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Role of Remote Sensing & GIS in Forest Fire Zonation in Pachmarhi Biosphere Reserve of Madhya Pradesh

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Abstract

Forest fires are a big threat to physical environment. It not only change the land use/ land cover pattern, vegetation type and cover, ecosystem, biodiversity of the area, but also harm the wealth, property, money, health even the life of the people in that area. In total, forest fire has great concern on human health and on the socio-economic situation of affected countries. It also has profound impacts on the chemical environment too by changing the composition of air, formation of clouds, increase in degree and duration of global temperature and all these in total, effect the climate change by producing toxic and harmful gasses in the environment. Remote sensing data is most promising data for such work as it have synoptic and repetitive coverage and mapping can be done at a lesser cost and shortest time than any conventional methods. Remote sensing technique together with GIS has been emphasized for mapping variables and integrating the same for generation of fire risk zonation maps in representative wildlife habitats of Madhya Pradesh. Satty's Analytical Hierarchical Approach (AHP) is very effective for the development of models as it is a multi-parametric and logical one. Various spatial and non-spatial layers can be utilized analyzed in it and effective result can be synthesis. Overall 2.5% of the study area comes under very high risk zone and 53.8% as high risk zone, which shows a high need for fire aversion. Easily accessible areas which are more vulnerable of fire and most of them are deliberate because of anthropogenic reasons. Vegetation is in better condition at high elevations in contrast with the lower elevations, purely because of accessibility. An aggregate are of 7.1% is either under low or low fire hazard.

Key words: Fire risk zonation, Analytical hierarchical process (AHP), Multi criteria decision making (MCDM).

Introduction

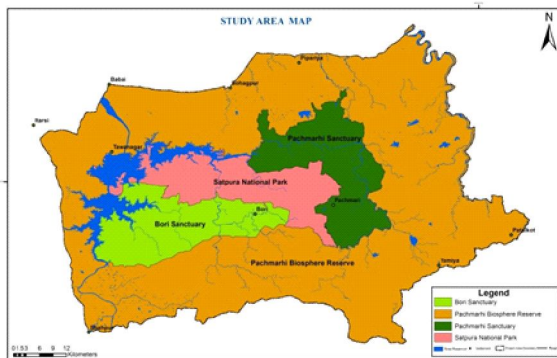
Forest fires are one of the major causes of worldwide damage to forest ecologically, economically and aesthetically. In our country also damage is extensive, especially in Himalayan coniferous forest and deciduous forest lying in the central part of India. Madhya Pradesh is 1st largest state in the country, occupies 12.27 % of nation's

forest cover and 25.15% of State. Total 11% of its forest cover comes under 9 National Parks and 25 sanctuaries. These protected areas have very good record of fires occurring there because wildlife is involved with them. These areas are prone to forest fire as forest management practices like thinning, loping, creation of fire lines are prohibited to maintain the ecosystem. As these areas are subjected to fire during summer season, it is imperative to take preventive measures well in advance. The variables considered for this

study are vegetation, slope, habitation and transport network. Remote sensing and GIS is important tool for mapping and management of forest fires.

The first application of remote sensing in forest fire dates from 1960, when several aerial infrared scanners were tested for fire spot detection. Remote sensing has been effectively used in various hazards rating system. This study is also an attempt to exploit the capabilities of remote sensing and GIS techniques and to suggest an appropriate methodology for forest fire risk zone mapping. The maps generated will be very help for forest department to prevent/minimize fire risk and take proper action.

Satty's Analytical Hierarchical Approach (AHP) has been adopted in this study, as it is very effective for the development of models. It is a multi-parametric and logical method in which various spatial and non-spatial layers can be utilised for analysis and synthesis of effective result.



Study Area :

Pachmarhi Biosphere is situated between latitude 20°10' to 22°50' N and longitude 77°45' to 78°50' east and lies in three districts viz. Hoshangabad, Betul and Chhindwara of Madhya Pradesh. The northern and western boundaries being along State Highways are easily approachable from Bhopal, Jabalpur, Chhindwara and Nagpur but the interior part (forested areas) are accessible only in fair weather and part of the southern boundary on foot. Piparia is an important railhead connected to Itarsi Junction.

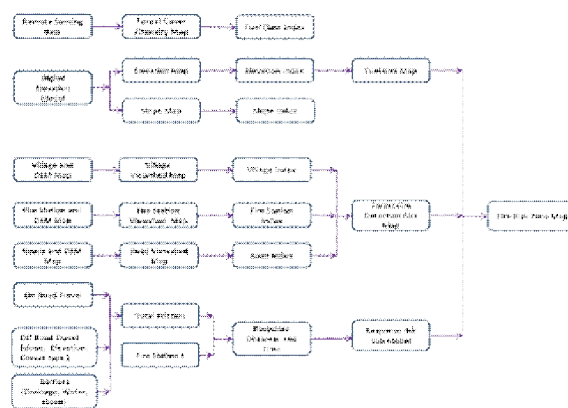
Methods and Materials

Data :

Resourcesat P6 – LISS III data of April 2013 (spatial resolution 23.5m) and Survey of India topo sheet on scale 1:50,000 were used.

