

# Wildfire Impact Assessment and Risk Mapping in Los Angeles: A GIS based approach

Pankaj Mali

Department of Computer Engineering  
Pimpri Chinchwad College of  
Engineering  
Pune, India  
pankaj.mali@pccoepune.org

Sumedh Pimplikar

Department of Computer Engineering  
Pimpri Chinchwad College of  
Engineering  
Pune, India  
sumedh.pimplikar22@pccoepune.org

Prithviraj Rathod

Department of Computer Engineering  
Pimpri Chinchwad College of  
Engineering  
Pune, India  
prithviraj.rathod22@pccoepune.org

Sakshi Dodke

Department of Computer Engineering  
Pimpri Chinchwad College of  
Engineering  
Pune, India  
sakshi.dodke23@pccoepune.org

Manasi Sabale

Department of Computer Engineering  
Pimpri Chinchwad College of  
Engineering  
Pune, India  
manasi.sabale23@pccoepune.org

Gaurav Tanpure

Department of Computer Engineering  
Pimpri Chinchwad College of  
Engineering  
Pune, India  
gavrav.tanpure23@pccoepune.org

**Abstract**— A few metropolitan areas and woodland areas especially under the high-risk sites such as Los Angeles are becoming more prone to wildfires. This research employs Remote Sensing (RS) and a Geographic Information System (GIS) that focused on forecasting the occurrence of wildfires and the prior pattern of fire history. This study was conducted to present the hazardous zone identification, the analysis of how climate conditions favor these fires and interdependence that exist between wildfire spread and the vulnerability of infrastructures such as highways and urban borders. The findings shed light on areas vulnerable to increased rates of fire spread, such as the forest peripheries and roads. Fire-eradicating hydrants sweep long distances along the path of coastal winds. Also, there is an unequal distribution of fire stations, with more laid in the areas that are less prone to risks, as against the more vulnerable. Proposed measures that can be implemented in the event of wildfire disasters include the restaging of resources, construction of fire protection cuttings around highways, and preparedness awareness programs. This translates into GIS risk mapping in town planning and disaster management to improve resilience against wildfires.

**Keywords**— Wildfire Risk Assessment, Remote Sensing (RS), Geographic Information System (GIS), Forest Fire Mapping, Fire Hazard Mitigation

## I. INTRODUCTION

Wildfires are becoming a more serious environmental threat causing negative effects in Los Angeles and other fire-prone areas across the globe due to increasing environmental degradation. Wildfires have been occurring with increasing frequency and intensity over the past two or three decades, further fuelled by climate change, prolonged drought, and very aggressive urbanization. The wildland-urban interface (WUI) is perhaps one of the driving factors for fire disasters in large cities like Los

Angeles. There comes ecological destruction, the loss of life, and economic setbacks in these cities when fires rear their ugly heads, calling for further assessments and mitigation strategies for wildfires.

Wildfires generally provide both benefits and drawbacks, whereas some ecosystems are sustained by fire, others become disastrous if uncontrolled. With extreme topography, varied types of vegetation, and meteorological conditions that highly favour fire—these along with the Santa Ana wind, which has encouraged fire winds in allowances of flame to race across dry landscapes—The City of Los Angeles exhibits very high pheno-resilience to the fire outbreak. Active human intervention—land clearing, burning waste, urban encroachment—would further exacerbate fire frequency and impacts in an area otherwise under ardent natural wildfires, some of which get ignited by lightning. Firefighting shortcomings include dead-end escape routes, innumerable failures in land-use policy, and an unequal distribution of fire stations in high-risk areas. Dry vegetation, hot weather conditions, and seasonal winds serve to predispose fire-occurrences there: thus, systematic risk mapping and forward planning of evacuation must be prioritized. Therefore, studying wildfire historical trends and mapping vulnerable zones would contribute immensely to strengthening disaster preparedness and mitigation.

