



AOMSUC-15 FYSUC-2025

FIFTEENTH ASIA-OCEANIA METEOROLOGICAL SATELLITE USERS' CONFERENCE
THE JOINT 2025 FENGYUN SATELLITE USER CONFERENCE

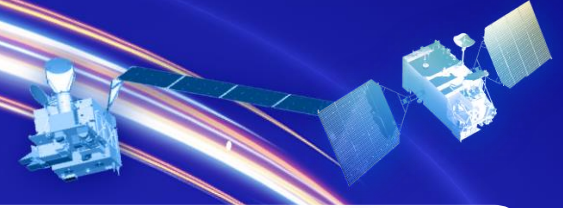
THE ASSESSMENT OF THE SEVERITY OF FOREST FIRES IN THE KINGDOM OF ESWATINI

By Zakhele Khumalo



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- The Kingdom of Eswatini is mostly prone to forest fires during the winter season especially from May to September, one of the incidents in July 2007 was forest fires and wild fall fires that covered part of South Africa and Eswatini.
- This situation made the Government of Eswatini to declared forest fires a national disaster in August 2008 (Dlamini.,2007).
- Normally, in Eswatini El Nino Southern Oscillation warm phase occurs from April to September which is normally in winter'
- ENSO increases dry weather conditions over the region causing forest fires to spread over a wide area due to less rainfall and low relative humidity during the season, and also with strong winds.

• **Problem of the statement**

- Weather is a key contributor to the severity of forest fires phenomenon.
- The Southern African continent including Eswatini experiences, dry weather conditions such as low relative humidity and less rainfall with high winds, which are common states of the atmosphere hence causing the supporting environment for the fire outspread
- Forest fires drastically crippled Eswatini's economy, from forestry, sugar industry and tourism as our major economy relies on Agriculture.

• Justification

- Justification of the study Eswatini depends on subsistence and commercial agriculture to sustain its economy. This is maintained through forest plantation, and sugar cane plantation both at micro and macro scale. The knowledge of fire management, at the community level, seems to be a huge problem in Eswatini. The country has had a drastic increase in forest fire cases for the past twenty years, assessing the severity of forest fires will be the best method to improve the early warning system and education on forest fires. Studying the past experiences between climate and forest fire patterns in the country is important for the Eswatini forest plantation. This includes determining the temporal and spatial variation of temperature, wind, relative humidity, and rainfall towards forest fires.

▶ Objectives

- a) To determine the temporal and spatial variation of some climatic parameters, Natural Difference Vegetation Indices, Leaf area index and forest fires over the western part of Eswatini.
- b) To establish the relationship between climatic parameters with forest fires and Nesterov Index.
- c) To assess the risk of fire incidents using the Fire danger index and Nesterov index over the western part of Eswatini.

▶ DATA AND METHODOLOGY

- **Estimation of missing data**

- There are several ways of estimating missing data. In this study, it was done with the help of Microsoft Excel software. All missing data were identified and filled in using a moving average method.

- **Test for data homogeneity**

- This was very useful in detecting discontinuity in the data that may have occurred in method time, methods of observation, change of site of the instrument and change of storage medium. In this study, a single mass curve was used to test the homogeneity of the data

- **Single and double mass curve**

- A single mass curve was developed by accumulating rainfall, dry bulb and wet bulb temperature, Maximum temperature and fire spot data, back in time and plotted on the graph. A change in slope may represent inconsistency; to correct inconsistency you get the ratio of two slopes and adjust accordingly.

- **Time series Analysis**

- A time series is a collection of observed data at equal intervals of a specified time, usually daily, monthly and yearly data. Many time series show or depict characteristic variations and analysis of such variation constitutes time series analysis.



METHODOLOGY

- **Graphical Approach**

- Time series analysis of daily dry and wet bulb analysis to calculate the Nesterov index, and relative Humidity, temperature and rainfall fire spots satellite data was graphically displayed. Streamline analysis of wind data speed and direction in correlation with satellite MODIS data for fire smoke or burned area.