Methodology :

Boundary of Pachmarhi Biosphere reserve was digitized from SOI toposheet in ArcView and study area image was subset from satellite data. FCC was rectified

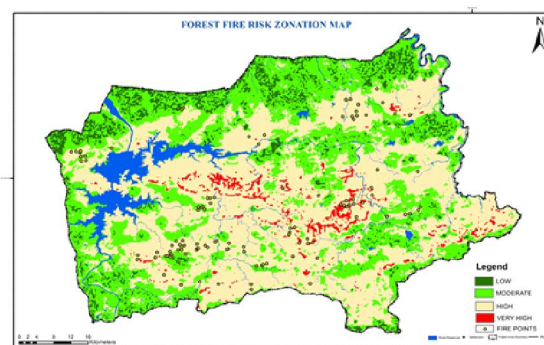


Methodology Flowchart

with toposheet using first order nearest neighbour rules with the help of ERDAS. SRTM data was used to generate Digital Elevation Model (DEM) of the area. The topographical factors like, altitude and slope layers were derived from DEM. The database prepared includes forest type map, vegetation elevation, elevation, slope and standard topographic map. The field visits were performed for ground truth verifications to collect the information such as location of vegetation types, burnt areas and its extent. Available fuel was assessed by collecting the litter from the surface in different vegetation types. The fuel contents were estimated by taking the fresh and dry weight of the samples. These samples were tagged with GPS. Thus surface fuel content per unit area was calculated with the help of the formula.

$$\text{Fuel Moisture Content} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Dry weight}} \times 100$$

The model followed various steps. First, each data layer was grouped in respective classes. The classes within each of the variables were formed according to a literature review and field experience obtained from the study area. Analytical hierarchical process (AHP) was used to determine the relative importance Weights (RIW). The flowchart for the methodology is shown in Figure 2.



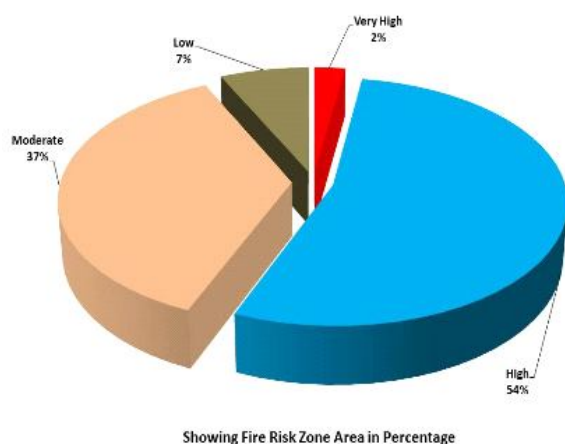
In this study spatial modelling has been done to obtain the combined effect of fuel risk index, Forest Response index fire detection index. Different weights have been assigned as per the importance of the particular variables in relation to the area under study.

Results and Discussion

The final fire risk zone map has been generated by integrating the fuel risk, detection risk and response risk factors in the form of maps. Accordingly maximum 122.09 sq. km area comes under very high risk zone. In this fire risk zonation model, fuel has been given maximum weight, as fuel contribution more in such incidences.

Fire risk Map :

Finally the fire risk zone was compared with the actual site disturbed by the fire. It was observed that fire occurrence has a definite pattern. Mostly the starting point of fire were concentrated in areas adjacent to human interventions such as settlement, roads etc. It was interesting to note that most of the points representing the history of past fires occurred on the very high and high risk zones of this model. This shows the agreement between the expected risks and proves the reliability of the present approach. The annual incidence of forest fire often causes irreversible damage to the environment, loss of regeneration status and even at times total loss of the vegetation cover along with the increase in the rate of soil erosion. It is therefore imperative to keep regular record of all the important factors influencing the forest fire in order to enable planners to draw up protection programs. By preparing a fire risk zone map of the area, probability of forest fire can be indicated. This would indicate the probability of the fire incidence and extent of its spared. The resulting risk map would help authorities in taking remedial measurement against fire incidence.



Validation of Forest Fire Risk Model :

Finally the forest fire risk model was produced by incorporating the recent fire incidences collected from field. This was validated with fire information given by Forest Survey of India on its website (April 2015- April 2016). Results showed that out of 113 points of FSI, 23 points come under very high fire and 40 under high risk areas.

Conclusion

The study shows that the methodology adopted is reliable and dependable. Analytical Hierarchal Process (AHP) was adopted for choosing the relative significance weight which is additionally helpful. Only 2.5% of the area is figured as very high hazard zone and 53.8 % as high hazard zone, which shows that the area needs a high alert for flame aversion. The areas which are easily accessible or less incline confirms the purpose of flame, that a large portion of them are deliberate flames because of anthropogenic weight. The confirmations are more regular in the moderate danger zones which spread around 36.7% of the study territory. The vegetation at high elevations is in better condition to lower elevations, simply because of inaccessibility of the area and due to fewer interventions vegetation is good. An aggregate area of 7.1% is under low fire hazard. Individuals must be made aware about the results as the main reason of forest fire in the area comes under man made fires.

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