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GISCIENCE FOR FOREST FIRE MODELING: NEW ADVANCES IN WILDLAND FIRES WITH MANAGEMENT

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ABSTRACT

Wildfire is one of the complex and damaging natural phenomena in the world. Wildfires pose an enormous challenge to predict and monitor complicated integration chemistry with the physical aspects of solid-gas stage combustion and heat transmission spatially diverse vegetations, topography, and detailed time and space conditions at various spatial and time scales. The research community has greatly enhanced its efforts in the last 25 years to better understand wildfires by improving observation, measurement, analysis and modelling. The fast development of spatial data analysis and computer technology has been facilitated. This combination allowed new decision promotion systems, information collection, analysis methods, growth, and existing fire management instruments. In several countries, despite this activity, forest fires remain a serious problem. Factors that raise the world risk of wildfires are climate change, urban-rural migration and the creation of the interface between urban and wildlands. These events demonstrate the tremendous destructive force of wildfires of great magnitude, sometimes well beyond our concrete containment and control capability. In addition to firefighters, foresters and other organised systems, the scientific community is key to addressing the problems of fire recognition in the countryside. Advances in our understanding of fire-fighting mechanisms and the relationship between fire activity and the natural and constructed environment can lead to successful fire risk decision support systems, the predictions for fire propagation and the reduction of fire risk. The convergence of forest ecosystems and forest fires has become the growing threat posed by human influences and other factors to ecosystems, resources and even human lives. Climate change will change forest fire regimes to enhance forest fire understanding and to build strategies for mitigation and adaptation. The study highlights broad aspects of forest fire in combination with climate change, urbanisation and other pressuring that have broad regional and global implications.

Keywords: Forest Fire, Satellite images, GIS, Ground Truth, Biomass

INTRODUCTION

Fire is one of the most well-known earth unsettling influences after human, metropolitan and horticultural exercises (Bond and Wilgen, 1996) and jeopardizes environments, characteristic assets and human existence. Many reports were set up on woods fires (Wooster *et al.,* 1998; Bond *et al.,* 2005) which show that the majority of the flames are because of human way to deal with timberland zones (Di Bella *et al.,* 2006), freeing from the woodland land for land-use by consuming of dead and leaving biomass and this consuming is a wellspring of air gases which impacts the atmosphere, lower atmosphere and stratosphere (Beringer *et al.,* 2003). The natural part of fire is to influence a few factors, for example, plant network advancement, water preservation, soil supplement reusing and organic variety. Forest fires are considered vital natural processes that initiate the natural exercise of plant succession. 6,000,000 km^2 of timberland have been lost far and wide in under 200 years, predominantly because of backwoods fires (Dimopoulou and Giannikos, 2002).

Woodland fires massively affected the accompanying nations like Indonesia, Brazil, Mexico, Canada, USA, France, Turkey, Greece and Italy. Woodland fire-influenced a great many hectares of timberland verdure all through the world consistently. They are ultimately causing ample of economic damage to forest resources, biodiversity, atmospheric pollutions, houses, real estates and damage to other environmental, recreational and amenity values. During 1997-98 a blend of dry season conditions welcomed on by El Nino has caused phenomenal backwoods fires around the world. The utilization of fire in the land-use framework in the South East Asian area has caused backwoods fires and brought about severe natural risks and furthermore hurt human wellbeing. Deciduous woods types are generally defenceless to backwoods flames and record for around 40% of the multitude of timberland fires in India (Rodgers *et al.,* 2002; Wikramanayake *et al.,* 1998). Various studies reveal that anthropological events are usually the leading cause of forest fires in India (Saha *et al.,* 2001). Along with various factors, forest fires happen to be one of the major causes of degradation in Indian forests. India has a variety of climatic zones, including broad zones as tropical region in the South, Northwestern deserts, Himalayan Mountains and the wet region of the Northeast. The forest cover in India is 678,333 km^2 and constitutes 20.64% of its geographic area out of which very dense forest comprises 1.56%, moderately dense constitutes 10.32% and open forest constitutes 8.76% (FSI, 2003). Forest fires cause significant damage to the environment, human health and property, and property, which in turn endangers life. Forest fires have received increased public attention globally during last few years due to their significant short and long-term threat to forests ecosystem and to public safety and property. Accessibility to roads, settlements and agricultural practices within forest areas many times leads to forest fires. Human influences such as the deliberate and accidental contribution of people cause forest fires and these fires are misused in forest conversion, grazing, mining of non-wood forest products, poaching, hunting and setting of land to assert in dispute.