- **Trend analysis**

- For graphical approach trend line analysis is used to examine the daily trend for the month variation trends, daily trends graphical representation.

- **Simple Correlation Analysis**

- Correlation analysis involves the examination of the relationship between two variables by use of scatter diagrams. It also involves computing a correlation coefficient that gives the degree of the relationship whether positive or negative. The Value of R (correlation coefficient) ranges from 1 to -1. If the linearity equation is obtained, the $R=0$ or near zero this means there is almost no relationship between the variables.

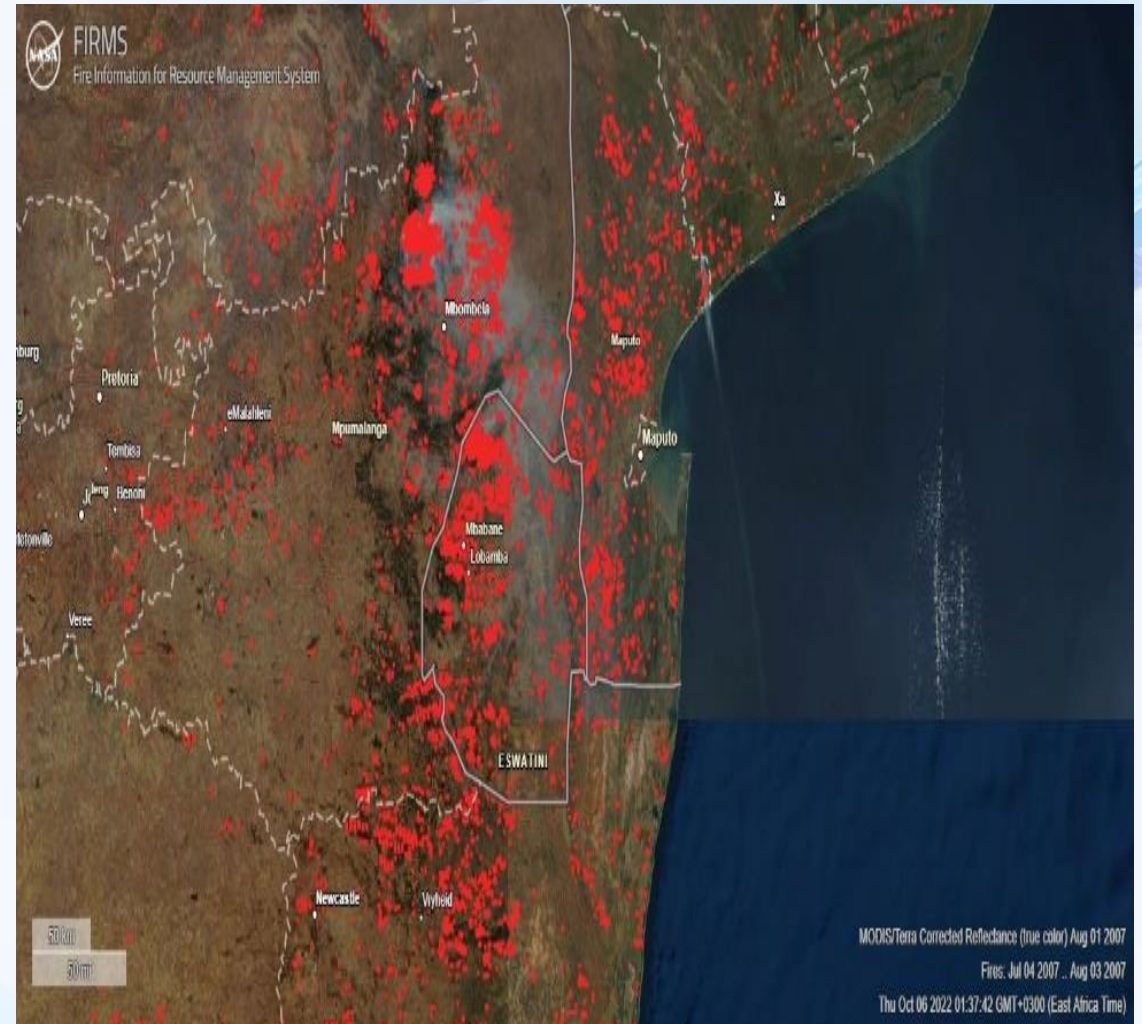
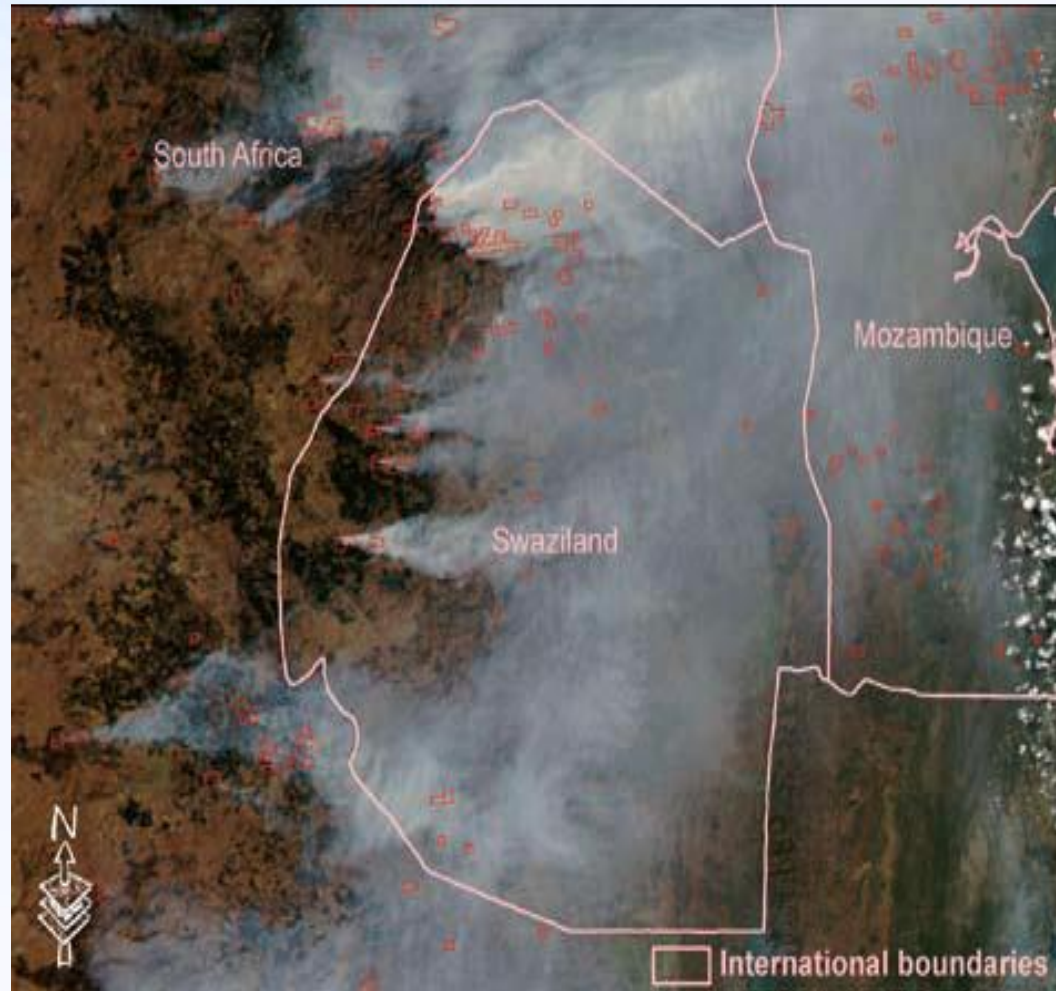
Simple and Multiple Linear Regression Analysis

• The regression objective is to build probabilistic models, for hypothetical testing and constructing confidence intervals on a regression coefficient. The use of the sample data to estimate unknown parameters of the model. This is attainable through Fishers student test distribution the assumption that each parameter has a normal probability density distribution and that k-1 population variance is equal.

