Report

INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY
HYDERABAD

Forest Fires

Literature review, Analysis and Solutions

Project in Environmental Science and Technology

Monsoon'22

Our Team - Team 33:

- Naimeesh Narayan Tiwari (2020101074)
- Harshita Gupta (2020101078)
- Khush Patel (2020101119)
- Siddharth Mavani (2020101122)
- Joel Alex (2020101118)
- Janardan S (2020111005)
- Rohan Chowdary (2020101130)

SCAN ME

Abstract

In this project, we have case studies on forest fires in various regions around the world and also have summarized how they have impacted the biodiversity and economy. Similarly we have analyzed global gas emissions and have developed a monitoring tool and a prediction model. We also have hosted a website with all our findings and have a live map which is used to track the live forest fires across the world. For this, we have used a NASA prototype web service which gives us the live fires across the world. NASA and Google API's were also used in the monitoring tools. For the prediction model, we have done data mining which uses data from local sensors which is known to influence the forest fires and predict the amount of area which is burnt. All datasets we have used are verified and have generated graphs using the data from these datsets.

Contents

1. Introduction

1.1 Literature Survey

In the initial stage we followed Data mining techniques and applications by Bharati Mahadev Ramageri. For prediction model we used the techniques mentioned in A Data Mining Approach to Predict Forest Fires using Meteorological Data by Paulo Cortez. For understanding forest fire spread we mainly used models from The Mathematical Model of Short-Term Forest Fire Spread by Chiu, S. , Li, Y. and Zhao, J..

1.2 Objectives

Our objective was to develop a one-stop solution for forest fire management and monitoring. We developed a package of tools and protocols with prediction models, monitoring tool and a well-researched set of protocols which authorities can use for forest fire management.

2. Methodology

2.1 Data Collection and cleaning:

Data is collected in the form of JSON and CSV files. Pre processing is done on the data to remove noise and outliers

2.2 Data Visualisation:

With the processed data, different visualisation tools such as Tableau and MS Excel were utilised to better understand the trends and relationships

2.3 Wildfire Simulation:

A python based fire simulator is created from scratch which shows how wildfires respond to environmental factors such as Temp and Humidity

2.4 Data Monitoring:

Data is then monitored through a website created using JavaScript. It allows users to view wildfires across the US

3. Case Studies

3.1 Canada

3.1.1 Data

We have extracted our datasets for analysis from the National Forestry Database of Canada.

It has various datasets:

1. Number of Fires by cause, year, and jurisdiction
2. The area burned by cause, year, and jurisdiction
3. The number of fires and area burned by month in a jurisdiction
4. dataset on property losses from fires

3.1.2 Data Visualization and Analysis

Some Statistics

- 2.5 million ha of land burns in Canada on average annually.
- The main causes of fires being Human activities and lightning strikes.
- Lightning strikes accounts for around 80% of the land burnt.
- Protection and Relief work costs around a billion dollar every year.

Area burnt and number of Forest fires

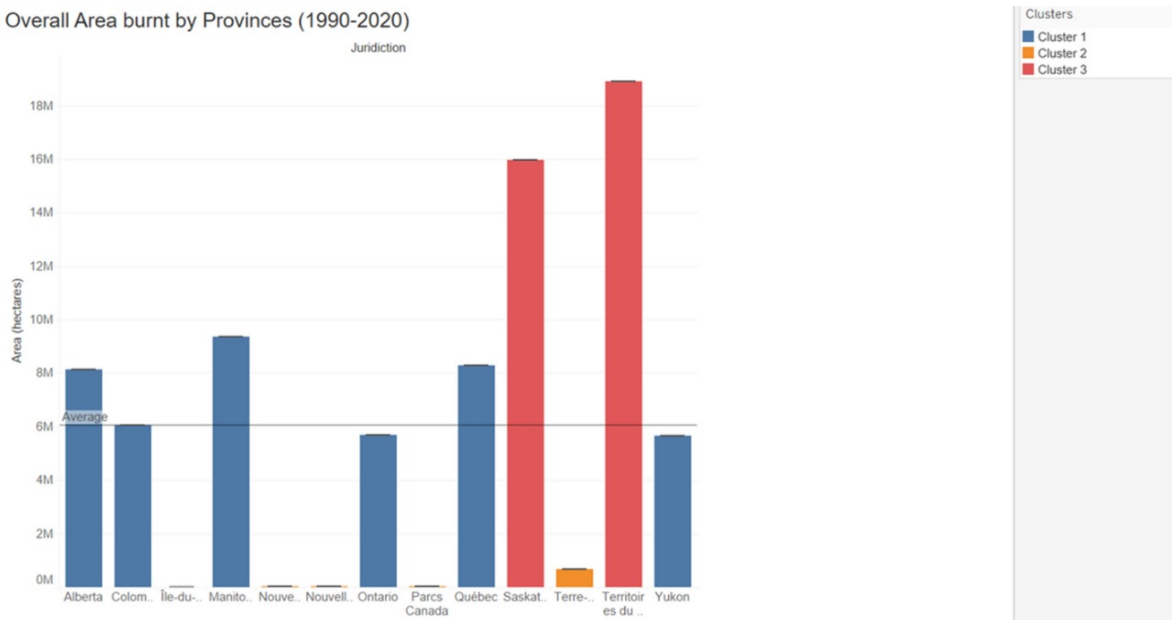


Figure 1: Overall Area Burnt By Provinces 1990-2020

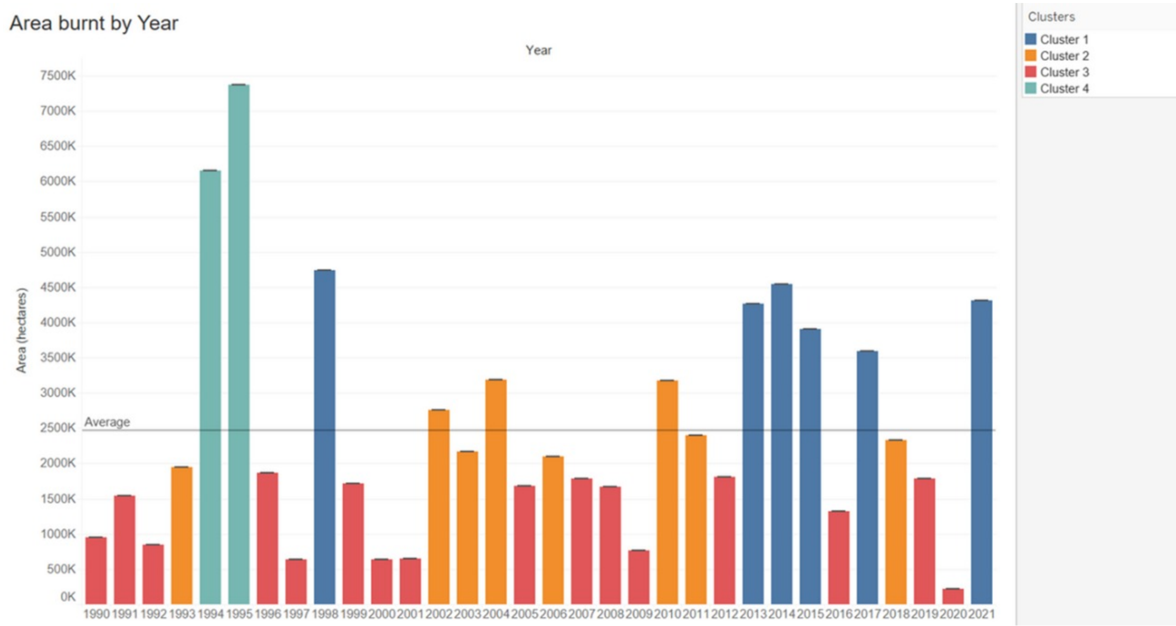


Figure 2: Overall Area Burnt By Year 1990-2020

From Figure 1, Northwestern Territories record the most forest fire due to extreme temperatures and due to a fairly dry climate. The topography being mountaneous also sees more lightning strikes hence observing more forest fires. From Figure 2, The data for 1995 and 1994 peaks due to more inclusive reporting of forest fires.
Analysis by Month

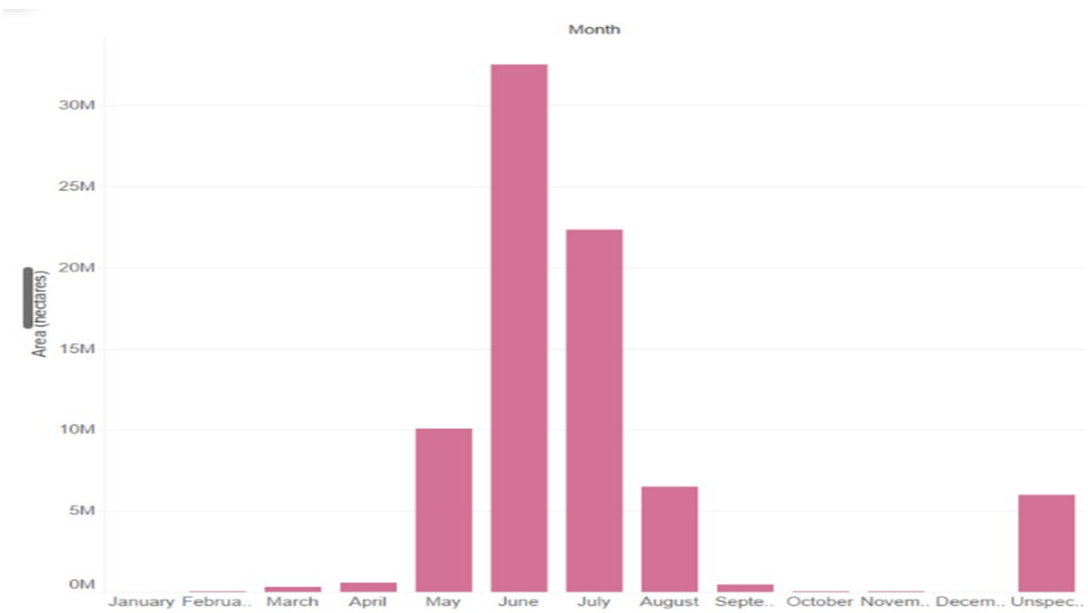


Figure 3: Province wise Analysis by Month 1990-2020

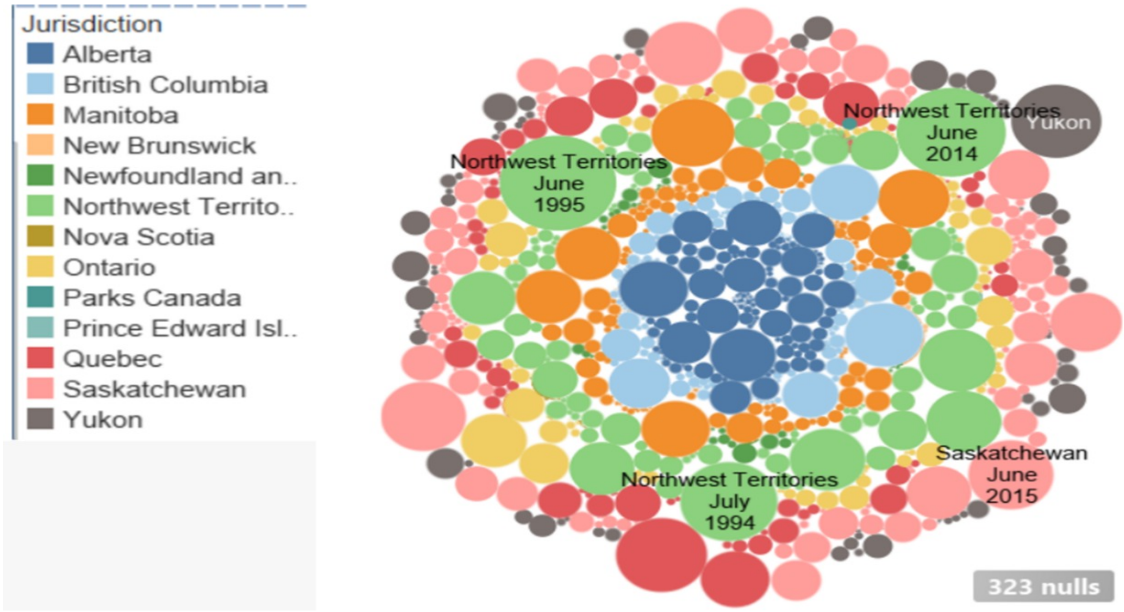


Figure 4: Overall Province Wise Analysis by Month 1990-2020

From Figure 3 and Figure 4, the monthly analysis gives us the average estimate of seasonal causes behind forest fires. June and July notice the most forest fires in terms of area due to warmer climate.

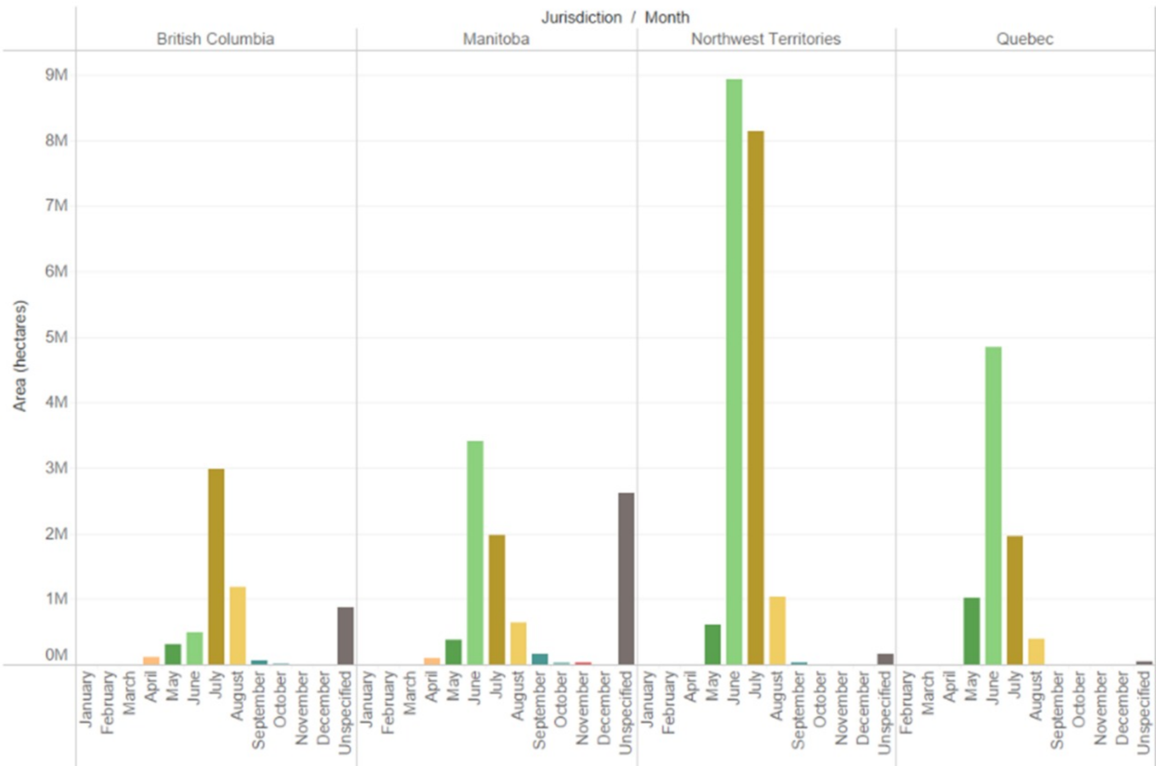


Figure 5: Regional Analysis 1990-2020

From Figure 5, after analysing the Major regions in Western, Central, North-Western and Eastern Canada, we can notice the behaviour by month/season is uniform across various different parts in Canada. Overall, Temperature and drier climates positively impact the occurences of forest fires.

