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Assessing Fire Risk in Forest Ranges of Guntur District, Andhra Pradesh: Using Integrated Remote Sensing and GIS

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Abstract: ***Guntur district in Andhra Pradesh falls under one of the fire risk zones, which cover the forest ranges of Sattenapalli, Vinukonda, Macharla, Repalle, Wild-life Krishna and Sagar. Especially forest fire in these areas has laid stress on the fragile forest eco-system due to human activities and natural causes, which reflects in forest degradation. For better management of natural resources it is very important to understand the natural set up of the region along with factors governing them. Therefore, an attempt has been made to assess & map the potential fire occurrences in the region, which are important for forest management planning, using Remote Sensing & GIS technologies. In the present study Remote Sensing data (LISS-III) were used for assessing & mapping various thematic maps. The Potential fire occurrence maps were generated from the developed risk index model, which is an integrated function of various landscape parameters (like slope, aspect, vegetation types, canopy density, roads and villages) derived from the landscape mapping using GIS. This model gives various levels of risk concerned within the forest blocks of study area, and the statistics estimated would help to take up preventive measures and future predictions.***

Keywords: Forest Fire, Risk, Degradation, Remote Sensing and GIS.

1. Introduction

Forest is one of the most important renewable natural resources, which plays a significant role in the human life and environment. Forest fire occurs quite frequently in India during summer season, causing loss of resources resulting in degradation of ecological setup in quite a significant way. This could be anthropogenic in origin or due to the natural factors such as lighting, friction etc. The contributions of natural fire are negligible when compared to man made, which are intentional for timber harvesting and agriculture etc. The effective management of forest fire prevention requires an adequate understanding of environment, human activities and knowledge of risk conditions (like slope, aspect, drainages pattern, weather conditions, vegetation types, fuel type) and their complex relationship to fire ignition and spreading [3]. Numerous models for assessing the fire risk were developed throughout the world [4], while the earlier models were non-spatial and a recent advance in GIS has facilitated with tools for the development of spatial fire risk models. Guntur district of Andhra Pradesh was chosen for the study area as the area reported with many forest fire and falls under fire risk zone that cover Sattenapalli, Vinukonda, Macharla, Repalle, Wild-life Krishna and Sagar forest ranges. The present study has been carried out to assess and map the potential fire occurrence areas using IRS -1D, LISS-III imagery and GIS.

2. Study Area

Guntur forest division in Andhra Pradesh is located at tropical region lining between the Geo-coordinates 79° 10' to 80° 55' E longitude and 15° 4' to 16° 50'N latitude (Figure 1&1A), which occupies 1857 sq. km forest-cover out of 11,400 sq.km geographical area of the district. According to the AP forest academy records [5], the forest-covered blocks are Sattenapalli (579 sq.km), Vinukonda (415 sq.km), Macharla (450 sq.km), Repalle (90 sq.km), Wild life - Krishna (20 sq.km) and Nagarjuna Sagar (125 sq.km) come under the forest ranges of the district.

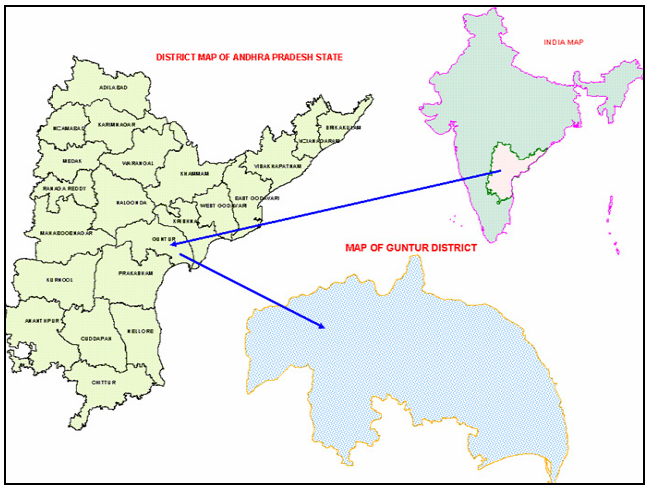

Figure1: Location map of Guntur District

The general layout of this area is gently undulating hilly terrain and 500 m above the mean sea level. The vegetation cover is influenced by soil depth, slope, and water holding capacity, organic matter, drainage pattern etc. The main types of forest are Dry evergreen scrub, Southern dry mixed deciduous, Mangrove, Hardwickia binata, Acacia Arabic and grass types of Schima nervosum, Cysopagan momatus, Hetropagon contortus etc. The major rivers running from west to east are Krishna; Gundla Kamma .The average annual rainfall is about 815.7 mm in this area.

