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"Fire risk zoning of Bandipur National park using Remote Sensing and GIS Techniques"

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Abstract:

Forest fires occurring due to both natural and anthropogenic reasons are cause of serious concern as they have adverse effect on the region's flora and fauna, apart from causing huge revenue loss. Prevention of forest fires is very difficult. However by using Remote Sensing and GIS technology it is possible to generate fire risk zone map which is useful in minimizing the frequency of fires by taking appropriate measures depending on the vulnerability of forest to the fires. Fire risk zone map of Bandipur National Park is prepared using Landsat series satellite images. Satellite images provide synoptic view of the area making it easier to acquire information regarding spatial distribution of fire activity and impacts of both pre and post fire scenario. Forest Fire instances, especially in southern parts of India where Bandipur national park is situated is caused more by activities other than weather induced. However the spread of forest fire is caused by wind conditions. Factors like previous fire instances, accessibility of roads, elevation, slope and type of vegetation are useful for generating a potential fire risk zone map. Risk zones are classified as very high, high, moderate and low. Depending upon the risk factor, fire control measures can be taken up appropriately. Study shows 7.5% of the national park area is under Very high risk zone and 29% in High risk zone. The geospatial data from satellites also permit regular updation of the Fire Risk Zonation and appropriate management decisions to reduce the damage.

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Introduction

Forests are one of the vital natural resources on earth and plays a key role in the maintenance of ecological and hydrologic cycles. Imbalance in the nature cycles occurring due to both natural and anthropogenic causes has short and long term effects. One such serious act of human intervention is the occurrence of forest fire. In India, forest fires typically occur in the summer season from January to May when trees shed their leaves littering forest floor with dry leaves and twigs converting entire forest, especially deciduous forests into a potential fire hazard zone. Forest fire in ideal conditions of high temperature and winds can reduce large chunk of forest into ash a very short time. Organic matter required to maintain favorable humus level in soil is destroyed which affects vegetation and subsequently the food chain. Forest fire has potential to affect eco system on a large scale. As per FSI (Forest Survey of India) report published in 2013 nearly 55% of India's forest are prone to fires, 7% of it is prone to severe fires. Assessing damage caused by forest fire consumes considerable time when ground methods are employed. However, the technology of remote sensing and GIS can be effectively used for the detection of active fires and to identify fire-affected regions in post fire scenario. Repetitive nature of satellites is useful in monitoring the forest fire and thereby taking precautionary measures in containing the fires. High-spatial and high-spectral resolution imagery is an added advantage in the remotely sensed data. Using GIS it is possible to analyze various factors and generate fire risk zone map and thus take preventive measures to contain the fire and reduce the damage by identifying fire prone areas.

Area:

Bandipur national Park is located in the revenue boundaries of both Mysuru (Nanjangud and HD Kote Taluks) and Chamarajanagar (Gundlupet Taluk) districts of Karnataka state, India. The park is spread over 874 sq. km and extends between 11^0 35' -11^0 55' N and 76^0 12' -76^0 51' E. It was notified as Tiger Reserve in during 1973-74. The park supports enormous numbers of wildlife including elephants, large carnivorous and is home to innumerable species of birds. Average rainfall in the park varies from 914mm to 1240mm. The highest altitude in the region is 1454.5m above MSL (Gopal Swamy Hills). Vegetation type includes moist and dry deciduous forest, semi-evergreen forest, shrub lands, grass lands. However park is dominated by deciduous type of forest. Two highways, NH 67 and NH 212 connecting Tamil nadu (Ooty) and Kerala (Sulathan Bathery) respectively cross the National park. To contain fire and reduce the damage by identifying fire prone areas.

Material and Methods:

Landsat Series satellite imagery having sensors providing spatial resolution of 30m is used along with thematic layers is used for the study. To identify the previous burnt areas, Landsat series data obtained from USGS portal for 12 years for summer seasons of April-1995, March – 1997, April – 1999, March – 2001, April – 2006, April – 2009, April – 2012, March – 2014, April – 2015, march – 2016, and March – 2017 is used. Topographical factors of slope and elevation are derived from Carto Dem having spatial resolution of 30m. Along with satellite images, topographic maps 53A (01, 05, 06, 09, 10, and 14) having scale of 1:50,000 is also used. Topographic maps are used for geo-referencing of satellite images along with extraction of thematic features like vegetation type and roads that are considered for study. Georeferencing and feature extraction was done using ArcGIS 10.3.1. Previous Burnt areas were identified using Landsat Series data for the period from 1995 to 2017. Forest

administrative boundary including forest range boundary of study area was obtained from Karnataka State Remote Sensing Application Centre (KSRSAC), Government of Karnataka.

