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FOREST FIRE SUSCEPTIBILITY MAPPING USING GIS AND REMOTE SENSING IN HIMACHAL PRADESH

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Abstract

This paper utilizes remote sensing and GIS tools to investigate the susceptibility of forest fires in Himachal Pradesh, a state located in Northern India. The study examines several factors, including topography, vegetation cover, temperature, and human activities, to identify regions at high risk of forest fires. The findings reveal that the state's mountainous forests and dry weather conditions increase its vulnerability to forest fires. The study stresses the importance of conducting a thorough evaluation of the susceptibility of forests to wildfires to manage and control ignition sources and decrease the impact of forest fires. This study aims to evaluate the susceptibility of forest fires in Himachal Pradesh by analysing various independent variables. The study area covers the entire state of Himachal Pradesh, and geospatial technologies such as Arc GIS, remote sensing, and Google Earth were utilized to identify areas that are susceptible to forest fires. The variables analysed include slope, aspect, elevation, land surface temperature, proximity to roads and settlements, and the fire risk index model. The findings provide a comprehensive understanding of the forest fire risk in Himachal Pradesh, which can help policymakers in formulating effective strategies for forest fire management and prevention. Furthermore, this research emphasizes the effectiveness of remote sensing and GIS tools in evaluating forest fire susceptibility and serves as a valuable resource for forest managers and policymakers in developing strategies for forest fire prevention and management in Himachal Pradesh.

Keywords : MODIS; GIS and Remote Sensing; Forest Fire susceptibility; Fire risk.

1.Introduction

Wildfires in forests pose a significant environmental threat, as they can inflict extensive harm to the natural ecosystems, habitats of wildlife, and human settlements (Phan et al., 2021)(Jung and Kim, 2013). The occurrence of wildfires worldwide plays a significant role in shaping and altering ecosystem dynamics. (Krawchuk et al., 2009)(Upreti, 2023). Changes in land use, climate, and atmospheric composition are causing alterations in the occurrence, strength, and geographical range of wildfires. (Bowman et al., 2009). Forests have a central role in maintaining ecological equilibrium and have played a vital part in shaping the course of human civilization (Tiwari et al., 2021).Persistent high temperatures and a series of extreme weather events have contributed to the rise in forest fires in central India. (Jain et al., 2021). Most forest fires are caused by human activities such as the collection of non-timber forest products and agricultural practices (Gcs, 2021). It is difficult to evaluate and track worldwide patterns and changes in forest fire occurrences due to the insufficient spatial and temporal coverage of data collected on the ground. (Giglio et al., 2023). The utilization of Google Earth Engine (GEE) and Quantum Geographic Information System (QGIS) platforms has enabled the calculation of bands and vegetation indices such as NBR, NDVI, and BAI, which highlight the extent of burned areas and the severity of burns using near-infrared (NIR) and shortwave-infrared (SWIR) wavelengths (Diwakar, 2023). This method is a cost-effective and time-efficient approach for detecting wildfire areas and mapping their severity in higher elevation regions. (Thapa, 2021). MODIS (Moderate Resolution Imaging Spectroradiometer) imagery is a useful tool for identifying these areas by gathering data on Land Surface Temperature, Burn Severity, Vegetation Indices, and Fuel Availability (Dhar et al., 2023)(Kanga et al., 2017). By utilizing middle and thermal infrared bands, the MODIS satellite can pinpoint thermal anomalies and generate fire locations with relatively high accuracy. (Petrov, 2020)(Khanal, 2015). The use of satellite-based remote sensing technology and GIS tools has proven to be effective in preventing and managing forest fires(Jaiswal et al., 2002)(Gai et al., 2023).

Himachal Pradesh, a state in India, is particularly susceptible to forest fires due to its vast forest cover and dry climate conditions. It is one of the most affected states in India in terms of annual forest fire damage. These fires not only threaten the state's biodiversity but also its economy, as many communities rely on forests for their livelihoods (Lamat et al., 2021). It is essential to comprehend and develop strategies to decrease forest fires, regulate and manage the causes of ignition, and recognize areas that are at risk.(Parajuli et al., 2020)(Loghin and Jacob, 2023). Therefore, conducting a thorough assessment of forests' susceptibility to wildfires, which takes into account both human and environmental factors, can be beneficial in addressing the problems related to forest fires (Sunar, 2023).

2. Study Area

Himachal Pradesh is a northern state of India that spans over an area of 55,673 square kilometres. (Balasubramanian, 2013) (Upgupta, 2015).. It is bordered by Jammu and Kashmir to the north, Punjab to the west, Haryana to the southwest, Uttarakhand to the southeast, and the Tibet Autonomous Region of China to the east with a population of approximately 7 million people as per the Census of India conducted in 2021. The combined forest and tree cover in Himachal Pradesh amounts to 15,453 square kilo meters, which constitutes 27.76 percent of the state's total geographical area. (Negi, 2017). Himachal Pradesh's forested regions, located in the Indian Himalayan region (IHR), are mountainous and hilly and spread over three climatic zones - the outer Himalayas, inner Himalayas, and Alpine zone. The state lies between latitude 30° 22′ to 33° 12′ N and longitude 75°45′ to 79° 04′ E, with altitudes ranging from 248 meters to 6735 meters above mean sea level. The important factors identified to affect forest fires include first and secondary topography, climate, vegetation cover and related human activities (JoR Eslami, M Azarnoush and Urnal, 2021).The Topography of the state is characterized by high-altitude mountain ranges, sub-tropical forests, and dry climatic conditions, which make it prone to forest fires that mainly occur during the summer months. The Himalayan range exhibits a wide variation in climate and vegetation as elevation changes, ranging from glaciers at the highest points to subtropical forests at lower elevations. The highest elevations are covered by ice and rock, while grasslands and scrublands can be found between 3,000 and 5,000 meters. Temperate coniferous forests are located just below the tree line, transitioning to temperate broadleaf forests between 3,000 to 2,600 meters. These broadleaf forests are found between 2,600 to 1,500 meters, while the Himalayan subtropical pine forests mix with moist deciduous forests in lowland plane areas below 1,500 meters. The summer season typically starts in March or April and lasts until May or June, while the monsoon season arrives from June onwards (Ahmad and Goparaju,2018). The primary factors contributing to forest fires in the state include natural phenomena like lightning strikes, anthropogenic activities such as agricultural burning, and human-induced causes like unattended campfires and cigarette smoking. The incidence of forest fires is rapidly increasing, causing extensive damage to forest ecosystems and landscapes (Dutta et al., 2023)The rugged terrain of the state, along with limited access to some areas, makes it challenging to control forest fires once they begin (Gaur et al., 2021).