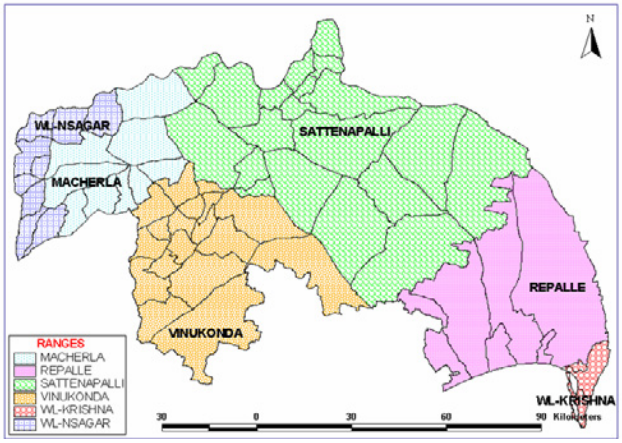

Figure1A: Location map of Guntur District and Ranges

3. Materials and Methods

A Multi spectral satellite data of IRS-ID (LISS III) of December 2000 with 23.5 m resolution of geocoded standard FCC: Bands (2, 3and 4) was visually interpreted to delineate land cover in conjunction with SOI toposheets. Before carrying out the detailed visual Interpretation, ground truth data was collected for each of the forest types and land use/land cover for the purpose of determining criteria on Imagery and preparation of interpretation key

Table 1: showing the interpretation Key

S. No	Variable	Weightage
1	Vegetation Type	10
2	Canopy Density	2
3	Slope	2
4	Aspect	2
5	Villages	3
6	Roads	3

These interpreted details were transferred to a base map prepared from SOI (1:50000) topographical sheets. Pre processing of the data was done in ERDAS Imagine 8.7 and Image enhancements were done following the standard Interpretation techniques [2]. Land cover mapping was done using unsupervised classification of multi spectral data supported by topography of the region and ground truth information. As regards, land cover mapping, GIS data as an input, was useful for selecting a sample strategy for ground truth data using Arc GIS 8.1. Digital Elevation Model derived from the 50m contour of 1:50,000 scale maps. From DEM data, various parameters like slope and aspect were derived and used in analysis. Fire Risk assessment model was developed based on slope, aspect, distance from roads & villages, vegetation types, and canopy density factors. These factors are highly influenced in the forest fire according to A.P forest Academy. An adopted methodology for fire risk mapping and assessment is given in a flow chart (Figure. 2).

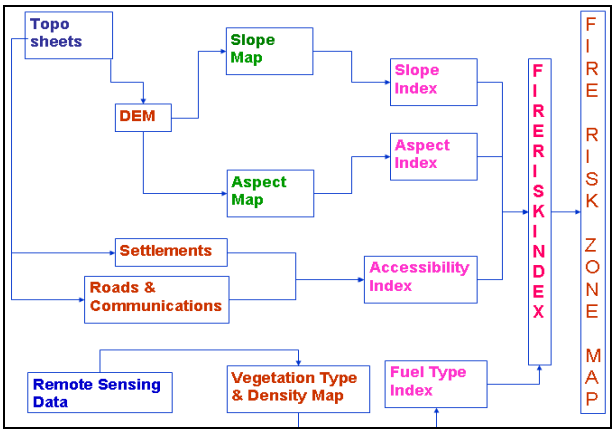

Figure2: Fire risk mapping and assessment Flow chart

Different variable weightage were assigned, accordingly for the other parameters of fire sensitiveness and rating has been determined that presented in Table. 2 for each class ranking [1].
In the present study the following equation is adopted by A.P forest Academy:

Fire Risk (FR) = {[w_a * Aspect value] + [w_d*Density value] + [w_t * Type value]+[w_s * Slope value]+ [w_v * Villages value] + [w_r * Roads value]}

i.e. Where, w_a =Aspect weightage, w_d =Density weightage, w_t =Type weightage, w_s =Slope weightage, w_v =Village weightage, w_r =Roads weightage.