Fire is rapid combination of fuel, temperature and oxygen. When all three of these elements (fuel, oxygen, and heat) are present in proper proportions, a fire will start burning. A chemical reaction is the breakdown of a material to release energy in the form of heat and light. To start a fire you must have a source of heat. Fire requires a sufficient portion of oxygen for it to continue burning. Air usually contains around 21 percent oxygen. Heat is useful for us in providing and releasing steam. Forest fire is an uncontrollable fire which spreads or starts in a natural vegetation area and thus the probability or chances of occurrence of forest fire depend on the causes of ignition and environmental preconditions.

Causes of forest fire

There are various causes of forest fire which includes natural and human induced factors. The natural causes includes- Lighting, Volcanic eruption, and Friction between quartzite stones and dry bamboo culms causing forest fires. for conversion of forests to agricultural lands,fires are very rarely seen and reported. Accidental causes of forest fires generally happens unknowingly and thus creating havoc sometimes, loss of resources and human life. Forest fires can be classified mainly into natural and human made depending upon their origin.

Natural causes of forest fires

Forest fires are caused by climate changes and natural vegetation cover. Getting a normal tropical and sub-tropical climate is very favourable for very particular kinds of forest fires. Not only that there are trees and shrubs with harmful flammable chemicals; pine and other coniferous forests also have volatile chemicals. If fires start unintentionally, they can be set off by lightening before or after storms caused by falling boulders and landslides. Lightning ignited 90% of forest fire in United States and 10% of bush fires in Australia.

Human made causes of forest fires

Human made Forest Fires are caused by both callous and intentional human actions. Burning forests for the purpose of cultivation is common all over the world. Jhoom cultivation or Podu or most commonly called shifting cultivation is also prevalent in the northeastern, central and the lower regions of the Himalayan ecosystem in India. Some of the other anthropogenic causes for forest fires are grazers, hunters, campfires, cigarettes and matches, domestic ignition also a motor vehicle and coal locomotives. The following reasons are responsible for the accidental forest fires in Indian region especially:

Throwing of burned cigarette/bidi pieces in forest areas by travelers without thinking about the possibility of forest fires. Some burning materials left behind in forest by tourists, hunters, workers, fuel-wood collectors and grazers without thinking about the possibility of fires.

The scintilla fall from the wooden torches, used as a source of light during night is also a reason for forest fire.

Honey from honey combs of wild bees in the forests, extracted by villagers during nights by burning night touches. The ember (ash) of burning torches fall on dry grasses and leaves, sometimes turn into cause of forest fire.

Coal driven railway engines sometimes cause fire in the forest on either track of railway track by throwing or sprinkling live embers from the furnace in the forest area. However with the use of diesel engine, a risk of forest fires has been minimized.

Villager’s burn pastures for bringing out the new flush of grasses, and from these pastures fire spread into the adjoining forests.

Forest fires sometimes also caused from the spread of embers from the charcoal kiln, so proper supervision or precaution is required during the burning of charcoal in the forest areas.

Uncontrolled poor supervised departmental debris burning is again a source forest fires.

Control burning of chirpine forest during February is sometimes becomes a cause of forest fire if not properly supervised and goes out of control.

Incendiary causes of forest fires

Incendiaries causes are the act or practice of an arsonist and illicit burnings. The general motives observed behind cause of incendiaries in forest (Gupta and Sharma, 2004) are following as:

In case of illicit filling and illicit resins trapping the defaulters maliciously burn the forests to cover their illegal deeds.

Hunters or a poacher burns forests to facilitate killings or Careless activities of tourists many times lead to forest fire.

Dissatisfied villagers burn forests or plantations, if their genuine demands or requirements of pasture fuel and timber are not supplied with care by the department.

Sometimes land grabbers or encroachers intentionally burn forest areas, adjacent to their cultivation lands, orchards to extend their holdings illegally in government forest areas. Sometimes land hunger and the deficiency of pastures also appeal people to do black deed of destroying forest by incendiaries.

Finding out forest products like herbs and guchhies people use to burn grasses because due to presence of grasses these things sometimes may be out of sight

Sometimes due to the rivalry with the forest department people sometimes burn the forest.

