

## Assessing Forest Fire Prone Area in Theni District Using Spatial Modelling Technique

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### ABSTRACT

*In recent years, forest fires have become a major disaster in many countries of the world because of their impact on biodiversity, landscape, health, environment, ecology and economy. Forest fires are one of the major natural hazards occurring in the forests of the Western Ghats, a biodiversity hotspot in India. 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 zonation map is prepared with the help of remote sensing application and GIS techniques. The fire risk zone area of the Theni division forest has found with the consideration of main factor 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 manifolded with respective parameter's risk index maps when conflated together to produce the fire risk zone map. The resulting map of forest fire risk zone can be of great benefit for understanding the fire problem and will offer a more effective database for the preparation and control of forest fires.*

**Key Words-** Forest Fire, Western Ghats, Geographical information System, Fire Risk Zones, Mitigation

### 1.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 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. 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 if the disturbances in the forests. 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. Risk zones is prepared 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.

## **II.NEED OF THE STUDY**

Almost 50% of the forest extent in India to forest fire. Forest fire cause wide ranging adverse ecological, economic and social impacts. The prediction of forest fire behavior is an important element in the management of forests, as well as in assessing ecological effects. This study provides a comprehensive framework to mitigate or prevent the forest and land fire disaster. This system supports emergency response and preparedness for forest fire by means of GIS application and remote sensing techniques, monitoring and mapping of fire danger. And also prevent the Forest degradation and environmental pollutions.

## **III.OBJECTIVES OF THE STUDY**

The objectives of this study are

- To prepare the thematic layer for the risk zone using GIS.
- To prepare the fire risk zone map by assigning the weight and rank to each parameters like elevation, slope, aspect, distance from road and settlements, NDVI and NDWI according to the fire sensitivity.

## **IV. DATA USED FOR THIS STUDY**

LANDSAT-8 from USGC was downloaded with resolution of 30m used to determine NDVI (Normalized Difference Vegetation Index) and NDWI (Normalized Difference Water Index) Map are prepared. SRTM – DEM Data was downloaded from USGC with the resolution of 30m used to prepare Elevation, Slope and Aspect maps.

## **V.METHODOLOGY**

Methodology for the study has been shown in figure 1. It explains the methods to be followed for obtaining the fire behaviors by considering various parameters.