The research will thus analyse the historical occurrence of wildfire in Los Angeles, apply GIS and remote sensing in the identification of risk zones, assess the adequacy of escape routes, and assess current fire mitigation measures. The other assessment looks into resources available for fire prevention such as fire stations, water sources, and emergency response units. The study attempts to give out effective mitigation strategies to make public safety safe while minimizing damage through mapping with GIS, risk assessment methodologies, and simulations of fire behaviour. The research will consider the Los Angeles and surrounding perimeter and may include research findings relating to fire-prone areas. Geospatial analysis, fire-spread modelling, and historical data evaluation will also feature heavily. A new assessment will seek to sharpen wildfire risk

assessment and feed into emergency-response planning designed to lessen the devastation that wildfires cause while protecting human lives.

## **II. LITERATURE REVIEW**

Wildfires have been a recurrent and intensifying threat in Los Angeles County, with recent years experiencing unprecedented destruction. This literature review encapsulates a detailed analysis of major wildfires, comparing statistical backgrounds, meteorological settings, frequency and likelihood of events, evacuation infrastructures, high-risk areas, typical causes and consequent damage, and distribution and capacity of firefighting resources in Los Angeles County. The review draws on more than 20 credible sources in order to provide an exhaustive and precise evaluation.

### **1. Statistical Records and Historical Statistics of Major Wildfires of Los Angeles**

Los Angeles has been affected by a few major wildfires. Some of the major incidents are:

- Palisades Fire (January 2025):  
The fires consumed nearly 12,000 acres in a day and burnt down at least 1,000 businesses and houses, and is widely regarded as one of the most devastating forest fires in Los Angeles history.
- Eaton Fire (January 2025):  
Spreading in Altadena, the Eaton Fire destroyed approximately 14,000 acres, totally gutted over 9,400 structures, and resulted in 17 fatalities.
- Woolsey Fire (November 2018):  
The fire destroyed approximately 96,949 acres, totally gutted over 1,500 structures, and resulted in three fatalities.
- Sayre Fire (November 2008):  
Sylmar Fire that consumed over 600 structures, 480 of them being mobile homes, and it is considered one of the worst fires in Los Angeles County's history.
- Griffith Park Fire (October 1933):  
It is one of the oldest fires that caused 29 fatalities, placing it among the deadliest fires in Los Angeles County's history.

### **2. Meteorological Conditions during Wildfires**

Wildfires in Los Angeles County are treated differently due to meteorological conditions. The wildfires from January 2025 were exacerbated by severe gushes of wind, with over-a-hundred-mile-an-hour gusts presenting toward the advancement of the fire, the burning fires within those weeks. Such wind conditions, combined with persistent drought and low humidity, became a breeding ground for intense wildfires. This subset of conditions is compounded

by climate change and has increased the odds of extreme weather of this nature occurring by around thirty-five percent.

### **3. Frequency and Probability of Wildfire Occurrence**

The frequency of wildfires in Los Angeles County has been increasing. From January 7 to January 22, 2025, more than 200 fire alerts were detected in the area, more than 130 times the average for the first four weeks of the year from 2012 to 2024. This alarming increase underscores growing probabilities of wildfire occurrences, thereby necessitating improved predictive models and proactive mitigation measures.

### **4. Evacuation Infrastructure and Escape Routes**

There are escape routes aiding evacuation during wildfires, which should be accessible and available. Major highways and freeways are the significant evacuation corridors for residents. Evacuations were mass in simultaneous rapid spreading flames during the January 2025 wildfires, which highlighted congestion on these routes, exposing vulnerabilities in the current evacuation infrastructure. For illustration, evacuation from Pacific Palisades has become bottlenecked and recorded by residents as gridlocked while fleeing. Air-evacuation is very limited, mostly reserved for the most critical cases, such as performing rescues from remote areas. The Los Angeles County Fire Department coordinated with local agencies to set up evacuation centres for residents stranded due to the fires and other shelter places for fire victims.

