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A study on Socio-Economic and Ecological consequences of Forest Fires in Uttarakhand India

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ABSTRACT:

Uttarakhand known for its Glaciers, holly rivers, biodiversity, peaceful and pollution free environment since ancient period. This is a land of spirituality, land of Tap and land of God (Devbhoomi). Famous Hindu temples Kedarnath, Sri Badrinath, Yamnotri and Gangotri located in this state. The origin point, Gaumukh of river Ganga also located near Gangotri. The state has total area of 53,566 km2 ,86% land of state covered with mountain and 65% area of the state covered with forest. The vegetation of the state can divide into four zones i.e., Sub-tropical, temperate, sub alpine and alpine. Temperate, sub alpine and alpine zones have occupied by mainly various species of Pinus (Chir) with several other species of plants. The dry chir leaves usually cover the almost all forest land during summer seasons. The dry leaves of chir are useless. Some locals use these leaves for cattle bed and sheds only. During summer season these leaves caught fire and massively damage the vegetation and wild life of the state. The forest fires are also responsible for loss the human life also every year. Government spends about Rs. 2500 to 3000 lacs of amount to protect the forest from fire and forest management every year. The proper utilization and management of chir leaves may be very useful to control the forest fire. The chir leaves can be used properly precured and processed to convert into brickgettes. These brickguetts are used in several industries for fulfilment of energy. The proper use of chir leaves not only prevents damages of forest and wild life it also reduces the forest fire prevention cost. The industries based on chir leaves also generate revenue and employment of the state. Such industries may help to make woman groups economically sound.

KEYWORDS: Chir leaves, Pirule, Devbhumi, Glaciers, Heritage

1. INTRODUCTION:

Uttarakhand formerly known as **Uttaranchal** (the official name until 2007), came in existence as 27 state of India on 2nd November 2009. It is often referred to as the "Devbhumi" (lit. 'Land of the Gods') due to its religious significance of this state. Famous spiritual places called *CHAR DHAM* of northern India i.e., Gangotri, Yamnotri, Kedarnath and Badrinath situated in this state. Besides these



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numerous Hindu temples, pilgrimage centers, tourist places and adventurous sports centers also found throughout the state. Uttarakhand is known for the natural environment of the Himalayas, the Bhabar and the Terai regions. Physio- graphically this state can be divided into three zones namely the Himalaya, Shivalik and the Tarai region. Uttarakhand has a total area of 53,566 km² (20,682 sq. mi) of which 86% is mountainous and 65% is covered by forest. The recorded forest area (RFA) in the State is 38,000 sq km of which 26,547 sq km is reserved forest, 9,885 sq km is protected forest and 1,568 sq km is unclassed forests. Most of the northern part of the state is covered by high Himalayan peaks and glaciers. In the first half of the nineteenth century, the expanding development of Indian roads, railways and other physical infrastructure was giving rise to concerns over indiscriminate logging, particularly in the Himalaya. Two of the most important rivers originate in the glaciers of Uttarakhand, the Ganges at Gangotri and the Yamuna at Yamunotri. They are fed by myriad lakes, glacial melts and streams. According to the 2011 Census of India, state has a population of 10,086,292, making it the 20th most populous state in India. Uttarakhand state surrounded by the Tibet Autonomous Region of China to the north, the Nepal to the east: the Indian states of Uttar Pradesh to the south and Himachal Pradesh to the west and north-west. The state is divided into two divisions, Garhwal and Kumaon, with a total of 13 districts. The winter capital of Uttarakhand is Dehradun, the largest city of the state, which is a rail head. Gairsain, a town in Chamoli district, is the summer capital of Uttarakhand. The High Court of the state is located in Nainital.

Due to the diverse nature of forest in Uttarakhand these forests are prone to forest fires. The state is richly forested and typically exhibits forest fire activity from February to June, with a peak in fire incidence in May and June. Forest fire is one of the major disasters in the forests of Uttarakhand. These are many indigenous and endangered floral and faunal species which are adversely affected due to forest fires. The forest fires have been categorized into three types:

- Ground fires
- Surface fire
- Crown fires.