A superstitious belief amongst the village people says burning of fire brings rains to that part although this holds no reality.

Types of forest fire

All forest fires are classified into three categories which are based on the pattern and nature of its ignition and spread ground fire (litter humus, surface undergrowth and bushes, deadwood and stumps); crown fires (top branches, entire tree) and surface fires (peat), (Kurbatsky, 1964).

Crown fires

A crown fire is a fire that begins from top of leaves or branches, and progresses up to the last branches (Brown and Davis, 1973). In undulating terrain, a crown fire can catch up with another fire by burning faster in windy areas. Fire in a tree is a common thing, which happens most often in low-lying coniferous forest, where trees are near each other. As it is uncontrollable by ground forces, land-based air attack would be an uncontrollable force on the ground and is unstoppable by the capabilities of ground force. This makes it dangerous for ground forces and wildlife in its route. Crown fires in tropical woodlands can spread 5 or more miles per hour, but grass fires in savannas may spread at a pace of only 2 to 4 miles per hour.

Surface fires

With the incidence of surface fires, it is easy for tall vegetation and tree crowns to be burned and lost. It is the most common kind of fire that is sometimes seen in trees. It can be a low energy in grass, pines, and under shrubs but at the maximum it may display extremely flammable of ample fuel.

Ground fires

A ground fire may be identified as duff, muck, or peat consumes the organic materials beneath the surface litter of the forest floor. In many forest types a mantle of organic materials accumulates on top of the mineral soil. A ground fire may and often does follow a surface fire, depending on the moisture content of the organic layer. This form of fire frequently spreads within an area rather than radiating into the air and usually does not burn hot. Because of low-resistance organic material, the fires from dry landscape can go completely underground. Ground fires are often hard to detect and are the least spectacular and slowest moving and also the most destructive of all the fires.

Responsible factors for forest fires

Topographical factors

There are various factors, which affect the forest fires, generally include Topographical factors. These factors generally refer to the landscape type, that is primarily the, slope, aspect and elevation. The slope is the gradient of the land, and is generally expressed in percent or in degrees. Highly sloping terrain accelerates the spread of fire. Among all these factors slope is considered to be the most critical. Because warm air rises, preheating uphill fuels, fires advance uphill faster than they travel downhill. A slope raises the fuels in front of the fire, thus bringing them closer to the flames, and also acts like a chimney carrying heat and flames uphill.

In certain situations, slope angle is more critical than wind speed when evaluating the rate of fire spread. Steep slopes increase the spread of fire because they allow the fumes of petrol to spread quickly over the landscape. South and west slope will have longer fire season, longer regular burning time and a greater number of fires than on northern slopes, and more of fires that start there will grow big (Brown and Davis, 1973; Artsybashev, 1983; Antoninetti, 1993). The fire will spread twice as quickly if it is burning on a hill (Brown and Davis, 1973). It is crucial to consider the rate of forward spread of fire in fire control operations. Generally, the slope facing north is cooler while that facing south is colder. Aspect of slope determines how much sunlight is obtained. South and West slope gets the most sunshine because of the direct sunlight. This is because northern aspects store more moisture and so it retains the green atmosphere for a longer time. The higher the elevation, it is claimed that the region would have better climate and is expected to be colder. Elevated areas have more rainfall, resulting in a harsher fire season that is short, and milder fires (Brown and Davis, 1973; Artsybashev, 1983; Antoninetti, 1993).

Climatic factors

Some of the climatic factors *i.e.* Relative humidity (RH), Temperature, Precipitation, Wind speed, Fuel Type and Fuel Moisture is the prominent responsible factors for forest fire. Relative humidity is the expression of the amount of moisture in the air compressed to the total amount that is capable of holding at that temperature and pressure. When RH falls below 30% the beginning is intense and the danger from fire branch is also present when the relative humidity is 60% a fire may cause (Brown and Davis, 1973; Artsybashev, 1983; Antoninetti, 1993).

Temperature strongly affects the moisture content in forest fuels. High temperature helps dry fuels quickly. Moisture moves from warmer fuel to the air even if the RH of the air is high. When the temperature is below 4^{o}C, firebrand will not ignite dung, although rotten wood will ignite down to 0^{o}C. Below 0^{o}C grass will not support a fire unless the fuel is dense. An area where the crown density is high will keep the ground cooler as it is less exposed to direct sunlight, cleared area are often burned when the air temperature are high (Brown and Davis, 1973; Artsybashev, 1983; Antoninetti, 1993).

