International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 7 (2018) pp. 264-269

ASSESSING FOREST FIRE PRONE AREA IN KURANGANI, TAMILNADU USING REMOTE SENSING & GIS

Balaguru M
M.E Student , Department of Civil Engineering,
Anna University Chennai,
TamilNadu, India.

Navammuniyammal M
Assistant Professor, Department of Civil Engineering,
Anna University Chennai,
TamilNadu, India.

Vidhya R
Professor, Department of Civil Engineering,
Anna University Chennai,
TamilNadu, India.

Sathyavathi G
M.E Student , Department of Civil Engineering,
Anna University Chennai,
TamilNadu, India.

Abstract

The Remote sensing and GIS techniques are very helpful for handling the large amount of data. Recent advances in the field of fire science, along with the availability of high resolution remote-sensed satellite imagery, powerful image. Processing software, Geographical Information systems (GIS), and affordable computer hardware has enabled the development of sophisticated, yet easy to operate fire simulation applications. In the present study, the fire risk zone map will be found with the help of remote sensing application and GIS techniques. The fire risk zone area of the Kurangani - Theni division forest has been found with the consideration of main factors such as Slope, DEM, Aspect, and Distance from settlement, NDVI and NDWI map. After the preparation of factor maps, the weightage and ranking are assigned with the help of fire influence intensity of each parameter. The resulting Weightages and ranks are manifold with respective parameter's risk index maps when conflated together to produce the fire risk zone map. It is identified that 19.68% is under high risk, 38.46% is under moderate risk and 16.95% is under low risk. The forest fire in Tamil Nadu's Theni hills that claimed the lives of more than 20 trekkers and severely injured many others is a heart-rending tragedy. The forest fire area which is assessed is compared and verified with the real time issue on March 11, 2018. Using forest fire simulation results, the extent of fire damage, rate of spread and direction of spread can be predicted which helps to protect and preserve the forest.

Keywords: Fire risk zone area map, GIS, Kurangani – Theni, Real time issue, Remote sensing

Introduction

Forests are major natural resources and they play an important role in maintaining environmental balance. But in this world, every year about 5 billion hectares of forests are damaged due to forest fires. Forest fires are considered as a potential hazard with biological, ecological and environmental consequences. It occurs frequently in tropical countries particularly in the dry and hot seasons causing serious damage to the forest resources and agricultural production. The health of a forest in any given area is a true indicator of the ecological conditions prevailing in that area. One major environmental concern is the occurrence of forest fires (also called wildfires), which affect forest preservation, create economic and ecological damage and cause human suffering.

The forest fire is a major cause of degradation of Indian forests and also it causes wide range of adverse ecological, economic and social impacts. Since the numbers of forest fire incidents are increasing every year, continuous monitoring is of great importance, not only to understand present trends but also to devise a model to predict the possibility of fires in future.

Fire is the greatest enemy of standing vegetation and wild animals. Small trees and regeneration are often affected very adversely. Even big trees are not spared due to the disturbances in the forest. A precise evaluation of forest fire problems, and decision on solutions can only be satisfactory when a fire risk zone mapping is available. Forest fire risk zones are locations where a fire is likely to start, and from where it can easily spread to other areas. About 90% of the forest fires in India are started by humans and meteorological parameters.

Many researchers used different models to predict the forest fire risk, based on a lot of meteorological data and fire frequency data. Most of them mapped forest fire risk zones by directly using remote sensing and Geographic Information systems (GIS) that contain topography, vegetation, land use (Road and settlement) information. A common practice was that forest fire risk zones were delineated by assigning subjective weights to the classes of all the layers, according to their sensitivity to fire or their fire inducing capability.

The recent technologies like remote sensing and GIS helps us by giving a quicker and cost effective analysis for various applications with accuracy for planning. The development in satellite data acquisition techniques and information technologies provide new opportunities for forest fire mitigations and follow up monitoring and rehabilitation efforts economically.