3. Materials and methods

3.1 Independent variables

In this study, independent variables directly associated with forest fires were considered. These variables include aspect, slope, elevation, vegetation, temperature, roads, and settlements (Heidarlou et al., 2023). (Figure 3)

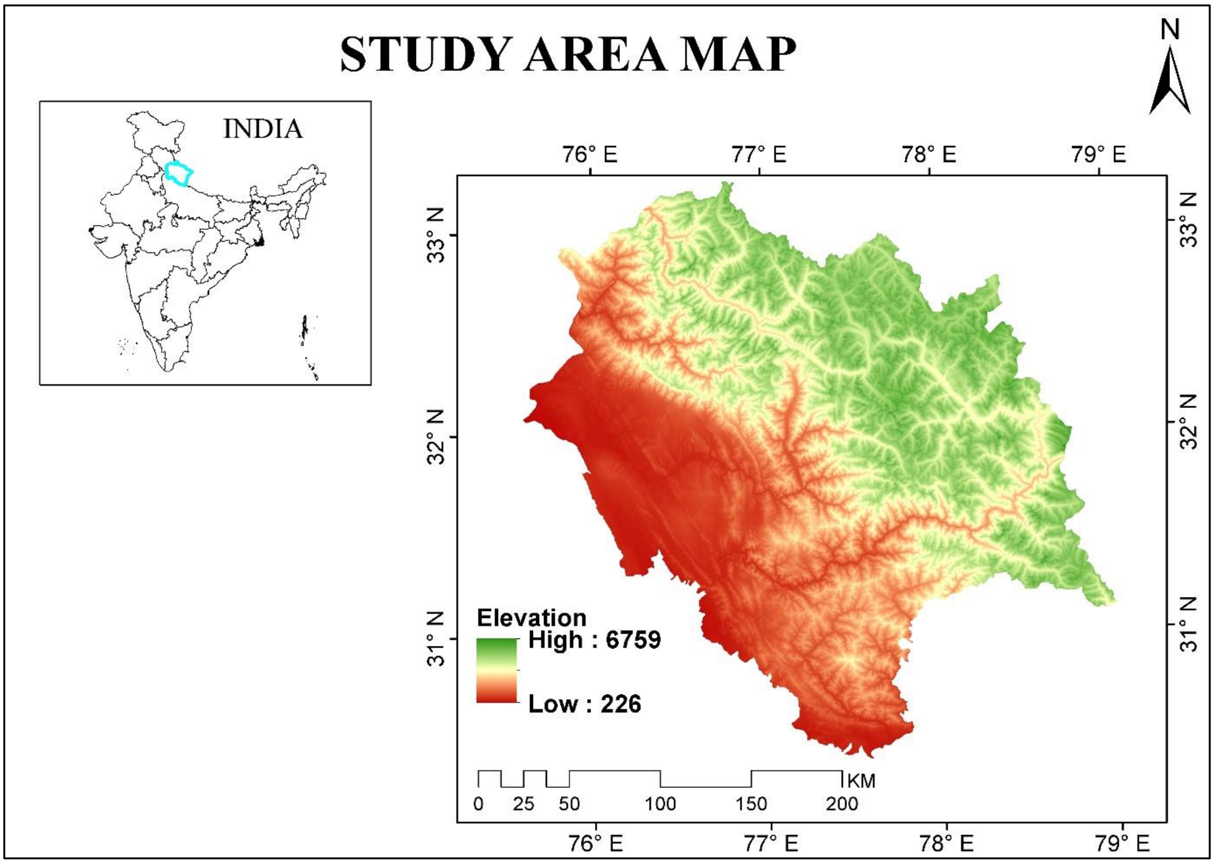


Figure 1. Study area map

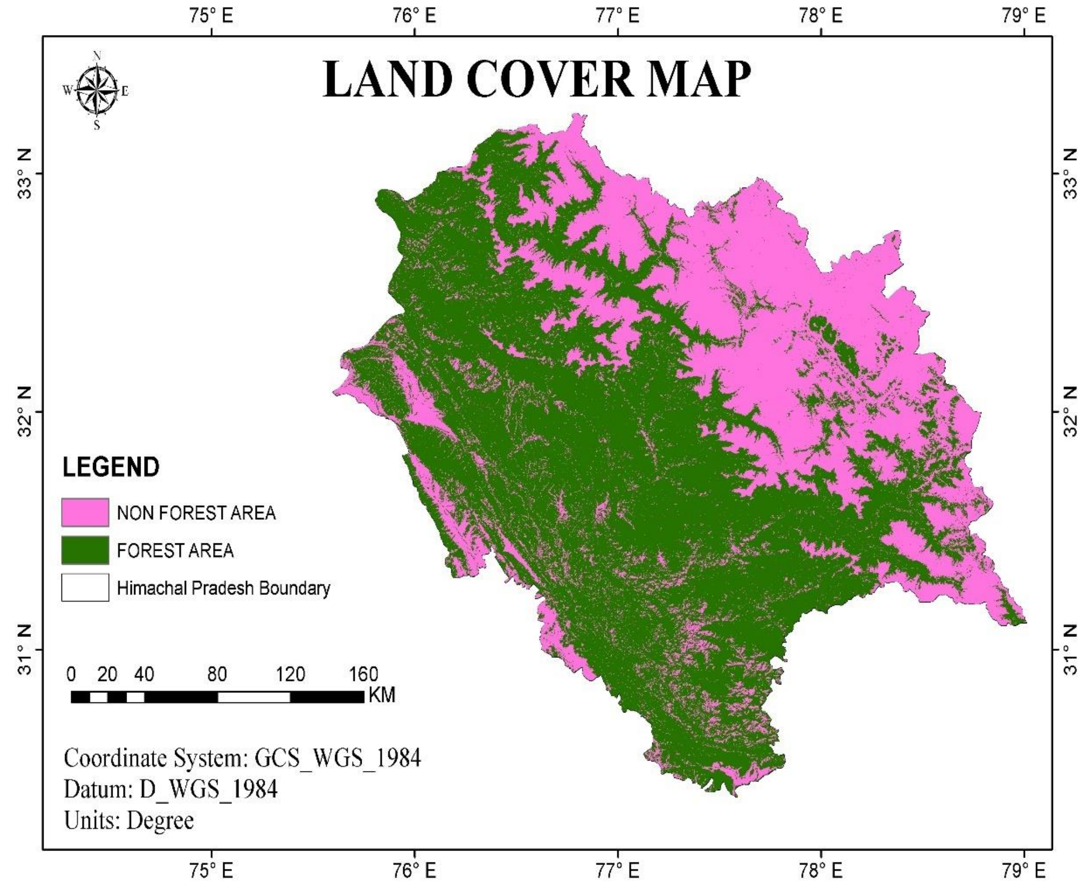


Figure 2. Land cover class of the study area.

DATASET	FILE TYPE	DATA TYPE	DETAILS	SPATIAL RESOLUTION	SOURCE
ASTER DEM	Tiff	Raster	Elevation, Slope, Aspect	30m	USGS
LAND COVER	tiff	Raster	Land Cover Classes of Himachal	30m	Bhuvan official website
Land Surface Temperature	HDF	Raster	Monthly temperature (8day data)	1 km	USGS/MODIS/ MOD11A2 V6
Study Area Boundary	SHP	Polygon	Outlines of study area (Himachal)		ARCGIS online
Settlement Points	SHP	Points	Cluster of settlements		Google Earth

Table 1. Dataset used in the study.