Based on the fire sensitivity Index model (Table. 2), the study area has been categorized into very high, high, medium, low and very low zones as shown in Figure.3.

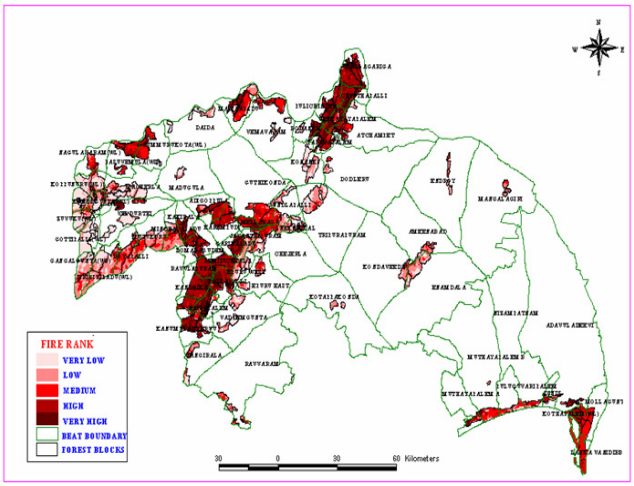

Figure3: Fire risk zonation within forest blocks of District

Area in hectares

RANGE \ CLASS	DENSE	OPEN	SCRUB	BLANKS	WATER
MACHERLA	300.44	758.86	1,254.83	508.24	0.00
REPALLE	0.00	181.86	248.62	148.94	19.23
SATTENAPALLI	756.70	1,897.93	2,102.31	371.54	10.64
VINUKONDA	649.34	1,723.81	1,879.39	337.62	62.45
WL-KRISHNA	0.00	201.79	296.34	108.62	147.83
WL-NSAGAR	140.23	553.41	1,456.89	1,166.03	209.73

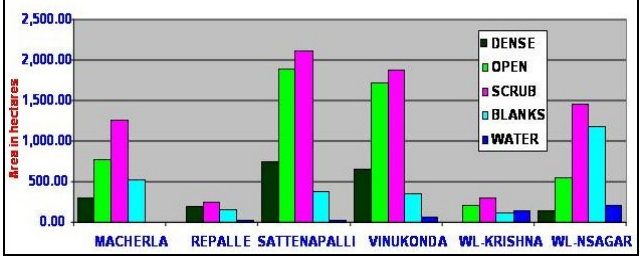

Figure 4: Range wise fire risk statistics of District

Table 2: Showing the Ranking and Fire sensitivity index.

Variable	Class	Rank	Fire sensitive	value
1.Vegetation (Wt-10)	Pure Bamboo	5	Highest	100
	Grass land Bamboo mixed Pure Teak	4	Higher	90 87 85
	Teak mixed Red Sanders Mixed Teak	3	High	80 70 67
	Mixed/Miscellaneous Miscellaneous Scrub Sal Mixed	2	Moderate	60 50 35
	Coastal-Plantation Semever green Moist mixed Mangroves	1 2 3 4	Low/ No Risk	10 3 3 1&1
2.Canopy Density (Wt-2)	Dense Canopy Open Canopy Scrub Blanks/Others	1 2 3 4	High Moderate Low Low	100 90 50 5
3. Slope In degrees (Wt-2)	0-10 10-30 >30	1 2 3	Low Medium High	20 60 100
4.Aspect (Wt-2)	N, NE E, S/E NWS W, S/W	1 2 3 4	Low Medium High High	40 60 80 100
5.Road In Buffer (Wt-3)	2500-1500 1500-500 500-0 mt	1 2 3	Low Medium High	25 45 100
6.Villages In Buffer (Wt-3)	2500-2000 2000-1500 1500-1000 1000-500 500-0 mt	1 2 3 4 5	Low Medium High High High	30 45 55 75 100

4. Results & Discussion

The fire risk zonation is an integrated approach of all the parameters such as slope, aspect, canopy density, vegetation types, roads and villages buffer [10]. Intersecting all the above parameters, which are directly or indirectly influencing go risk, obtains the integrated fire risk zonation map. Slope is considered to be the most critical parameter as the warm air rises and gets hot on the hills. Fuels and the fire advances up hills than down hills. This is a very important parameter for fire risk zonation mapping [9]. The fire risk zone area statistics were generated based on the slope and its range is classified as low, medium, high risk (Figure5). Results show that Sattenapalli, Vinukonda and Repalle hill range areas are falling under high risk as the areas bear high slopes (Figure. 6)