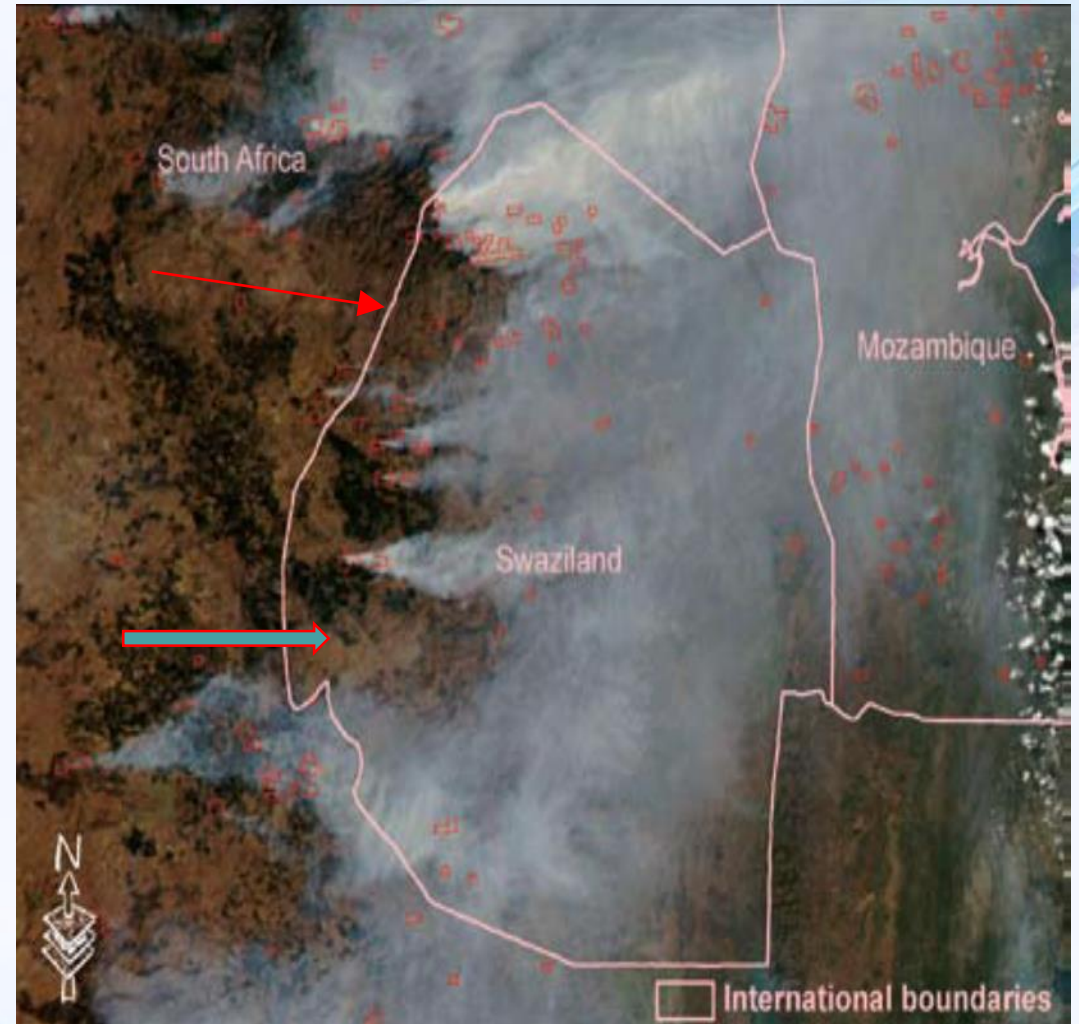