Rainfall affects soil moisture and fuel moisture. It is necessary to measure the area of rain in order to avoid fires caused by dry periods. Wind speed affects the burning rate of fuel density by influencing the rate of oxygen supply to burning fuel. Strong winds increases the rate of fire spread by tilting the flame towards the unburned fuels; receive energy by radiation and convection at a higher rate. These two mechanisms are particularly responsible for building large fire from smaller areas. Wind is one of the most important factors because it can bring a fresh supply of Oxygen and also put the blaze towards a new fuel source. Fuel moisture is often involved in selecting a specific fuel to catch fire. Coniferous forests contain a greater amount of chemical compounds that create violent combustion. This quantity varies in a state of flux due to seasonal conditions as it responds to precipitation, humidity and temperature. Size and shape of the dead fuel decide how quickly it can take on or lose water, depending on its surroundings. Let me tell you, before gasoline can burn, the moisture in it has to be warmed to the boiling point.

Accessibility factors

The proneness of the forests and the nearby habitation, roads and agricultural areas, to fire is determined by the access humans have to the forests. The extent of human interference with the forest can help in assessing the potential risk areas from man-induced fires.

Impact of forest fire

Impact of forest fire on flora

Forest fire is one of the natural forces that have influenced plant communities over evolutionary periods of time. In western North America, the open character of *Pinus ponderosa* forests results from natural fires. In temperate and arid regions, where fires are frequent, forests and woodlands have evolved with adaptive traits to ensure survival or to enable them to compete with fire tolerant species. Ground fires keep combustible fuels at low levels and prevent hotter, more destructive fires. Mature trees have thick bark, which enables them to survive ground fires. Without fires, less fire-tolerant species such as *Abies sp*. appear in the under story and eventually dominate the stand. A similar relationship has been documented for *P.kesiya*, *P. mercusii*, and *P. roxburghii* in Asia (Goldammer, 1990).

Impact of forest fire on fauna

Few studies have examined the adaptation of animals to fire, but zoologists believe that animals with flexible habits and diets thrive after fires, and those animals that eat food found only in mature forests seldom survive (Tiwari, 1986). The effect of fire on animal's changes over time, but the biggest impact is the modification of their habitat.

Impact of forest fire on sustainable development

Forest fire is a natural component of many ecosystems, but it can adversely affect the ability of forest to maintain its genetic diversity. Fires kills vegetation; even fire-tolerant trees that sustain injury from fire may be more susceptible to attack by insects and fungi. The impact of fire depends on its rate and burning depth. Usually, many years are required for a site to recover from a forest fire. The destruction of vegetation by fire causes soil erosion, especially on steep slopes, which can lead to landslides and the siltation of water bodies and tanks (FAO, 1993). When forests burn, a high proportion of the carbon is released into the atmosphere as carbon dioxide and other greenhouse gases. Increasing atmospheric levels of the gases cause concern because they influence global climate (FAO, 1990).

Global Scenario of forest fires

Wildfire burned over 750,000 km^2 around the world each year. Rothermal, 1993 confirmed wild fire as major havoc destroying forest resources and playing major role in economic loss. An estimated 2700-6800 million tones of plant carbon were burnt annually in tropics due to shifting agricultural practices (Bond and Wilgen, 1996; Rowell and Moore, 1997) reviewed global fires around world which affected 22 million hectares of land. Forest fire adversely affected 130 million human beings and 14 million of forest health. There are many causes of forest fires but one of the scene happened in China during 1999, where drought over the major parts created encouraging environmental conditions for forest fire. It damaged over 2,000 forests, 12,000 hectares of forest area with loss of 33 people and 198 people were injured in the first two months (Dong, 1998). Due to fires most of the tropical dry forests around the world have been converted into anthropogenic grassland and other land use conversion (Murphy *et al.,* 1986; Sagar *et al.,* 2004). According to the Federal Forest Service of Russia (1999) around 28,176 fire numbers, 541,309 hectares of forest and 194,787 hectares of non-forest areas inside forest lands got affected (Rowell and Moore, 2000). In Canada, till September 1999, 7,200 fires cases were reported causing loss of 1,678,000 hectares of land. FAO (2005) estimated that fire occurrences and fire impacts experienced very high impact at regional as well as at national scale during 1980's and 1990's.