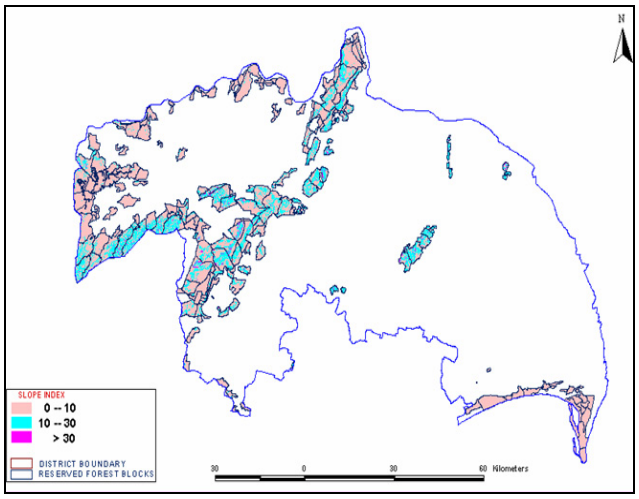

Figure 5: Slope map within the forest blocks of District.

RANGES	LOW	MEDIUM	HIGH
MACHERLA	20,947.25	8,733.30	431.50
REPALLE	6,904.89	0.00	0.00
SATTENAPALLI	37,925.68	16,101.02	735.51
VINUKONDA	36,191.09	12,665.61	962.91
WL-KRISHNA	8,336.45	0.00	0.00
WL-NSAGAR	31,363.38	5,683.31	84.25

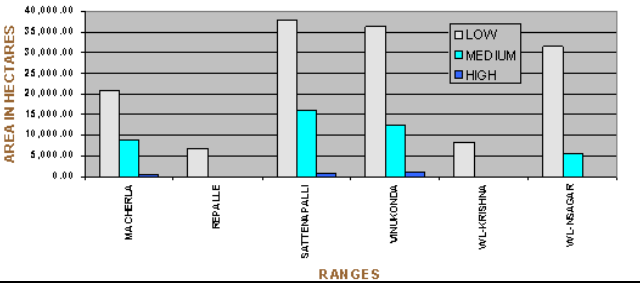

Figure 6: Range wise slope area statistics in fire risk zones

Range-wise fire risk area statistics are of four classes of directions based on aspect parameter (Figure 7) shows high risk of W, SW. Whereas low risk areas of N, NE, E, SE, S and NW respectively. Mostly the SW is considered as Sathanepally and Vinukonda where as Repalle and WL-Krishna is totally towards NW-S. The graphical representation is shown in (Figure 8).

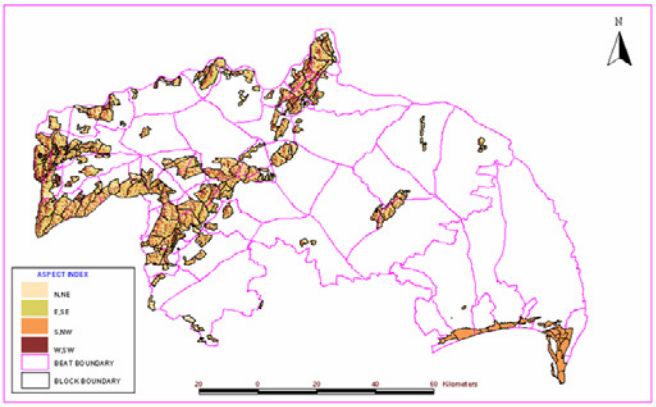

Figure 7: Aspect map within the forest blocks of District.