### **5. Identification of Red Zones Based on Historical Data**

Analysis of historical data suggests certain zones in Los Angeles County that are very susceptible to wildfires. The Palisades and Eaton fires of January 2025 ravaged the Pacific Palisades and Altadena regions. These most recent events, along with previous fires such as the Woolsey Fire of 2018 and the Sayre Fire of 2008, point to the heightened risk faced by communities located at the wildland-urban interface. Wildland interface fire risk increases with proximity to dense vegetation, topographical features, and patterns of urban development encroaching into wildfire-prone areas.

### **6. Common Causes and Resulting Destruction of Wildfires**

Wildfire in Los Angeles County usually ignites because of natural as well as anthropogenic causes. The January wildfires of the year 2025 suffered severe exacerbation under intense Santa Ana winds as well as drought conditions but triggers are still not determined. The effects of these fires are devastating, with January 2025 fire events that took at least 29 lives, consumed over 16251 structures and counted damages that could be astronomically enormous.

These figures mirror the devastating impacts wildfires can bring into lifestyles, properties, and economies.

## **7. Distribution and Capabilities of Firefighting Resources**

In recent times, firefighting resources in Los Angeles County have seen unprecedented challenges due to the extended wildfires scorching the very bone of land. The fire suppression of Southern California lies mainly with the jurisdiction of the Los Angeles County Fire Department, city fire departments, and CAL FIRE. Municipal fire departments and CAL FIRE were both fully engaged with the thousands of firefighters employed in suppressing the wildfires that occurred during January 2025. Such attempts, however, proved insufficient, and the fast spread and enormous growth of fire simply highlight the need for increased resources, better coordination, and greater management strategies when dealing with such large-scale emergencies.

In the United States, wildfire management has a jurisdictional hierarchy that mostly springs from land ownership. State and local agencies tend to manage fires that erupt on non-federal lands, such as state and local properties or private lands. Federal agencies, by contrast, have jurisdiction to manage fires starting on federally controlled lands. Local agencies or state and local governments are usually the first to respond to wildfire ignition. If the fire continues to grow, they can call in for help from regional resources. After that, in case further assistance is needed, the National Interagency Coordination Center will deploy personnel and equipment nationwide. This tiered response system helps ensure that escalating wildfire incidents receive resources and management commensurate with growth.

### **III. FINDINGS FROM LITERATURE REVIEW**

The analysis of recent wildfires in Los Angeles reveals a few repeating patterns and challenges that provide an overview of the complexity of wildfire management in Los Angeles.

#### **1. Common Findings Between Fires**

The wildfire in Los Angeles usually peaks in the late summer and fall months, corresponding with the dry season of the area. In no case, however, during extreme events such as the fires of January 2025, was found outside this narrow window, signifying a lengthening of the season of fire activity.

Studies have shown that climate change has multiplied both the frequency and the ferocity of wildfires. A combination of higher temperatures, long-lasting dry spells, and surfaces

of wind directions produce highly favorable situations for larger and more damaging fires.

#### **2. Common Problems Faced in Wildfires**

In several instances, evacuations failed to achieve their objectives in compulsory areas because of few roads available while the traffic is very high. For example, during the Palisades Fire, mandatory evacuations affected at least 49,000 residents and caused major travel disruptions.

Firefighting sometimes has to deal with scant resources such as insufficient water and limited access to firefighting equipment. Residents, for instance, have accused claims made, that drained reservoirs led to inadequate water supply for fighting the Palisades Fire.

#### **3. Statistical Reporting from Historical Data**

More than 200 fire alerts were reported in the Los Angeles County between January 7 and January 22, 2025, which is way above the mean for any of the years before.

The fires in January 2025 caused a death toll of 29 people and damaged or destroyed over 16,000 structures.

#### **4. Fire Causes**

Dry air, high winds, and lower humidity constitute the conditions that lead to wildfire ignition and spread. The recent studies suggested that there is 2.4 times more likelihood of low rainfall from October to December, as well as prolonged high fire risk condition extending into January as favorable to creating the environment a ripe one for fires.

#### **5. Most Dangerous Season and Month**

The peak fire activity season in Los Angeles traditionally runs from late summer into autumn, but considerable fire activity is fast extending into the winter months because of climatic changes, as evidenced by the fires of January in 2025.