California, Nevada, Oregon, Utah and Idaho had seen around 300 number of forest fire cases in august 1999 due to lightning. 400,000 hectares of land got affected by fires in Alaska, mainly caused by lightning (Global Firefight Project, 1999). Washington, Arizona, Illinois, Indiana, Mississippi, Georgia, Kentucky and Texas also reported very high to extreme fire incidents at the end of September 1999. 76,131 number of forest fires burning cases which damage around 1,954,157 hectares of land in US were reported in 1999. Tropical Asia, Africa, North & South America and Oceania also experienced extreme wildfire situations due to extremely dry years in the northern temperate/boreal forest zone. Global region of major habitat types in important conservation Eco- regions got influenced due to forest fires (The Nature Conservancy, 2004). The distribution of fire impact on eco-regions was categorized into three levels which were mentioned as 46% (fire influenced), 36% (fire sensitive) and 18% (fire independent).

The fires of 2004 in Indonesia burned millions of hectares of Sumatra and Kalimantan. The exact area is still unknown. One estimate is that about 2.0 million ha (including savannah with grassland) burned in 2004 alone. Several organizations have begun the lengthy and complex task of interpreting satellite images to determine the total area burned. Large quantities of smoke generated by ground fires fed by slow burning fuels affected neighboring countries, negatively influencing human health, interfering with transportation system, and disrupting the multimillion dollar tourist industry, all the which contributed significantly to the economic and social cost of fires. Many under-ground fires continued to burn into mid-2004 in natural peat/coal beds, threatening new outbreak of fire (FAO, 2005).

Globally, 1997 and 1998 were the worst years for wildlife and forest fires in recent times. Although forest fires occur every year in the arid and semi-arid zones of the world, nearly all type of forests burnt in 1997-1998, even some tropical rain forests which had not burned in recent memory. In 2000, wildfires raged in Indonesia, Papua New Guinea, Australia, Mongolia, the Russian Federation, Columbia, Peru, Kenya, Rwanda and other parts of Africa. By mid-2004, fires were reported in Indonesia, the Amazon, Mexico and Central America, USA, Western Canada, Russian Far East and parts of Europe. National disasters were declared in many of these places and national and international resources were mobilized to fight the fires based on Information availability on forest health and vitality (FAO, 2005).

Indian Scenario of forest fires

There are several forms of forest vegetation present in the region, from highland forests to lowland forests. There are semi evergreen, deciduous, subtropical broadleaved hill and pine forests and temperate broadleaved montane forests in the area. Because of increased domesticated animal and human population, the forest coverage of Singapore is decreasing very soon. Fire is the enemy of forest resources and flora-fauna. Regeneration and small trees even big trees are frequently getting adversely affected by the fires. Annual fires may also decrease the growing of the grass, herbs and shrubs etc. (Kandya *et al.,* 1998). The occurrence of forest fires may be due to following reasons: shifting cultivation practices, controlled burning, deforestation, floor is often burnt by villagers to get a good growth of grass, fire wood burning and others. The most important, and adversely impacting on the climate, is India's illegal use of fire to clear forests (Bahuguna *et al.,* 2002) and 55% of the total forest cover of India is prone to fires annually (Gubbi, 2003), which are mainly due to human induced factors, like slash and burn agricultural practices, controlled burning, deforestation, tourist activities (camp fire), fire-wood burning causing loss of about INR 440 crores. People have been clearing and burning forests for shifting cultivation for starting of civilization (Gadgil *et al.,* 1985; Schule *et al.,* 1990), though nowadays this is not a practice in almost all parts of the country, except for Northeast (Raman *et al.,* 1998). It is supposed that burning of forest helps to get good growth of fresh fodder for their livestock and livelihood (Gadgil *et al.,* 1985), and ultimately to facilitate the collection of non-timber forest products (Raman *et al.,* 1998).