3.1.3 Forest Fire Policies

Canada's Forest Fire management Strategy can be summarised as:

- Fire has ecological benefits so suppression should be done on various ranges.
- Monitoring and Prediction tools are important.
- Prescribed burning for lower risks.

3.2 Portugal

3.2.1 Data

The dataset contains forest fire data from the Montesinho National Park, which is located in the northeast region of Portugal. The data used in the analysis was collected from January 2000 to December 2003. The dataset contains the following attributes:

- X: X-axis spatial coordinate within the Montesinho park map
- Y: Y-axis spatial coordinate within the Montesinho park map
- month: Month of the year
- day: Day of the week
- FFMC: Fine Fuel Moisture Code index from the FWI system
- DMC: Duff Moisture Code index from the FWI system
- DC: Drought Code index from the FWI system
- ISI: Initial Spread Index from the FWI system
- temp: Temperature in Celsius degrees
- RH: Relative humidity in percentage
- wind: Wind speed in km/h
- rain: Outside rain in mm/m2
- area: The burned area of the forest (in ha)

3.2.2 Data Visualization and Analysis

From Figure 6, we can make following observations:

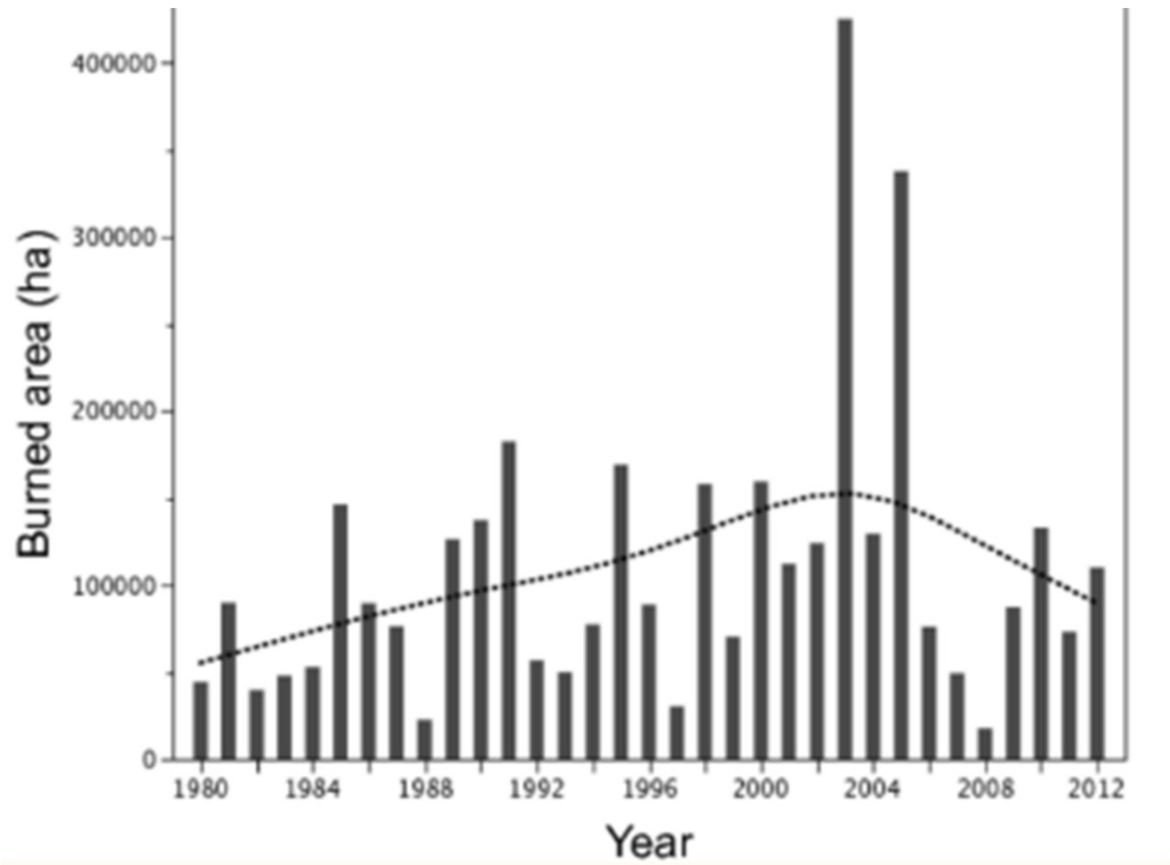


Figure 6: Portugal Burnt Area By Year

- Forest area decreased 4.6% between 1995 and 2010 corresponding to a net decrease of 0.3% year or 104 ha/year.
- The decrease in pine forest area is the major driver of the observed decrease in forest surface.
- The area occupied by pine forest diminished by 263 x 103 ha between 1995 and 2010.

From Figure 7 and Figure 8, we can see that the summer and fall seasons witness the most forest fires because of higher temperature and lower relative humidity. These environmental factors makes it extremely difficult to contain fires and increases ISI by a huge margin. These are the natural factors behind forest fires. Whereas, there are certain anthropogenic factors too. Portugal's peak tourist season tends to be from late June to early September. People prefer to go hiking and trekking in these 2 seasons. This means there will be bonfires, camp fires etc in the forests and more risk of forest fires which we can notice from Figure 9.

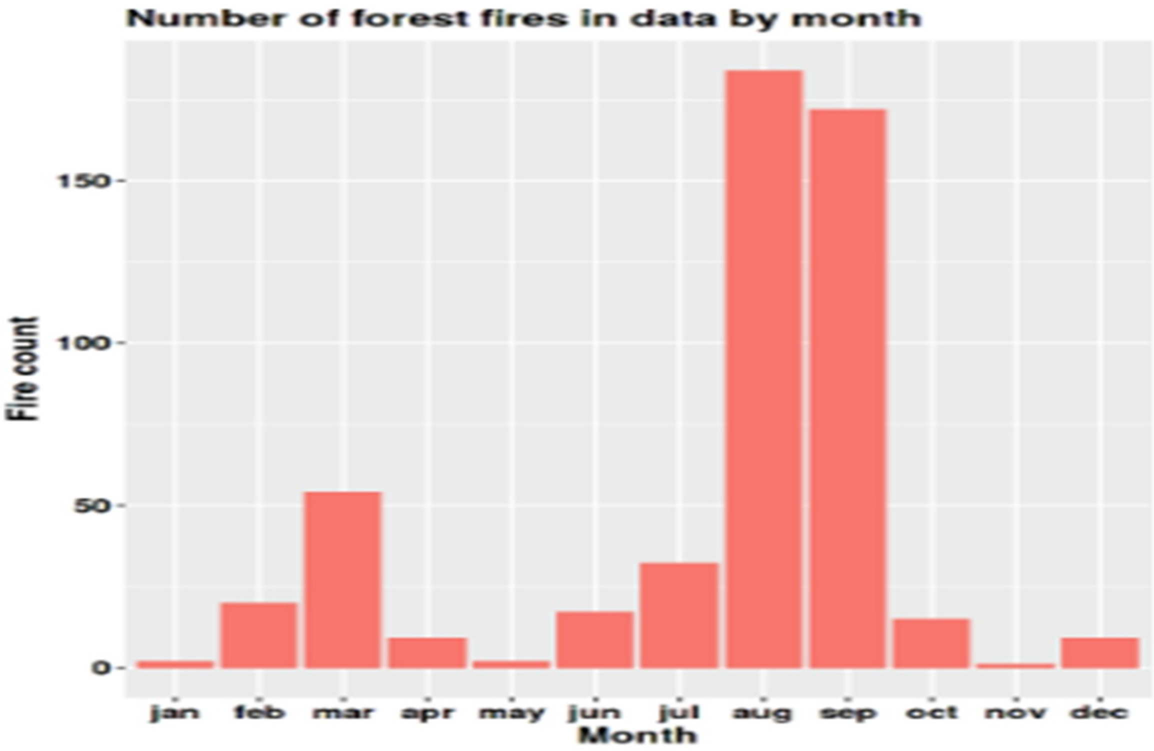


Figure 7: Portugal Forest Fires By Month

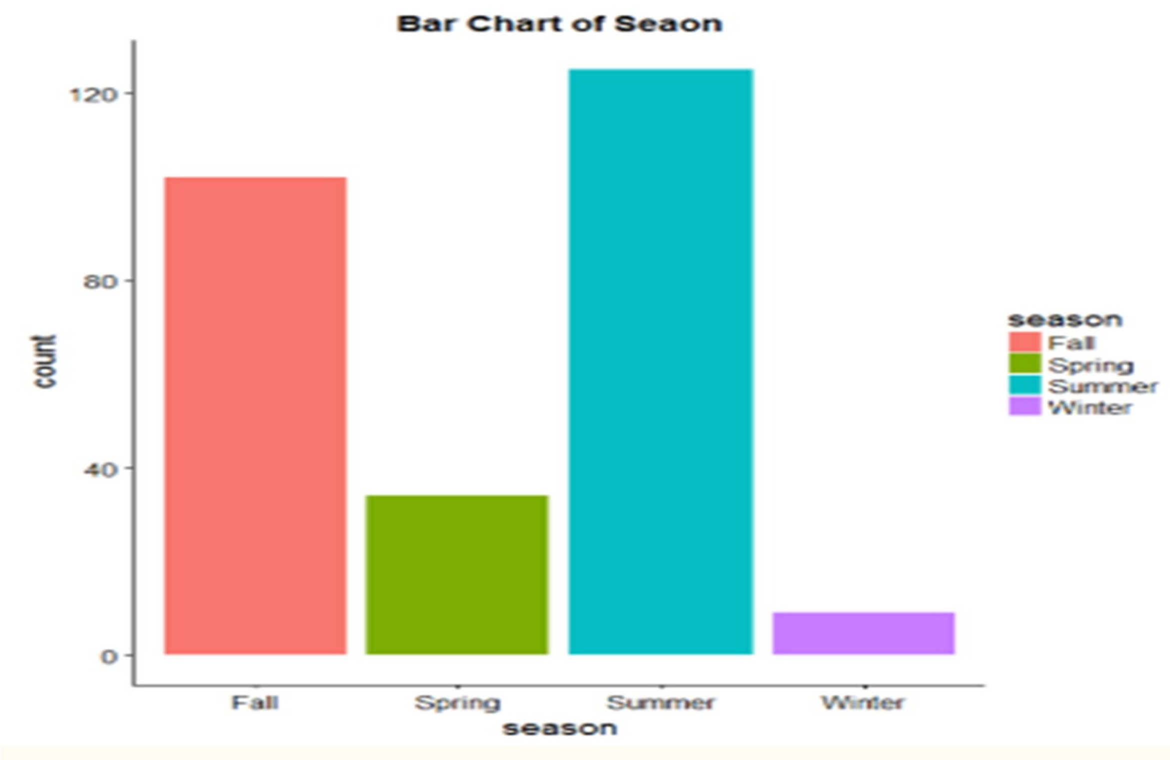


Figure 8: Portugal Analysis For Seasons

Figure 9: Number of Tourists in Portugal by Month

3.2.3 Political and Institutional Factors

Prior to the wildfire crises of 2003 and 2005 fire management policies have been markedly reactive, inconsistent and short-sighted. Before the 1974 revolution, Forest Rangers had authority over the forests. However, post-revolution, the enforcement capacity diminished and power was transferred to Portuguese forest service (PFS). In 1980, Fire suppression was transferred from the PFS to the national fire fighting service. After the catastrophic fires of 2003 and 2005, the current national fire system, the DFCI, and fire plan were established in 2006.

3.2.4 Forest Fire Management Strategy

Summarising Portugal's forest fire management strategy from various reliable sources, we list following key points:

- Promoting forest and environmental education
- Drafting legislations in favour of forest conservation
- Better integration of fire-fighting teams
- Ecosystem restoration and Post fire recovery Programs
- Improved Communication among several Executive bodies

3.3 Brazil

3.3.1 Data

The dataset we used here reports the number of forest fires in Brazil divided by states in 20 years (1998-2017). It was obtained from the official website of the Brazilian government. The metadata is as follows:

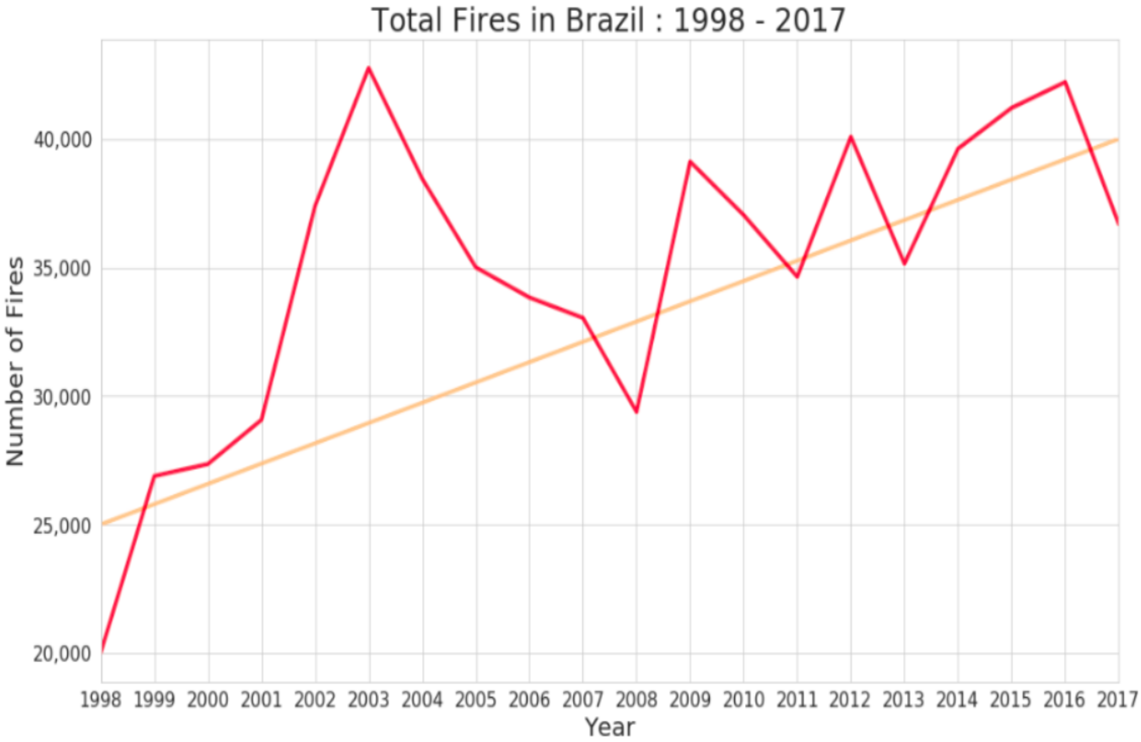
- year: years when forest fires happen
- state: Brazilian state
- month: the month when forest fires happen
- number: number of forest fires reported
- date: date when forest fires were reported