Study Area

Kurangani is a hill station at the top of the Western Ghats accessed from Bodinayakanur in the Indian state of Tamil Nadu. The hills are characterized by frequently-changing weather, low-hanging clouds, chilly atmosphere and strong winds, and are home to a wide range of flora and fauna including Indian gaurs, barking deer, languor's, wild cats, and possibly leopards and tigers. Kurangani has more than 6 small streams. All those streams join together into the Kottakudi river, where they flow into the Vaigai Dam. The Kurangani Hills near Bodinayakanur in Theni district are suitable for trekking and nature walks, including a distance of about 12 km walk from Kurangani village to the top Station through the central village. Those who visit Munnar in Kerala can also enter the trekking route by walking down the dense woods and plain grasslands. It takes around four to five hours to complete the trek from Kurangani village, the foot hills of the Hills, to reach the top station, while a two-and-a-half hour is enough for the return trip. Hike begins at about 35 km from Munnar to reach the top Station which is on the border of Theni district. The figure 1 indicates the map of the study area.

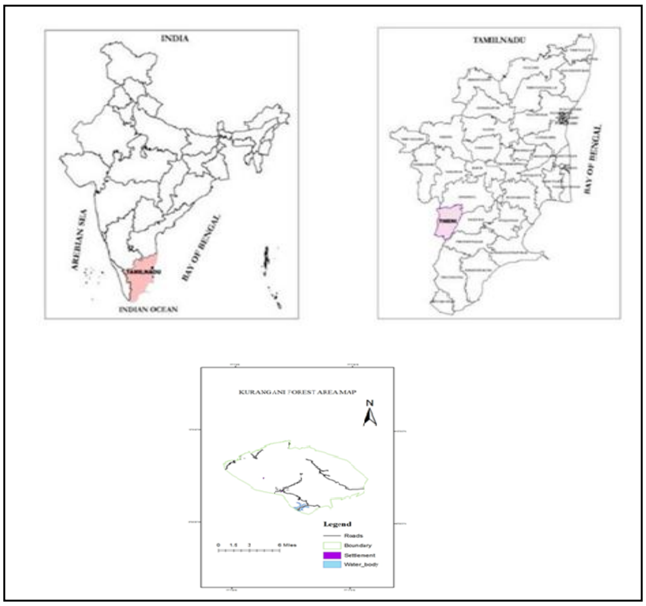

Figure 1: Study Area

Methodology

Methodology for the study has been shown in figure 2. It explains the methods to be followed for obtaining the fire behaviours by considering various parameters.

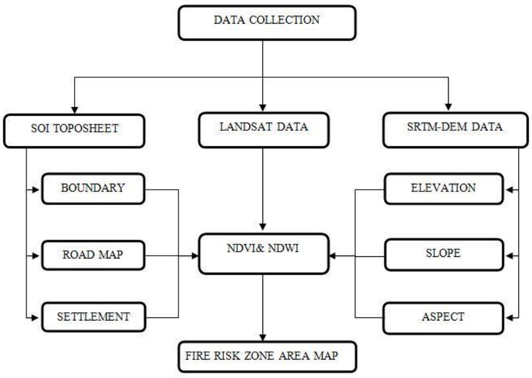

Figure 2: Methodology Flowchart

Data Description

SOI Toposheet

The land use map (Road and settlement) is prepared from SOI Toposheet. The Road and settlement map digitize from Toposheet using Arc GIS. The toposheet given by the survey of India (SOI) contains the details about the natural features. So the reserved forest area details are also clearly available in the Toposheet.

SRTM-DEM Data

The SRTM data is with a resolution of about 30m. The DEM data contains the details about the study area's topographical features. The topography is nothing, but the Elevation, Slope and Aspect and the study area details. So the Elevation, Slope and Aspect maps can be prepared from SRTM-DEM data.

LANDSAT Data

Landsat 8 consists of Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images which contain nine spectral bands with a spatial resolution of about 30 meters for Bands 1 to 7 and 9. The resolution for Band 8 (panchromatic) is 15 meters. In addition to this, it also has two Thermal IR bands with a spatial resolution of about 100m (later resampled into 30 m). Before calculating the NDVI the DN data must be converted to reflectance using the equations given in their website. Here the IR and NIR bands are 4 and 5 respectively. The calculation of NDVI can be done using the formula, NDVI = ((Green-NIR) / (Green +NIR)) using NDWI (normalized difference Water Index) map which is generated using green and near infra-red band. The calculation for NDWI can be done by, NDWI = ((Band3-Band5) / (Band3+band5)).