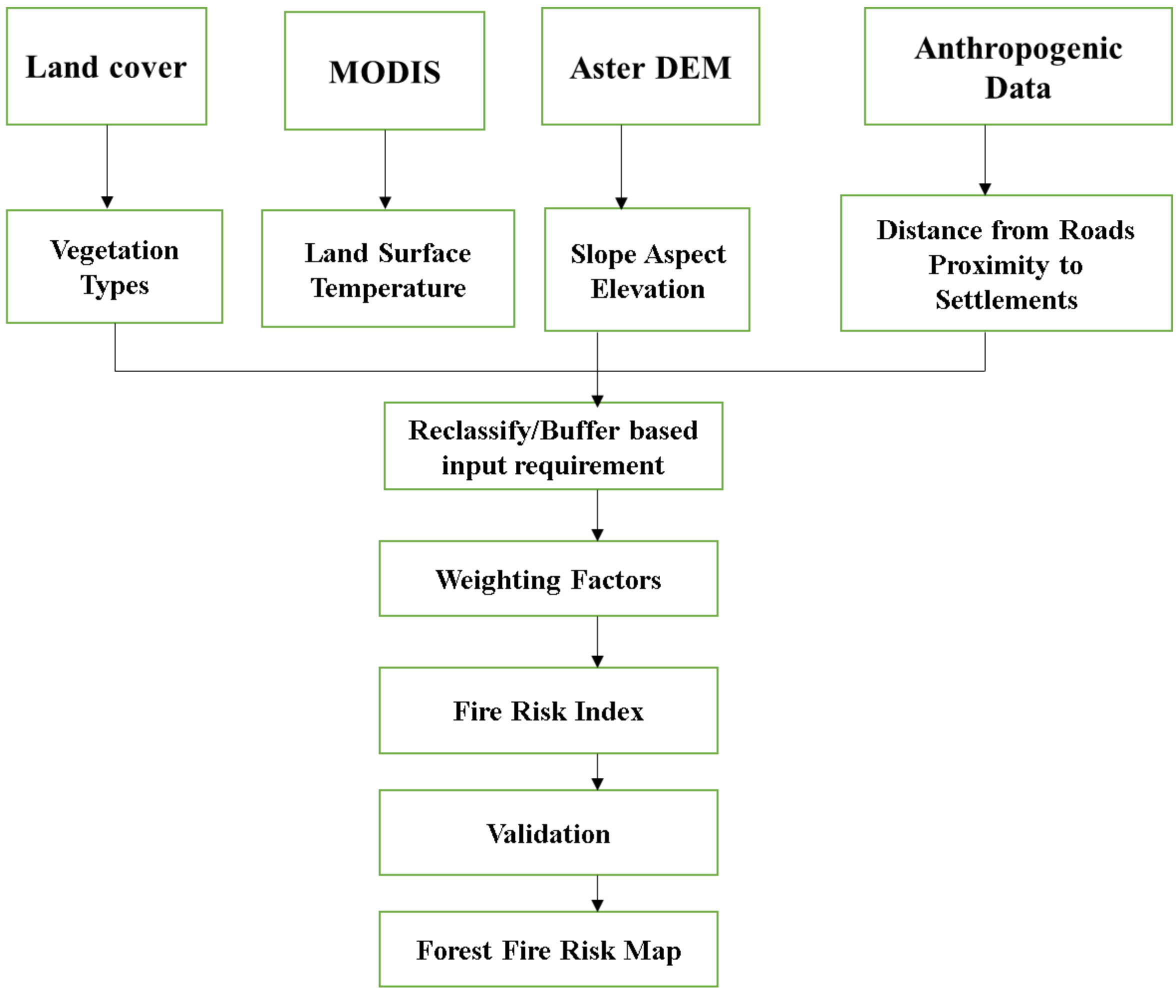


Figure 3. Methodological framework.

3.1.1. Topography

Himachal Pradesh is a state with diverse topography, ranging from high-altitude mountain ranges to fertile valleys characterized by the presence of several mountain ranges, including the Pir Panjal, Dhauladhar, and Shivalik ranges. With an average elevation of 6,500 feet (1,981 meters) above sea level and several peaks over 20,000 feet (6,096 meters (Forest Survey of India, 2019). The topography is also marked by deep gorges, river valleys, and plateaus, which are home to a wide range of flora and fauna. Due to its mountainous terrain, the state faces unique challenges in land use and management, including forest fire management. Several studies have examined the impact of the state's topography on forest fires, including Kumar et al.'s (2016) study, which used remote sensing and GIS techniques to map forest fires in the Chir pine forests of the state(Farooq et al., 2022)

Forest fire susceptibility was assessed by considering various factors such as topography, vegetation, human activities, and climate conditions. This was done using parameters like Digital Elevation Model, slope, aspect, distance from roads, and a fire risk index model. Forest fires have negative impacts on the ecological, economic, and social aspects of an area. (Deepa Rawat, V P Khanduri, 2020).