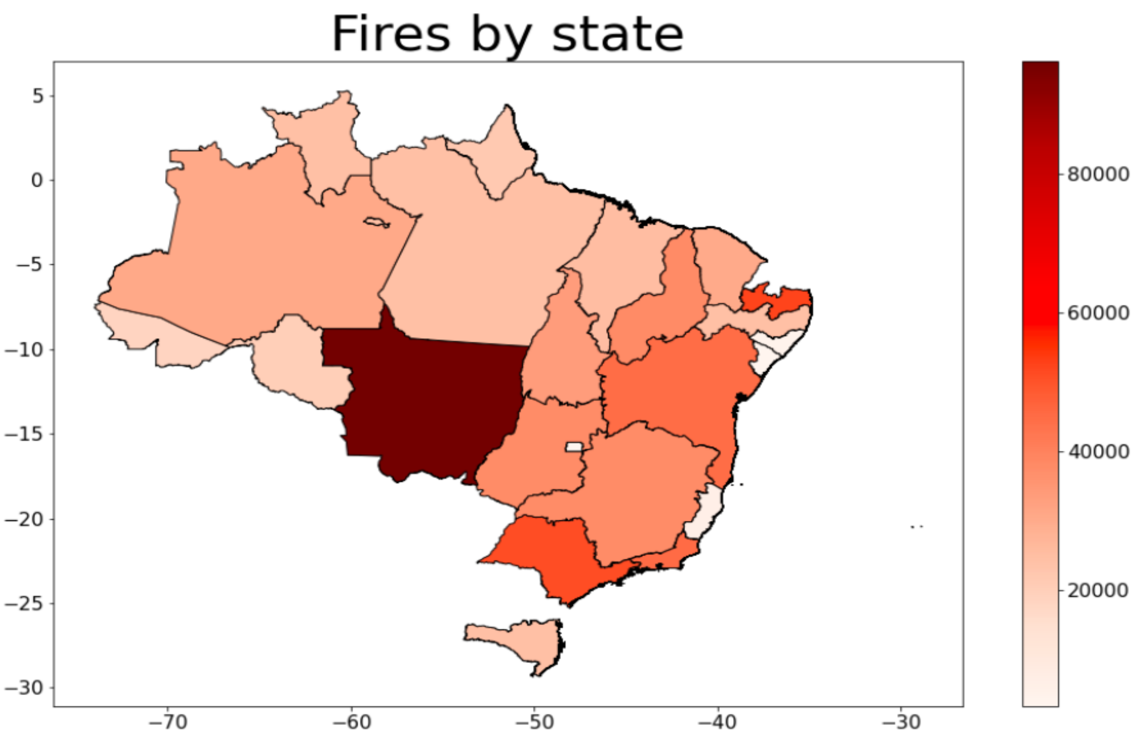
Figure 10: Brazilian states

3.3.2 Analysis

Here, we tried to understand the forest fires in a time series that can help take action to prevent them. Looking at the time series, we observe that there were an average of

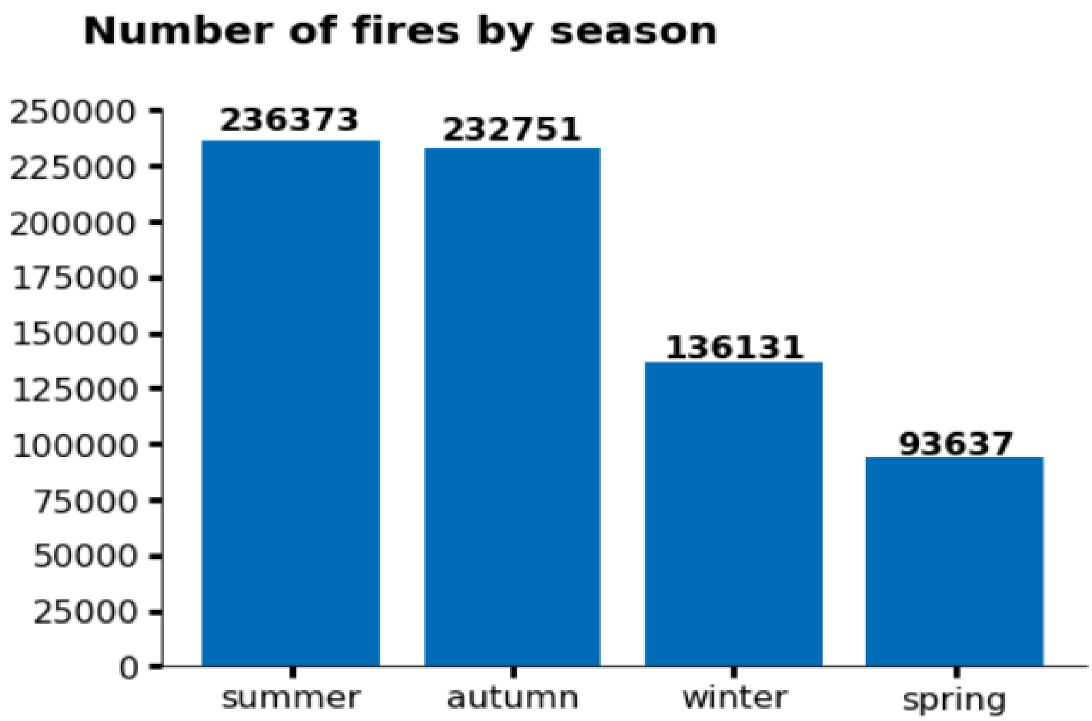
4,800 fires per year, the number of forest fires increased dramatically from 20,000 in 1998 to 40,000 in 2016 and the largest number of fires was in 2003, 2015 and 2016.

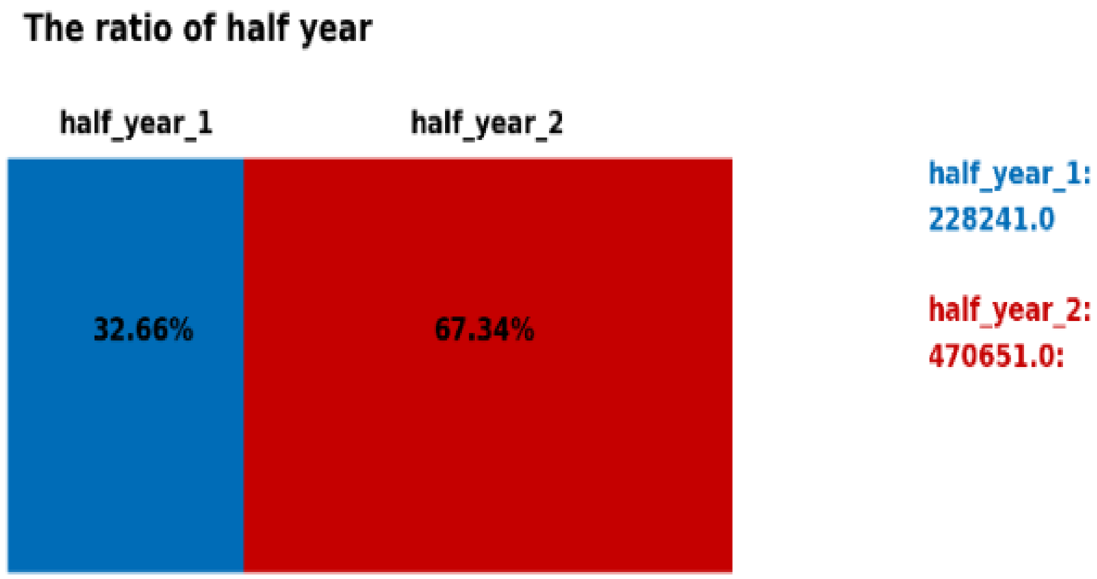




Looking at fires by state, we saw that Mato Grosso was the state with the most fires and Sergipe with the least number of fires reported in the last 20 years.

Looking at the time series and analysing the number of fires reported in each month, we observed that almost 70 per cent of the fires occurred in the 2nd half of the year, the largest number of fires were reported in summer and autumn 23k, the least number of fires were in spring, 9.3k and the highest number of fires was in July.

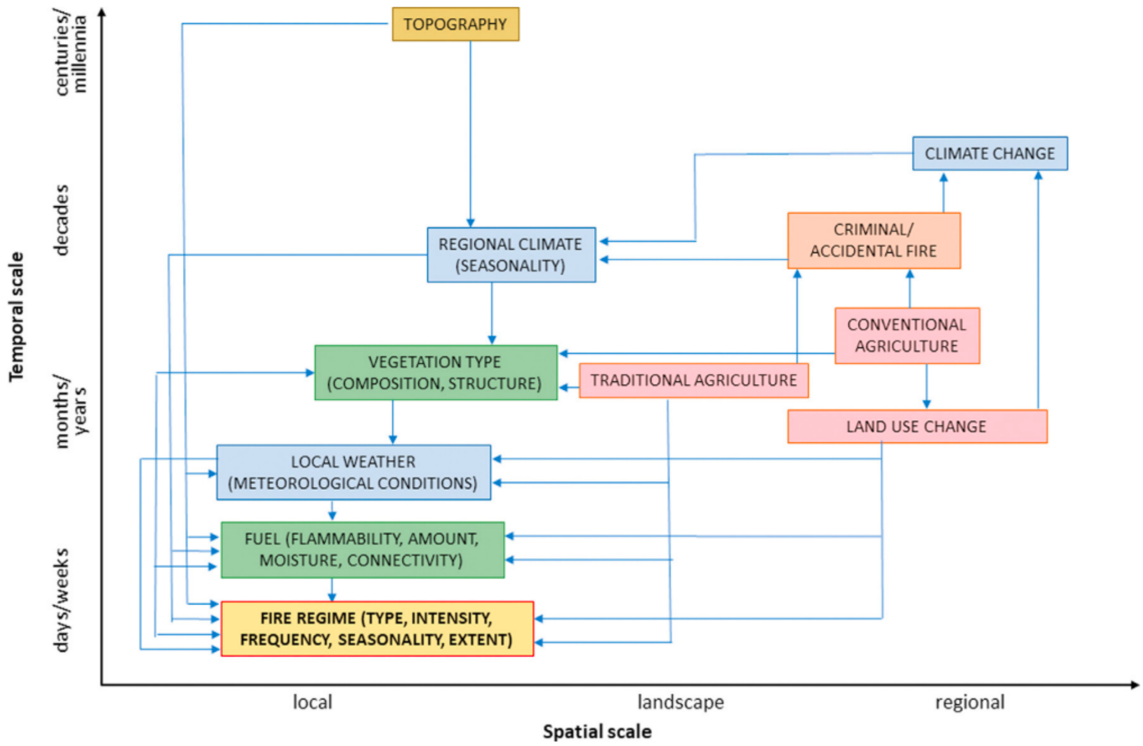




3.3.3 Inferences

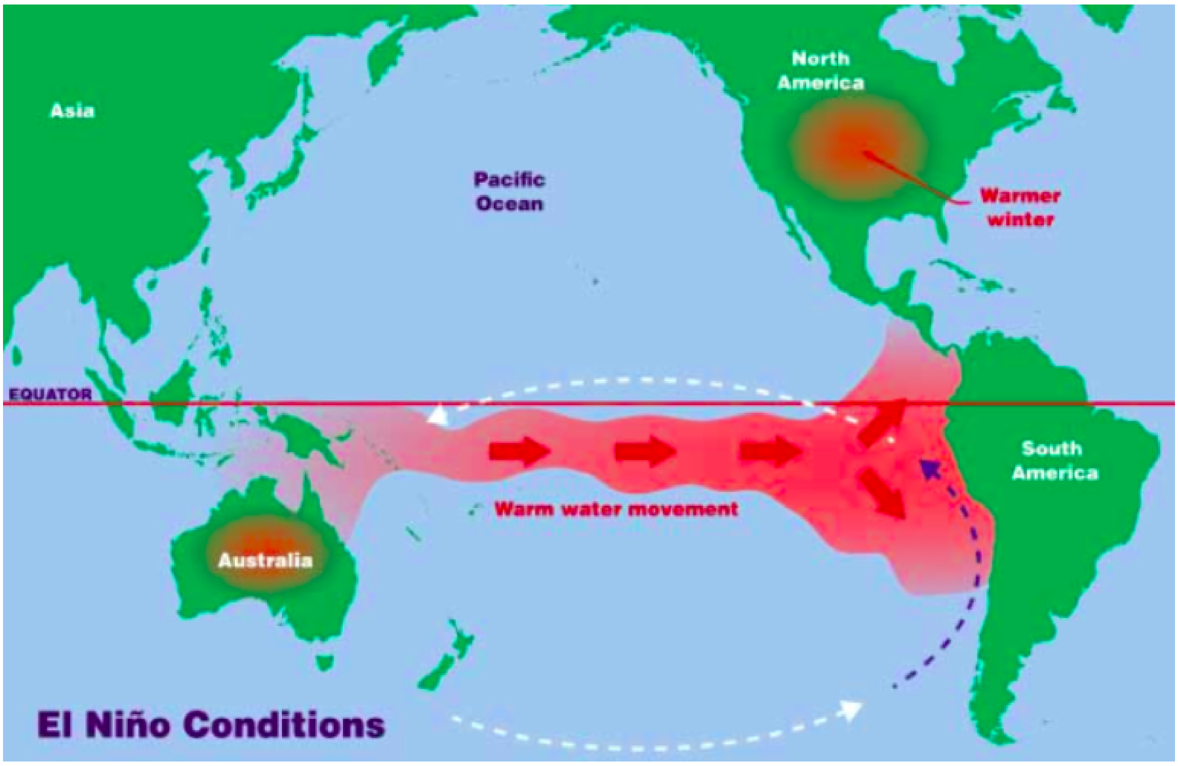
From the literature review and our own analysis, some of the reasons we inferred for the increasing number of forest fires in Brazil are as follows:

- Dry weather, wind and heat: More extreme droughts are linked to global warming
- El Niño: Almost one million hectares of primary and secondary forests was burned during the 2015–2016 El Niño season which led to over 30 million tonnes of CO2 emission
- Accidental Forest Fires: In both Mata Grosso and southern Para, the area of standing forest affected by accidental forest fires exceeded the area of new deforestation in 1995 (Alencar et al. 1997)
- Human activities: Conventional agriculture, deforestation, lack of adequate environmental policies and surveillance



3.3.4 El Nino

El Niño is a climate pattern associated with a warming of Pacific Ocean currents that has a global influence on the weather. During El Niño, dry conditions lead to even lower water tables, which makes both the forests and peat vulnerable to fire. Humans take advantage of these drought conditions to burn the woods to clear more croplands. The intense drought made a tropical forest, one of the world's largest carbon sinks, into a massive source of emissions. The annual mean precipitation during the 2015-2016 drought period was the lowest in 35 years.