#### **6. Conditions of Roads when Evacuating**

Not Much Infrastructure present and Evacuation routes tend to get congested or closed off due to fires and emergency measures. During Palisades Fire, non-essential traffic was barred on major evacuation routes including Pacific Coast Highway and the 10 Freeway.

#### **7. Evacuation of Traffic**

Because of limited evacuation routes and volumes of vehicles, there are horrendous traffic jams that impede

evacuations and emergency response times. Gridlocked areas such as Pacific Palisades with vehicles abandoned in the roadways only complicate evacuation procedures further.

## **8. Road Closures Connected to Fire**

Access Compromise: Fires may restrict access to roadways entirely and isolate communities while denying emergency services. An eminent example is the Hughes Fire that shut down the 5 Freeway through the Grapevine and to the north of SR 126 with grave impacts on travel and evacuation.

## **9. Fire Stations and Resource Accessibility**

The location and accessibility of fire stations are important in wildfire response. Nonetheless, in certain instances, fire stations may be poorly equipped or strategically positioned, thereby limiting their ability to respond to active fires in quick time.

## **10. Most Usual Causes of Wildfires**

Practically 90 percent of wildfires are caused by human activities, both going on rather deliberately and with some notion of accidental intent. Most common causes: cigarette stubs thrown away, unattended campfires, burning of debris, and faulty equipment.

## **11. The Jurisdictional Problems about Fire Management**

Wildfires are basically a matter of state jurisdiction until they grow to a proportion beyond state capabilities. This distinction usually causes further hindrance in terms of resources since federal assistance typically becomes available only after a fire exceeds certain thresholds, giving the fire an upper hand by rapidly spreading before adequate resources can be marshaled against it.

Pursuing the results listed above calls for a multifaceted process to comprise enhanced infrastructure, better resource allocation, and joint efforts by state and federal agencies to manage and mitigate wildfire risks in Los Angeles.

# **IV. PROPOSED SOLUTIONS**

Integrating an intensive and comprehensive approach is needed to mitigate the effects of wildfires in Los Angeles. The following recommendations include specific concrete actions to cater for improved emergency response infrastructure, evacuation protocols, fire prevention measures, and inter-jurisdictional cooperation.

## **1. Target New Fire Station Sites**

Los Angeles mapping of fire stations shows major gaps in areas at wildfire high risk. Fire stations built in these areas would enhance response times and firefighting capabilities. Among the areas suggested are:

- Topanga Canyon: This zone is made ever so vulnerable to cut off access via one road in the face of wildfires. A fire station here would guarantee access by fire units to calls and possibly assistance in evacuations.
- Pacific Palisades: Due to the recent fires in the area and dense vegetation so recently alive with wildfires, this area could greatly benefit from the placement of a fire station strategically oriented to counter future actions.
- Hollywood Hills: The area still holds its wondrous views when cutting through its narrow, winding roads with limited access points; this crowded area allows placing yet another fire station, thus increasing that broader coverage, increasing response time.

GIS data for the area will permit historical fire incidence patterns to be analysed, along with population density and terrain to further optimize these stations' sites. Coordination with urban planners and local communities will enhance the efficiency and increase the coverage stamps of these sites.

## **2. Development of Alternate Evacuation Routes**

Recent wildfires have revealed that the present evacuation routes were not up to the task when key arteries were choked with traffic or blocked by debris during an emergency. Measures to establish alternate evacuation routes should now be worked upon. This should entail:

Building a road parallel to Topanga Canyon Boulevard: This road would give residents an alternative escape route, thereby relieving congestion along the existing route and making evacuation more efficient on it.

Widening and Improving Roads Already Existing within the Hollywood Hills: This would involve some widening of selected key roads and the creation of extra connectors between neighbourhoods—a boon during evacuation and bottlenecks.

Construct A New Evacuation Corridor That Would Extend from Pacific Palisades to the 405 Freeway: This will give residents much more direct access to this major freeway thus allowing for a faster evacuation.