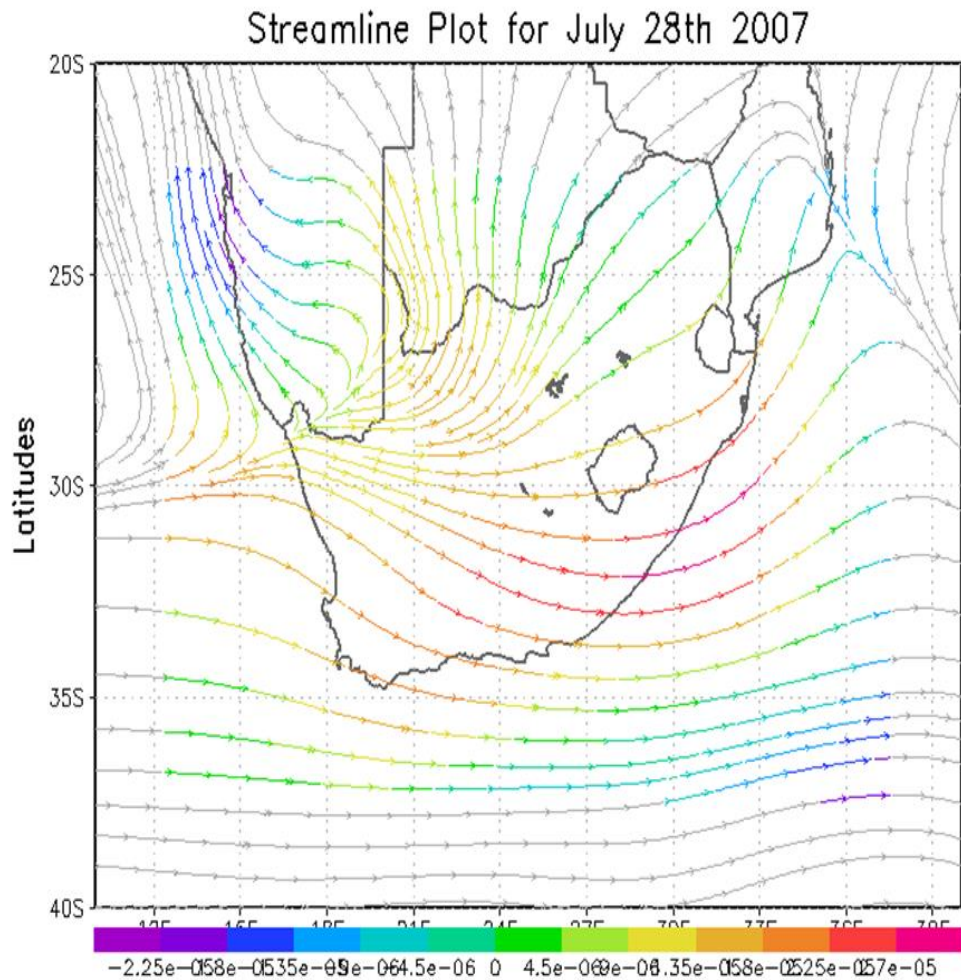
The rejection region is when:

