Analysis And Empirical Decision for Post Forest Fire Effects on Atmosphere and Vegetation Loss

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Abstract

Forest fire is a major natural disaster in the world. This has provided major challenges for researches to study and predict on ecology imbalances. The high severity forest fire causes most loss to the vegetation and atmosphere by producing chemicals like Carbon to air. So the effects of fire have to be detected within forest region in order to detect the loss. This detection helps to forest department to make a decision for the re-use of the forest zone. Currently satellites are providing continuous monitoring of the fire with videos. But in real time videos cannot provide the data of fire for the loss into the ecology. So proposed work gives a framework where fire occurred place data is collected and stored to do analysis and prediction of fire to ecology. This paper presents comprehensive analysis based on air quality degradation, vegetation loss and high lights need for effective land management strategies. Different supervised learning algorithms are used to predict effect on the atmosphere. The prediction on the effects air and vegetation loss is obtained with the good accuracy from the work.

Keywords - Forest fire, natural disaster, satellites, atmosphere, supervised learning algorithms

1. Introduction

India is the seventh largest country in area and tenth largest in forested area, it covers almost 23.68% . In 1995 in the hills of Uttar Pradesh and Himachal Pradesh area of 677,700 hectares has been destroyed due to forest fires . In 2016 forest fire has been occurred in Indian states and destroyed almost 3,500 hectares of forest.

The Karnataka state is located between 11 30'and 18 30'N latitudes and 74 10"and 78 30" E longitudes. The state covers an area of 1, 91,790 sq.kms. This accounts for 5.8% of the total geographic area of the country. The coastline with Westrenghats covers 300 km long, which forms the western boundary. The state has border area Goa in the North- West, Maharashtra in the North, Andhra Pradesh inthe East, Tamilnadu in the South and South - East and Kerala in the South-West.

Karnataka's forest covers 19.58% of the total area. According to the survey of Karnataka fire occurred as many as 17,852 times affecting about 5,72,417 km of which most of the cases reported from deciduous forests. About 2330 km of forests have been lost due to forest fire . In March 2012 a major forest fire occurred in Bandipur and Nagarahole almost 1348 hectares has been destroyed. In 2014 one more fire occurred in Nagarahole and almost 60 hectares of forest area were destroyed. Recently four forest fires occurred in ten days and destroyed 700 acres of tree in Karnataka.

The forest degradation is considered with high preference in protecting the Nature, the survey has been conducted over the different technique to detect forest fire. The forest fires are generally caused by climatic conditions and human interventions. The analysis has given that 30% of Carbon di oxide increase is due to forest fire in the atmosphere [1].

The high severity and frequently occurring fires, will cause change in the eco-system patterns. In detail understanding of these factors can be done with remote sensing. The purpose of post fire analysis is to recover the forest areas and to

facilitate the sustainability of the forest. In order to identify the post fire patterns the survey is conducted on the remote sensing data. Forest fire is a major disturbance in eco-system causing loss to the lives, soil degradation. This paper aims to analyse these factors using Supervised learning techniques .The results found were good at accuracy.

2. Literature survey

Once the fire occurs with high severity it mainly effect on the soil color and hydrophobicity changes in the vegetation. This can be quantified to detect the soil degradation. The carbon emission to ecosystem is given in the Indian government websites and also crbon reports[1-4] The Fire Burn Index is integrated with several factors to analyse post fire activity. This post effect is having low correlation between soil depth factors and organic material in the soil [5-7].

The soil properties loss is detected using the remote sensing data. The remote sensing data is extracted with satellite images and classification algorithms are applied to detect soil loss. The Regression model is used to determine the relation among burn severity and soil loss .The remote sensing with this algorithm has given 95% accuracy for prediction of soil erosion.
All the countries across the world are responding to the post effects, which is of major concerns to facilitate the replantation possibility in the fire occurred area. The burned area of herbs, sherbs and deciduous forest will increase Carbon Cycle and Nitrogen cycle in faster way. The forest replantation is nothing but the influence of organic matter [8-10].

The forest compositional, functional parameters in the forest area are dependent on each other. Different species presence and composition will replace the structural and functional attributes. Many of them include attributes like canopy layering and nutrients cycling processes for the development of plant community. The Space borne Synthetic Aperture Radar (SAR) has provided the data for the regrowth of grass, shrub and young plants in the wild fire lands[11-15].