Ground fires are not easily predictable it consumes organic matter like duff, musk or peat present beneath the surface litter of the forest floor. Surface fire is characterized by the fast moving fire which consumes small vegetation and surface litter along with loss debris and the Crown fire burns the top trees or shrubs without any close link with the surface fire.



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Map of India showing states



Map of Uttarakhand



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Topography of Uttarakhand



With the elevation of 7,816 metres (25,643 ft) above sea level, Nanda Devi is the highest mountain in Uttarakhand

With the elevation of 190 metres (620 ft) above sea level, Sharda Sagar Reservoir is the lowest land point in Uttarakhand.

Review of literature

Forest fires have become a recurrent and destructive environmental issue in Uttarakhand, a Himalayan state in India with over 45% forest cover. These fires not only affect biodiversity and ecosystems but also pose serious challenges to livelihoods and forest-based economies. Several studies have documented a rising trend in forest fire frequency in Uttarakhand over the last two decades. Binjola et al. (2022) documented that forest fires have shown increased frequency and spread across forest divisions, especially in pine-dominated areas. Chand et al. (2023) identified peak fire activity during April–May, driven by pre-monsoon drought and human activities.



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Forest fires in Uttarakhand are primarily attributed due to Anthropogenic factors: Including the burning of forest floor for fodder regeneration, collection of Mahua flowers, or clearing agricultural residue. Climatic factors which include rising temperatures and prolonged dry spells exacerbate fire risk. Negi (2022) highlighted the contribution of traditional slash-and-burn practices and unmanaged pine needle litter as fire hazards. Fires destroy habitats, especially in sensitive Himalayan ecosystems. Significant carbon stock loss from Chir Pine and Sal forests. Smoke-related respiratory issues have been reported among local populations. Gupta & Mishra (2024) examined the carbon and ecological losses from 2016 fires and estimated damages to run into crores of rupees. In 2018, a massive forest fire caused damages worth lakhs. The fire affected various regions, leading to significant economic losses(India Today 2018). Insufficient infrastructure, policy gaps and limited community involvement are also responsible for forest fire in Uttarakhand. The National Green Tribunal (NGT) report (2024) noted that Uttarakhand lacks a dedicated forest fire cell and has poorly maintained fire lines. A study by Tiwari et al. (1986, 1987) reported significant annual forest fire incidents in Uttarakhand, with areas affected ranging from 562.44 hectares in 2005–06 to 4,983 hectares in 2002–03. The economic losses varied annually, with the highest recorded in 2003–04 at ₹13.14 lakhs. Approximately 4,538 hectares were affected by nearly 1,600 fire incidents, leading to nine fatalities and significant impacts on wildlife and tourism(Wikipedia). At least 11 forest fire incidents were reported across Uttarakhand on May 22, 2015. These were caused by flints flaring up under strong winds and rising temperatures. The fires destroyed about 14.25 hectares of forest, with the maximum damage in Dehradun alone (about 5.75 hectares). However, no loss of life was reported (Hindustan Times. (2015, May 22). During 2016 Six people, including three women and a child, were killed in fire-related incidents. Additionally, seven others were injured (Times of India. (2016, April 30). Fires destroyed critical habitats for ground-nesting birds, mammals, reptiles, and insects. Forest fires in wildlife reserves (e.g., Corbett Tiger Reserve, Rajaji National Park) forced animals to migrate and disrupted breeding cycles. Species like the Himalayan monal, cheer pheasant, yellow-throated marten, and butterflies (e.g., Byasa polyeuctes) lost breeding grounds and food sources due to repeated fires (Economic Times 2019). Joshi, R. et al. (2018) observed that fires led to loss of topsoil and microbial biodiversity. The organic layer critical for decomposition and nutrient cycling was often destroyed, affecting root and fungal interactions. Repeated fires lead to fragmentation, making it harder for species to migrate and breed (Rawat and Sharma, 2015)

2. MATERIALS AND METHODS:

This paper is based on extensive review of literature and in-depth discussions with a range of stakeholders (viz., local people, forest officials and field staff, researchers and academicians). Data regarding forest fire from 2015-2022 have been taking from official website of Uttarakhand Forest Department. The information was pooled and synthesized and put in the context of a popular document providing forest fire management points in anticipation that it will invite attention of a wider section of society and sensitize them to take proactive role to save the forest wealth and biodiversity.