The factors considered are type of vegetation, proximity to roads, slope, elevation, which contribute in making an area prone to forest fire. Following are the details of the factors considered for generation of forest fire zone map for study area.

(i) Vegetation Type: Bandipur National park majorly is dominated by deciduous type of forest, which in fire season acts as potential fuel for forest fire. Hence considering vegetation type is a must for study as it has direct influence on behavior of fire. Vegetation type is broadly classified into deciduous, semi-evergreen and other types.

(ii) Proximity of roads: As roads provide easy access to forest, proximity of roads to forest is factor which must be considered. This parameter becomes vital in the study area because two important and busy National highways i.e. NH 67 and NH 212 connecting Tamilnadu (Ooty) and Kerala (Sulathan Bathery) respectively cross the National park. Unmetalled/cart roads inside forest area are restricted for public use, but they also give access to forest.

(iii) Slope: Geographic slope has significant impact on behavior of fire and also in its subsequent suppression/ aggression. If the terrain is flat, then it is easy to douse the fire when compared to dousing fire in steep terrains. Also fire spreads quickly across the slopes as compared to flat grounds. Slope is generated from Carto Dem which has resolution of 30mts.

(iv) Elevation: Elevation is natural factor which necessarily does not influence initiation of fire, but it can be closely linked to human behavior and may have indirect influence on fire ignition. Places having lower elevation can be easily accessed by people making the area susceptible to fire. Elevation values are obtained from CartoDEM having 30M resolution.

Fire affected area identification:

Individual imageries are layer stacked to subset the area of Interest. Once AOI is generated, appropriate bands are selected to identify burnt areas for various years. Also Normalized Burnt Ratio parameter is used to delineate them. The input factors are divided into various classes and values are assigned to them as per their sensitivity. Appropriate weightages are designated to factors depending on their influence in forest fire, in scale of 1 -5. Since no fire can occur without fuel hence type of vegetation is assigned highest weightage of 5. Slope has vital influence on behavior of fire, hence it is assigned second highest weightage of 4. Road and elevation are assigned weightage of 3 as they give ease of access to forest and lead to anthropogenic causes that are main reason of

forest fire. All the factors along with their weightages are reclassified and integrated using AHP tool. The forest fire risk zone is calculate using the following equation.

$$FFR = [W_1 * VT] + [W_2 * RD] + [W_3 * SP] + [W_4 * EV].$$

Where,

- FFR = Forest fire Risk Factor.
- $W_{(1-5)}$ = Weightages for respective parameters.
- VT= Vegetation Type.
- RD = Roads.
- SP = Slope.
- EV = Elevation.

Appropriate weightages are assigned to their respective factors and the fire risk zone map is generated based on multi criteria decision analysis.

