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Microclimate Characteristics and Trends: An Investigation on Land Slides and Floods in Kerala

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Abstract:- The paper discuss long-term trends in temperature, rainfall, and wind speed from 2018 to 2024 using Automatic Weather Station (AWS) data from Nilambur region. A special study is made on the climate changes during floods and land slides recently happened in kerala state especially Kavalappara and Chooralmala, which are in an air distance of 30-35 km from Nilambur. The study basically relied on the parameters temperature, rainfall and wind speed. To analyze the data we used different approaches. First one was Trend Analysis to identify increasing and decreasing trends in each parameter. Second way of analysis approach was Seasonal Variation Analysis in which detected fluctuations in different seasons. Another one is Correlation Studies in which checked inter-dependencies between temperature, rainfall, and wind speed. The last one is Extreme Event Identification through which intensely studied outliers or anomalies indicating unusual climatic activity. Key roles of climate variables such as temperature, rainfall and wind speed are analyzed and developed a suitable equation to forecast the land slides and floods in kerala.

Keywords: *Microclimate, Automatic Weather Station, land slides, Floods.*

1. Introduction

Landslides, especially in regions with steep terrain and high rainfall, have increasingly become a significant natural hazard, with devastating consequences for both human life and property. Such tragic events was the Kavalappara landslide on August 2019 and Chooralmala landslide on July 2024 [1,2]. This landslide led to the loss of several lives and caused extensive damage to infrastructure. The disaster was exacerbated by heavy rainfall during the monsoon season, a factor strongly influenced by local micro-climatic conditions [3,4]. Understanding the microclimate of these regions is crucial for assessing the potential for similar events in the future and for developing strategies to mitigate their impact.

Microclimate refers to the localized atmospheric conditions that differ from the surrounding regional climate [5]. It plays a significant role in weather variations, agricultural productivity, and environmental stability. With increasing concerns about climate change and extreme weather conditions, the study of microclimate has gained significance. The variables temperature, rainfall and wind speed has significant key role in the total weather condition of a region [6]. Traditional weather stations measure broad regional climate conditions, but they often fail to capture the fine-scale variations that can occur over smaller areas. With the advent of Automatic Weather Stations, however, it is now possible to monitor microclimate conditions more precisely and continuously. These stations, equipped with sensors to measure variables such as temperature, humidity, wind speed, wind direction, and rainfall, offer real-time data that can provide deeper insights into local climate variations [6].

This study investigates microclimate characteristics and trends using Automatic Weather Station data collected from an AcuRite Iris (5-in-1) Weather Sensor installed at Amal College of Advanced Studies (Autonomous), Nilambur. The dataset spans from 2018 to 2024 and includes three key meteorological parameters. One is Temperature (°F), second one is Rainfall (mm) and Wind Speed (mph). Through a comprehensive analysis of the data, the study will identify key climatic parameters that define the microclimate of the region, investigate any significant trends over time, and examine the factors contributing to these trends. By understanding these dynamics, the research aims to contribute to the broader scientific understanding of localized climate variations and offer valuable insights for disaster preparedness, urban planning, agricultural practices, and climate adaptation strategies.

2. Procedure for Paper Submission

A. Data Collection

The data used in this study was obtained from an AcuRite Iris (5-in-1) Weather Stations continuously records various meteorological parameters. The key aspects of data collection include the data source which provided by AWS software. The Parameters Considered are Temperature (°F), Rainfall (mm), and Wind Speed (mph). Data collected from 2018 to 2024.

B. Data Processing

To identify microclimate trends, the following steps were followed. First one is Data Cleaning through which removed erroneous or missing values to maintain consistency. The second one is Computing daily Averages in which aggregated data for meaningful trend analysis. The third one is Graphical Representation in which we used line graphs to visualize the parameters - temperature, rain fall, and wind speed. The last one is Comparative analysis in which we made Year-wise comparison of temperature, rainfall, and wind speed.(2018-2024), Seasonal pattern identification, and detection of extreme weather events and anomalies such as Kavalappara land slide and Chooralmala land slide.

C. Analysis Approach

To analysis the data we used different approaches. First one was Trend Analysis which helped to identify increasing and decreasing trends in each parameter. Second way of analysis approach was Seasonal Variation Analysis in which detected fluctuations in different seasons. Another one is Correlation Studies in which checked inter-dependencies between temperature, rainfall, and wind speed. The last one is Extreme Event Identification through which noted any outliers or anomalies indicating unusual climatic activity.