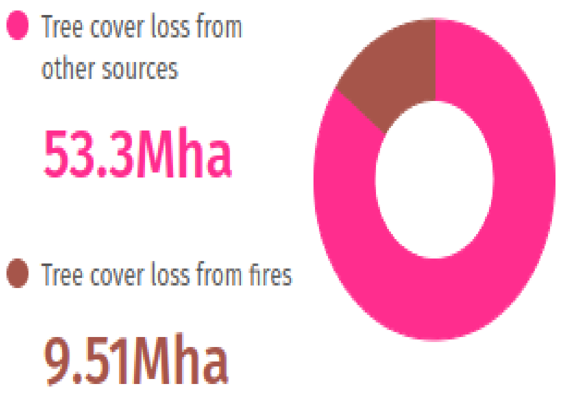
3.3.5 Towards effective fire management

- Land management: Combat risk of recurrent forest fires
- Command and control against illegal fires: Fire management as such can only be efficient if agencies are properly equipped, supplied and trained.
- Adopt alternative land use techniques: e.g. agroforestry, crop-livestock-forest integration, rotation between crop and pasture, no-tillage cultivation, shredding of cut vegetation, allowing a transition to more sustainable and fire-free types of land use.
- Development of monitoring systems: Research on fire should integrate different knowledge areas from biological to human science.

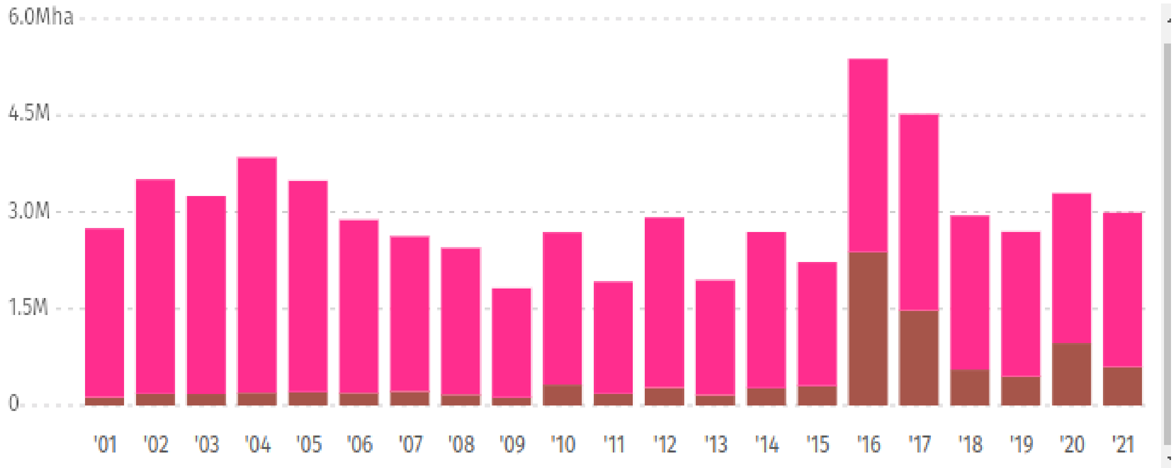
3.3.6 Tree cover loss on GFW

As a part of the literature survey, we looked at the data analysis on tree cover loss due to forest fires in Brazil on Global Forest Watch. [16]

Fires were responsible for **15%** of tree cover loss in **Brazil** between **2001** and **2021**.



From **2001** to **2021**, **Brazil** lost **9.51Mha** of tree cover from fires and **53.3Mha** from all other drivers of loss. The year with the most tree cover loss due to fires during this period was **2016** with **2.38Mha** lost to fires — **44%** of all tree cover loss for that year.



3.4 India

3.4.1 Data

We have extracted our datasets for analysis from the data.gov.in website.Open Government Data Platform India or data.gov.in is a platform for supporting Open data initiative of Government of India. This portal is a single-point access to datasets, documents, services, tools and applications published by ministries, departments and organisations of the Government of India. The datasets were in the form of csv files separately for each specific year. We combined all the datasets together to form a csv file containing all forest fire incidences from 2014 to 2021.

3.4.2 Data Visualization and Analysis

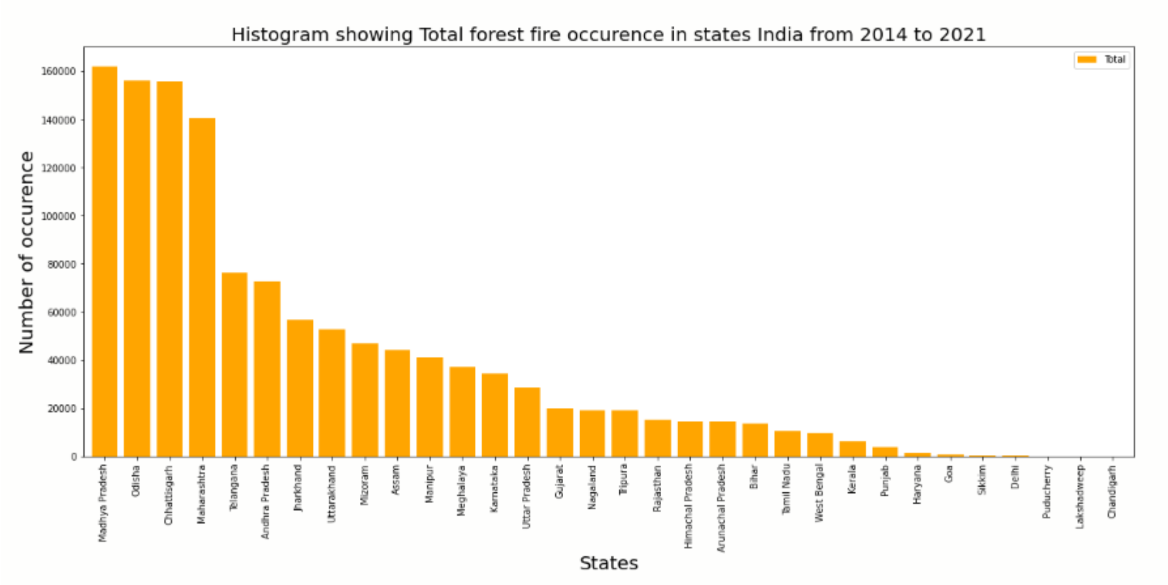


Figure 11: Total forest fires 2014-2021

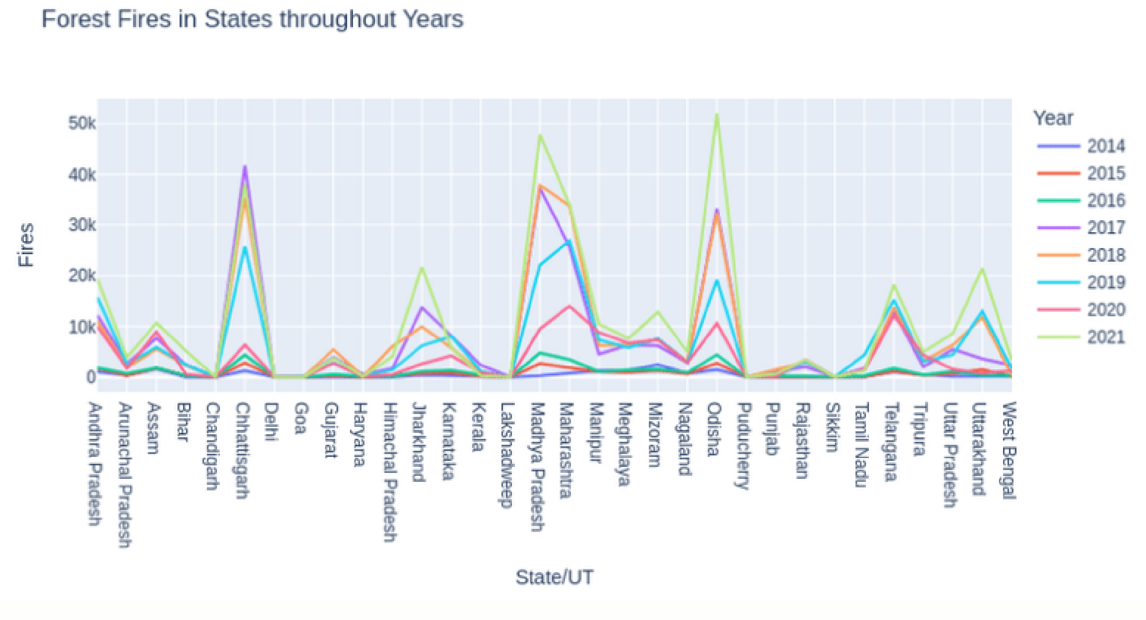


Figure 12: Forest fires by state

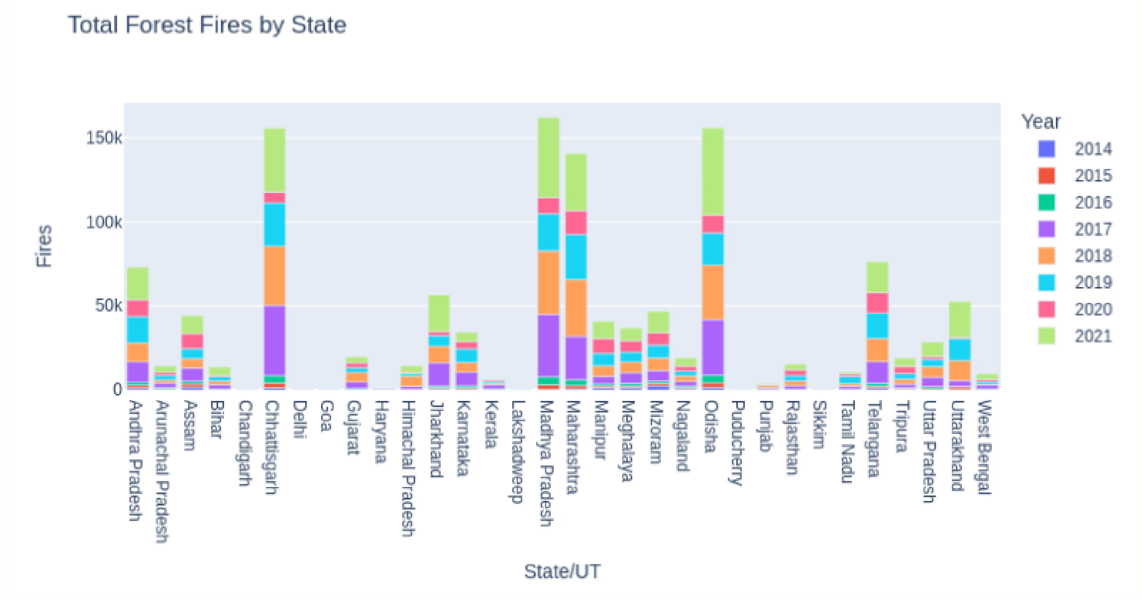


Figure 13: Total Forest fires by state

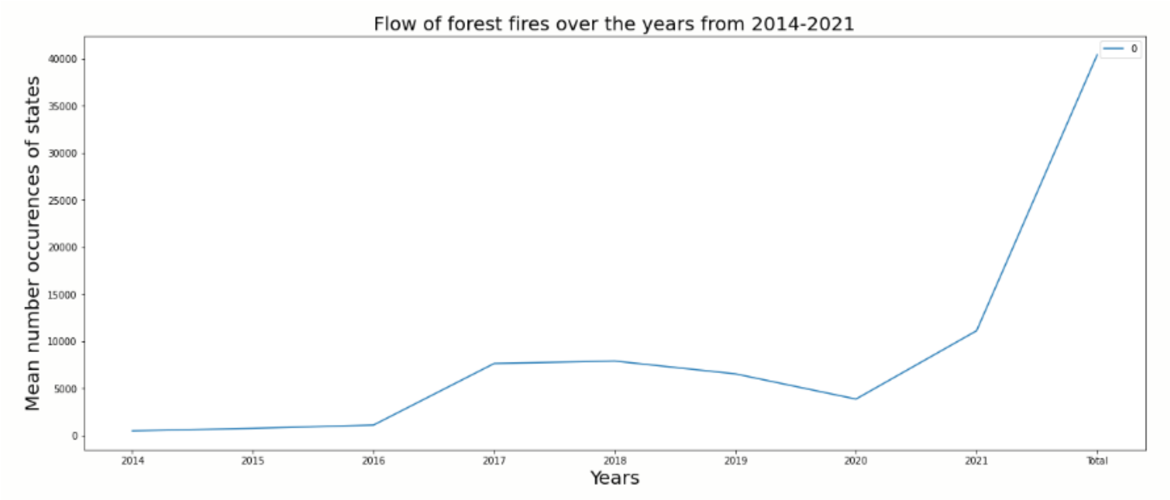


Figure 14: Flow of forest fires

The spike seen in Figure-13 from 2016 can be mainly attributed to one of the worst forest fires to ever occur in India. The 2016 Uttarakhand forest fires were a series of widespread, damaging wildfires that took place in Uttarakhand, India between April and May 2016. The fires were caused by a heatwave that spread across Uttarakhand and were the worst recorded in the region with a reported 4,538 hectares (11,210 acres) of forest burnt down. Officials detected nearly 1,600 total fires which were brought under control by 2 May, and as rain fell the following day, it reduced the impact of the wildfires. An initial report on 4 May noted that 3,500 hectares (8,600 acres) had been destroyed by the fire.