RANGE \ CLASS	E,SE	N,NE	NW,S	W,SW
MACHERLA	8,558.30	7,632.68	9,203.23	4,659.27
REPALLE	0.00	0.00	6,904.89	0.00
SATTENAPALLI	16,891.70	11,280.17	14,764.07	11,729.26
VINUKONDA	15,361.37	9,252.34	14,011.11	11,092.23
WL-KRISHNA	0.00	4.42	8,331.39	0.00
WL-NSAGAR	10,768.95	7,324.58	9,232.23	9,784.74

Area in hectares

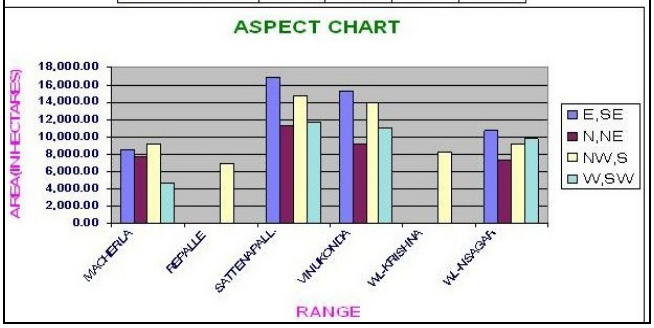

Figure 8: Range wise aspect area statistics with in fire risk

Canopy density is an important parameter to assess the ecological conditions viz, light penetration through canopy, under growth, surface reflectance, rain fall interception etc in a forest landscape [7].The area statistics of canopy density shows that the dense classes are prominent in Sattenapalli and Vinukonda ranges (Figure 9). The species such as Albizia amara (Narliga), Ziziphus, Accaia and Gyrocarpus Janquini that are considered to be fire prone particularly in these areas (Figure10). The change in the cover and density has been increased due to human need for fuel and fodder.

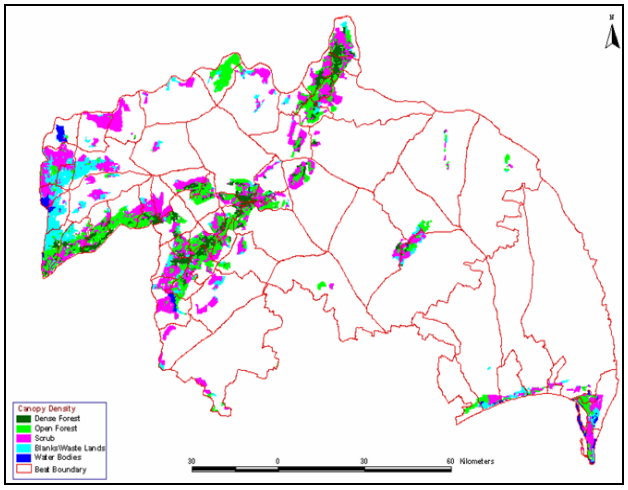

Figure9: Vegetation map within forest blocks of District

RANGE \ CLASS	DENSE	OPEN	SCRUB	BLANKS	WATER
MACHERLA	300.44	758.86	1,254.83	508.24	0.00
REPALLE	0.00	181.86	248.62	148.94	19.23
SATTENAPALLI	756.70	1,897.93	2,102.31	371.54	10.64
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Area in hectares

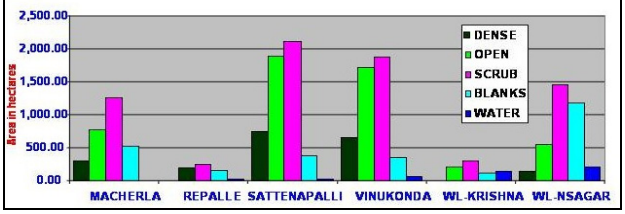

Figure10: Range wise vegetation statistics within in fire risk zones

The vegetation types are divided into deciduous and coniferous [8]. The vegetation in the study area are found to be dry mixed deciduous forest, miscellaneous mixed forest, miscellaneous scrub, plantations, degraded with sparse scrub and wastelands (Figure 11) according to the A.P forest records and their assigning values of different types (FSI, 2000).

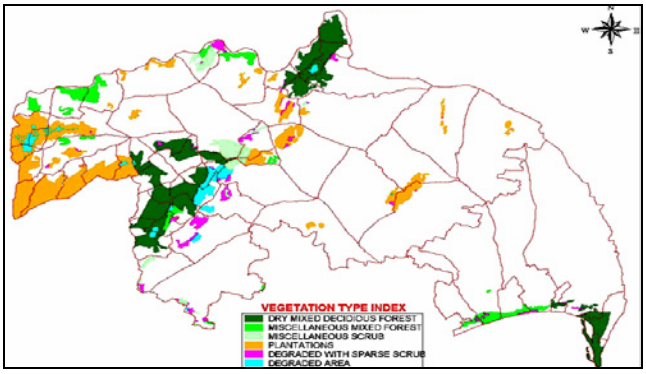

Figure11: Vegetation type map within the forest blocks of District

The other parameters like road and village buffered areas play a major role in identification of the fire risk zones (Figure 12 &13). Most of the fires in this study area are caused by accident or intentionally due to proximity of forest to villages and roads [10].These prone zones have been ranked based on the value of selected parameters within the buffer distances.