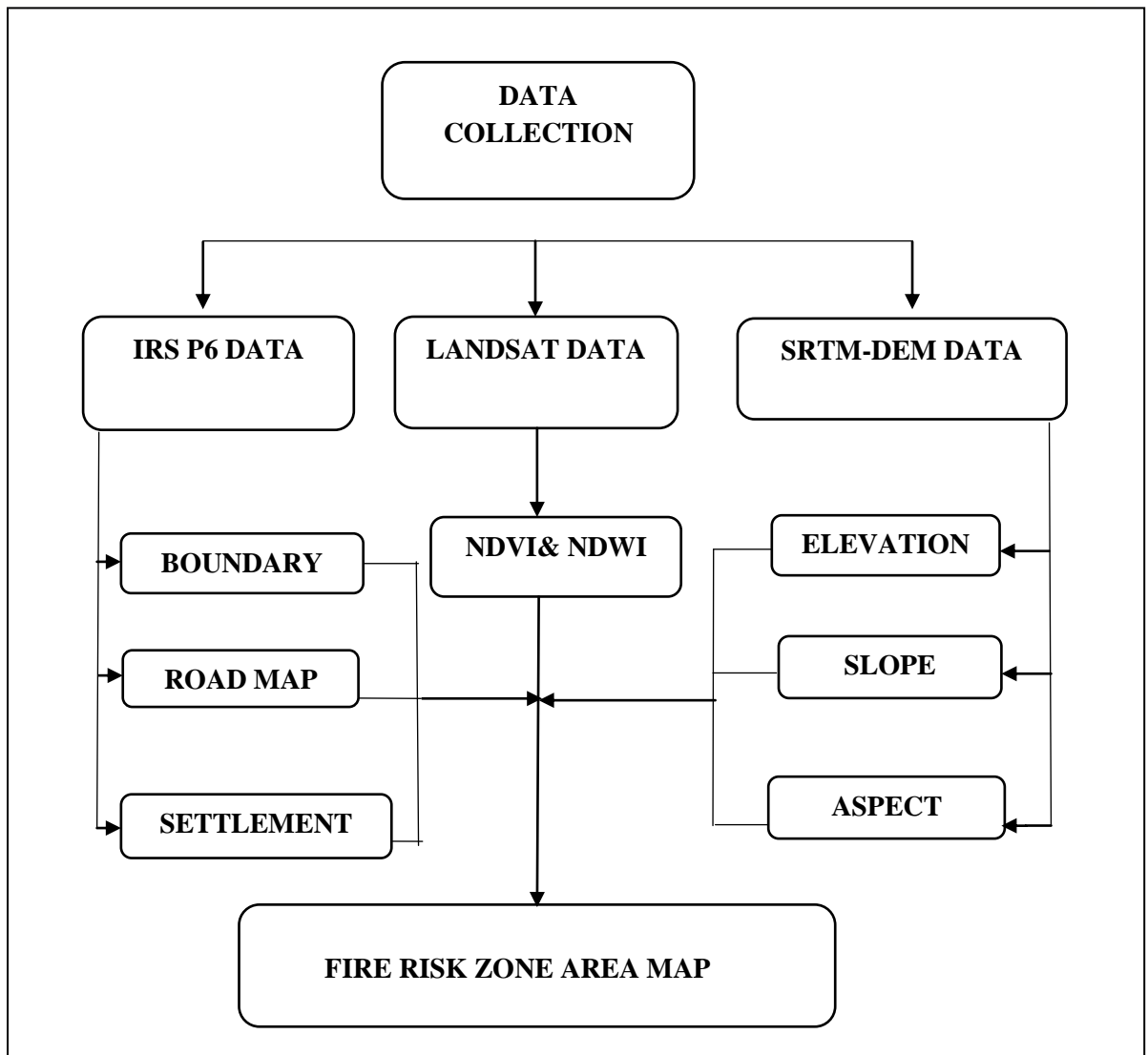


Figure 1: Methodology for Risk Zone Map

### 5.1 STUDY AREA

The Theni Forest division was constituted after bifurcating the erstwhile Madurai south Division with headquarters at Theni. The Theni forest division was formed for effective control of forest offences like encroachments in the vulnerable forests tracts along the interstate border of Tamilnadu and Kerala, for management of the forests through intensive silvicultural operations and to settle the Ex-Zamin lands. There are 27 forest areas in Theni district constituting a total area of 795.81 sq.km. The total area of the forest in Theni division is 187.622 sq.km and it lies between latitude of 9° 31' and 10° 15' North and the East longitudes of 77° 10' and 77°42'. The Geographical area of this division consisting of forest situated in Periyakulam, Uthamapalayam, Bodinaickanur, Theni and Andipatti taluks. The district is bounded by the Kodaikanal forest division in the north, the Kerala state and the Grizzled Giant Squirrel wildlife sanctuary in the south, the Madurai forest division in the east and the Kerala state in the west and southwest. The terrain of this division

may be divided into four naturally distinct regions. (1) The Western Ghats, (2) The Cumbum Valley (3) The Varshuhanadu valley and (4) The Plain tracts. The study area map is shown in figure 2.