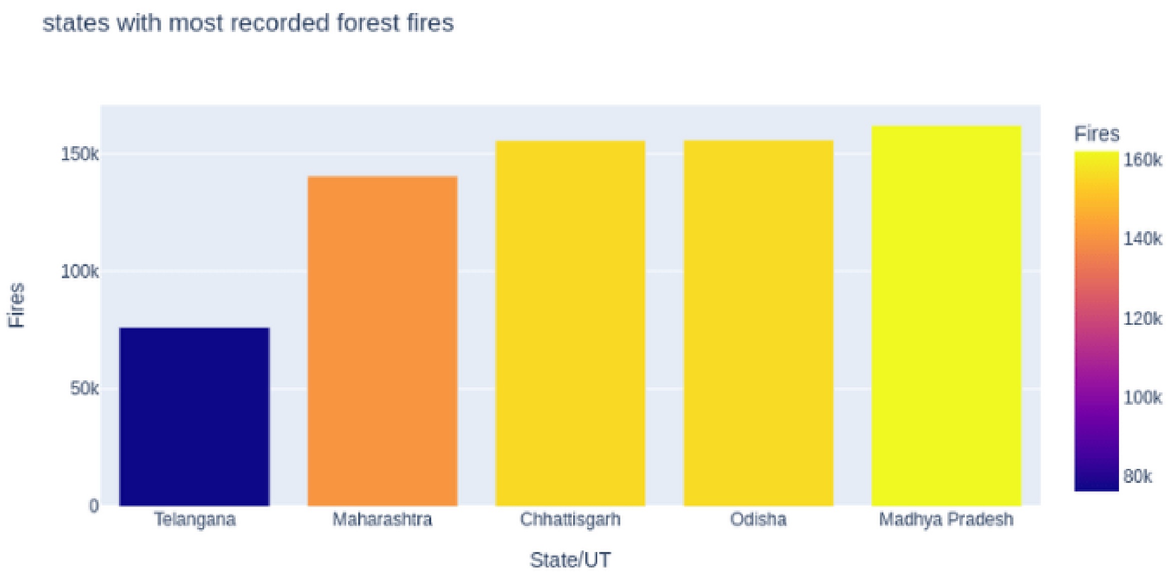


Figure 15: States with most fires

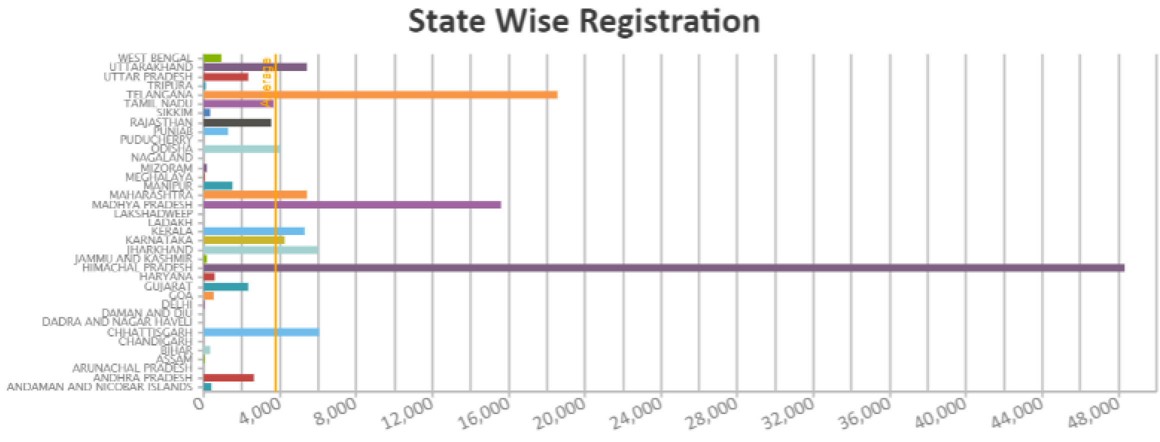


Figure 16: Statewise Registration

From 2017, FSI has also started disseminating alerts obtained from SNPP-VIIRS sensor. Registered users receive SMS and Email alerts having geo-coordinates of the fire location as well as a weblink to view it on their browser. By comparing the two figures, Figure-14 and 15, we can see that the top 5 states with the most recorded forest fires all have above average registration for Fire alerts. This is necessarily a good thing because it shows that people are more aware of the dangers of forest fires and are prepared to face it.

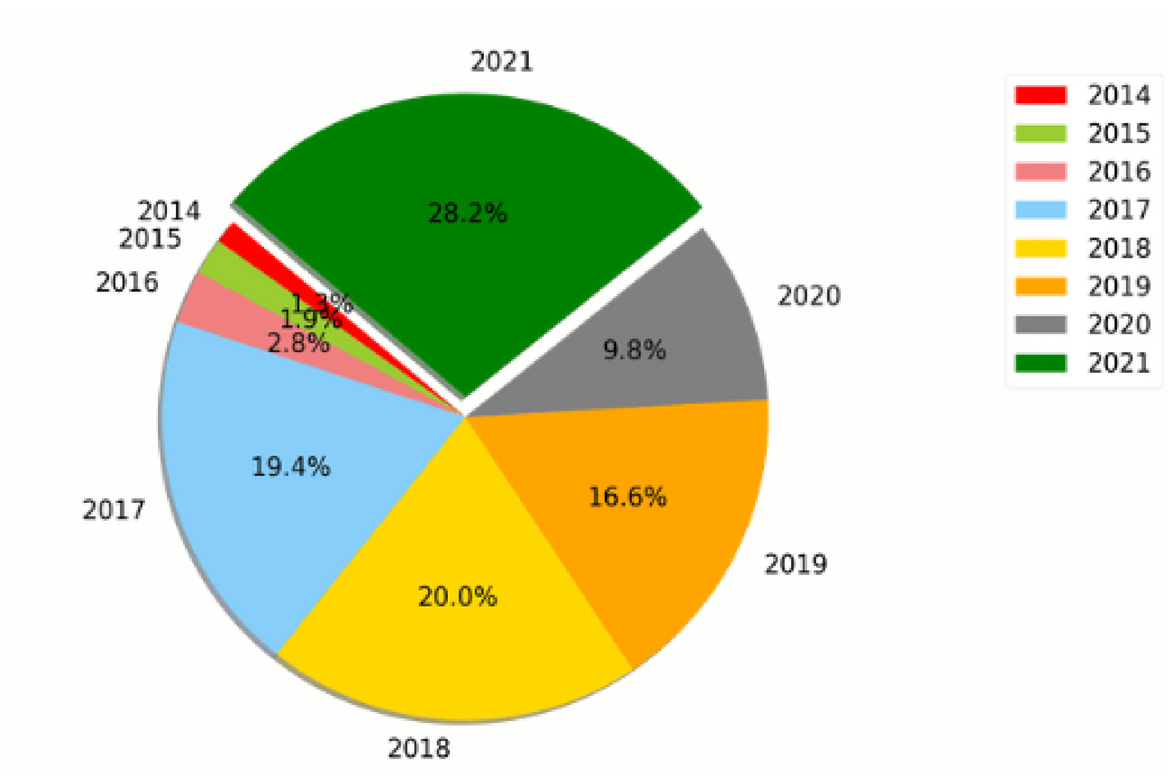


Figure 17: Percentage by year

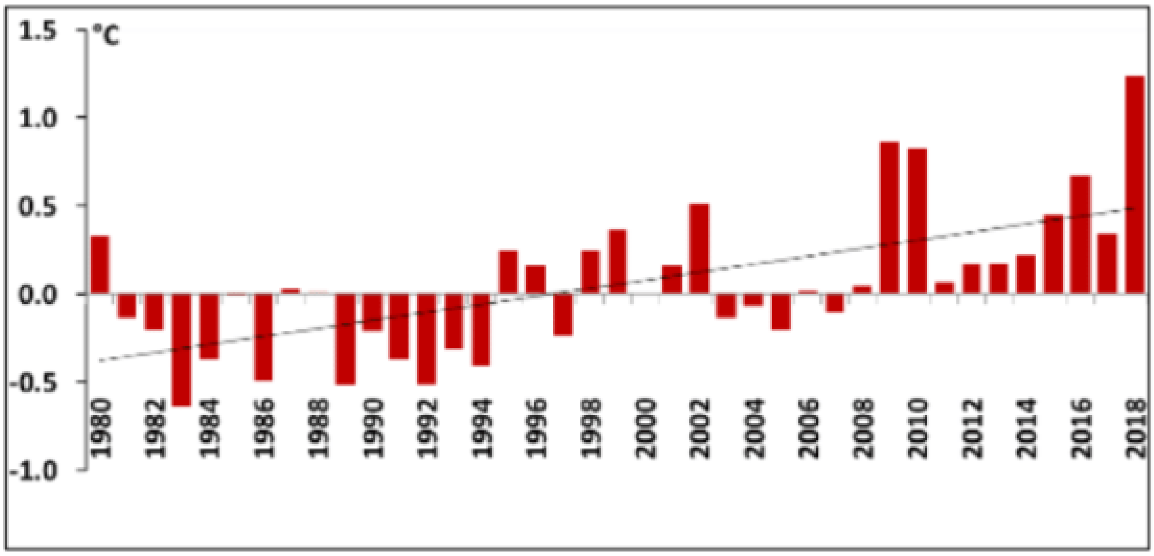


Figure 1.1: Mean temperature anomaly (°C) in India since 1980 (Source: IMD, Srivastava et al. 2009)

Figure 18: Mean temperature

Figure-18 is a pie chart created with the help of a dataset given, while Figure-19 is taken from literature review,a report made by the Forest Survey of India(FSI). We can see that as mean temperature increases throughout the years, a similar trend is also seen in the number of forest fire occurences.

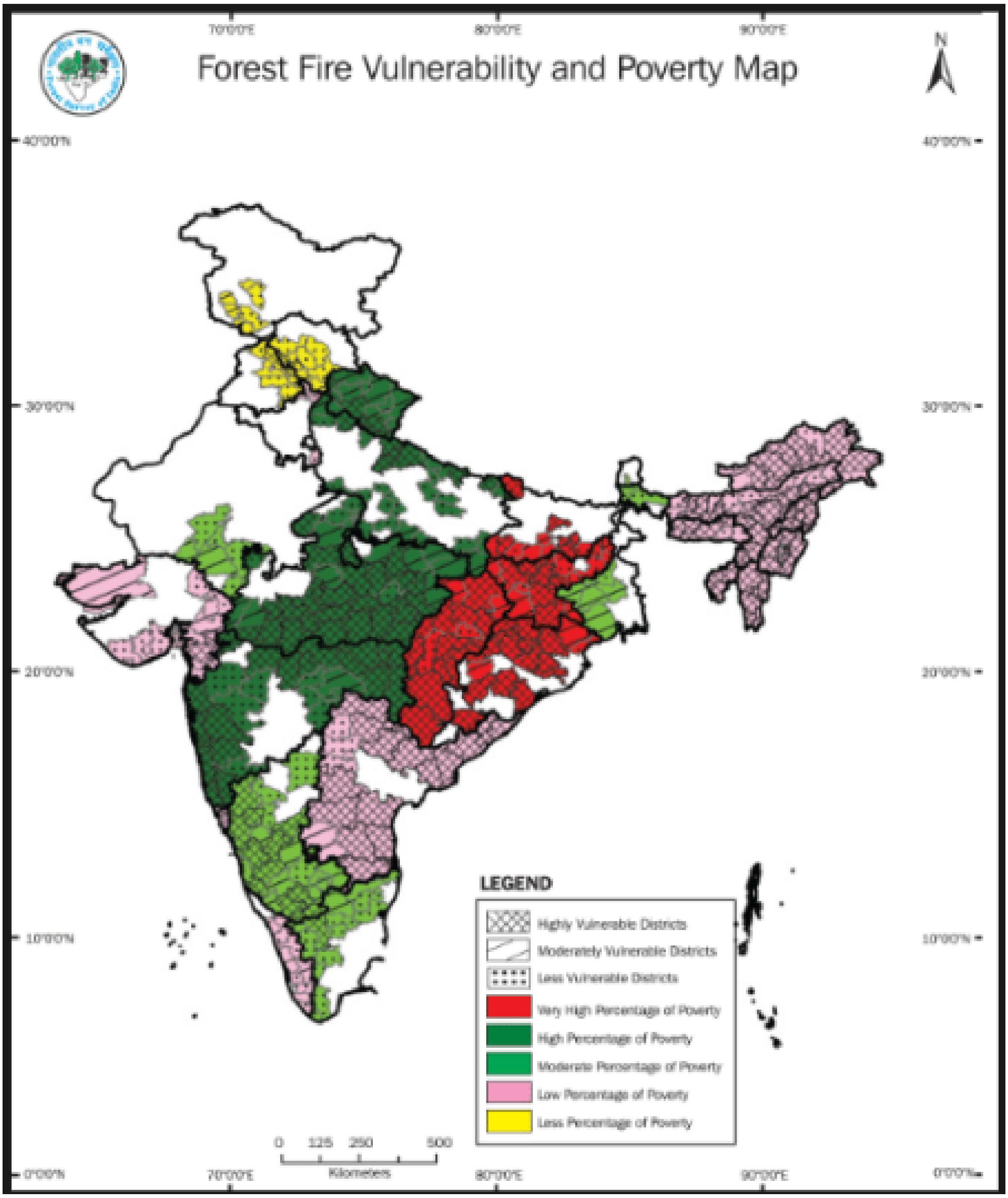


Figure 19: Forest fire vulnerability and poverty

- People below the poverty line has to be overly dependent on forests for resources and any carelessness on their part easily leads to fires.
- Since livelihood of many people around the forests depends on forests, forest fires affect their livelihood directly, thus inflicting poverty.

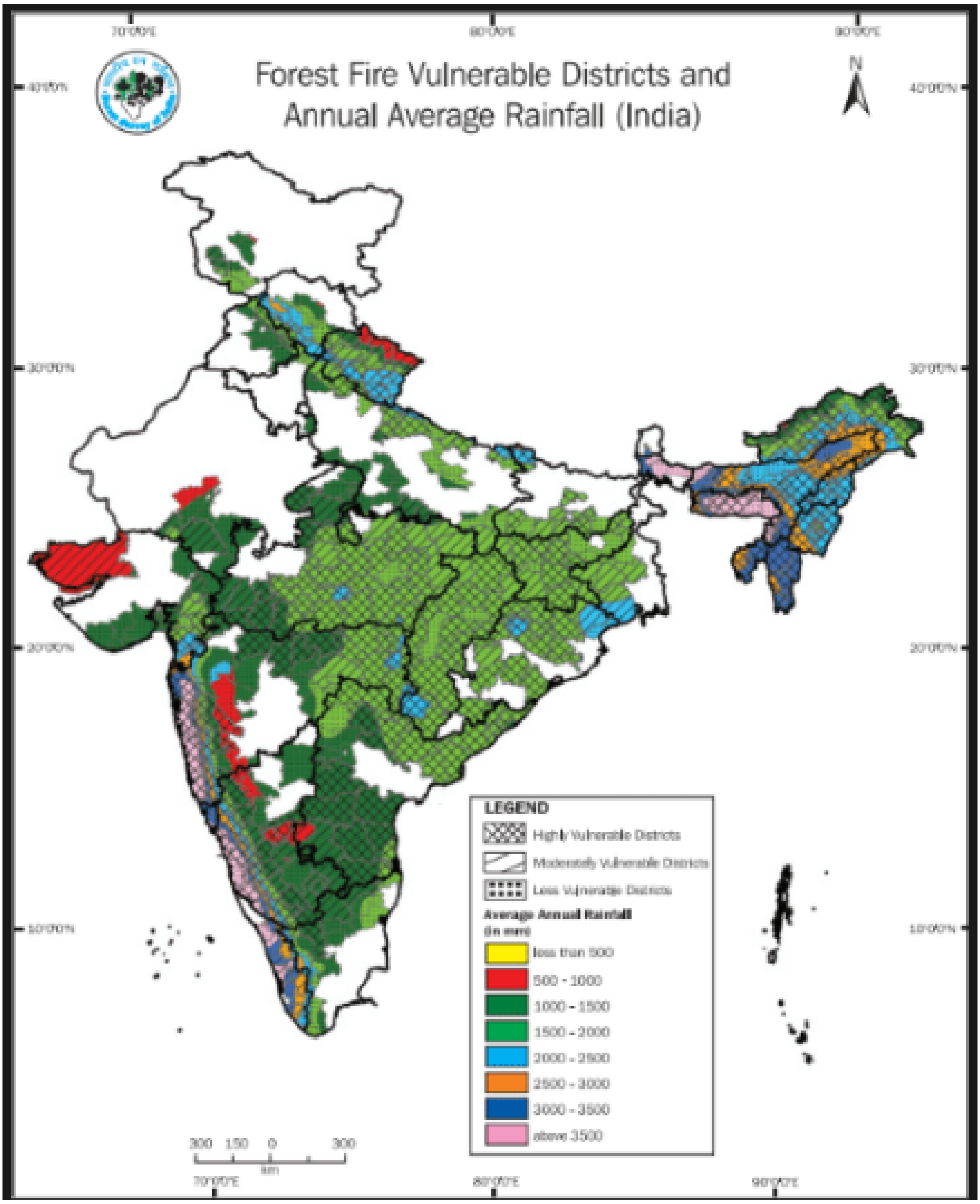


Figure 20: Forest fire vulnerability and average rainfall

- Less rainfall leads to more dry forests which increases the chances of forest fires.
- Smoke from wildfire affects raindrop formation in clouds, thus reducing rainfall.