The study focuses on the state of Uttarakhand, India, which is characterized by its hilly terrain, rich biodiversity, and significant forest cover. of specific regions within Uttarakhand that have been frequently affected by forest fires, including areas like Kumaon and Garhwal. Conduct structured surveys and questionnaires with local residents, forest officials, and other stakeholders to gather firsthand information



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on the socio-economic impact of forest fires. Conduct in-depth interviews with affected families, community leaders, and local business owners to understand the direct and indirect impacts of forest fires on their livelihoods and well-being. Utilize reports and data from the Forest Department of Uttarakhand, disaster management authorities, and other relevant government agencies. Review academic papers, articles, and previous studies related to forest fires and their socio-economic impacts. Use satellite imagery and remote sensing data to assess the extent of forest fires and the areas affected over time. Calculate the economic losses due to forest fires, including damage to property, loss of timber, agricultural losses, and costs associated with firefighting and rehabilitation efforts. Employ statistical tools and software (e.g., SPSS, R) to analyse survey data and quantify the socio-economic impacts. Analyse qualitative data from interviews and open-ended survey responses using thematic analysis to identify key themes and patterns related to the social impacts of forest fires Examine the effects of forest fires on socio economic public health, including respiratory issues and other fire-related injuries. Assess the impact on livelihoods, particularly for those dependent on forest resources, agriculture, and tourism. Investigate patterns of migration due to loss of homes and livelihoods. Study the disruption of educational services and impact on children's education in affected areas. Explore changes in community dynamics, social cohesion, and mental health issues arising from the trauma of forest fires. Review existing forest fire management and mitigation strategies implemented by the state government and local communities. Develop evidencebased recommendations for improving forest fire management, enhancing community resilience, and reducing the socio-economic impacts of future forest fires. Ensure that all participants in surveys and interviews provide informed consent. Maintain the confidentiality of respondents' identities and personal information. Take steps to minimize any potential distress or discomfort caused to participants during data collection. This comprehensive material and methods section will provide a robust framework for assessing the socio-economic ramifications of forest fires in Uttarakhand.

3. OBSERVATIONS:

Incidents due to Forest Fire-

Uttarakhand state is one of the Himalayan states full of forest wealth. The recorded forest area in the state is (38,000 sq km), of which 26,547 sq km is reserved forest, 9,885 sq km is protected forest and 1,568 sq km is unclassified forest. Forest fire incidents are frequent in Uttarakhand due to abundant dry leaves of pine shaded during summer season. Perusal of data from table 01 and figure 01 shows that 13643 incidents occurred during 2015 to Nov 2023 in Uttarakhand. Highest number of forest fire incidents in this duration (2813) recorded during 2021 followed by 2186 during 2022. During 2016 and 2018 more than 2000 incidents of forest fire recorded. The minimum forest fire incidents (135) recorded during 2020. Observation shows that most of the fire forest incidents found in reserved forests (RF). On an average more than one thousand per year forest fire incidents recorded in between 2015 to Nov 2023. The highest fire incidents 1835 recorded in reserve forests (RF) during 2021 followed by1641 incidents during 2019. Minimum forest fire incidents in reserve forest observed during 2020. Only 73 incidents of forest fire incidents found in this year. Almost same year wise pattern of forest fire followed in soyam and van panchayat forests but less in number in comparison to reserve forests. The maximum forest fire incidents (978) recorded in year 2021 followed by 744 during 2016 in swam/van panchayat forests. The minimum forest fire in soyam and vanpanchayat (62) recorded during 2020. On the basis of media report fire forest incidents increased during 2023 to June 2024. Uttarakhand experienced widespread forest fires, with 11,256 incidents reported across 11 of its 13 districts from November 2023 to June 2024.



