Study of Forest Fire Severity through Normalized Burn Ratio Analysis using Remote Sensing

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Abstract - Forest fires are a type of natural catastrophe that poses a risk to the vegetation and fauna of the hill stations. Due to the presence of vast enormous areas of land adorned with aged trees, vegetation, and wildlife, safeguarding the ecosystem is both critical and arduous. A Geographic Information System and Remote Sensing assist in resolving this issue through the continuous monitoring of the forest using satellite, aerial, and drone-based imagery gathered from a variety of sources in India and Abroad. Landsat8 series Band 4, Band 5, Band 6 and Band 7 is used for the study. Following the correction and analysis of reflectance values for pre-fire and post-fire imagery, the Normalized Burn Ratio (NBR) is computed and processed. Finally, the difference in NBR based on the pre-fire event and post-fire event for the Yercaud hill station is analyzed and the severity level is classified for the chosen area of interest.

Keywords – Forest fire, Normalized Burn Ratio, Remote Sensing, Severity, and Vegetation.

1. Introduction

Forest fires are a significant concern not only in the Indian state of Tamil Nadu, but also on an international scale due to their detrimental effects on biodiversity and the environment. Among the most destructive natural calamities is fire. It not only directly endangers people’s safety but also destroys forests by destroying trees that provide oxygen endangers people’s safety but also destroys forests by destroying trees that provide oxygen...
2. Study of Forest Fire

damage that forest fires cause to the region’s flourishing vegetation
examination of the contributions of vegetation, permafrost, the carbon cycle, and forest fires to climate change at the present time. This is because of these parts interact with one another.

One of the main reasons, ecosystem services are deteriorating and human existence is declining is forest fires. The ranking is high among the most pressing issues because of this. Government forest preservation and management policies fail to meet their objectives in many parts of the world.

Forest fires diminish the attractiveness of the jungle because they disrupt the natural ecological processes that impart the Amazon Forest with its distinctive appearance. The Amazon has experienced an alarming rise in the occurrence of forest fires, which has been ascribed to deforestation, reduced forest cover, and prolonged droughts.

3. Materials and Methods

The imagery utilized for the Yercaud hill is in the Salem district and its area is extracted from the LandSAT8 data which was acquired from the United States Geological Survey explorer site.

Fig. 1. Study area showing Yercaud hill station

![Study Area](image1.jpg)

Yercaud hill station Boundary was obtained using the Bhuvan Portal. As a part of preprocessing the data, basic parameters required to convert Top of Atmosphere(TOA) spectral radiance were obtained from the meta data file with the extension .MTL file. The parameters were as follows for the Prefire analysis.

Reflectance Multiband 2 = 2.0000E-05, Reflectance add band 2 = -100000, θ SE SUN_ELEVATION = 47.68833645, θ SE θSZ = 47.68833645, θ SE θSZ = 42.31166355, θ SE Radian = (Degree * 3.141/180), θ Radian = (42.31166355 * 3.141/180) = 0.738477840943572395, Cos θ Radian = 0.9999169397.

For the post fire analysis, parameters are as follows,

Reflectance Multiband 2 = 2.0000E-05, Reflectance add band 2 = -100000, θ SE SUN_ELEVATION = 57.06623077, θ SE θSZ = 90 - 57.06623077, θ SZ = 32.93376923, θ SZ Radian = (Degree * 3.141/180) = 0.5746942731, Cos θ SZ Radian = 0.9999496969.
Using the raster calculator tool from the spatial analyst extension, Band reflectance was computed first. Then, the reflectance values were corrected for all the bands used in this study. Normalized Burn Ratio, NBR was computed using the formula, \( \frac{(\text{Band 5} - \text{Band 7})}{(\text{Band 5} + \text{Band 7})} \) for both the pre-fire and post-fire analysis. After that, difference in NBR of pre-fire and post-fire is determined and named as dNBR. After that reclassification of dNBR data is carried out as per the severity level assigned and negative values indicate trees and plants burned areas and positive values indicate improved vegetation as well as greeneries.
4. Explorations on Fire Behavior Modelling in the previous studies

LiDAR technology allows for the precise measurement of several forest attributes, including heights, biomass, canopy cover, and volume size. Moreover, it allows for the assessment of forest fire impact by comparing point clouds derived from LiDAR data acquired at two separate time intervals (before and after the fire) (Peña-Molina et al., 2024).