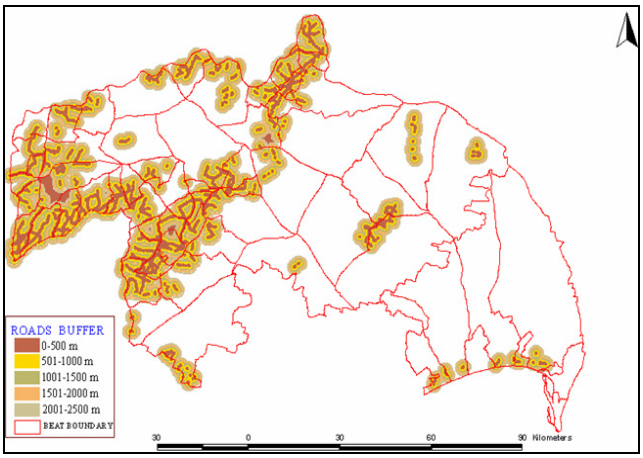

Figure12: Buffering of roads within the forest blocks of Guntur District.

The levels of fire risk are classified based on the integrated approach of fire risk zonation maps. From the derived map, out of the six ranges, Macherla, Repalle are very low level fire risk zones, where as Sattenapalli and Vinukonda are high and very high fire risk zones. WL-Krishna is in medium and WL-N Sagar is in low-level fire risk zone.

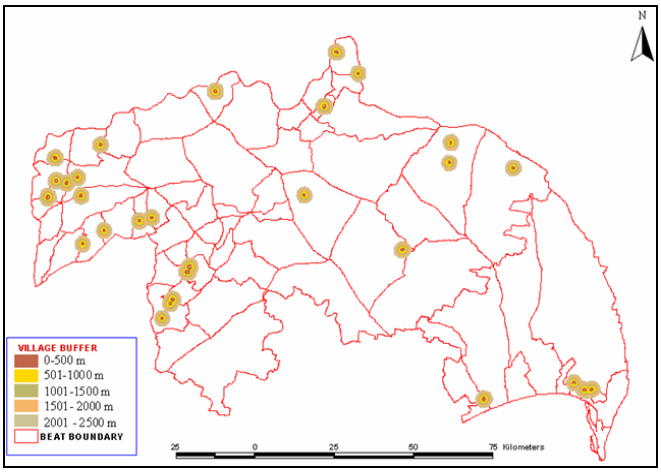

Figure13: Buffering of villages within forest blocks of District

From the area statistics shown in Figure 4, Sattenapalli and Vinukonda are high to very high fire risk zones. This is due to steep slopes, aspect, and canopy density and vegetation type such as dry mixed deciduous and miscellaneous forest types. According to area statistics of Macharla, Repalle and WL-N Sagar range have low to very low levels of fire risk, where as WL-Krishna indicate a medium risk. The Fire Resistance Species found in these ranges are Chloroxylong swietenia (Billudu, Satinwood), Webera corymbose (Papid), Soymida febrihuge (Somi),Hardwickia binate (Narape) [11].

5. Conclusions

The forest cover map of present study area classifies forest into six classes; it is easy to use and therefore show the advantages of satellite data analysis with in reach of day-to-day practitioners. Most of the fires in this study area are caused by accident or intentionally due to proximity of forest to villages and roads. The forest fire prone area map facilitates the managers to concentrate on critical areas (very high, high risk zones) during the dry seasons and would help to plan the fire lines and improve the infrastructure, communication in order to efficiently and effectively prevent or minimize and combat fire occurrence. GIS based models that use thematic overlays of landscape variables to infer where a fire is likely to occur, which is important to ensure that management objectives can be achieved with minimal computation and cost [6]. The present approach has been able to provide acceptable accuracy, suggests suitable preventive measure to resolve forest fires and risk measures for better management.

6. Acknowledgements

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