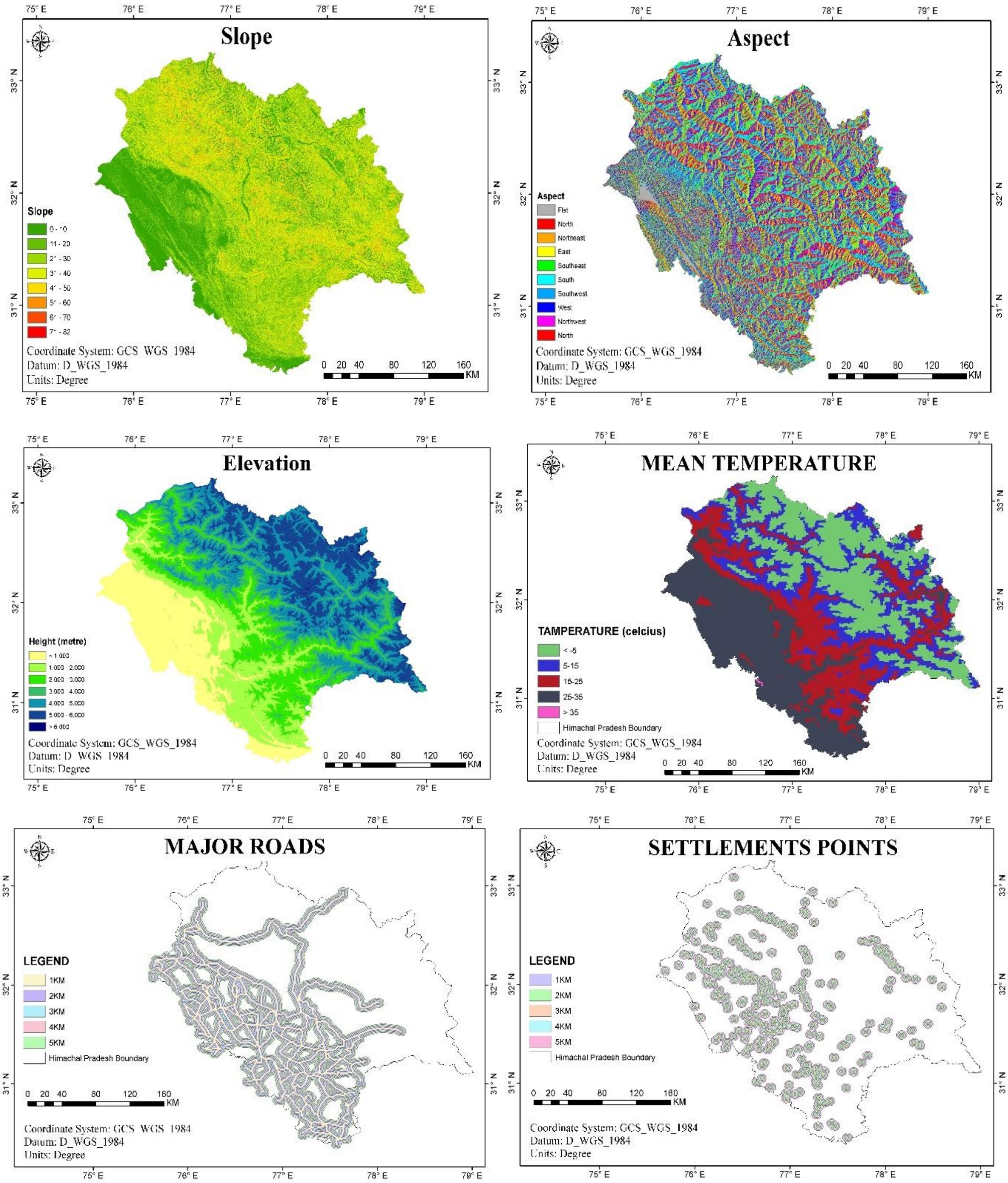


Figure 4. Variables (a) Slope (b) Aspect (c) Elevation (d) Mean land surface temperature (e) Distance from road and (f) Proximity to settlement.

3.1.2. Land cover

The spread of fire is heavily influenced by the type of land cover, making it a critical factor with a significant weightage in determining the risk. The proportionate representation of vegetation types was estimated using ArcGIS to extract the vegetation data. Land cover is a crucial factor in the spread of forest fires, and it has a significant impact on the level of risk. Therefore, to understand the vegetation cover and its impact, a vegetation analysis was performed by classifying the data into different categories. The vegetation cover was determined using ArcGIS by calculating the percentage of different types of vegetation in the study area (as shown in Figure 2).

3.1.3. Land Surface temperature (LST)

High temperature is directly related to the relative humidity and moisture content of the fuels. The LST algorithm uses brightness temperatures in the MODIS bands 31 and 32 to produce day and night LST products at 1 km spatial resolutions in swath format. It uses the MODIS Level-1B 1-km and creates LST HDF Figure 4. Variables (a) Slope (b) Aspect (c) Elevation (d) Mean land surface temperature. In this study, monthly mean land surface temperature from 2003 to 2022 was extracted from NASA/MODIS. The pre-monsoon period (April- June) is high-temperature tenure in Himachal Pradesh that results in drought and forest fires. To generate an effective model for the fire risk area, monthly temperature of the pre-monsoon season (April June) for each year (2003-2022) was averaged and then generated a layer (Figure 4d).

3.1.4. Proximity to roads and settlements

The distance between the forest and roads or settlements is an important factor in identifying areas at risk of fires, as human activity can increase the chances of fires occurring. Previous studies have shown that areas closer to roads and rivers have a higher incidence of fire scars due to increased movement and human activity. To assess this risk, proximity to the road network and settlements was measured with a resolution of 1:250000 and grouped into different categories, ranging from 0-1000 m to above 4000 m. Multiple ring buffers were then created at 1000 m intervals using ArcGIS.