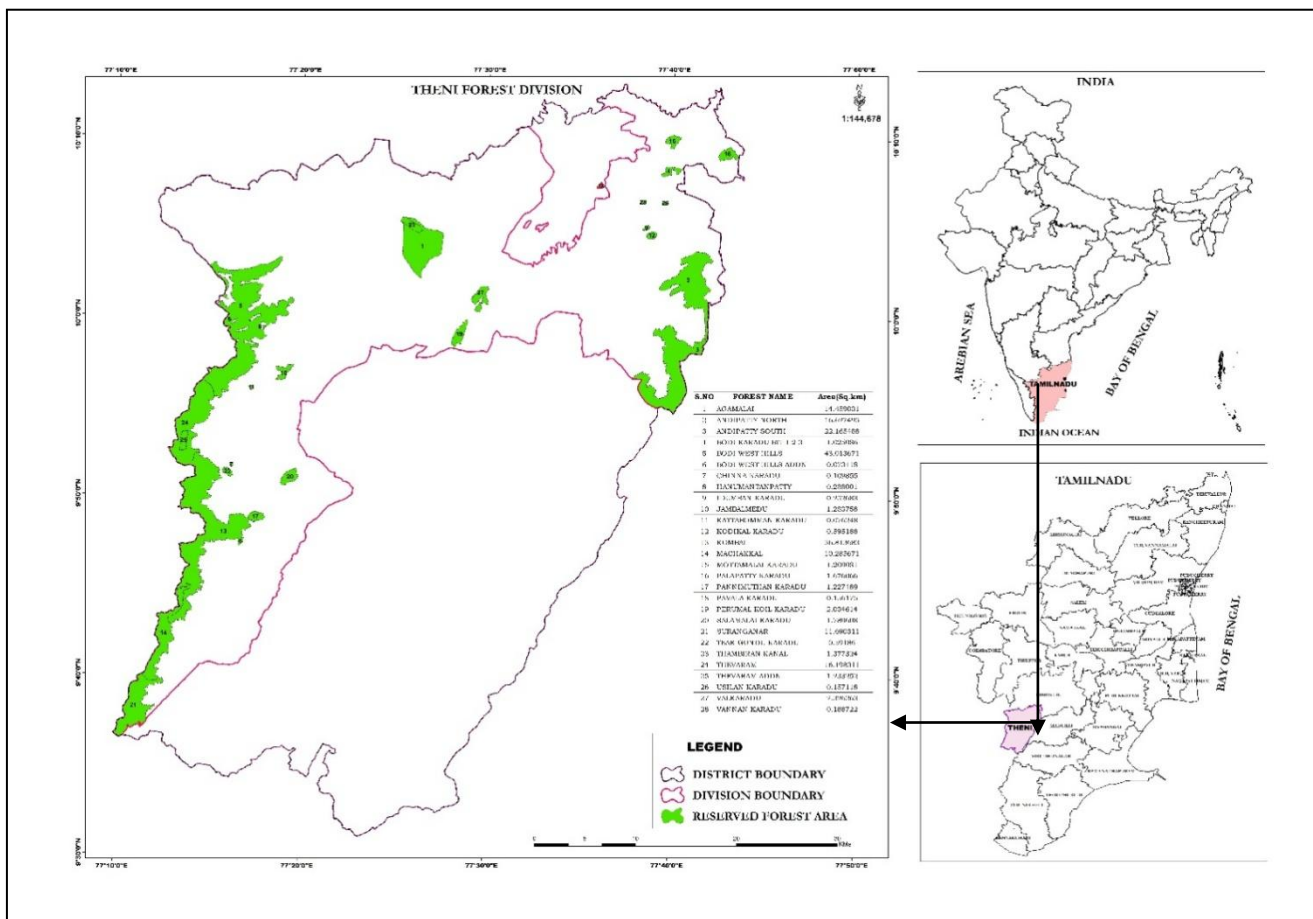


Figure 2 Location of the study area

## 5.2 Preparation of Thematic Maps

Slope, Aspect, Elevation, NDVI, NDWI, Distance from roads and distance from settlements are prepared using ARCGIS.

### 5.2.1 Slope map

The slope map is shown in fig 3 and 4. Slope can be defined in terms of ratios, percentages, or per mil (formulas). Slope is as ratio of rise over run or height over distance and then expressed in percentage. The slope values range from 0 to 89.92% in which 0-5% indicates horizontal slope, 5- 10% indicated flat slope, 10-35% indicates moderate slope and greater than 35% indicates very steep slope. The Bodi west hills, Andipatty north, Andipatty south, Agamalai and kombai lies along high slope whereas perumalkodi karai, valkaradu and Thambirankanal forest lies along moderate slope. The slope map is prepared from Elevation map by using Arc tools in Arc map software. The Arc map having spatial analyst tool bar. Using slope tool from the spatial analyst tool bar slope map can be derived from Elevation map.



### 5.2.2 Elevation map

The Elevation map of Theni Division forest in figure 5 and 6. The Elevation of the forest varies from 219m to 2436m. Agamalai, pannimuthan karadu, suranganar, valkaradu and Idumban karadu lies in low elevated areas. Thamibarankanal, kodikal karadu, jamal medu, Andipatty north, Andipatty south and Bodi karadu lies in High elevated areas. Elevation of an area above the sea level influences fire risk for the fact that fire spreads quicker uphill than downhill.