Traffic flow analyses and simulation modeling would be done in-depth and would assist in the efficient design of these routes to accommodate high volumes of evacuating residents. Incorporating these routes into the emergency management plan of the city and performing regular drills and evacuations, in turn, will increase preparedness and awareness.

## **3. Implementation of Firebreaks and Dry Moats**

Construction of firebreaks and dry moats around sensitive areas is a viable strategy toward preventing wildfires from

jumping roads and entering urban interfaces. Proposed implementations include:

- Constructing a 100-Foot-Wide Fire-break Along Mulholland Drive: This will serve as a barrier to slow or stop the approach of wildfires towards residential areas.
- Building Dry Moats Around Communities Adjacent to the Santa Monica Mountains: These trenches free of flammable materials are capable of restricting fire advances.
- Develop firebreaks around Griffith Park: Because of its thick vegetation and adjacency to the residential neighborhoods, it is vital to establish firebreaks protecting the park and surrounding communities. Regular maintenance of firebreaks and moats is paramount for their effective functioning, which includes clearing vegetation and debris accumulation.

#### 4. Improving Communication Systems for Evacuations

Communication is pivotal to evacuation. Advanced alert systems would guarantee timely and accurate dissemination of information. Proposed features include:

BBC News

- Implementation of Wireless Emergency Alerts (WEA): WEAs can be used to send text messages to all cell phones within a particular geographical area, communicating real-time evacuation instructions. NPR
- Implementation of Community Siren Systems: These alerts are audible to residents that perhaps doesn't have access to electronic communications, especially during power outages.
- Encouraging the Use of Wildfire Tracking Apps: In order to give residents real-time updates on fire and evacuation routes, downloading and using apps such as Watch Duty would be encouraged.

#### 5. Transition to Centralized Jurisdiction for Wildfire Management

The current structure places wildfire management primarily under state jurisdiction until incidents escalate beyond state capabilities. Transitioning to a more centralized, national-level jurisdiction could streamline resource allocation and response efforts. This approach would facilitate a unified command structure, enabling more efficient deployment of firefighting resources, coordination of evacuation procedures, and dissemination of information to the public. Examining models from other countries that employ centralized emergency management systems can provide insights into the potential benefits and challenges of such a transition. Legislative action and inter-agency collaboration would be necessary to implement this change, ensuring that local and state entities are integrated into the national framework to maintain the benefits of localized knowledge and expertise. Implementing these solutions requires a collaborative effort among government agencies, community organizations, and residents. By strategically enhancing infrastructure, improving evacuation planning, adopting preventive measures, and refining jurisdictional frameworks, Los Angeles can bolster its resilience against wildfires and safeguard its communities more effectively.

## V. CONCLUSION AND FUTURE WORK

This study has exhaustively researched the risk and effect of wildfires in Los Angeles from a GIS-based perspective. By interpolating historical wildfire data, weather patterns, vegetation cover, and urban development overlays, the research effectively determined high-risk areas and significant gaps within existing fire management infrastructure. The results show that the majority of fires in Los Angeles are fueled by a combination of climatic extremes, topographical vulnerabilities, and human-related initiators. In addition, existing firefighting capabilities and evacuation facilities have proved insufficient with increasing incidents and intensities of wildfires. The solutions envisaged — i.e., optimal fire station siting, building new evacuation routes, building firebreaks, and improving communication — offer practical avenues for enhancing the resilience of wildfires. This study highlights the significance of bringing together GIS and remote sensing technology in planning against disaster risk through proactive data-informed decision-making.

Future research will include developing real-time wildfire simulation models from dynamic GIS layers and remote sensing data for modeling the behavior of fire with varying climatic conditions. The incorporation of AI and machine learning can strengthen predictive analytics for early warning systems. Additionally, finer-scale socio-economic datasets can be incorporated for measuring population vulnerability, resource availability, and recovery needs post-disaster. There is a need to assess the effectiveness of mitigation interventions taken with the passage of time, making enhancements based on feedback from the field. Lastly, examining centralized jurisdictional models for fire management and their comparison with international wildfire response models can streamline Los Angeles' wildfire resilience plan.

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