- $F > F_{N-K}^{K-1}(\alpha)$
- F=Fisher test
- k-1=difference
- n-1=difference
- α =rejection region

Burned Area Grid MODIS Data with Fire Spots



▶ STREAMLINES AND FIRE BURNED GRID

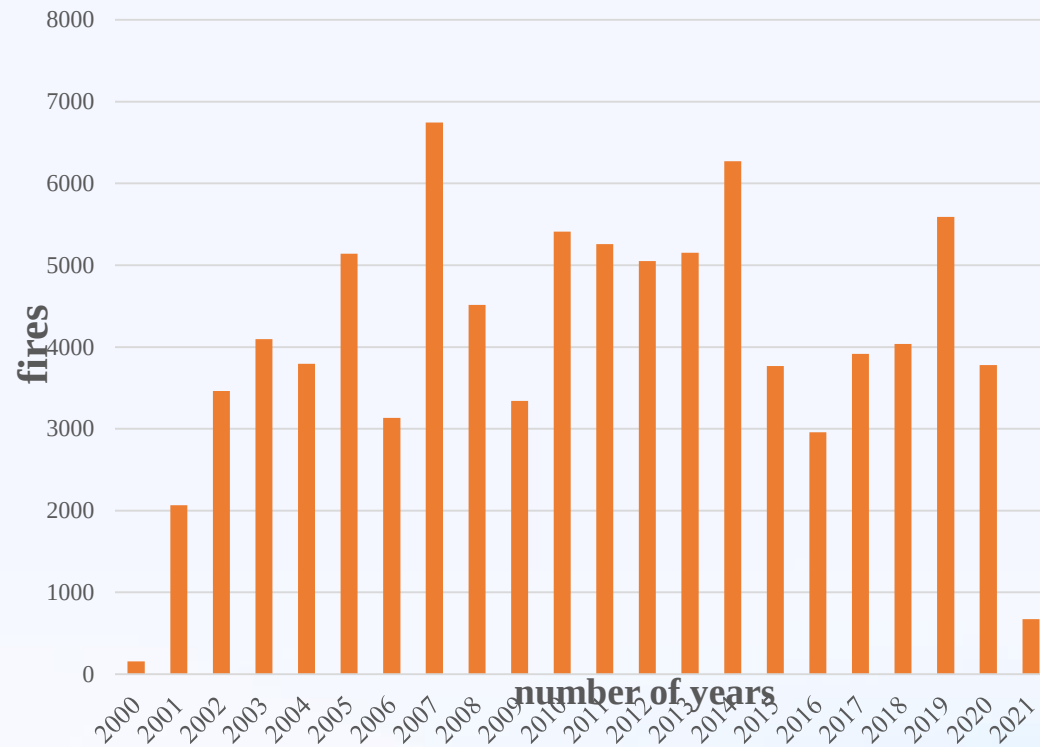




FIRES AND RAINFALL

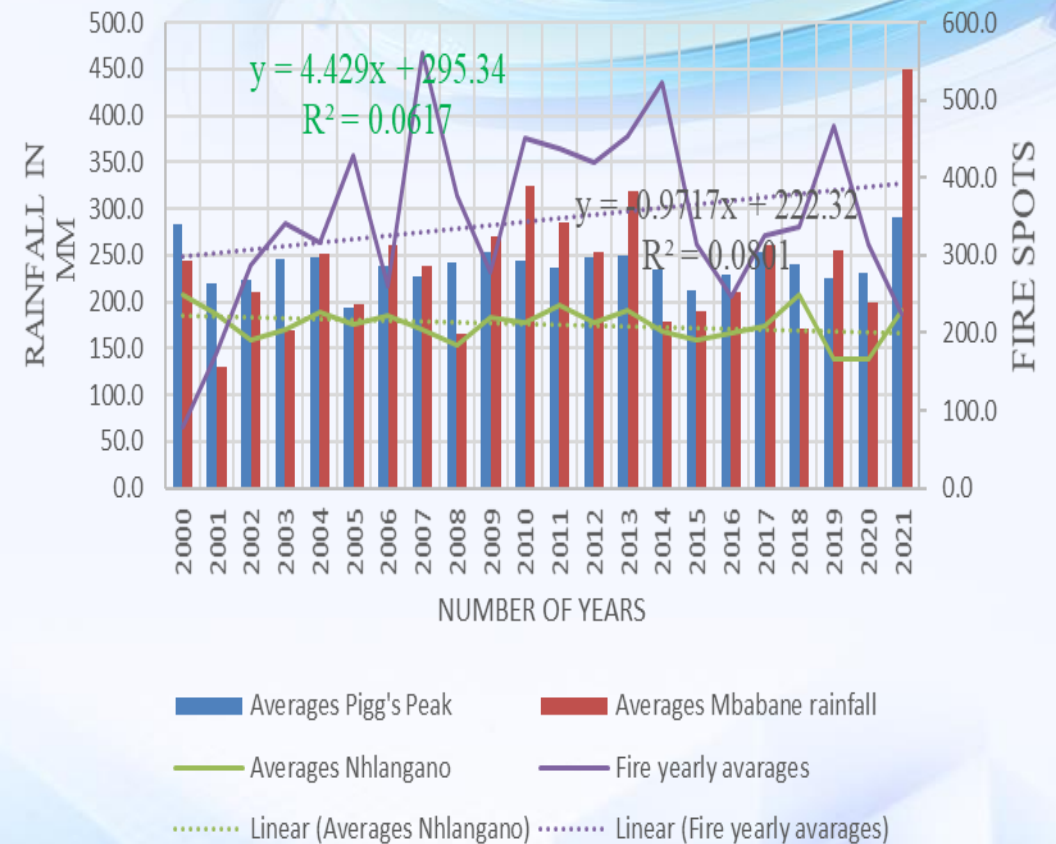
FIRE SPOTS

OBSERVED FIRES IN ESWATINI



RAINFALL VS FIRE

YEARLY AVERAGE FIRE VS RAINFALL AVERAGES FOR MBAB,PP,NHL STATION



▶ CORRELATION ANALYSIS

CORRELATION ANALYSIS

The correlation between fire and rainfall is weak positive 0.245 on average for all the stations however the mean value is 1469.4. the standard deviation was positive 1574 on average and the covariance of 40382.15, while the coefficient of determination is 25.65 which is 260 % perfect. The formula for R is:

$$R(X, Y) = \frac{COV(X, Y)}{SDTDEV(X) * SDTDEV(Y)} \dots \dots \dots \text{equation 6}$$

Where Cov is a statistical measure of correlation fluctuation between the two parameters and a statistical measure of distance a quality is likely to lie from its average value.

REGRESSION ANALYSIS AND HYPOTHESIS TEST

- A Simple Regression model was developed for each station as indicated above and against fire data. Multiple regression was tested using the Fisher Test giving an average of tabulated 10.0 in Table 4 below and F computed 8.0, the significance of positive 1 type one error, for the null hypothesis.
- $H_0 = \mu_1 = \mu_2$ (There is no relationship between rainfall parameters and fire)
- F tabulated > F computed