In India, intentional fires are set in different parts for various reasons (site-specific). In Northern region (Central & Western Himalayas), people set fire mainly in pine forests (*Pinus roxburghii*) in summers for getting herbaceous growth of fodder during monsoons. Countries in the Himalayan areas are suffering from recurring fires. Only traditional methods of fighting fires are being used. In central India, fire is used for clearing the forest floor prior to the collection of flowers and fruits of *mahua* flowers (*Madhuca indica*) or in stimulating a fresh flush of leaf crops such as tendu leaves (*Diospyros melanoxylon*). In Western region, tribal people practice '*Raab'* cultivation, in which, dried biomass is burnt in-situ and they use ash as fertilizer. In South India, especially in Western Ghats, fires are set in the upper slopes before monsoons, to fertilize agricultural fields down slope. Tribals in this region also put fire for collection of Non timber forest products like shed antlers of deer, honey etc (Ramakrishnan, 1985; Johnsingh, 1986). Accidental forest fires happen mainly during burning of crop remains in agricultural fields. It also happens during fire tracing works by the forest department. Quite often, it is due to the careless tourists throwing cigarette butt, or cooking on the roadside or during campfires etc (Semwal and Mehta, 1996). In India, forests are prone to fires during the summers in the months of February to April mainly. According to Forest Survey of India (FSI) approximately 54.7% (3.73 million hectares) of forest land burns annually (Bahuguna *et al.,* 1999) and results economic loss of approximately US$ 110 million (MoEF, 1999). Quite heavy, heavy and recurrent forest fires are noticed just over 0.08, 0.14 and 5.16 percent respectively. Around 6.17% of forests are destroyed by fires. 17,852 cases of fires were reported over a period of 5 years during 1985-1990 affecting an area of 5.7 million hectares (Saigal, 1989). The vulnerability of forest to fire varies between sites depending on the type of vegetation and weather conditions. Fire also takes place in the thick coniferous forests of the Himalayas made of pines (*Pinus roxburghii* & Pinus wallichiana), fir (Abies pindrow), spruce (Picea smithiana), deodar (Cedrus deodara). The susceptibility and vulnerability of forests to various forms of burning.

In Indian forests the other parts of the country are dominated by deciduous forests, which are also damaged by fire. In coniferous forests in Himalayan region, *Pinus roxburghii are* fire prone and many wildfires occur during the winter drought. In 1995 severe fires occurred in the hills of Uttar Pradesh and Himachal Pradesh with an estimated damage of 677700 hectares area and timber worth Rs. 17.50 crore (US $ 4.3 million) was destroyed. Additionally, one single fire incident in the states of Tamil Nadu caused a loss of around US$ 43 million in sandal wood forest during 1996-1997. The impact of forest fire, especially in Indian context, has different perspectives-ecological, economic and social. These include loss of timber, fuel wood and fodder, loss of natural regeneration, biodiversity & wildlife habitat, global warming, effect on soil development, nutrient circulation and increased soil erosion, changed rates of water & water circulation etc (Rodgers, 1986).

Geospatial techniques and forest fire

Remote sensing and Geographic Information System has been successfully used in determining the fire danger in the past. Fire danger includes both risk and hazard. Remote sensing has a tremendous scope in forest fire mapping. Remote sensing can aid in three key ways to assist forests fires during preparation. Active fire mapping sector mapping and fire danger zone mapping etc. Monitoring these fires has become easier with the availability of satellite data obtained with high temporal repeatability, spectral variability and wide spatial coverage. To track fire incidence, fire progression and to assess damage, international organizations like NOAA (U.S. National Oceanic and Atmospheric Administration), NASA and satellites like Terra and Aqua, IRS P4 (OCEANSAT), IRS P6-AWiFS (Indian Remote Sensing - Advanced Wide Field Sensor) and SPOT-VGT (Système Pour l'Observation de la Terre-Vegetation) are being used. Till recently, polar satellites most widely used for detection tasks have been the NOAA-AVHRR (Advanced Very High Resolution Radiometer) (Li *et al.,* 2001), the EOS-MODIS (Moderate resolution Imaging Spectroradiometer) and the European sensor ATSR-2.

Satellite-based remote sensing has been widely used over the past 20+ years for national to global-scale many environmental monitoring activities, including forest fires. Different approaches exist for assessing forest fire hazard at different spatial and temporal resolutions. Those approaches require different spatial variables to predict the probability of fire occurrence. The integration of these variables in a single risk index requires that a weight be applied to each variable according to its importance on the fire occurrence by using approaches range from a qualitative-subjective way, a quantitative-objective scheme, statistical approaches (regression analysis), or artificial neural networks (Chuvieco and Congolton., 1999).

