fires. Pine and oak seedlings have been completely eliminated in some of India's forests, and plant and animal groups are being completely wiped out in northern Himalayan forests due to summer fires there. Nests, burrows, and eggs are also being destroyed, and the species of animals that do not have enough agility to escape rapidly advancing fires, such as the smaller ones, are being killed (Sewak et al., 2021).

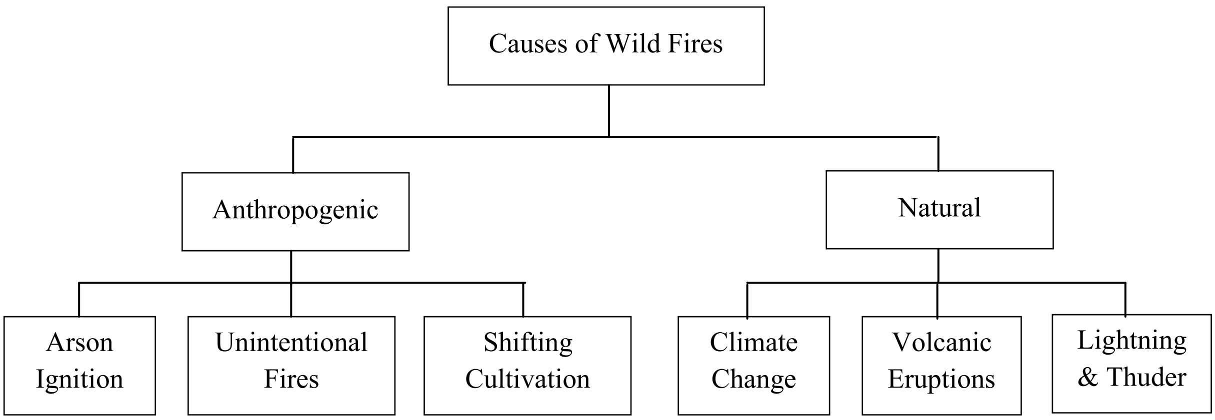

Figure 1. Causes of Wild Fires

The study found that bushland and pastureland are more prone to ignition nature due to their unique characteristics regarding flammability and ignition speed. Authors suggested that the fires that may occur in bushland are related to that restoration rate, as they recover fast after the fire. This, in turn, leads to fuel production shortly afterward which the forest takes a long time to regenerate (Oliveira et al., 2014). Shrubland fires can spread fast under moderate burning conditions and they can turn into intensive fires under extreme conditions destroying society and the environment (Cruz et al., 2013). Land cover may limit fire improvement when forests mingle that decreasing fire spreading. On the other side, topography plays a key role in fire ignitions, and areas with a slope of 25% have a negative role in fire spreading (Oliveira et al., 2014).

Fire Spread Simulation

Forest fire spreading models (FFSM) has evolved for over 60 years. Basically, these models provided a scientific technique to locate a spreading speed that could easily be matched with the observed prevalence rate (Filippi et al., 2014). FFS demands various data which is divided into two essential categories: dynamic and static data (Brun et al., 2017; Filippi et al., 2014). Dynamic throughput data keep steady during the prediction term (Brun et al., 2017), and static data is available for all forest fires that occur in the same area, which includes flora and topographic information (Brun et al., 2017). A Flora map (vegetation map) is also known as a fuel map. It shows us the vegetation variety of the forest. Each vegetation sort has specific characteristics such as moisture content, fuel type, flammability, and intensity. Topographic information includes elevation, slope, and aspect (Brun et al., 2017).

CONCLUSION

Forest fires have a catastrophic impact on human beings and the ecosystem. This can lead to serious health problems and destroys the environment and vegetation. It is now clear that there is a definite connection between climate change and the incidence and magnitude of wildfires. It is noticeable that wildfires have increased during the last decade, and so we must now take urgent prevention measures to deal with these threats. Actions should include better-controlled fires, and protecting plants and animal species through the creation of public awareness schemes and establishing rules that restrict camping in forests and the setting of fires there. To conserve and preserve our environment and ecosystem we must now take serious and sustained action to save our precious woodlands and general environment.

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