3.3. Determining the fire risk index model

To ensure practicality and accuracy of the model, a literature review was conducted to assign weights to each independent variable based on their potential to cause forest fires. Each variable was categorized into distinct classes ranging from 1 (Very High) to 5 (Very Low) based on their level of influence. The weights were then calculated as a percentage of their influence, as shown in Table 3, and all the layers were overlaid in ArcGIS to develop the risk model. The equation for the fire risk index (FRI) was derived using the weighted variables:

$$FRI = 40\%LC + 20\%LST + 10\%S + 10\%DR + 10\%PS + 5\%A + 5\%E \quad (1),$$

where LC is land cover, LST is land surface temperature, S is slope, DR is distance from road, PS is proximity to settlement, A is aspect, and E is elevation. Finally, the analyses resulted in a fire risk zone map.

Variable	Class	Weight (%)	Value Assigned	Rating
Land	Closed forest (evergreen, deciduous)	40	1	Very high
	Open forest		2	High
	Grassland		3	Medium
	Shrubs		4	Low
	Needle leaved open forest		4	Low
	Needle leaved closed forest		5	Very low
Temp (C)	>35	20	1	Very high

	30-35		2	High
	25-30		3	Medium
	20-25		4	Low
	5-20		5	Very low
Slope (%)	<5	10	1	Very high
	5-15		2	High
	15-25		3	Medium
	25-35		4	Low
	>35		5	Very low
Distance to Road (M)	<1000	10	1	Very high
	1000-2000		2	High
	2000-3000		3	Medium
	3000-4000		4	Low
	4000-5000		5	Very low
Proximity to Settlement (M)	<1000	10	1	Very high
	1000-2000		2	High
	2000-3000		3	Medium
	3000-4000		4	Low
	>4000		5	Very low
Elevation(M)	57-1000	5	1	Very high
	1000-2000		2	High
	2000-3000		3	Medium
	3000-4000		4	Low
	>4000m		5	Very low
Aspect	South	5	1	Very high
	Southwest		1	Very high
	Southeast		2	High
	West		3	Medium
	East		3	Medium
	Northwest		4	Low
	Northeast		4	Low
	North		5	Very low

Table 3. Weight, value, and rating assigned to different variable.