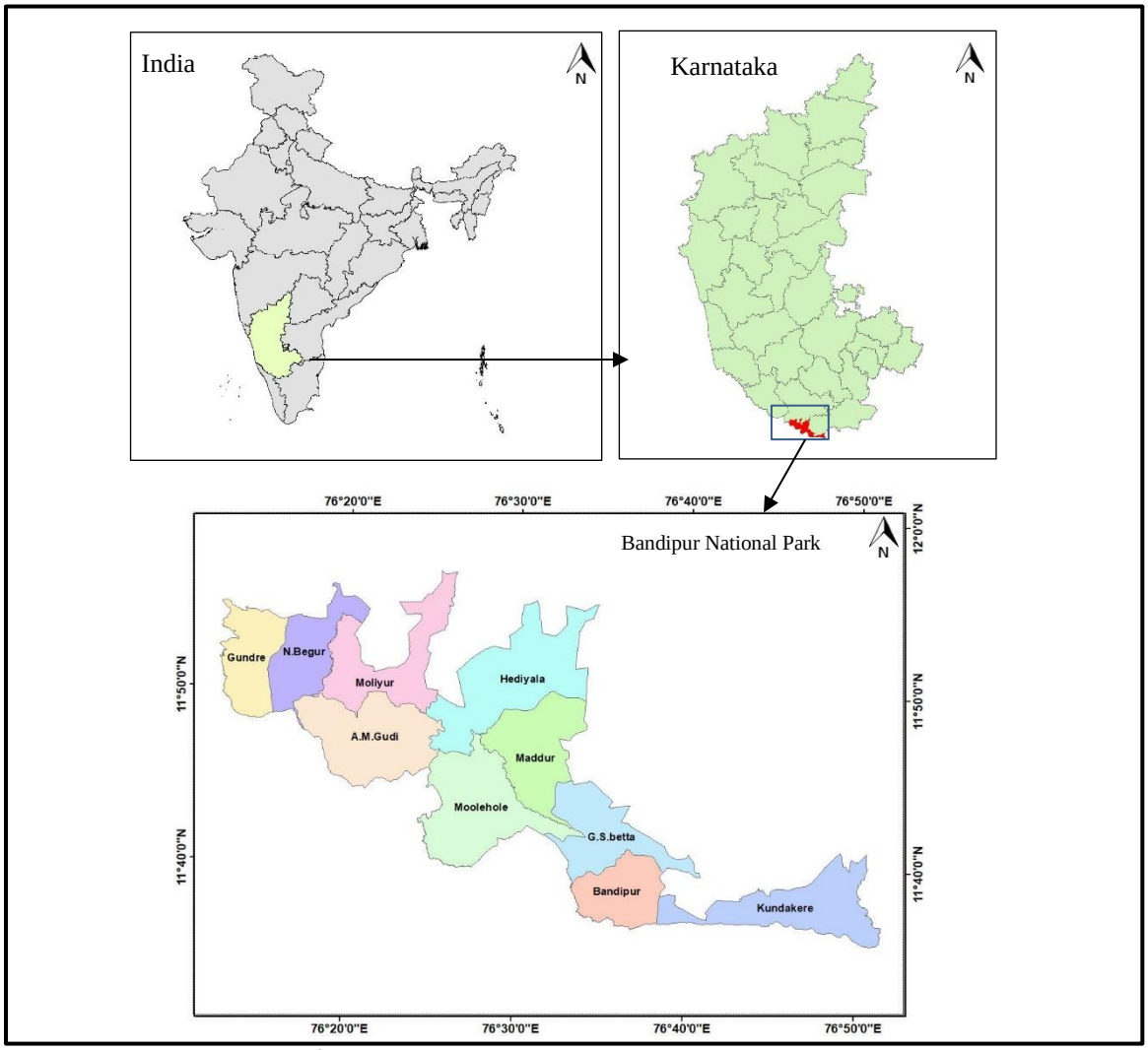
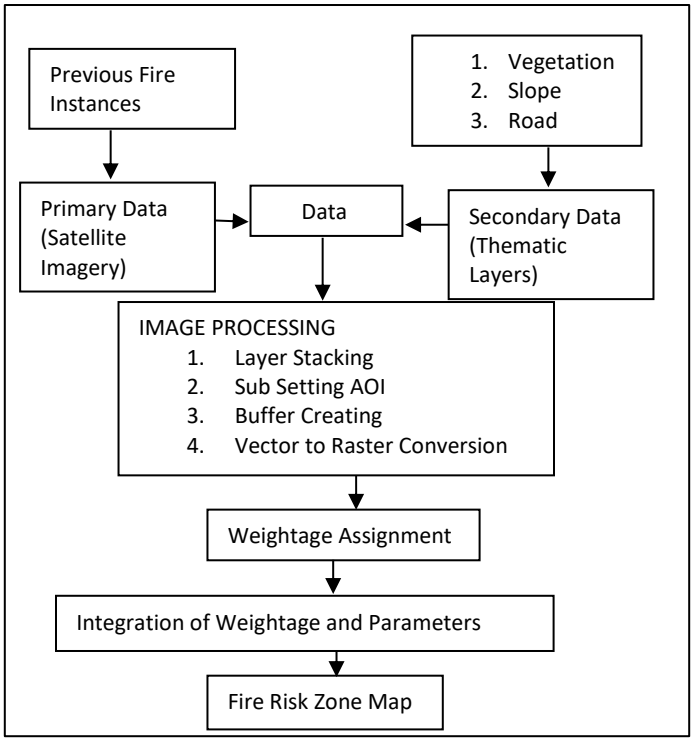