Thus, from Figure-19 and Figure-20, it can be shown that Rainfall, poverty and forest fire vulnerability are interdependent on each other.

3.4.3 Initiatives

A timeline of the initiatives taken by the Indian government to combat forest fires:

2004: Started dissemination of forest fire alerts based on MODIS data up to district level through email/FAX.

2008: Initiation of SMS alerts on number of fires in State/District

2012: -Introduced KML files in email alerts up to district level along with SMS alert

-Publication of "Vulnerability of India's forests to fires" report.

2016: -Introduction of automated email alerts to nodal officers using python script

-Pilot study on country-wide burnt scar assessment for 2015 and 2016.

-Pre-warning alerts piloted for Uttarakhand, Himachal Pradesh and Madhya Pradesh

2017: -Complete automation of entire FSI Forest Fire Alert System

-SNPP-VIIRS sensor added to FSI forest fire monitoring system

-Forest Fire Alert dissemination up to beat level

-Pre-Fire Alerts piloted for pan India

2018: Introduction of improved feedback system for forest fire alerts

4. Impact on Biodiversity

4.1 How they affect on different scales

4.1.1 Global Scale

They are a significant source of emitted carbon, contributing to global warming which could lead to biodiversity changes.

4.1.2 Regional Scale

Changes biomass stocks, alters the hydrological cycle with subsequent effects for marine systems such as coral reefs, and impact plant and animal species' functioning.

4.1.3 Pyrophytic Conversion

In tropical forests, dead trees topple to the ground, opening up the forest to drying by sunlight, and building up the fuel load with an increase in fire-prone species, such as pyrophytic grasses which makes them susceptible to further burns.

4.1.4 Effect on Flora

Fires can kill virtually all seedlings, sprouts, lianas and young trees because they are not protected by thick bark which hinders recovery of the original species, in forests not adapted to fires

4.1.5 Effect on Fauna

Large scale death of forest vertebrates and invertebrates, as well as longer-term indirect effects such as stress and loss of habitat, territories, shelter and food which slows recovery rate of the forest.

4.1.6 Phtosynthetic Activity

Smoke from fires can block of sunlight and significantly impact photosynthesis, which can be detrimental to health of humans and animals.

4.2 How fires affect biodiversity of aquatic ecosystems and water quality?

- Fires increase runoff, erosion and nutrient transport in the boundaries of aquatic habitats, reduce macrophyte vegetation and thus increase insolation and water temperature.
- Water turbidity, conductance, C, N and P concentrations also change, and dissolved O2 is reduced.
- Ashes in high concentration can kill native fish and be toxic to invertebrates depending on their chemical composition.

4.3 How fires affect wildlife

- Fire effects on animals can be direct/immediate (e.g., death, harm), indirect (e.g., changing habitat and food sources), or, in the long-term, induce animal evolutionary responses to fire regimes.
- Animals from non-flammable ecosystems are usually much affected by wildfires, while those (some endemic) of fire-prone ecosystems are adapted or may even need fire to survive because of the ecological cascade associated with post-fire ecosystem regeneration.

4.4 Effects of fire on soil properties and soil organic matter

Depending on the characteristics of soil, vegetation and fire effects on soil properties may vary substantially, from fertilization of the top layers due to ash deposition (which adds cations and balances pH) to changes in soil aggregate stability, pore size and distribution, water repellency, nutrients stocks and availability, and soil biota, thus influencing soil functions and ecosystem services.

4.5 Fire and Grazing

- In grassy ecosystems, fire and grazers interact in positive-and-negative feedback.
- After burning, grasses quickly resprout, offering palatable and nutritious tissues that attract herbivores, which thus concentrate grazing in these burned patches and reduce biomass and fire risk.
- Less-grazed patches, with more biomass, will eventually burn, thus creating a mosaic of grazed and ungrazed patches that control fires at the landscape level.
- Such spatio-temporal mosaic of burned and unburned patches favors fire-dependent species, and also maintains species that are more sensitive to fire, being thus positive in terms of biodiversity conservation.

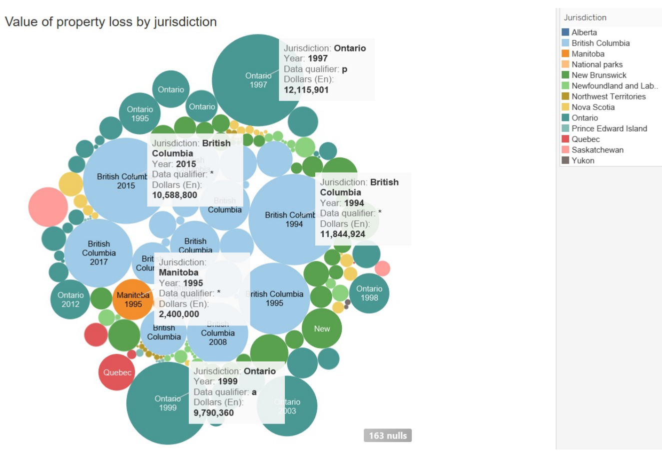
5. Impact on Economy

Some of the main impacts of forest fires on the economy are:

- Tourism is badly affected
- Heavy infrastructure damages are caused
- Forest fire control efforts require significant expenditure
- Forest fires result in high death tolls affecting families socially, medically, as well as economically.

Some of the interesting statistics which show how badly these fires affect the economy are:

- The costliest wildfire in U.S. history, 2018's Camp Fire, resulted in a loss of about 10 billion dollars at the time.
- Each additional day of exposure to smoke from a wildfire lowers a community's wages by around 0.04
- In Nepal, property values in areas which get affected by severe forest fires annually decreased by 4.48



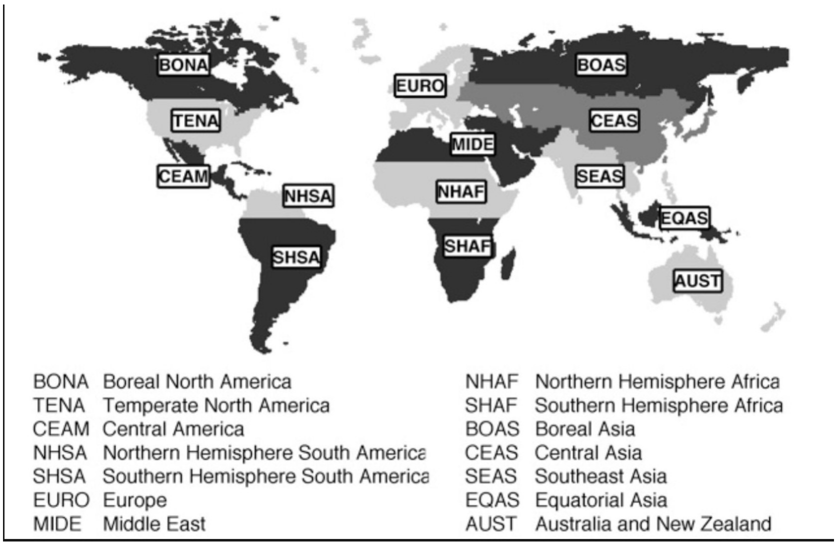
6. Global Gas Emissions

6.1 The Dataset

The Global Fire Emissions Database (GFED4) [13] has been selected for analysing forest fire impacts on Global Emissions

6.1.1 Features

- Fully Verified dataset split according to 14 main regions: BONA, TENA, CEAM, NHSA, SHSA, EURO, MIDE, NHAF, SHAF, CEAS, SEAS, EQAS, AUST and BOAS
- Contains all major fire emissions and analysis done on CH4, CO2, CO, BC, DM, NOx, NMHC and H2
- Contains relevant data over a 25 year period (1997-2022) for improved analysis
- Emissions split among different fire types: Savanna, grassland, and shrubland fires; Boreal forest fires; Temperate forest fires; Tropical deforestation degradation; Peat fires; Agricultural waste burning



6.1.2 Processing

- Data Tables initially stored in difficult to use txt formats converted into dataframes with high utility for graphing and prediction models.
- Data is processed such that any insignificant fire types can be reduced from the overall emissions
- Any desirable emissions can be selected easily for analysis

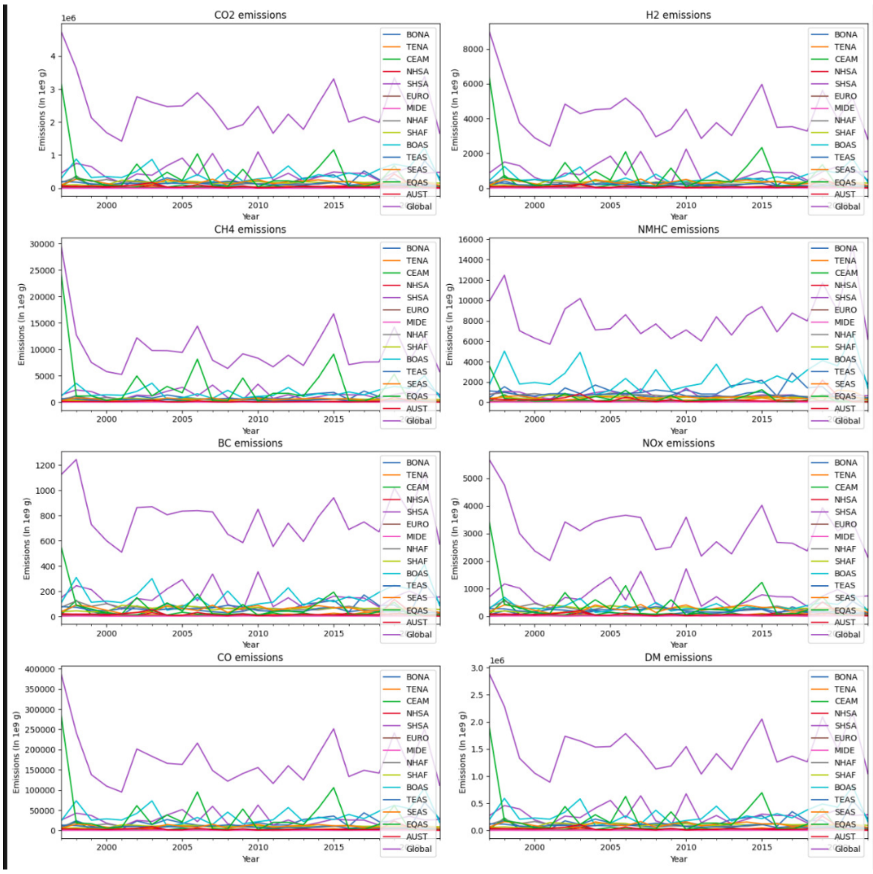
6.2 Analysis

6.2.1 Global gas Emissions

- Most significant forest fire emissions are selected from the database
- As time passes there are peaks and troughs in emissions due to forest fires and factors effecting these are Fire size, spread, duration and speed which are mostly region dependant [14]
- CO2 is the largest emitted by a decent margin. The gases are visualized in an exponentially scaled graph to view trends in emissions.
- The general trend of average emissions is mostly stagnant.

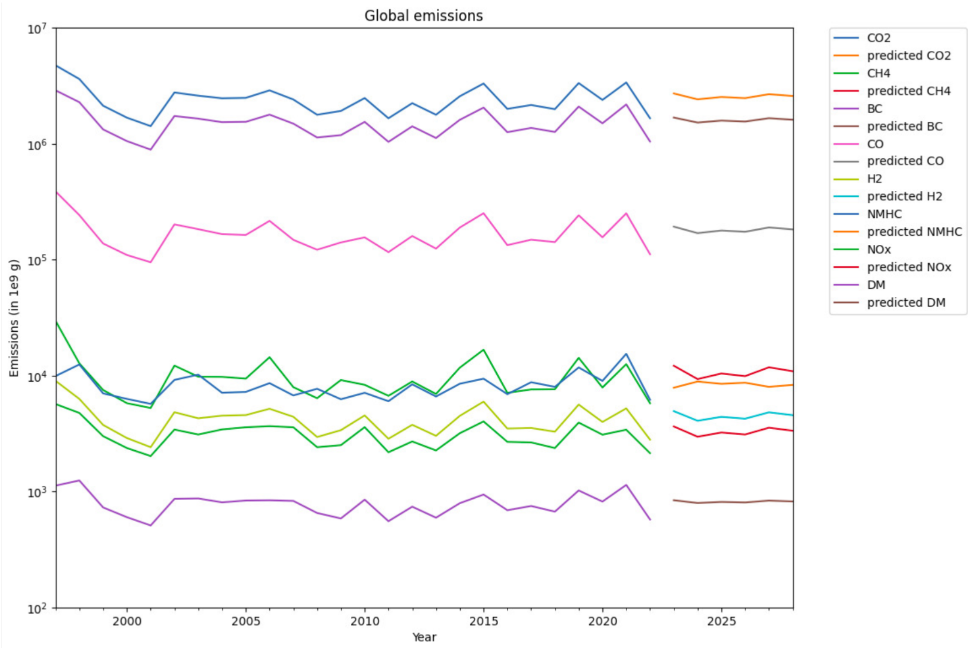
6.2.2 Regional CO2 Emissions

- The largest fires occur in lower latitudes since they have higher temperatures facilitate larger and longer fires
- Decreasing fires in NHAF and SHAF due to High precipitation, decrease in vegetation coverage and human intervention in these regions [14]
- Massive peaks in recent times for AUST and BONA



6.3 Prediction Model and Visualization

- Linear Regression model selected over other classifiers because it's most effective in classifying future values based on independant variables
- Logistic Regression considered but discarded since it classifies future data into wide intervals which is too vague
- Prediction Model supports the hypothesis that general trend in emissions is mostly stagnant



7. Monitoring Tools

For live monitoring, we pulled data from NASA Open API and used Google Maps API to display the location of wildfires around the world.