4. Results and discussion

4.1. Fire risk index model

The fire risk index model is a technique that evaluates the likelihood of forest fires by considering multiple environmental and human-caused elements. This model considers several factors including topography, vegetation cover, climate, and human activities like land use and road networks. Each of these factors is given a numerical value, and the model integrates them to produce a comprehensive evaluation of the fire risk in a specific area. This information is helpful in developing strategies for preventing and managing forest fires (R. S. Ajin, 2017)

Forest fire risk zones refer to areas where there is a high likelihood of fires igniting and spreading to other regions (Kanga et al., 2023)

Geospatial analytics, which involves the use of GIS and remote sensing, is a powerful tool for assessing the risk and trends of forest fires (Dhar et al., 2023).Fire risk models offer a useful framework for comprehending the characterization of fire risk (H. Adab, 2018)

A risk zone map for the study area was generated using the Fire Risk Index (FRI) method, which comprised five fire risk zones: very low, low, moderate, high, and very high (Kerala, 2023)

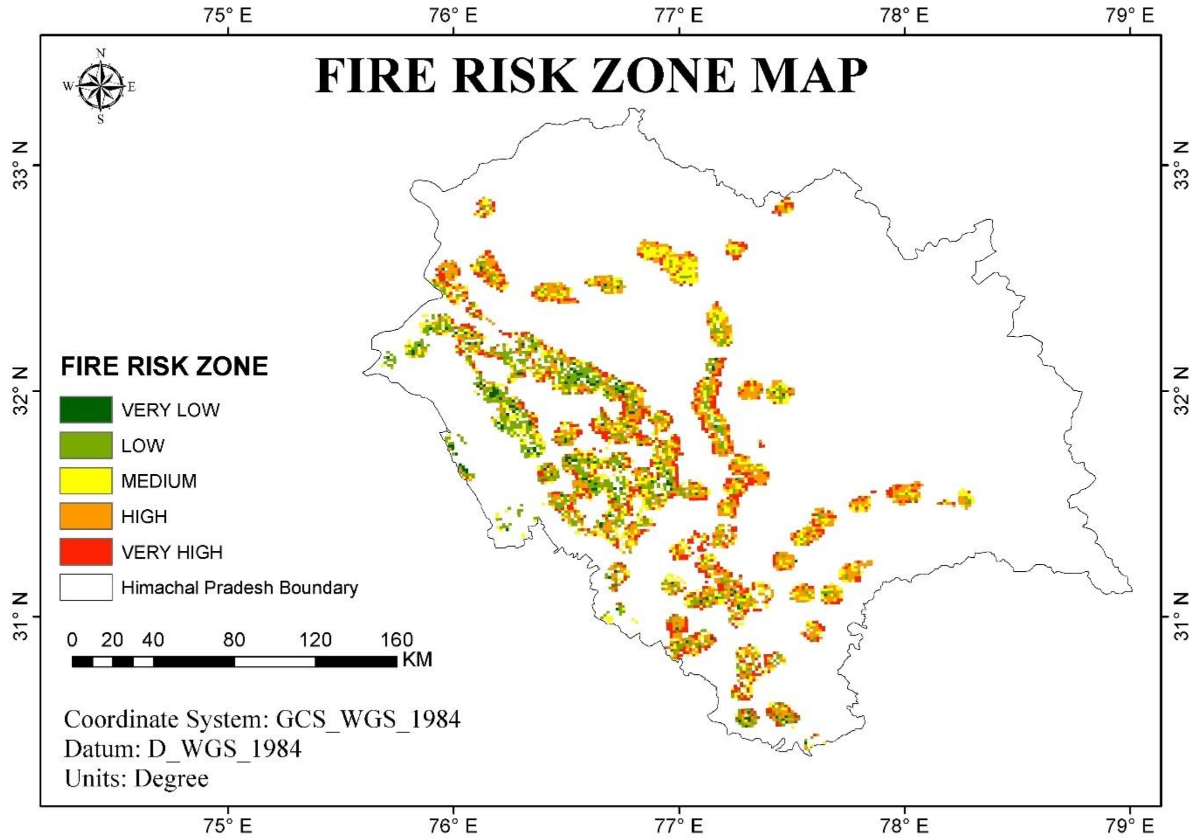
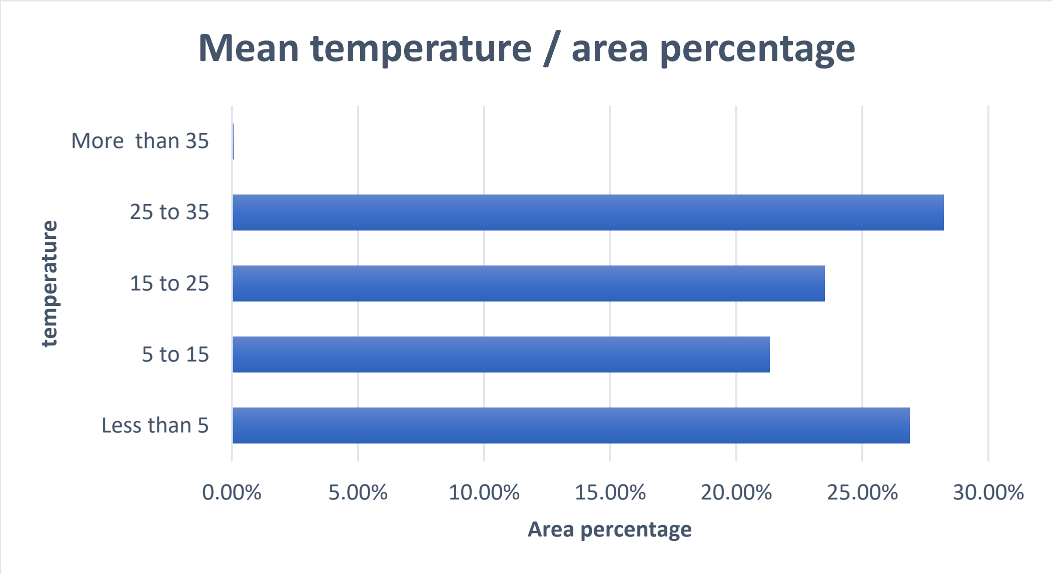


Figure 8. Developed forest fire risk index map combining all influencing variables. Map

4.2. Model validation

Integrating the fire risk map with fire incident data not only provides a comprehensive and consistent final risk digital map, but also enables the map to be incorporated into a coherent risk assessment process.