The data obtained by SAR is used as forest recovery attributes for plant growth. The attributes in the data include sun light, water (Ph and soil moisture) and mechanical factors (fire affected area). These attributes are continuously monitored using remote sensing sensors for reusability of forest land area[16]

The forest fire is the major environmental concern, as it causes air pollution, loss of vegetation and soil erosion in the forest eco-system. During the forest fire, many chemicals are liberated. Some of them are Carbon di oxide, Carbon monoxide, Sulphur oxide, lead and so on .These chemical contents increases the Particulate Matter in air causing respiratory problem to the wild animals and nearby village people. Hence based on the liberated smoke the air quality is analyzed in this research work and is discussed in this paper.This paper concentrates on the loss of vegetation or burned forest area due to fire. This vegetation loss directly depends on the fire severity. Based on the fire severity the burned land area is predicted. The dry vegetation burn will cause the high severity fire which intends to cause more loss to the vegetation.

Based on the fire severity the other factor loss in soil chemicals is also analyzed. The soil loses it's chemical properties by the high severity fire. In order to analyze these above factors Indian forest system uses MODIS data. The Carbon contents produced by the fire and burned land prediction is conducted based on Satellite information [12-13].
The loss in vegetation and soil erosion are predicted using hypothetical models. Since this loss mainly depends on the fire severity, the hypothetical model is used to predict loss in the vegetation and soil [17-20].Many government websites gives the details on the fire severity and burning losses on the vegetation[21-24].

The Machine learning tasks can be used for the appropriate prediction for the post fire effects on soil and air. The Proposed work helps to predict the major loss of forest fire.

3. Materials and methods

The data is collected from the web site www.aranya.org (Bhuvan project). Data base is mainly emphasized on the Indian forest vegetation. The Indian forest vegetation mainly includes burning of Pine, Neem, Herbs, and Sherbs. The data set contains Type of vegetation burnt , Time of fire , concentration of air pollutants Carbon pollutants(CO) mg/m3 , Nitrogen

Pollutants(NO2) µg/m3 , Ozone(O3 or smog) µg/m3 , Sulphur Pollutants(SO2) µg/m3 ,Total Particulate Matter(PM) µg/m3 as attributes .

3.1CART Algorithm in Air Pollution Prediction:

The Classification and Regression Trees (CART) algorithm is a popular machine learning technique used for prediction and modeling tasks .When it is applied to air pollution prediction,algorithm can be used to develop predictive model estimates pollution levels based on input variables.

$$Gini = 1 - \sum_{i=1}^{n} (pi)^2$$

Cart algorithm utilizes Gini Impurity criterion to partition the dataset and construct a decision tree. This is achieved by seeking optimal homogeneity for the subnodes through the utilization of the Gini index.
CART is a supervised learning algorithm that decides the target class of records based on available data set. The reason for using CART is, it helps to overcome missing values. The attribute with the highest normalized information gain is used for the decision. In this work based on highest information gain on the chemical parameters, classification of the air quality is performed. The leaf nodes represents target classes such as Very Good(a), Medium (b),Poor(c)poor quality of air.
During the forest fire as the vegetation burns out, it liberates smoke. This smoke contains chemicals such as Nitrogen dioxide (NO2), Carbon dioxide (CO2), Carbon monoxide (CO).The concentration of these chemicals are 0.2%, 0.5%and 1.2% respectively. These chemicals are mainly responsible for the increase of Particulate Matter in the air .The chemical properties of air will interact with solar radiations, in turn increases Carbon and Nitrogen compounds in the air. In order to predict the increase in the pollution level Java48 algorithm is used. The data set consists of continuous values of air chemicals.

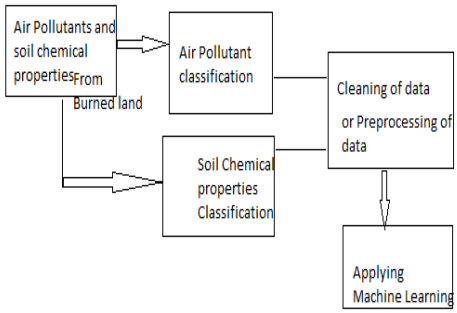

Fig1:Block diagram for the post fire effects analysis

The figure 1 shows the proposed method for the post fire effect on the soil and air. The data of soil after fire and pollutants liberated during fire are collected .The collected data can be classified as air pollutants and soil chemicals. Then applied with data cleaning to make analysis and prediction.

4. Results and Discussion

4.1. Air pollution results

CART is the classification process of developing a model of target variable classes from a larger set of records. This algorithm makes rule for the prediction of target class labels. The main target classes identified are Good, Medium, Poor and Very Poor. CART is used in the experiment to classify air quality into different target classes. 10-fold cross-validation technique is used. Among the 10 folds, nine of the partitions are used for training and one for testing.The sample of monitored and collected data during forest fire, which is stored in database is shown in the table1.

This classification tree represents that if SO_2 is less than 67µg/m^3 are classified as good air quality index. If SO_2 is greater

than 67 and Temperature is greater than 29 degree centigrade and PM is less than 5 and for fire duration less than 2hours is classified as Medium air quality index. The remaining records are classified as Poor and Very poor air quality index. The obtained CART visualization tree has pruned Ozone (O3) attribute. It also pruned attribute type of Vegetation. The SO2 has highest information gain value. So SO2 is considered as first split. The Temperature, Particulate Matter (PM) and duration of fire attributes are considered in the next nodes.