Increasing amounts of NASA imagery are being made available through web services and a sizeable portion of it is being created and released in near real time. Because of this capability, NASA imaging can be utilised more frequently to monitor live natural disasters like forest fires.

According to NASA, The Earth Observatory Natural Event Tracker (EONET) [5] is a prototype web service with the goal of providing a curated source of continuously updated natural event metadata; providing a service that links those natural events to thematically-related web service-enabled image sources

8. Forestfire Impact Prediction

Fast detection is a key element for controlling forest fires. Since traditional human surveillance is expensive and affected by subjective factors, there has been an emphasis to develop automatic solutions grouped into 3 categories Satellite-based, Infrared/smoke scanners, and Local sensors (e.g. meteorological).

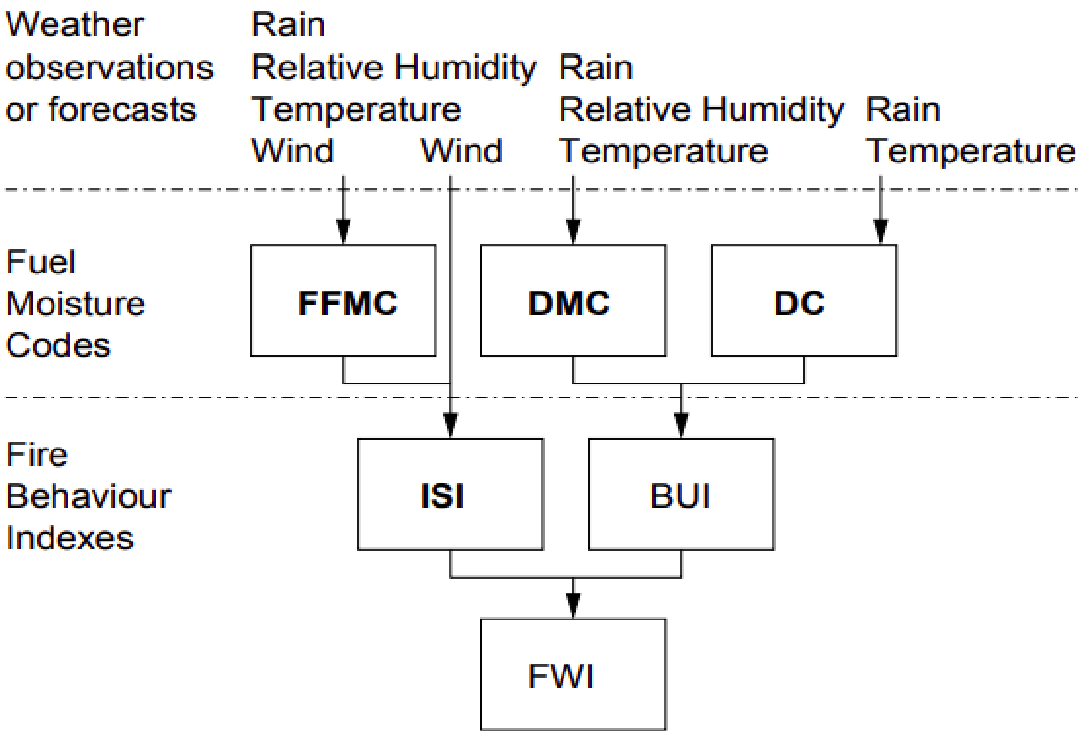
In this section, we try to propose a data mining approach that uses meteorological data as detected by local sensors in weather stations, and that is known to influence forest fires, to predict the burned area. The advantage is that such data can be collected in real-time and with very low costs when compared with the satellite and scanner approaches. This knowledge will be useful for prevention (e.g. warning the public of fire danger) and to support fire management decisions (e.g. level of readiness, prioritizing targets or evaluating guidelines for safe firefighting). When small fires are predicted then air tankers could be spared and small ground crews could be sent. Such management would be particularly advantageous in dramatic fire seasons when simultaneous fires occur at distinct locations.

8.1 Data

We train and test our model on recent real-world data collected from the northeast region of Portugal. As discussed during the case study, Portugal is highly affected by forest fires. From 1980 to 2005, over 2.7 million ha of forest area have been destroyed due to forestfires. The data used in the experiment were collected from January 2000 to December 2003

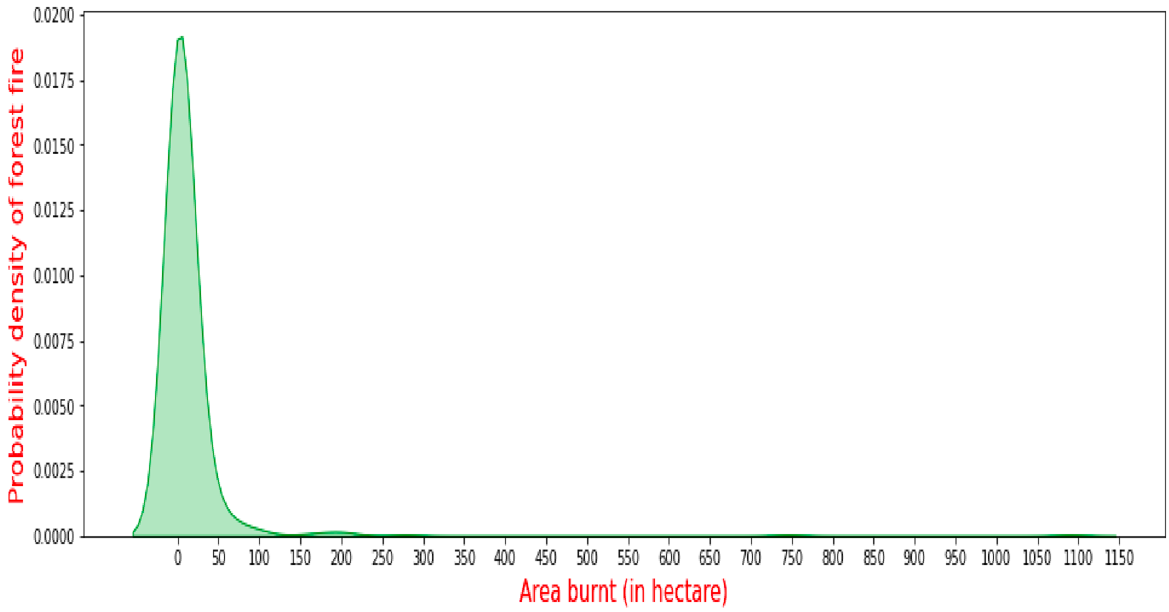
- Number of instances = 517
- Number of attributes = 12 + output attribute (area)
- Spatial variables = X and Y
- Temporal variables = month and day
- Meteorological data = temp, relative humidity, wind, rain
- 4 FWI(Canadian forest Fire Weather Index) components
- FFMC denotes the moisture content of surface litter and influences ignition and fire spread
- DMC and DC represent the moisture content of shallow and deep organic layers, which affect fire intensity
- ISI is a score that correlates with fire velocity spread
- BUI represents the amount of available fuel
- FWI index is an indicator of fire intensity and it combines the two previous components

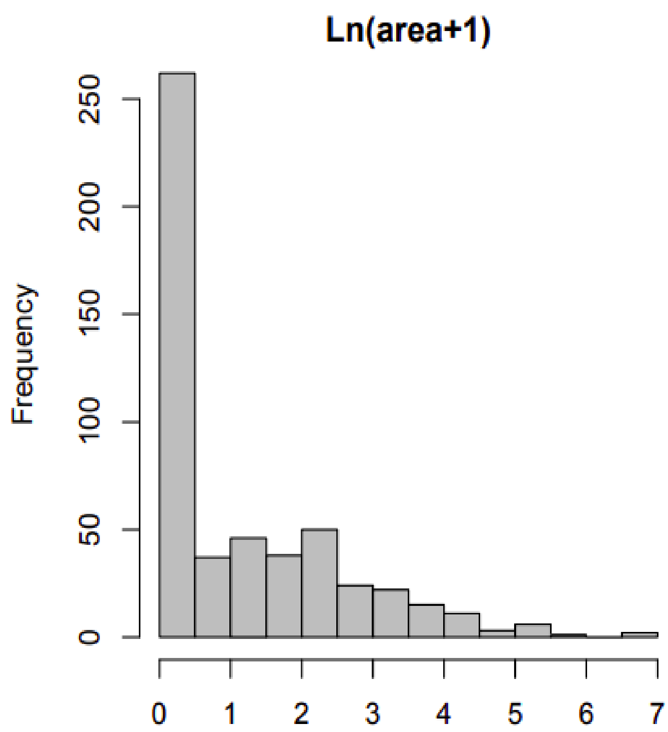
Attribute	**Description**
X	x-axis coordinate (from 1 to 9)
Y	y-axis coordinate (from 1 to 9)
month	Month of the year (January to December)
day	Day of the week (Monday to Sunday)
FFMC	FFMC code
DMC	DMC code
DC	DC code
ISI	ISI index
temp	Outside temperature (in °C)
RH	Outside relative humidity (in %)
wind	Outside wind speed (in km/h)
rain	Outside rain (in mm/m^2)
area	Total burned area (in ha)

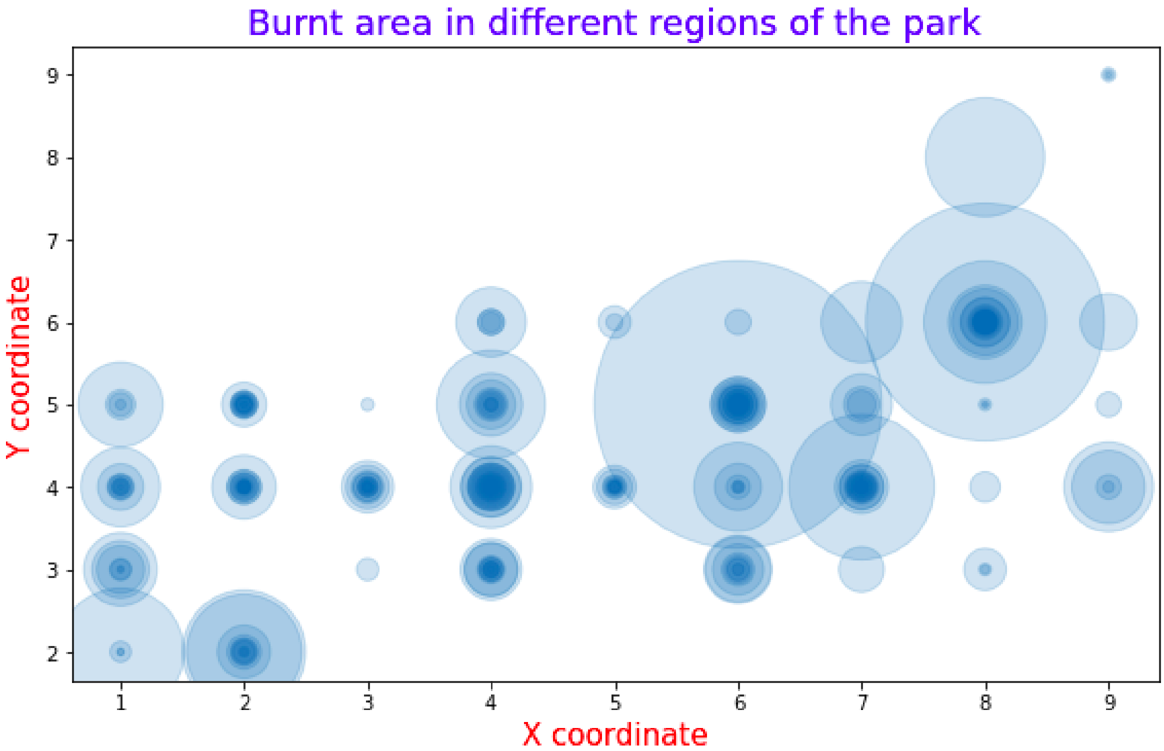


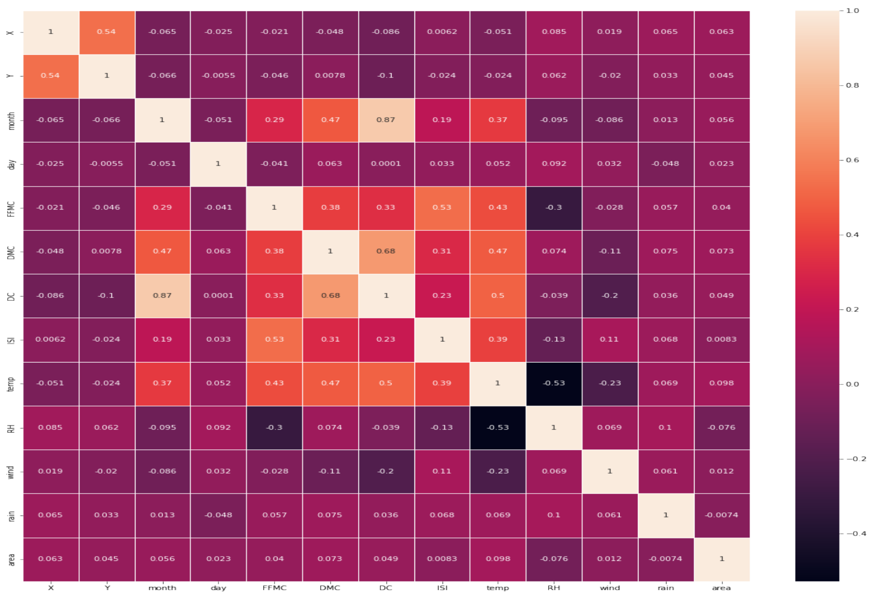
8.2 Exploratory Data Analysis

Data is positively skewed, the majority of the fires present are of small size. To reduce the skewness and improve symmetry, we use the logarithm transform.






Burnt area in different regions of the park
Y coordinate
X coordinate
1 2 3 4 5 6 7 8 9
2 3 4 5 6 7 8 9


X 1 0.54 -0.065 -0.025 -0.021 -0.048 -0.086 0.0062 -0.051 0.085 0.019 0.065 0.063
Y 0.54 1 -0.066 -0.0055 -0.046 0.0078 -0.1 -0.024 -0.024 0.062 -0.02 0.033 0.045
month -0.065 -0.066 1 -0.051 0.29 0.47 0.87 0.19 0.37 -0.095 -0.086 0.013 0.056
day -0.025 -0.0055 -0.051 1 -0.041 0.063 0.0001 0.033 0.052 0.092 0.032 -0.048 0.023
FFMC -0.021 -0.046 0.29 -0.041 1 0.38 0.33 0.53 0.43 -0.3 -0.028 0.057 0.04
DMC -0.048 0.0078 0.47 0.063 0.38 1 0.68 0.31 0.47 0.074 -0.11 0.075 0.073
DC -0.086 -0.1 0.87 0.0001 0.33 0.68 1 0.23 0.5 -0.039 -0.2 0.036 0.049
ISI 0.0062 -0.024 0.19 0.033 0.53 0.31 0.23 1 0.39 -0.13 0.11 0.068 0.0083
temp -0.051 -0.024 0.37 0.052 0.43 0.47 0.5 0.39 1 -0.53 -0.23 0.069 0.098
RH 0.085 0.062 -0.095 0.092 -0.3 0.074 -0.039 -0.13 -0.53 1 0.069 0.1 -0.076
wind 0.019 -0.02 -0.086 0.032 -0.028 -0.11 -0.2 0.11 -0.23 0.069 1 0.061 0.012
rain 0.065 0.033 0.013 -0.048 0.057 0.075 0.036 0.068 0.069 0.1 0.061 1 -0.0074
area 0.063 0.045 0.056 0.023 0.04 0.073 0.049 0.0083 0.098 -0.076 0.012 -0.0074 1
X Y month day FFMC DMC DC ISI temp RH wind rain area
1.0 0.8 0.6 0.4 0.2 0.0 −0.2 −0.4

8.3 Experimental Results

We try out different data mining techniques e.g. Support Vector Machines, and Random Forests and distinct feature selection setups and the overall performance of each configuration was computed by regression score and mean absolute error (MAE).