Mean Temperature	percentage
Less than 5	**26.89%**
5 to 15	**21.33%**
15 to 25	**23.51%**
25 to 35	**28.23%**
More than 35	**0.05%**



5. Conclusion

Based on an analysis of MODIS hotspot data and other variables from 2003 to 2022, it has been found that Himachal Pradesh is highly susceptible to forest fires due to high surface temperature, low rainfall, and the presence of accumulated fuels in the forests. Himachal Pradesh experiences a significant number of forest fires during the dry season, indicating a need for an effective forest fire risk assessment, warning, and monitoring system. After integrating the Data, it is observed, in Himachal Pradesh, 26% of the area has a temperature below 5 degrees Celsius, while 21.33% of the area has a temperature between 5 to 15 degrees Celsius. Additionally, 23.51% of the area has a temperature between 15 to 25 degrees Celsius, 28.23% of the area has a temperature between 25 to 35 degrees Celsius, and only 0.05% of the area has a temperature above 35 degrees Celsius. The period between April and June, especially April, is the most susceptible to forest fires in the region. To address this vulnerability, it is crucial to adopt reliable and effective fire mitigation measures, provide fire preparedness training to local stakeholders and managers, and regularly monitor areas with high fire risk throughout the year. This may involve allocating sufficient resources for capacity building and research, and making informed decisions based on studies that explore possibilities for climate-resilient adaptation strategies (Wang et al., 2021). Provisions of the Indian Forest Conservation Act (1980) regarding forest fires should be strictly implemented. A specific circular may be issued by the state governments, regarding mobilisation of human and material resources like manpower, vehicles, etc. in case of forest fires. Other rules and regulations of the state governments in this regard should also be strictly implemented. To make an impact at field level, the guidelines may be translated in local languages and circulated to the field staff. Develop a comprehensive legal framework for fire prevention and control (Joseph et al., 2023).

References

Balasubramanian, A., 2013. Himachal Pradesh - At a Glance Welcome to the state of Himachal Pradesh *(Former Director : -Culture and Cultural Relations-Pondicherry University , Former Director -Educational Multimedia Research Centre-University of Mysore) (A Video Documentary Scri. https://doi.org/10.13140/RG.2.2.35733.22245

Bowman, D.M.J.S., Balch, J.K., Artaxo, P., Bond, W.J., Carlson, J.M., Cochrane, M.A., D'Antonio, C.M., DeFries, R.S., Doyle, J.C., Harrison, S.P., Johnston, F.H., Keeley, J.E., Krawchuk, M.A., Kull, C.A., Marston, J.B., Moritz, M.A., Prentice, I.C., Roos, C.I., Scott, A.C., Swetnam, T.W., Van Der Werf, G.R., Pyne, S.J., 2009. Fire in the earth system. Science (80-.). 324, 481–484. https://doi.org/10.1126/science.1163886

Deepa Rawat, V P Khanduri, S.P.S., 2020. Impact of forest fire on soil quality and resilience potential : A review College of Forestry , Ranichauri VCSG UUHF , Tehri Garhwal (Uttarakhand), India Department of Agriculture Statistics , College of Agriculture , Powarkheda , Hoshangabad , JNKVV Ja.

Dhar, T., Bhatta, B., Aravindan, S., 2023. Remote Sensing Applications : Society and Environment Forest fire occurrence , distribution and risk mapping using geoinformation technology : A case study in the sub-tropical forest of the Meghalaya , India 29.

Diwakar, A.K., 2023. (PDF) ASSESSMENT OF INCREASING THREAT OF FOREST FIRES ... (PDF) ASSESSMENT OF INCREASING THREAT OF FOREST FIRES ... 1–9.

Dutta, S., Vaishali, A., Khan, S., 2023. Forest Fire Risk Modeling Using GIS and Remote Sensing in Major Landscapes of Himachal Pradesh. https://doi.org/10.1007/978-3-031-15501-7

Farooq, M., Gazali, S., Dada, M., Gera, N., 2022. Forest Fire Alert System of India with a Special Reference to Fire Vulnerability Assessment of the UT of Jammu and Kashmir 1–10. https://doi.org/10.1007/978-3-030-89308-8

Gai, C., Weng, W., Yuan, H., 2023. (PDF) GIS-Based Forest Fire Risk Assessment and Mapping (PDF) GIS-Based Forest Fire Risk Assessment and Mapping GIS-based Forest Fire Risk Assessment and Mapping 1–7. https://doi.org/10.1109/CSO.2011.140

Gaur, S., Chaturvedi, S., Tanwar, R., 2021. Forest Fire Analysis 1–11. https://doi.org/10.1007/978-981-16-1048-6

Gcs, N., 2021. National Institute of Ecology.

Gholamnia, K., n.d. announcement format _ quote question _ answer.

Giglio, L., Randerson, J.T., Werf, G.R. Van Der, Collatz, G.J., Morton, D.C., Defries, R.S., 2023. long-term trends in multiple satellite � re 1–2.