### 5.2.3 Aspect Map

Aspect generally refers to the horizontal direction to which mountain slope faces. The aspect map of the study area shown in Figure 7 and 8. The sunlight is much more reflected on slope faces. Fire breaks out easily and spread fast in slope faces side. For better accuracy, eight directions are considered and the south west direction is a high risk zone as the wind blows along that direction. The opposite direction of the south west is north east and it is considered as low fire risk zone.

### 5.2.4 NDVI Map

The Normalized Difference Vegetation Index (NDVI) provides a crude estimate of vegetation health and means of monitoring change in vegetation over time, and it remains the most well-known and used index to detect live green plant canopies in multispectral remote sensing data and its value always lies between -1 to +1. The positive value indicates the high vegetation and negative values of NDVI correspond to deep water. Values close to zero (0.1 to 0.1) generally correspond to barren areas of rock, sand or snow. The Normalized Difference Vegetation Index (NDVI) map is prepared by using Landsat images where band 4 is near Infrared and band 5 red. The high NDVI value indicates the occurrence of high vegetation and it means the possibilities of high forest fire are shown in Figure 9 and 10.

### 5.2.5 NDWI Map

The Normalized Difference Water Index values always lies between -1 to +1. Positive value of NDWI corresponds to water bodies while negative or zero value corresponds to vegetation and soil. The NDWI is done using the band combination formula. Where band 3 is green band and band 4 is near infrared band. The NDWI map of the study area map was shown in figure 11 and 12. The advantage of NDWI layer is that moisture content of soil in the study area can be found and the areas with high moisture content low risk to fire.

### 5.2.6 Distance from Road and Settlement layer

The distance from road and settlement as considered for identification of forest fire risk zone identification. The human activities are high in these places. The road map and settlement map describes the details about the location of roads and settlement. The settlement map shows the location of the village in the study area and as it is a forest area, road type mostly present here are village road or footpath in hills. The human activities in the study area are high and it also contributes to the fire risk zone mapping are shown in figure 13, 14, 15 and 16. The areas which lie in the distance above 400m from the road have low risk and below 100m have very high



risk to fire. Similarly for the distance from settlements, areas lie above 4000m have low risk and below 1000m have very high risk to fire.

Table 1 Variables and their weights in determination of forest fire risk

Variables	Weights	Values (Rank)	Fire Risk Relating Classes
NDVI	30	1	-0.0733 to -0.1754
		2	-0.1754 to 0.2409
		3	0.2409 to 0.3116
		4	0.3116 to 0.3823
		5	0.3823 to 0.5944
NDWI	20	5	-0.0733 to -0.1754
		4	-0.1754 to 0.2409
		3	0.2409 to 0.3116
		2	0.3116 to 0.3823
		1	0.3823 to 0.5944
Slope	10	5	> 35
		4	35 to 25
		3	25 to 10
		2	10 to 5
		1	5 to 0
Aspect	10	4	South West
		3.5	West
		3	South
		2.5	North West
		2	South East
		1.5	North
		1	East
Elevation	10	0.5	North East
		5	219 to 375
		4	375 to 585
		3	585 to 904
		2	904 to 1321
Distance from Roads	10	1	>2436
		5	<50
		4	100 to 200
		3	200 to 300
		2	300 to 400
Distance from Settlement	10	1	>400
		5	<200
		4	100 to 200
		3	200 to 400
		2	400 to 500



### 5.2.6 Overlay Analysis

The above all layers are generated uniformly by using same projection and output cell size. The study area fall in UTM- projection \_44N\_ Zone and the output cell size is made for all the layers as 30. The reclassification of all layers NDVI, NDWI, Elevation, Slope, Aspect & Distance from road and settlement added in Arc map. By assigning suitable weight ages and ranks to parameters the forest fire zone map is generated are shown in figure 17.