This study investigates the impacts of recent wildfires on ancient colossal sequoia trees, formerly believed to be immune to anthropogenic alterations. Since 2015, the frequency of intense wild fires in sequoia groves has notably risen because of climate change and the implementation of fire suppression techniques. Following the wildfires that took place from 2015 to 2017, studies found that around 28% of giant sequoias died in regions categorized as moderately severe, while nearly 84% died in areas designated as high severity. There was a clear association between reduced death rates and characteristics such as early fire damage, lower elevations, and lower crown ratios. Extensive crown damage and fire wounds were identified as significant mortality indicators in the study that tracked the trees over time. The article emphasises the critical nature of the situation by providing a comprehensive account of the severe destruction caused to these ancient trees by previous fires, specifically the Castle fire of 2020, the windy fire of 2021, and the KNP complex fire of 2021. Management measures that increase the fire resistance of unburned groves should be prioritized if we are to stop the continuous loss of these remarkable old forests. This research underscores the significance of considering spatial synchrony in tree development and past growth suppressions in order to comprehend the ramifications of climate change and increased fire frequency on boreal forests.

There is a lack of satellite data analysis methods in populated areas, such as refugee camps, because the focus is mainly on studying natural land features. The study utilized random forest and Sentinel-2 data to create the Fractional Charred Index (FCI) for evaluating the effects of fire on the Rohingya refugee community in Teknaf, Bangladesh. The fire burnt 140 acres, destroying over 8000 structures, 1760, of which were severely damaged and 3,452 moderately damaged. A substantial correlation was found between fire intensity and differentiated spectral indices (dNBR and dCSI). The proposed method for assessing flames in inhabited regions, notably refugee communities, is effective and affordable. This technique has great potential in disaster relief and management.
5. Derived maps for the interpretation of Forest Fire Analysis

A fire propagation model with multiple dimensions is created to incorporate environmental and physical aspects, aiming to address the inherent uncertainty linked to fire propagation. The physical mechanism of fire propagation is well understood based on predictions of fire spread [23].

6. Results and Discussion

The topography of Yercaud hill station consists of several ecological classifications, each of which plays a unique role in the entire area. The total area of the fresh greens, low severity, and medium severity categories is around 57%. Furthermore, significant portions of the land are characterized by zones of moderate severity and abundant vegetation, indicating ongoing ecological enhancement and attention. Distinct locations characterized by extreme adversity, superior vegetation, higher social divisions, and comparatively smaller landmasses necessitate specific conservation initiatives. This comprehensive study offers an in-depth understanding of the environmental structure of Yercaud, consequently enhancing focused conservation initiatives and sustainable land management practices. The complex interplay between species variety and ecological balance is highlighted by the distribution of different vegetation types and levels of severity at this hill station. The analysis indicates that the seven classified classes based on the levels are as 1 - extreme severity, 2 - high severity, 3 - medium severity, 4 - low severity, 5 - fresh greenery, 6 - improved vegetation, low and 7 - improved vegetation, high and the percentages of each class are as shown in Table.1.

An analysis was conducted on 60,183 individual polygons prior to compiling the DNBR reclass summary. In the end, statistics were calculated for each polygon using the seven classes, and the resulting percentage is displayed in Table.1.

<table>
<thead>
<tr>
<th>Classes</th>
<th>Percentage (%)</th>
</tr>
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<tbody>
<tr>
<td>Extreme severity</td>
<td>1.22</td>
</tr>
<tr>
<td>High severity</td>
<td>9.44</td>
</tr>
<tr>
<td>Medium severity</td>
<td>24.67</td>
</tr>
<tr>
<td>Low severity</td>
<td>24.76</td>
</tr>
<tr>
<td>Fresh greenery</td>
<td>22.42</td>
</tr>
<tr>
<td>Improved vegetation, low</td>
<td>14.98</td>
</tr>
<tr>
<td>Improved vegetation, high</td>
<td>2.51</td>
</tr>
</tbody>
</table>

Table.1 Classification of Area based on the levels of burning
High classes, despite the severity of their conditions and the abundance of flora they contain, have a significantly limited focus, and require intensive conservation efforts in particular regions. The exhaustive examination sheds light on the diverse ecological composition of Yercaud Hill station and offers valuable knowledge that can serve as a foundation for the development of individualized conservation strategies and environmentally responsible land management.
7. Conclusion

To summarize, a thorough analysis of the Yercaud hill stations topography has yielded valuable information about the varied ecological makeup of the region. The environment demonstrates an overall favourable ecological status, as low to medium severity classes are prevalent and fresh vegetation covers approximately 57% of the total area. The existence of regions characterized by moderate levels of severity and a profusion of plant life signifies continuous ecological upkeep and enhancement, which in turn suggests an ecosystem that is...
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References