Thematic Layer Preparation

Elevation Map

The elevation map is prepared from SRTM-DEM data. resolution From the SRTM-DEM data, the boundary of the study area is added to the Arc map. The elevation details of the study area can be derived by using the extracted mask tool into the Arc tool box. The results are presented in meter (m).The prepared map is shown in Fig.3.

Slope Map

The slope map shown in Fig. 4 is prepared from elevation map by using Arc tools in Arc map software. The Arc map will have the spatial analyst tool bar. Using the slope tool from the spatial analyst tool bar, slope map can be derived from the elevation map. Here, the input data is taken as elevation data and the slope map is generated in percentage.

Aspect Map

The aspect map can also be derived from the elevation data. The aspect tool from the spatial analyst tool bar is used to derive the aspect map from elevation map. Here also, the input is given as an elevation data. The aspect map prepared is shown in Fig 5.

NDVI Map

The Normalized Difference Vegetation Index map (Fig 6) is prepared by using Landsat images where band 4 is Near Infrared and band 5 is Red. The NDVI can be calculated from, NDVI = ((BAND4 – BAND5)/ (BAND4+BAND5)).

NDWI Map

The Normalized Difference Water Index (NDWI) map which is shown in Fig 7 is prepared from the Landsat images. The Landsat images have 11 bands. The NDWI is done using the band combination formula where band 3 is Green band and band 4 is Near Infrared band. NDWI can be calculated from, NDWI = ((BAND3 – BAND5)/ (BAND3+BAND5)).

Road Map

The Road map in Fig 8 contains the details about the type of road and which roads are available in Kurangani forest area for finding the details about the fire. As the road side human activities is more, the road map is prepared by using visual interpretation and then digitized , for which the data is obtained from the IRS laboratory.

Settlement Map

The Settlement map contains the details about the built up area and commercial areas. The settlement map will be helpful for the identification of the places from the base map. The settlement map prepared is shown in Fig 9.
.

Weightages and Classes

The Weightages are given according to their fire sensitivity and the classes indicate the fire risk of each layer like very high risk, moderate risk and low risk. The details of weightage and classes of each layer is given below in Table 1.

NDVI Layer

The Normalized Difference vegetation Index provides estimate about the vegetation health and means of monitoring the changes in vegetation cover time, and it remains the most well-known and used index to detect live green plant canopies from the multispectral remote sensing data and its values lies between -1 to +1. So the weightage assigned for this layer is 30. The NDVI Value is reclassified by using the defined equal interval classification of five classes.

NDWI Layer

The Normalized Difference water index layer is the most important factor for the forest fire risk zone assessment which gives the water index value in the Kurangani; so that it can be used to easily assign the weight and rank in order to get fire risk zone area. The high NDWI value indicates the occurrence of the water bodies. The NDWI value varies from -1 to +1. So the weightage assigned for this layer is 20 and the values are reclassified by using the equal interval classification for all the five classes. The classes and weightage values are available in Table 1

Elevation Layer

The Elevation layer is also one of the important factors for the assessment of forest fire risk zone. The higher elevation indicates the low fire risk due to less temperature and high rainfall. The Elevation varies from 219m to 2436m .So the weightage assigned for this layer is 10 and the values are reclassified by using the equal interval classification for all the five classes.

Aspect Layer

The aspect layer is also similar to the slope layer. The aspect layers indicate the direction. So, according to the wind direction the high risk classes are assigned weightage value as10. The wind direction is mostly in south-west direction only and the classes are reclassified manually. The aspect layers consider 8 directions for higher accuracy result of the fire risk zone identification. The classes and weightage values are available in the Table 1

Distance from Road and Settlement Layer

The distance from road and settlement is considered for identification of forest fire zone identification. The human activities are high in these places. The Weightages is assigned for layer is 10 and the layers are reclassified by using define interval with five level of classification. The classes and weightage values are available in Table 1

Slope Layer

The slope and Aspect layers are assigned the same weightage. The slope and aspect data describe the topography of the forest area and these layers are assigned weightage value of 10.The slope values (%) above 35 considered as a high risk places. The fire spreading rates can also increases due to high slope values. So finally the slope layers values are reclassified by using define interval classification of five classes. The classes and weightage values are available in Table 1.