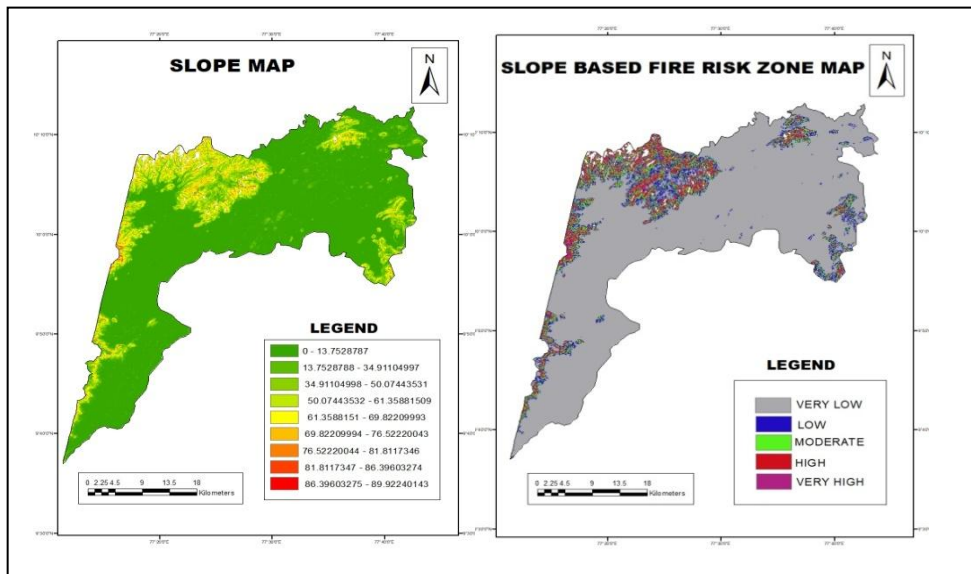


Figure 3 Slope map

Figure 4 Slope based risk map

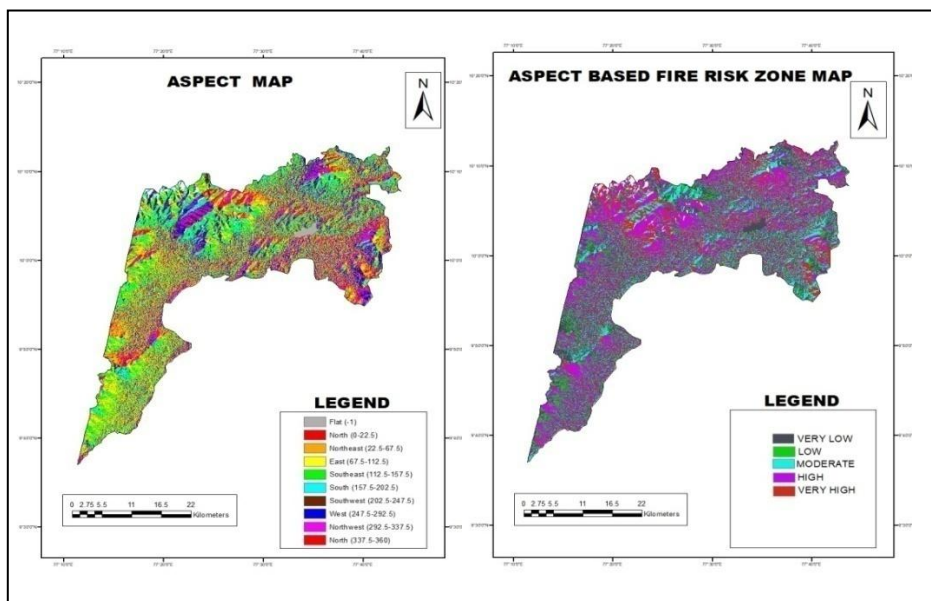


Figure 5 Aspect map

Figure 6 Aspect based risk map

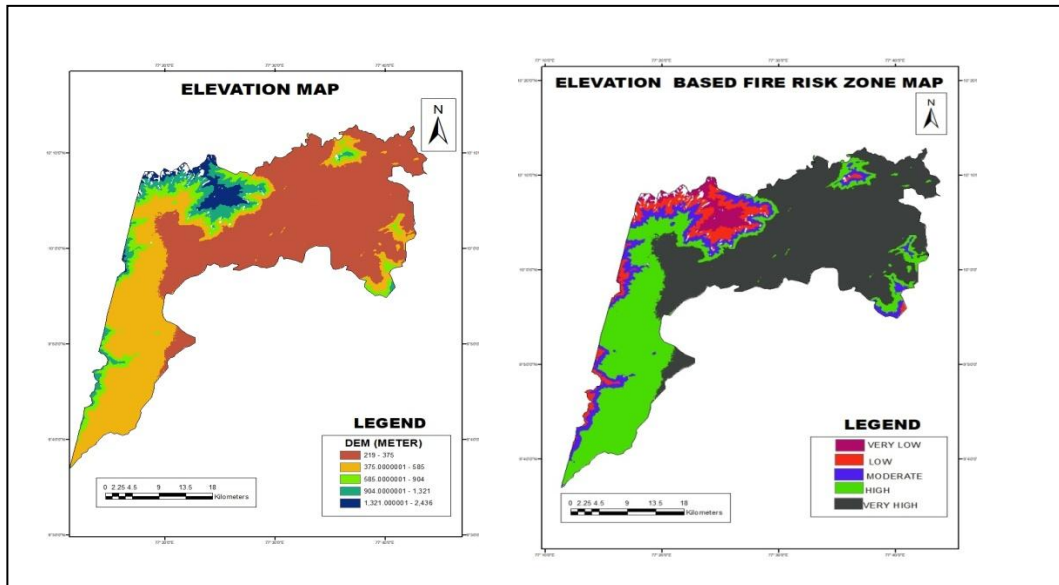


Figure 7 Elevation map

Figure 8 Elevation based risk map

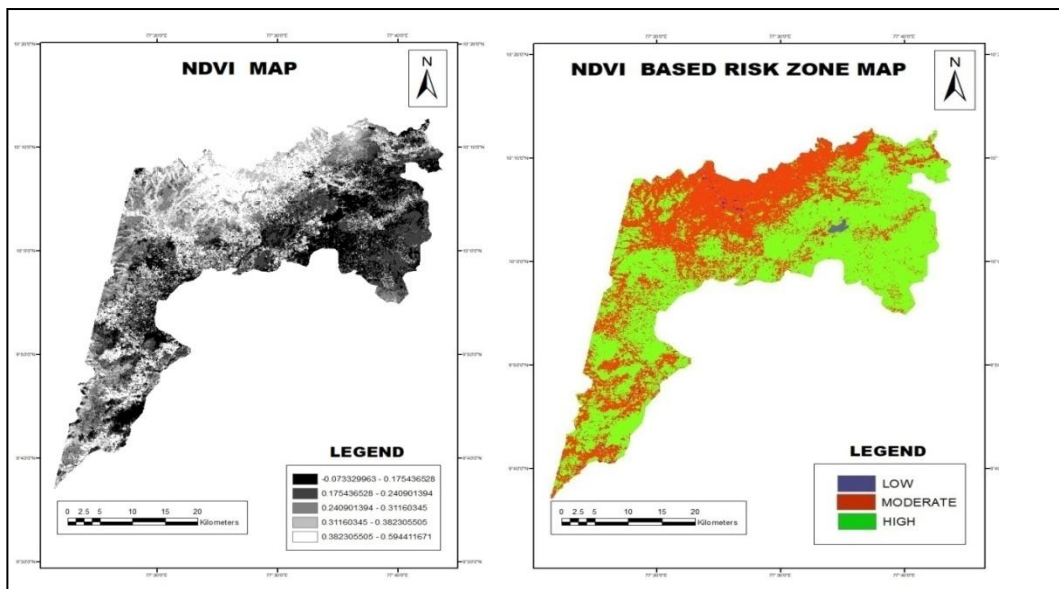


Figure 9 NDVI map

Figure 10 NDVI based risk map



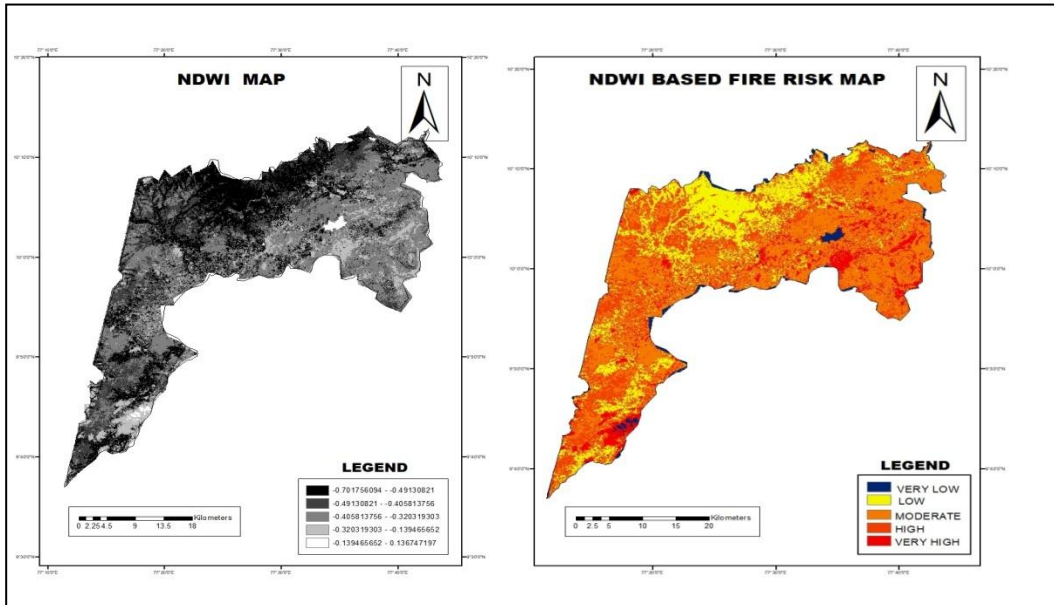


Figure 11 NDWI map

Figure 12 NDWI based risk map