- Therefore, we accept H_0 , that there is no relationship between the climatic parameter there for we accept the null hypothesis.

FIRE DANGER INDEX TABLE

Days	DB	DP	Wind Speed (knots)	RH	FDI	Interpretation	Nesterov Index	Interpretation
25	17.8	2.3	0.8	35	37	Very High	8560	High
26	11.4	11.1	16	97.7	36	Very High	99	Very Low
27	13.8	-4.1	9.8	28.4	51	Severe	7663	High
28	15.3	3.8	6.4	45.7	40	Very High	5478	High
29	13.5	5.9	1	59.6	28	High	3181	Medium
30	10.8	8.4	4.4	85	17	High	787	Low
31	16.2	-7.6	10.6	18.6	56	Severe	11934	Extreme



Conclusion:

- MODIS fire smoke satellites and fire spots are good to assess and monitor forest fire risk, while wind vector and magnitude, plus streamlines analysis can help monitor the fire trajectory or path. NDVI and leaf area index are best for vegetation monitoring. Time series analysis for temperature and fire shows direct proportionality but is inversely proportional to rainfall. Relative humidity, and wind daily time series analysis with Nesterov in the determination of temporal variation. Relative humidity is illustrated to be a weak correlation therefore Nesterov can be trusted for fire severity assessment. Correlation analysis and Multiple Regression Fisher test indicated that there is no relationship between climatic parameters and forest fire or the Nesterov index therefore we accept the null hypothesis and reject the alternative hypothesis. The Nesterov index and FDI forest fire risk are good tools for fire risk assessment.



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The end

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