Overlay Analysis

The above all layers are generated uniformly by using same projection and output cell size. The study area falls in UTM-projection_44N zone and the output cell size made for all the layers 30.The reclassification of all layers (NDVI, NDWI, Elevation, Slope, Aspect and Distance from road and settlement) added in Arc map. Using weighted overlay tool the Reclassifies values in the input raster are entered into a common evaluation scale of risk, or some similarly unifying scale Multiplies the cell values of each input raster by the raster weight of importance Adds the resulting cell values together to produce the output raster. Finally, a Forest Fire Risk Zone (FFRZ) map was produced based on these analyses using ArcGIS software. The overlay prepared is shown in Fig 10.

Table 1: Variables and weightages for Fire Risk assessment

Variables	Weights	Ranks	Fire Risk Classes
NDVI	30	1	-0.5245 to -0.3772
		2	-0.3772 to -0.3112
		3	-0.3112 to -0.2427
		4	-0.2427 to -0.0980
		5	-0.0980 to -0.1228
NDWI	20	5	-1 to -0.3333
		4	-0.3333 to -0.2627
		3	-0.2627 to -0.1843
		2	-0.1843 to -0.0039
		1	-0.0039 to -1
SLOPE	10	5	> 35
		4	35 - 25
		3	25 - 10
		2	10 - 5
		1	< 5
ASPECT	10	4	South West
		3.5	West
		3	South
		2.5	North West
		2	South East
		1.5	North
		1	East
		0.5	North East
ELEVATION	10	5	219 - 375
		4	375 - 585
		3	585 - 904
		2	904 - 1321
		1	> 2436
Distance from Roads	10	5	< 50
		4	100 - 200
		3	200 - 300
		2	300 - 400
		1	> 400
Distance from Settlements	10	5	< 200
		4	100 - 200
		3	200 - 400
		2	400 - 500
		1	> 500