Forest Fire and Affected Area-

During 2015 to Nov 2023 Forest fire affect about 22528.21-hectare (225.28 sq. Km) forest area (Table 02). The maximum forest fire affected area 4480.04 ha(44.80 sq. km) recorded during year 2018 followed by 2016 (4433.75 ha or 44.34 sq. km). Minimum area affected (172.69) from forest fire found during 2020. Maximum area of reserve forest as well as Soyam or van panchayat forest affected during 2018 i.e. 2657.14 ha (26.57 sq. km) and 1822.9 ha (18.23 sq km) respectively. Perusal from table 02 shows that the reserved forests area affected more than swam and forest panchayats forests. During 2015 to Nov. 2023, 13145.65 hectares of reserved forest area and 7237.256 hectares of soyam and forest panchayat areas have been affected by forest fire. Among all studied years during 2018, 2019, 2021 and 2022, reserved forest areas found the most adversely affected by forest fire. During 2018, 2657.114 hectares of reserve forest area was affected by forest fire, while during 2021, 2552.55 hectares and during 2022, 2526.114 hectares of forest area was affected. The least reserved forest area was affected by forest fire during 2020. During 2020 only 68.33 hectares of reserved forest area was affected by forest fire. In Soyam and Van Panchayat area, maximum 1822.9 hectares of forest area was affected during 2018. During 2016 and 2021, 1607.5 and 1391.33 hectares of forest area were affected by forest fire respectively. The year 2020 was the least affected in the Soyam or Van Panchayat area where only 104.36 hectares of forest area was affected by forest fire.

Forest Fire and Economic Loss-

Forest fire damage the forest vegetation, wild life and soil flora and fauna as well as human lives. It also adversely affects the environment of affected area. The forest fires have led to considerable environmental and economic damage, with the Uttarakhand Forest Department reporting a revenue loss of over ₹368 million during year 2015 to 2022 (table3). The maximum revenue loss ₹ 89.25 lacks reported during 2022 followed by ₹ 86.05 lacks during 2018. Forest fire also responsible for loss of human lives. The maximum human lives loss 06 and 31 injuries recorded during 2018. There are 2 deaths in year 2020,2021 and 2022 recoded due to forest fire while during 2019, 15 injuries recorded. The forest fires in Uttarakhand have caused significant damage, affecting over 1,300 hectares of forest and resulting in the deaths of five people. The fires have been ongoing since November 2023, with nearly 1,000 incidents reported. The most recent victim, a 65-year-old woman, succumbed to burn injuries while trying to protect her farm from the encroaching flames.

Forest Fire and Biodiversity loss-

The effect of forest fires on biodiversity in Uttarakhand is significant and multifaceted, given the state's ecological richness and fragile Himalayan environment. Forest fires, whether natural or anthropogenic, have become a recurring problem—especially during the dry summer months—and have had serious consequences on flora, fauna, soil, and ecosystem services. Fires destroy vegetation including valuable species like Sal (Shorea robusta), Chir Pine (Pinus roxburghii), and Banj Oak (Quercus leucotrichophora).Due to Forest fire sensitive seedlings and undergrowth are burnt, inhibiting natural forest regeneration and altering species composition over time. Forest fire adversely affect the fauna of this region the ground-nesting birds, small mammals, reptiles, and insects lose their homes. Fires fragment



habitats and force wildlife to migrate or perish. Many species—such as the Himalayan Monal, leopards, and deer—face breeding disruptions during fire seasons.

Fires burn the nutrient-rich topsoil and organic matter, leading to erosion and lower fertility. Beneficial microorganisms, fungi, and bacteria critical for nutrient cycling and plant health are destroyed due to forest fire. Forest fires reduce canopy cover, affecting groundwater recharge and local water availability. Burning of biomass releases large amounts of CO₂, reducing the forest's carbon sequestration capacity and contributing to climate change. Several species like the cheer pheasant, yellow-throated marten, and various butterfly species are at risk due to habitat loss and ecosystem imbalance.