H. Adab, K.K., 2018. Modeling forest � re risk in the northeast of Iran using remote sensing and GIS techniques. https://doi.org/10.1007/s11069-012-0450-8

Heidarlou, H.B., Shafiei, A.B., Erfanian, M., 2023. (PDF) Forest fire risk mapping using analytical hierarchy process techniq ... (PDF) Forest fire risk mapping using analytical hierarchy process techniq ... 1–9. https://doi.org/10.22092/ijfpr.2015.13172

Jain, M., Saxena, P., Sharma, S., Sonwani, S., 2021.   Investigation of Forest Fire Activity Changes Over the Central India Domain Using Satellite Observations During 2001 – 2020 5.

Jaiswal, R.K., Mukherjee, S., Raju, K.D., Saxena, R., 2002. International Journal of Applied Earth Observation and Geoinformation Forest fire risk zone mapping from satellite imagery and GIS 4, 1–6.

JoR Eslami, M Azarnoush, A.K. and F.K., Urnal, 2021. This is a preview . Log in through your library .

Joseph, S., Anitha, K., Murthy, M., 2023. Forest fi re in India : a review of the knowledge base 1–12. https://doi.org/10.1007/s10310-009-0116-x

Jung, J., Kim, C., 2013. Forest fire risk mapping of Kolli Hills , India , considering subjectivity and inconsistency issues 1–41.

Kanga, S., Kumar, S., Singh, S.K., 2017. Climate induced variation in forest fire using Remote Sensing and GIS in Bilaspur District of Himachal Pradesh 6, 21695–21702. https://doi.org/10.18535/ijecs/v6i6.23

Kanga, S., Sharma, L.K., Chandra, P., Nathawat, M.S., 2023. (PDF) Forest fire modeling to evaluate potential hazard to tourism sites u ... (PDF) Forest fire modeling to evaluate potential hazard to tourism sites u ... 1–10.

Kerala, N., 2023. RS and GIS Based Spatial Mapping of Forest Fires in Wayanad Wildlife Sanctuary , 1–14.

Khanal, S., 2015. (PDF) Wildfire trends in Nepal based on MODIS burnt-area data https://www.researchgate.net/publication/282963195_Wildfire_trends_... 1–7. https://doi.org/10.3126/banko.v25i1.13477

Krawchuk, M.A., Moritz, M.A., Parisien, M.A., Van Dorn, J., Hayhoe, K., 2009. Global pyrogeography: The current and future distribution of wildfire. PLoS One 4. https://doi.org/10.1371/journal.pone.0005102

Lamat, R., Kumar, M., Kundu, A., 2021. Forest fire risk mapping using analytical hierarchy process (AHP) and earth observation datasets : a case study in the mountainous terrain of Northeast India 1–42.

Loghin, A., Jacob, M.K., 2023. (PDF) Forest Fire Risk Zonation & Vulnerability Assessment of Jammu ... (PDF) Forest Fire Risk Zonation & Vulnerability Assessment of Jammu ... 1–5.

Negi, S.P., 2017. Public Full-texts.

Parajuli, A., Gautam, A.P., Sharma, S.P., 2020. Forest fire risk mapping using GIS and remote sensing in two major landscapes of Nepal.

Petrov, Y., 2020. Monitoring forest fires and their consequences using MODIS spectroradiometer data. https://doi.org/10.1088/1755-1315/507/1/012019

Phan, H., Yen, H., Nguyen-thoi, T., Phong, T. Van, 2021. Ecological Informatics Mapping forest fire susceptibility using spatially explicit ensemble models based on the locally weighted learning algorithm 63.

R. S. Ajin, A.-M., 2017. MAPPING OF FOREST FIRE RISK ZONES IN PEECHI- VAZHANI WILDLIFE SANCTUARY , THRISSUR , KERALA , INDIA :

Science, A., Fires, F., Srivastava, P., Garg, A., 2023. (PDF) Forest fires in India : Regional and temporal analysis (PDF) Forest fires in India : Regional and temporal analysis 1–5.

Seyed Vahid Razavi, n.d. search menu share announcement format _ quote question _ answer thumb _ up.

Sunar, F., 2023. (PDF) Forest fire analysis with remote sensing data (PDF) Forest fire analysis with remote sensing data 1–9. https://doi.org/10.1080/014311601300229818

Thapa, P., 2021. Forest Fire Area Detection using Satellite Remote Sensing Technologies.

Tiwari, A., Shoab, M., Dixit, A., 2021. GIS-based forest fire susceptibility modeling in Pauri Garhwal , India : a comparative assessment of frequency ratio , analytic hierarchy process and fuzzy modeling techniques 1–88.

Tomar, J.S.N.K.B.Đ.S.K.S.K.S., n.d. share announcement format _ quote question _ answer thumb _ up textsms share announcement format _ quote question _ answer thumb _ up textsms.

Upgupta, S.J.S.J.K.H.R., 2015. Climate change impact and vulnerability assessment of forests in the Indian Western Himalayan region : A case study of Himachal Pradesh , 10, 63–76.

Upreti, K., 2023. (PDF) Forest fire prediction using IoT and deep learning (PDF) Forest fire prediction using IoT and deep learning 1–8.

Wang, S.W., Lim, C., Lee, W., 2021. A review of forest fire and policy response for resilient adaptation under changing climate in the Eastern Himalayan region.

Forest Survey of India. (2019). State of forest report. Dehradun, India: Ministry of Environment, Forest and Climate Change.https://www.fsi.nic.in/forest-report-2019?pgID=forest-report-2019