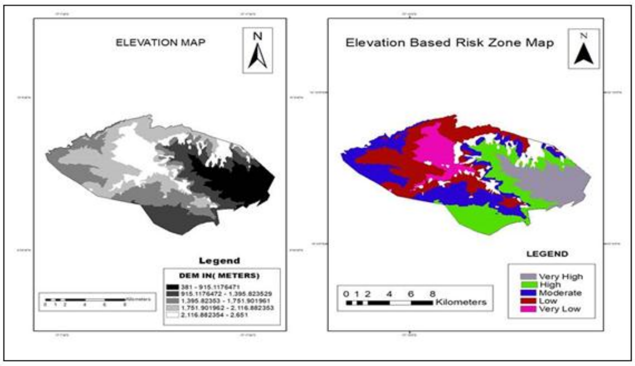

Figure 3: Elevation and Elevation based Risk Zone map

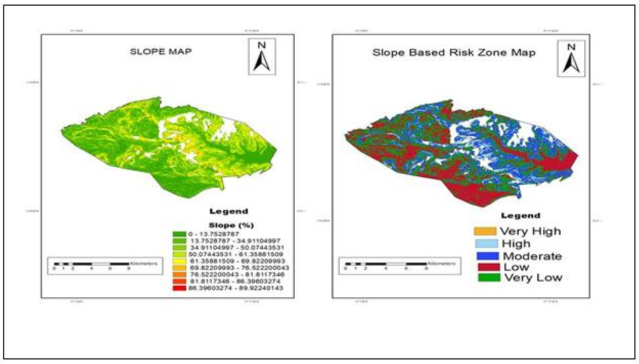

Figure 4: Slope and Slope based Risk Zone map

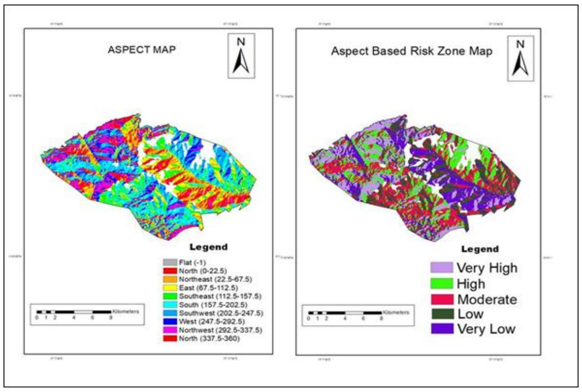

Figure 5: Aspect and Aspect based Risk Zone map

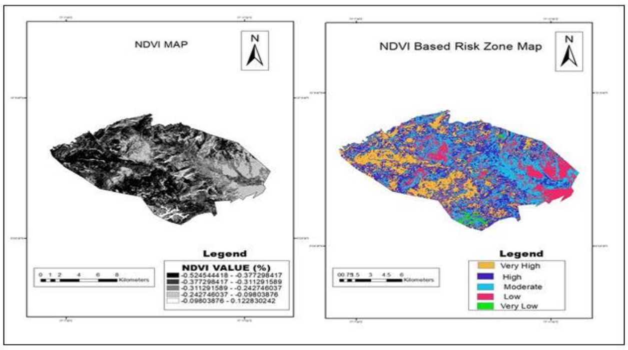

Figure 6: NDVI and NDVI based Risk Zone map

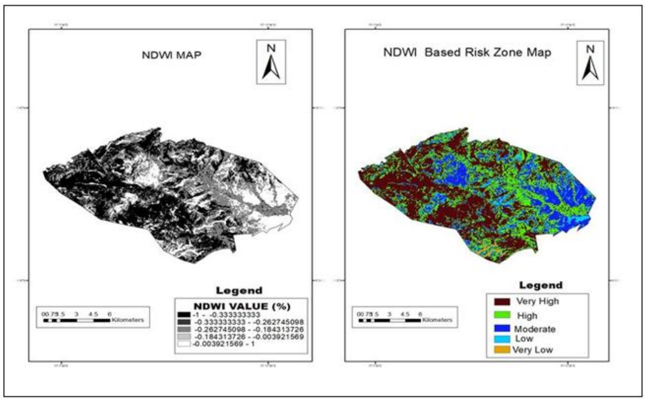

Figure 7: NDWI and NDWI based Risk Zone map

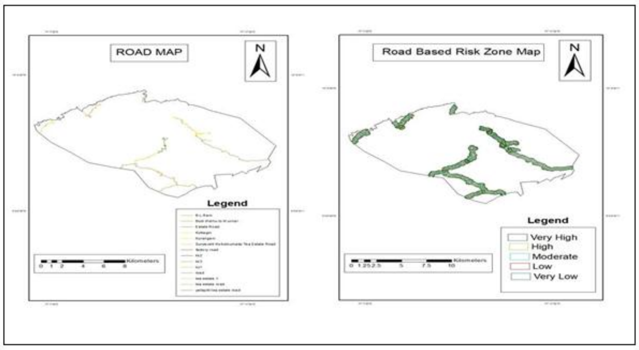

Figure 8: Road and Road based Risk Zone map

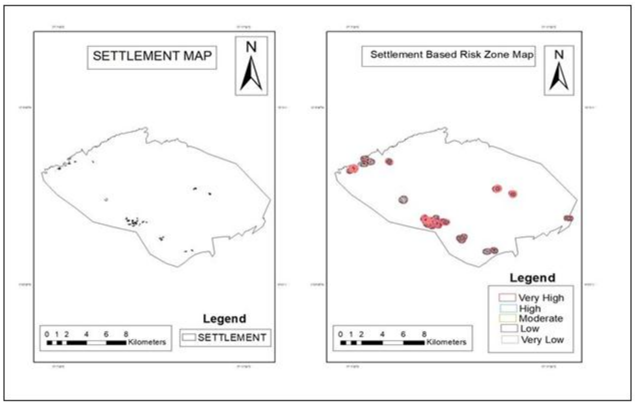

Figure 9: Settlement and Settlement based Risk Zone map

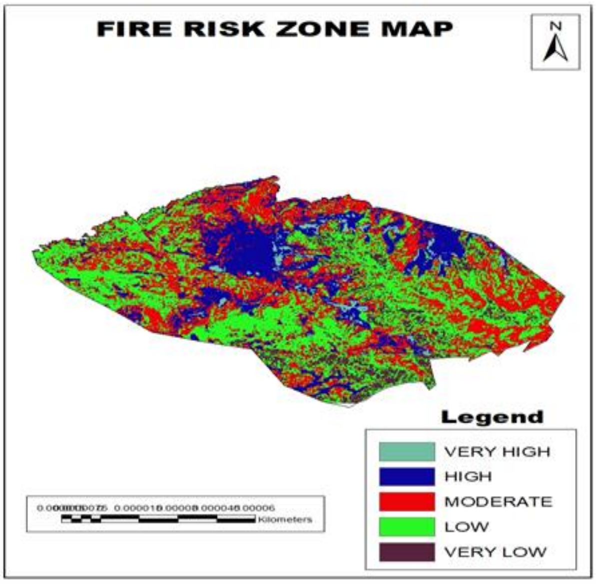

Figure 10: Fire Risk Zone Map

Conclusion

The various parameters that contribute to the forest fire like elevation, slope, aspect, distance from roads and settlements, NDVI and NDWI map has been prepared. The maps are overlaid to obtain the fire risk zone map. The proposed study was found useful in identifying the fire risk areas. The areas shown under very high, high and moderate 'fire risk' zones are those areas where fire can be unintentionally caused by human activities, and where fire could thus certainly be averted by taking precautionary measures. Hence, despite the fact that no fire prone areas can be demarcated where fire occurs due to natural or intentional human causes, it is advantageous to have a fire risk map to avert possible disasters caused by fire due to human activities. It should prove to be helpful to the Forest Department, as this type of fire risk zone map would enable the department to set up an appropriate fire-fighting infrastructure for the areas more prone to fire damage. Such a map would help in planning the main