Table 01

FOREST FIRE INCIDENCS FROM 2015 TO 2023 IN UTTARAKHAND						
YEAR	INCIDENCE NUMBER IN RF	INCIDENCS IN CIVIL SOYAM/VAN PANCCHAYAT	TOTAL INCIDENCES			
2015	332	80	412			
2016	1330	744	2074			
2017	500	305	805			
2018	1498	652	2150			
2019	1641	517	2158			
2020	73	62	135			
2021	1835	978	2813			
2022	1566	620	2186			
2023 Upto 01 Nov			910			
TOTAL	8775	3958	13643			



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Table No.02

Forest area affected due to forest fire during 2015 to Nov 2023 in Uttarakhand

AFFECTED AREA DUE TO FOREST FIRE FROM 2015 TO Nov.2023 IN UTTARAKHAND					
YEAR	AFFECTED RF AREA(HA)	AFFECTED CIVIL SOYAM/VAN PANCHAYAT AT (HA)	TOTAL AFFECTED AREA (HA)		
2015	585.65	115.96	701.61		
2016	1826.25	1607.5	4433.75		
2017	727.24	517.4	1244.64		
2018	2657.14	1822.9	4480.04		
2019	2202.35	779.2	2981.55		
2020	68.33	104.36	172.69		
2021	2552.55	1391.33	3943.88		
2022	2526.14	898.91	3425.05		
2023 Nov 01			1145.00		
Total	13145.65	7237.56	22528.2		



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Table 03

LOSSES DUE TO FOREST FIRE FROM 2015 TO Nov 2023 IN UTTARAKHAND					
YEAR	EVALUATION OF LOSSES IN RS.	HUMAN DEATH	HUMAN INJURY		
2015	794356	0	0		
2016	1826.25	6	31		
2017	1834311	0	1		
2018	8605375	0	6		
2019	5592588	1	15		
2020	456855	2	1		
2021	10603439	2	3		
2022	8925638.5	2	7		
2023 01 nov	2397220	05	Not available		
Total	36814388.75	13	64		

Human deaths. Injury and economic losses due to forest fire during 2015 to 2022 in Uttarakhand

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Forest fire incidences during 2015 to 2022



Forest area affected due to forest fire during 2015 to 2022 in Uttarakhand

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Human deaths. Injury and economic losses due to forest fire during 2015 to 2022 in Uttarakhand



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Forest Fire: burning vegetation



Massive burn of Forest



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Forest workers extinguishing forest fire

4. CONCLUSION:

The forest fires in Uttarakhand have been a devastating event, leading to significant loss of life and environmental damage. Since November 2023, in this year the forest fires have affected over 1,300 hectares of forest, resulting in the deaths of five individuals. The severity of the fires is attributed to a combination of factors, including the presence of highly flammable pine trees and possibly human activities. The fires have caused considerable economic loss to the Uttarakhand Forest Department, amounting to over ₹25 lakh during 2023. In response to the ongoing crisis, state officials have implemented measures such as banning the burning of fodder and solid waste near forests, and there is hope that the forecasted rains will help in controlling and extinguishing the fires. The authorities are also focusing on enhancing coordination and monitoring efforts to prevent further damage. Overall, the conclusion of this event highlights the need for better forest management practices and more effective firefighting strategies to mitigate the impact of such disasters in the future.

5. OUTCOME OF PRESENT STUDY:

Conducting research on forest fires in Uttarakhand can yield numerous benefits, impacting various sectors such as environmental conservation, public safety, policy-making, and community awareness. This study may be helpful to enhance scientific understanding about data collection regarding the frequency, causes, and patterns of forest fires in Uttarakhand. It also helpful to understand how forest fires affect biodiversity, soil health, water resources, and climate. The present study helps to policymakers develop effective forest fire management strategies based on scientific evidence and resource allocation, environmental conservation, biodiversity protection, ecosystem restoration, public safety and health, risk assessment, health Impact, community awareness and engagement, technological advancements, fire detection and monitoring, remote sensing, economic benefits and climate change mitigation.



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