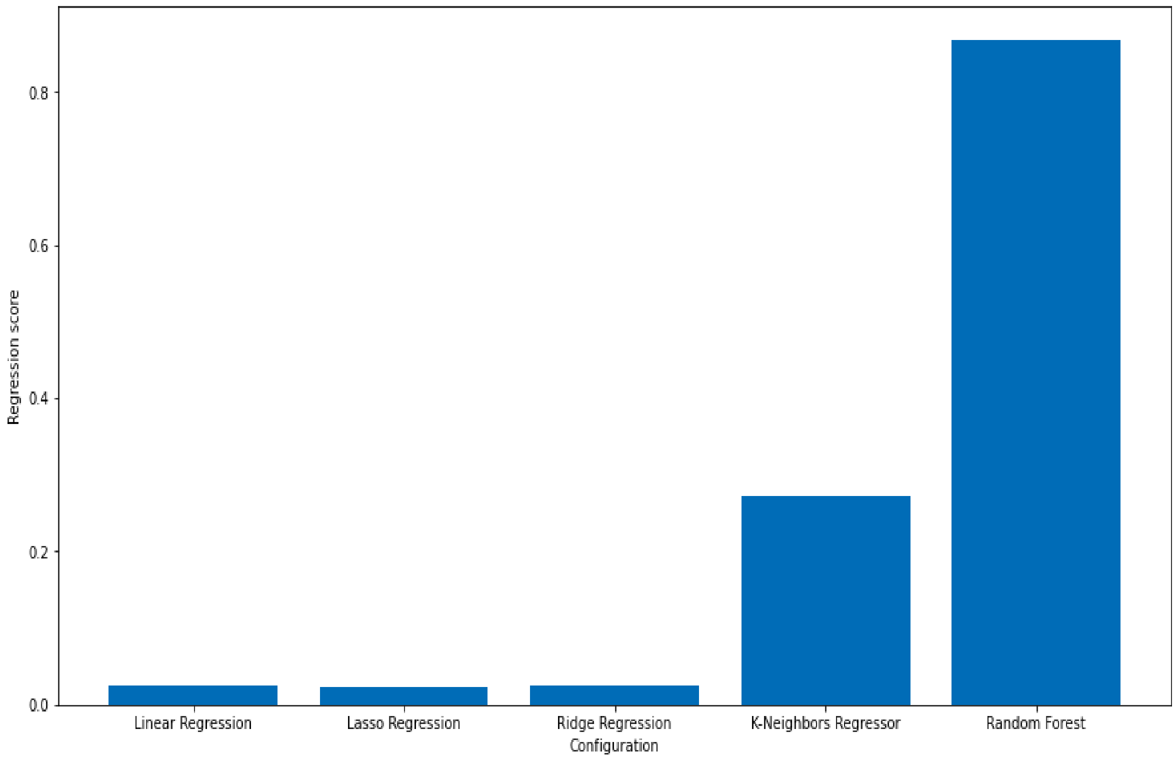
Models

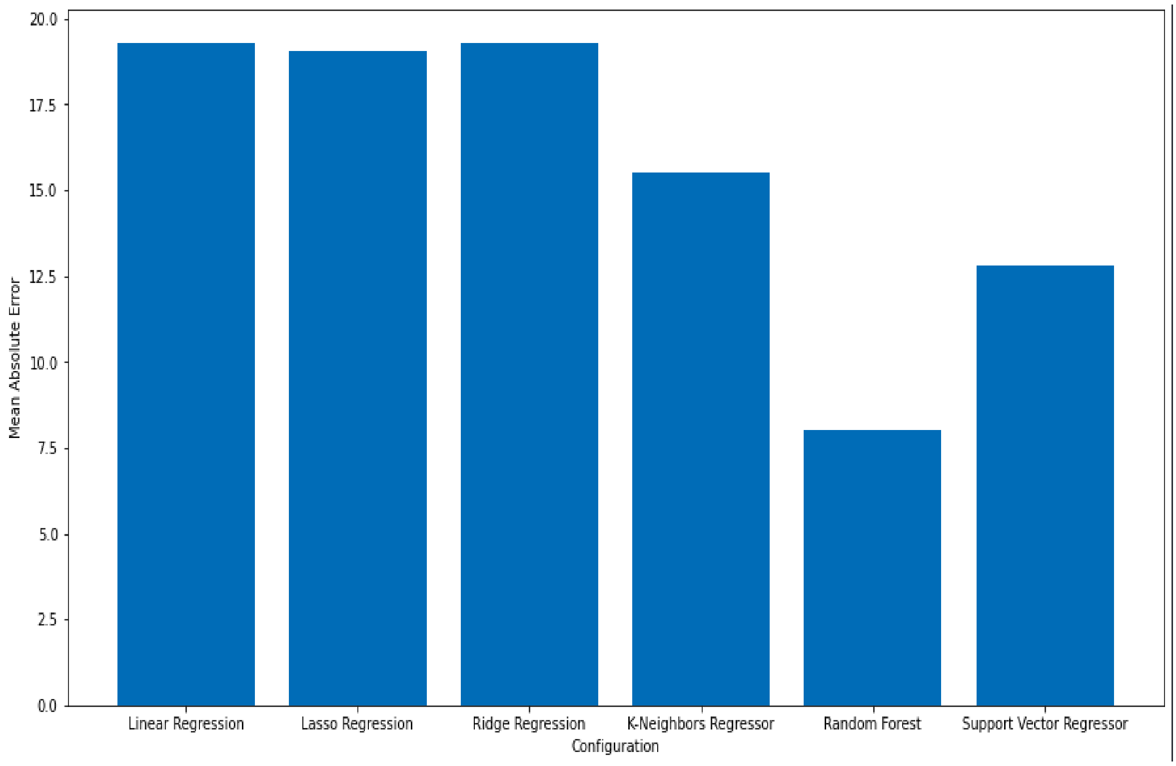
8.3.1 Models

- The multiple Regression (MR) model is easy to interpret but it can only learn linear mappings.
- Methods based on tree structures, such as Decision trees (DT) and Random Forests (RF).
- Nonlinear functions, such as Neural Networks (NN) and Support Vector Machines (SVM).

The best configuration uses an SVM and four meteorological inputs (i.e. temperature, relative humidity, rain and wind).

The proposed solution is capable of predicting small fires, which constitute the majority of fire occurrences. The drawback is the lower predictive accuracy for large fires. To improve it, additional information (not available in this study) such as the type of vegetation and firefighting intervention (e.g. time elapsed and firefighting strategy) can prove helpful.





9. Dashboard

In the dashboard, we displayed our research regarding wildfires in Canada, Portugal, Brazil, India and also our findings about the impact of forest fires in biodiversity and global emissions.

We also suggested plans for fire management that can be implemented to prevent and reduced impact of forest fires.

The dashboard links to our monitoring tool which uses NASA Open API to get data from its EONET web service to display wildfires across the globe. The locations are transfered on to the map using Google MAps API.

Deployed Website : Link

10. Plan of Action

Based on the analysis and visualizations done on various case studies including studying the disaster management policies especially forest fire management policies, we have compiled following sets of protocols:
Before Stage (When the prediction tool predicts a forest fire in next 15-30 days):

- Regular Monitoring Should be done using our plotting tool
- Alerts should be made in nearby residential areas

- Residents and Locals should be made aware of Helpline numbers
- Pay close attention to weather and drought conditions which can affect the flammability of vegetation.
- Restrict Tourists from setting up camp-fires
- Prescribed burning should be carried out. Materials burned in a planned fire include dead grass, fallen tree branches, dead trees, and thick undergrowth.

Prescribed Burning

Prescribed burning can be defined as the thoughtful and skilful application of fire to a specific site under selected weather conditions to accomplish specific land management objectives. Prescribed burning can be used to assist ecological system requirements such as:

- Forest Production
- Water Catchment Yields
- Erosion
- Responses of Fauna and Fauna within that System to Fire
- Fire Dependency of the System Required for Regeneration
- Weed Responses to Fire
- Predation

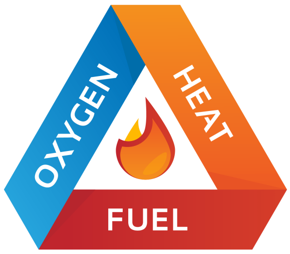
To implement a safe and successful prescribed burn, it is important to understand how various factors influence fire behaviour. Wind, relative humidity, temperature, soil moisture, fuel moisture, air mass stability, and topography are important elements to understand and consider when planning and implementing a burn:

1. Wind
   - Transport Wind Speed : 6 to 18 mph
   - Surface Wind Speed : 1 to 3 mph
   - Although it varies with topology, wind direction and wind steadiness
2. Relative Humidity
   - Preferred relative humidity for prescribed burning ranges from 30 to 55 percent.
   - When the relative humidity drops below 30 percent, prescribed burning can become dangerous.
3. Rainfall and Soil Moisture
   - Soil should be damp to moderately wet.
   - Prescribed burning should cease during periods of drought and resume only after a good soaking rain of at least 1 inch.
   - On clay soils, much of the rainfall is lost through surface runoff. Therefore, the duration of the rainfall is more important than the amount that falls.

4. Temperature
    - Highly depends on vegetation and hence on the region.
5. Fuel Moisture
    - FFM should be 10-20
    - Roughly, RH/2 = FFM
6. Topography
    - Fires burn more rapidly uphill than downhill. The steeper the slope, the faster and hotter the fire burns.
    - This is because the fuels above the fire are brought into closer contact with the upward-moving flames.

During Stage: Urgent Actions to be taken in case a forest fire initiates

Any fire requires three ingredients: Oxygen, Fuel and Heat.



- Cooling - tackling heat/temperature: One of the most common methods of extinguishing a fire is by cooling it with water.
- This process depends on cooling the fuel to a point where it does not produce sufficient vapour to burn. Smothering - by air-dropping sand
- Starvation - using prescribed burning

The main types of suppression tactics that can be implemented during a wildfire incident are:

- Direct attack
    - During direct attack, firefighters attack the fire aggressively by using hand tools and beaters and/or by applying water and/or retardants.
    - for flame lengths less than 2 metres
- Indirect attack
    - Indirect attack is where personnel and resources complete suppression activities some distance away from the fire front.
    - for flame lengths 2-3.5 m

- Aerial attack
    - Aircrafts/drones can be used for direct and indirect attacks.

After Fire

- Natural Regeneration: It depends on the abundance of seeds available. Moreover, it doesn't allow for species selection, stocking levels and spacing.
- Artifical Regeneration: Standard choice for regeneration.
- Emergency stabilization program and rehabilitation efforts

11. Conclusion

The project involved a deep dive into the forest fire histories and management systems of four major countries supplemented with an analysis of global emissions data and the development of a monitoring tool and dashboard for easy access and visualization of forest fire data.
An analysis of the forest management systems of the four countries as well as looking at the pattern of fires there, complemented with intensive literature review helped us formulate a 3 phase Plan of Action that countries can adopt to minimize the effects of forest fires.
The monitoring tool uses live data from NASA EONET api which can be used to supplement the proposed fire management strategies. Improvememt in the data collection of the EONET can further help with detection and quick action. Suggested improvements will also need to be supported by strict legal enforcement mechanisms to ensure that the likelyhood of forest fires go down

12. Future Work

Our future work includes mailing professionals in the field of disaster management and fire fighting for an interview since that can act as a really good source of credible information in a video format.

13. Acknowledgements

For this project we have used several sources of information such as NASA and government websites of various countries especially Portugal, Canada, India, and Brazil. The data in these websites was especially useful for us for our findings. Along with this we have taken reference from some internet websites like Kaggle, and ResearchGate for papers and data related to our project. We have also used maps from various sources. We would also like to thank Prof. Ramchandra Prasad for his invaluable guidance

throughout the course of this project, without which it would not have been possible for us to come up with our findings.

14. References

1. https://unesdoc.unesco.org/ark:/48223/pf0000367454
2. https://news.mongabay.com/2017/10/record-amazon-fires-stun-scientists-sign-of-s
3. http://nfdp.ccfm.org/en/data/fires.php
4. https://www.analyticsvidhya.com/blog/2021/10/forest-fire-prediction-using-machi
5. https://eonet.gsfc.nasa.gov/docs/v2.1
6. https://fsi.nic.in/forest-fire-activities
7. https://www.firstpost.com/india/in-india-as-incidence-of-forest-fires-spikes-in html
8. https://www.researchgate.net/publication/263621026_Forest_Fires_in_Portugal_Dynamics_Causes_and_Policies
9. https://www.iii.org/fact-statistic/facts-statistics-wildfires
10. http://www3.dsi.uminho.pt/pcortez/forestfires/
11. https://mapthesystem.sbs.ox.ac.uk/files/sfu-map-system-visual-mappdf
12. http://www.globalfiredata.org/data.html
13. https://geo.vu.nl/~gwerf/GFED/GFED4/tables/
14. https://iopscience.iop.org/article/10.1088/1755-1315/801/1/012013/pdf
15. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2001JD000484
16. https://www.globalforestwatch.org/topics/fires/#intro
17. https://www.kaggle.com/datasets
18. https://bhuvan.nrsc.gov.in/home/index.php
19. https://www.researchgate.net/publication/235992014_Mathematical_model_of_forest_fire_initiation_and_spread
20. https://www.agriculture.gov.au/sites/default/files/documents/ABARES_Forest_Fire_area_2019_20_data_tables_28Apr.xlsx
21. https://data.gov.au/data/dataset/2020-operational-bushfire-boundaries
22. https://data.sa.gov.au/data/dataset/?tags=bushfire
23. https://www.firenorth.org.au/nafi3/
24. https://storymaps.arcgis.com/stories/b7c3dd632a174d239bf72fa20226ca96

25. https://www.bioversityinternational.org/e-library/publications/detail/training-manual-on-spatial-analysis-of-plant-diversity-and-distribution/

26. https://aqicn.org/data-platform/register/

27. https://fsi.nic.in/index.php

28. https://data.gov.in/