roads, subsidiary roads, inspection paths, etc. and may lead to a reliable communication and transport system to efficiently fight small and large forest fires. This proposed fire risk zone map helped in identifying the area which was burned in the fire accident at the Kurangani forest area on March 11, 2018. From this fire risk zone map, it was estimated that the area burned during the fire accident falls under high fire risk zone. Thus the result of this study will be useful for future research on forest fire management.

References

[1] Amit Kumar Verma, Dharmendra Singh, Satindra Dev Sharma, Khanduri Kamlesh, Forest Fire Risk Zonation in Raipur Range, Mussoorie Forest Division using GIS and Remote Sensing Technology, International Journal of Advanced Scientific and Technical Research, vol. 6, pp -141-148 (2013).

[2] Ajin R.S, Ana-Maria Loghin, Mathew K. Jacob, Vinod P.G and Krishnamurthy, The Risk Assessment Study of Potential Forest Fire in Idukki Wildlife Sanctuary using RS and GIS Techniques, International Journal of Advanced Earth Science and Engineering, vol. 5: pp 308-318 (2016).

[3] Amit Kumar Verma and Sanjeev Kumar, Mapping fire hazard in Rajajinational park, future perspective of wildlife habitat conservation by using remote sensing and gis, International Journal of Technical Research and Applications,vol.3, pp81-88 (2015).

[4] Firoz Ahmad and Laxmi Goparaju, Geospatial Assessment of Forest Fires in Jharkhand (India), Indian Journal of Science and Technology, Indian Journal of Science and Technology, vol.60, pp353-363 (2014).

[5] H. Aghajani, A. Fallah, S. Fazlollah Emadian, Modelling and analyzing the surface fire behaviour in Hyrcanian forest of Iran, Journal of forest science, vol. 25, pp 793-816 (2011).