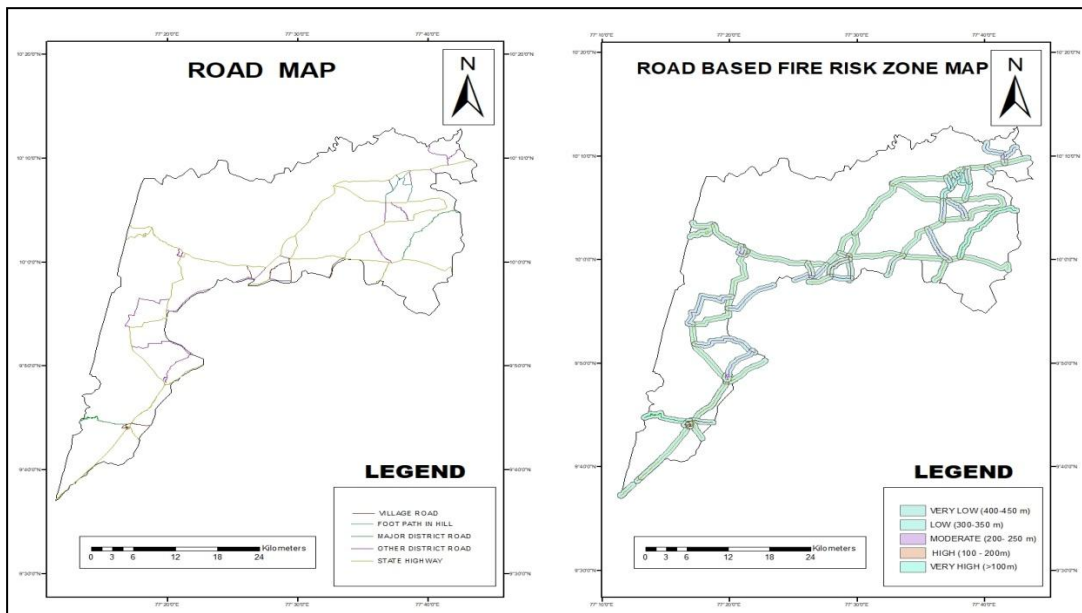


Figure 13 Road map

Figure 14 Road based risk map

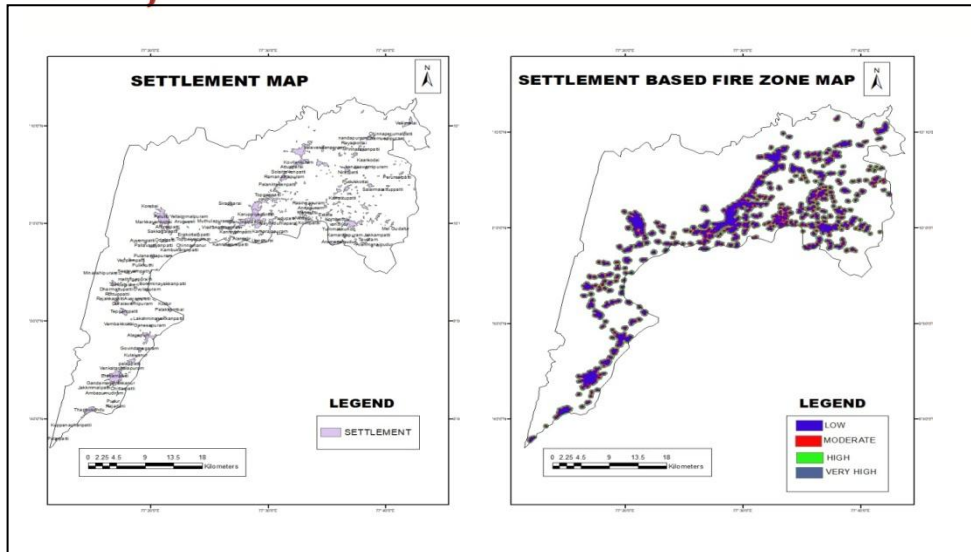


Figure 15 Settlement map

Figure 16 Settlement based risk map

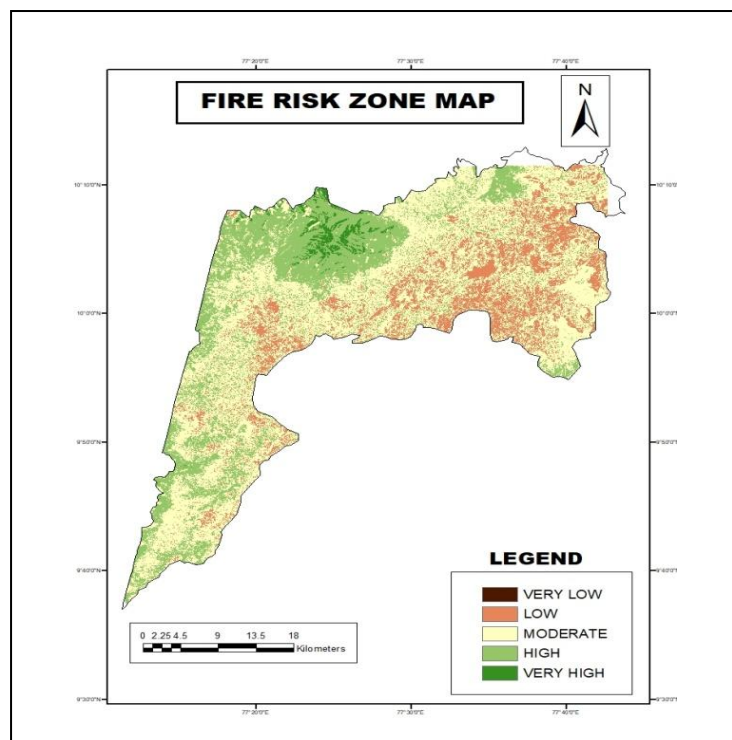


Figure 17 Fire risk zone map

to produce the fire risk zone map .The forest fire risk zone map contains the details about the very high risk places and very low risk places. It is identified that 5.801% of area is under high risk, 18.95% of area is under high risk, 38.46% of area is under moderate risk, 5.95% of area is under low risk and 16.95% of area is under very low risk.

## **VI.CONCLUSION**

The parameters that contribute to forest fire like elevation, slope, aspect, distance from roads and settlements, NDVI and NDWI map have been prepared. The maps are overlaid to obtain the fire risk zone map. The results indicate that the Agamalai, Suranganar, Thambirankanal and Thevaram areas are in high fire risk zone, Jamalmedu, Vannan karadu ,Andipatty north and Andipatty south areas are in moderate fire risk zones and Salamalai karadu ,Perumal koil karadu, Valakaradu and Mottaimalai karadu areas are in low fire risk zones. 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. The result of this study will be useful for future research on forest fire management.

## **VII. ACKNOWLEDGEMENTS**

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