In recent years, GIS has become increasingly successful in the analysis of spatial and non-spatial data. It has been possible to combine the capability of Vegetation, Cover, and structural layers into an integrated vegetation classification using GIS (Menakis *et al.,* 2000). GIS tools helps people to investigate the relationships between people and layers. This list can be used to analyse and correct differences between diverse methods of mapping the layer. Forest fire studies include both simulations and integrated fire testing programmes. Fire risk determination is also required for fire danger and the frequency of fire.

An integrated remote sensing and GIS-based multi-criteria approach to forest fire assessment offers significant advantages. This incorporated approach combines the spatial capabilities of remote sensing and GIS, with the analytical power of multi-criteria analyses. (Chuvieco and Congalton, 1989) used aerial infrared scanners to test spot fires. After the launch of Earth resources satellites (ERS) many studies were carried out to assess forest fires risk and area burnt (Tanaka *et al.,* 1983; Romme and Despain, 1989). For the assessment of fire risk many GIS techniques were used for data obtaining, processing and to store great volumes of data (Burrough, 1987). Different authors have demonstrated the capacity of GIS to improve the spatial analysis of fire danger indices, which are used for fire prevention and pre-suppression planning. The indices are mainly based on meteorological data (temperature, humidity, precipitation) and GIS provides tools for spatial interpolation of these data so that a more complete view of the geographical diversity of fire danger can be obtained. In India, spatial modeling for fire risk has been done. In addition to fuel type, height, slope, aspect and accessibility indices, one can obtain the combined effect of these variables. All variables were judged according to their significance. Cumulative fire risk values maps were obtained after integrating all the index maps and fire risk zonation map of Shimla district was generated.

Many traditional techniques of fire modeling and fire hazard mapping, strive to integrate accurate spatial representation of the determinants of fire behaviour, with mathematical models of fire behaviour (Rothermel, 1972, 1993; Andrews, 1986). While these techniques have great promise, they require very accurate high-resolution spatial data. Even if remote sensing is used to map variables such as canopy cover or fuel models, much time and energy must be devoted to gathering the field data necessary for accurate classification of the remotely sensed data. Once accurate spatial data is assembled for an area it must be integrated with mathematical models of fire behaviour, ignition points and climatic conditions (Medler, 2000). Fire behaviour models are typically placed into two broad categories: physical, or probabilistic.

Physical models are those based upon mathematical analysis of the fundamental and chemical process of fire spread. Sometimes observations from small-scale experimental fires are used to parameterize the formulas in addition to measurements the fuel bed, weather, and topography. Satellites have a role to play in detecting, monitoring and characterizing fires. Satellite systems currently in orbit provide information on different fire characteristics: location and timing of active fires, burned area, areas that are dry and susceptible to wildfire outbreaks, and aerosol emissions. These satellite systems such as MODIS, ENVISAT, and IRS sensors have capabilities in terms of spatial resolution, sensitivity, spectral bands, and times and frequencies of overpasses. Many of these GIS/remote sensing applications, however, are not fully integrated with organizational business processes, nor are they being used to their greatest potential in resource analysis. Success will also require a government initiative in data management and in the integration of data flows within and between agencies (Sunar and Ozkan, 2001).

CONCLUSION

The biggest impact on forest fires is the fuel type. This region needs to have coniferous forest trees to prevent forest fires. Various variables, such as aspect, slope, orientation, road conditions and elevation play a significant role in fire propagation. There will be an emphasis on the use of geospatial technologies to research carbon emissions, fire losses to forests, and loss of bio-diversity as a result of fire. For administrators of villages struggling with forest fire problems, high resolution remote sensing technologies will be utilised to distinguish fire issues. Wildlife population and migration corridor will be surveyed using the remote sensing, geospatial modelling and surveying methodology. The general approach would be to build a statistical model relating human activities to ecological variables, e.g., degradation ratios. A model could be built for evaluating the total biomass change after cutting. Forest fires are a significant threat in the area because of the numerous human activities in the region. There is a need to examine when tragedy happens and how many people died. Census data will be utilised to record socio-economic features of the area, such as population density, cultivators, agricultural labourers, sex ratio, and children in age group 0-6 years and literates. Climate change has significantly increased areas on fire per year in India. Increasing the size of burned areas and fire frequency would lead to losses of carbon.

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