Fig 1: Location map of study area - Bandipur National Park, Karnataka

Table 1: Weightages assigned to different parameters

Parameters	Classes	Reclassified Value	sensitivity
Roads	0-500m Buffer	5	Very High
	500-1000m Buffer	4	High
	1000-1500m Buffer	3	High
	1500-2000m Buffer	2	Moderate
	>2000m Buffer	1	Low
Slope (In degrees)	$0\text{-}5^0$	5	Very High
	$5\text{-}15^0$	4	High
	$15\text{-}25^0$	3	High
	$25\text{-}35^0$	2	Moderate
	$>35^0$	1	Low
Vegetation type	Deciduous Dense	5	Very High
	Deciduous Open	4	High
	Scrub Forest/Plantations	3	Moderate
	Grasslands	2	Low
	Semi Evergreen	1	Low
Elevation	0-450	4	High
	450-900	3	Moderate
	>900	2	Low

Table 2: Flow chart for generating Risk Map



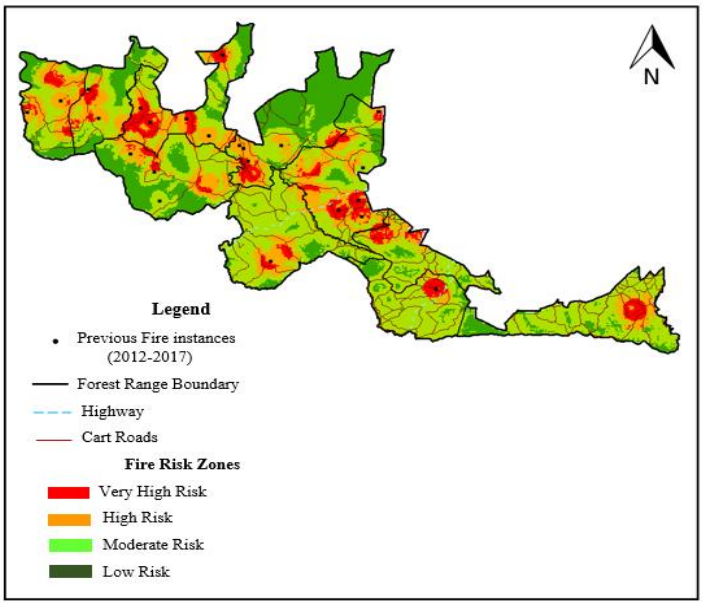


Fig. 2: Fire Risk zone Map.

Result and Discussions:

Forest fire risk zones were delineated into four classes depending on their FFR values into Very High risk, High risk, moderate risk and low risk zones. The map includes areas where there is chance of fire ignition and spreading. Analysis shows that in the study area 7.5% of area falls in "Very High risk" zone, indicating that these places are highly susceptible to forest fire and they demand highest priority of attention during fire season. 29% of study area falls in "High risk" zone where as "Moderate Risk" zone covers almost 42.5% of area where chances of forest fire occurrences are few but not ruled out. 21% of area of Study area falls in last category of classification i.e. "Low Risk" zone. Fire incidences in this region are rare. The generated risk zone map was overlaid with fire spots delineated from Modis data (250M) from 2012-2017. It is found that all the "very High risk" and "High Risk" zones are concentrated around these points, validating the study. The fire risk zone map helps in taking decisions even at management level, to come up with various strategies to beat fires. Depending on different risk zones, various precautionary measures against forest fires like fire lines, deployment of extra man power etc. can be taken by prioritizing the places where chances of occurrence of fires is high Forest fires apart from having immediate negative impact, also affects ecosystem in the long run.

As forest fires caused in the study region are majorly due to anthropogenic reasons, it is very difficult to come up with fore planned strategy in dealing with forest fires. However, generation of forest fire risk zone helps in scientifically mitigating the fire issues as more vulnerable regions will receive high attention in fire seasons as compared to less vulnerable areas. The method also calls for scientifically utilizing various resources available with forest department for containing forest fires.

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