Carbon pollutants (CO) mg/m^3	Nitrogen Pollutants (NO_2) µg/m^3	Ozone(O_3) µg/m^3	Sulphur Pollutants (SO_2) µg/m^3	Total Particulate Matter(PM) µg/m^3	Target class For Air quality Index
0-2	0-49	0-35	0-45	<=2.5	Good
3-7	50-125	36-80	46-100	3-5	Medium
>=7-9	126-250	81-150	101-150	6-9	Poor

Table1: The air quality index with pollution indexes

Table 1 gives air quality index categorization. The air quality depends on the chemical compositions produced during the forest fire. Table 1 gives air quality index categorization. The air quality depends on the chemical compositions produced during the forest fire. These liberated chemicals increases Particulate Matter (PM) in the air .In order to identify the air quality, it is required to analyze the smoke/gas contents during forest fire.

Sl. No.	1	2	3	4	5	6	7	8	9
Attribute	Duration of fire (Hours)	Type of vegetation	Temp (Celsius)	CO mg/m^3	O_3 µg /m^3	NO_2 µg /m^3	SO_2 µg /m^3	PM µg /m^3	Target class

Table 2: Sample data of Forest fire attributes

Table 2, gives the data set used for the experimental purpose. The data set consists of Carbon, Nitrogen, Particulate Matter concentrations with target air quality indices. The types of vegetation burnt considered are Herbs, Sherbs and Pine. The attribute ranges for temperature data is considered between 28 and 40 degree centigrade. The Carbon components considered for more than 4 mg/m^3, Nitrogen compounds values considered for more than 37 µg/m^3, Ozone components considered for more than 45 µg/m^3 and Sulphur compounds considered for more than 65 µg/m^3 in the air. The chemicals produced during the fire are measured with the duration. The target class labels are defined as good, medium, poor and very poor quality of air. These class labels are trained based on the smoke liberated from the fire.

4.2 Vegetation loss analysis

Vegetation loss analysis focuses on assessing the extent and impact of vegetation damage caused by forest fire .It involves evaluating changes in vegetation composition,species distribution , and overall vegetation cover in the fire –affected area.
According to Indian **Fire Statistics**, the loss of vegetation due to fire is more than 500 hectares of land within the districts of Karnataka .The categorization of burned land in hectares is shown in table 3

Lossof vegetation(hectares)	**Meaning**	**Fire severity**
0	No loss	No fire

1 – 100ha	Low	Low
100< V>=250	Medium	Medium
250<V>=500	High	Very High

Table3 Loss of vegetation categorization in presence of fire severity

Table 3 gives the categorization of vegetation loss during forest fire. Vegetation (V) is categorized with four different categories which is measured in hectares. Vegetation (V) for value 0 represents no fire and hence no loss in vegetation. Vegetation (V) between 1 to 100ha is considered as 1ow, and Vegetation (V) between 100 ha to 250 ha medium. The Vegetation (V) between 250 ha to 500 ha is Very high vegetation loss.

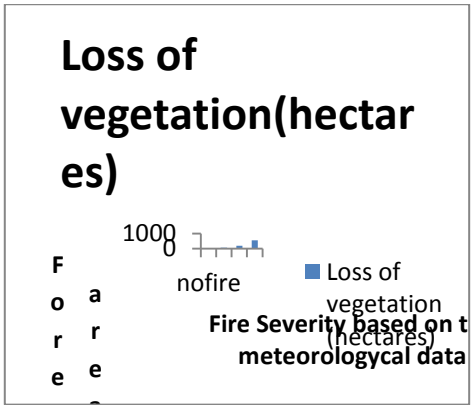

Figure 2 : Loss of vegetation based on the Fire severity

The figure 2 shows the loss of dry forest land based on different severity levels.In the figure x-axis represents fire severity and the Y-axis represents loss of forest area in hectares based on fire severity.The medium severity in fire causes loss of 100 hectares of forest area. The very high seveirity will cause more than 500 hectares of forest area.This work gives detailed analysis on the Karnataka westrenghts fire and its cause effects using the CART algorithm and statistical methods.

5. Conclusion

This paper aims to give details of post forest fire consequences using Supervised classification algorithms and helps in understanding of forest fire impacts and provides valuable insights to develop effective strategies aimed at minimizing ecological and atmospheric consequences of forest fires. This work gives detailed analysis on the Karnataka westrenghts fire and its cause effects using the CART algorithm and statistical methods.The high severity fire will cause more vegetation loss by releasing more Carbon component to the atmoshpere.So precautionary measures are required to prevent forest fire.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

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