[6] Khaldoun Qtaishat, Nawras Shatnawiand Maan Habib, Forest Fire Risk Zonation Using Remote Sensing and GIS Technology -Case study in Jordan, International Journal of Environment& Global Climate Change, vol.5: pp 2310-2318 (2011).

[7] Laxmi Kant Sharma, Shruti Kanga, Mahendra Singh Nathawat, Suman Sinha and Prem Chandra Pandey Fuzzy AHP for Forest Fire Risk Modeling in Shimla (India), International Journal of Disaster Prevention and Management, vol. 21, pp 160-171 (2012).

[8] Mohamed Said Guettouche, Ammar Derias, Modelling of Environment Vulnerability to Forests Fires and Assessment by GIS Application on the Forests of Djelfa,Algeria, Journal of Geographic Information System,Vol. 5, pp 24–32 (2013).

[9] M.A.Fische, C.M. Di Bell, E.G. Jobbagy, Fire patterns in central semiarid Argentina, International Journal of Arid Environments, vol. 78, pp 161 -168 (2012).

[10] Rajendran Sobha Ajin, Ana-Maria Loghin, Padmakumari GopinathanVinod and Mathew Karumamkott Jacob, Forest Fire Risk Zone Mapping Using RS and GIS Techniques: A Study in Achankovil Forest Division, International Journal of Earth, Environment and Health Science, Vol.02, pp 109-115 (2016).

[11] R.S. Suryawanshi , K.K. Da and M.E.Chavan, Forest fire risk zonation using Remote Sensing and GIS in Huynial watershed, TehriGarhwal district , International Journal of Basic and Applied Research, vol.02, pp 6-12 (2012).

[12] Shruti Kanga , Laxmikant Sharma , Prem Chandra Pandey, GIS Modeling approach for forest fire risk assessment and management, International Journal of Advancement in Remote Sensing, GIS and Geography , vol. 02, pp 30-44 (2014).

[13] Shlomit Paz, Yohay Carmel, FarisJahshan & Maxim Shoshany, Post-fire analysis of pre-fire mapping of fire-risk: A recent case study from Mt. Carmel (Israel), International Journal of Forest Ecology and Management, vol. 262 pp 1184–1188 (2011).

[14] Shruti Kanga, and Suraj Kumar Singh, Forest Fire Simulation Modeling using Remote Sensing & GIS, International Journal of Advanced Research in Computer Science,vol. 8, pp 326–322 (2017).

[15] Satyam Verma, Kuimi TampeimiVashum, Sathya Mani &Shanmuganathan Jayakumar , Monitoring Changes in Forest Fire Pattern in Mudumalai Tiger Reserve, Western Ghats India, using Remote Sensing and GIS, Global Journal of Science Frontier Research: H Environment & Earth Science, vol. 15, pp13-18 (2015).

[16] Shruti Kanga, Sumit Kumar and Suraj Kumar Singh, Climate induced variation in forest fire using Remote Sensing and GIS in Bilaspur District of Himachal Pradesh,India, International Journal Of Engineering And Computer Science ,vol. 6, pp 21695-21702 (2017).

[17] Tahir Malik, Ghulam Rabbani and Majid Farooq, Forest Fire Risk Zonation Using Remote Sensing and GIS Technology in Kansrao Forest Range of Rajaji National Park , International Journal of Advanced Remote Sensing and GIS, vol. 2, pp 86-95 (2013).

[18] U. Murthy Kandala, K. Gopi ready, Fire monitoring and assessment in Forest using remote sensing and GIS, SSRG International Journal of Industrial Engineering, Vol. 3, pp 26-29 (2016).

[19] Vinod P G, Ajin R. S and Mathew K Jacob, RS and GIS Based Spatial Mapping of Forest Fires in Wayanad Wildlife Sanctuary, Wayanad, International Journal of Earth Science and Engineering, vol. 09, pp 498-502 (2016).

[20] W. John Braun, Bruce L. Jones, and Jonathan S, Forest Fire Risk Assessment: An Illustrative Example from Ontario, Canada, International Journal of Probability and Statistics, vol. 10, pp 1-26 (2010).