3. Results and Discussions

A. Temperature Analysis

Our analysis reveals a discernible warming trend in average temperatures over the study period, characterized by a gradual increase in annual temperatures [7]. Peak temperatures were consistently observed during the pre-monsoon season (April–May), while the lowest temperatures occurred in the winter months (December–January). Notably, 2023 and 2024 exhibited higher-than-average temperatures, particularly during the summer season, whereas 2020 showed a brief cooling phase, potentially attributable to weather disturbances or prolonged monsoon activity. This warming trend may be indicative of climate change impacts or urban heat effects, with implications for evaporation rates, rainfall patterns, and humidity levels.

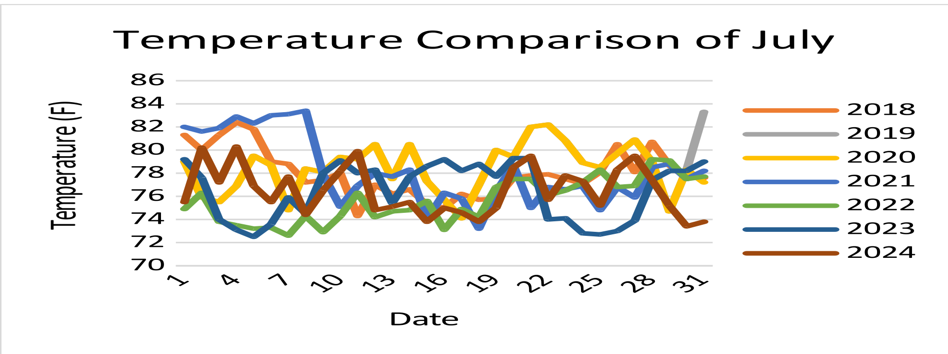

Fig. 1. The temperature comparison of the month July from the year 2018 to 2024.

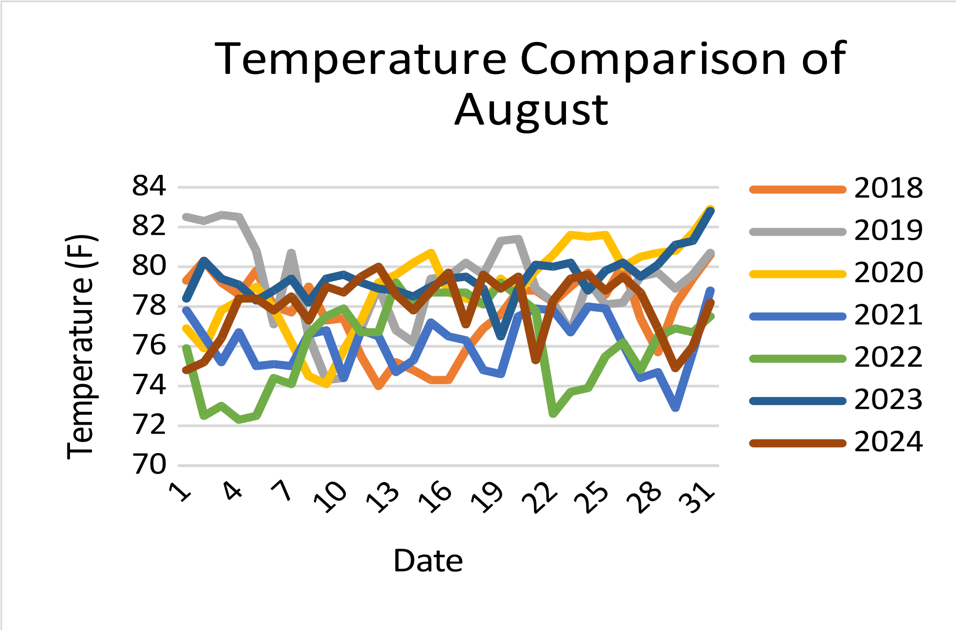

Fig. 2. The temperature comparison of the month August from the year 2018 to 2024.

B. Rainfall Analysis

Rainfall patterns in the region displayed significant inter-annual variability, with some years experiencing above-average rainfall and others facing deficit rainfall. Extreme rainfall events were observed in 2018, 2019 and 2024, coinciding with major landslides or flood events in the region. The majority of annual rainfall occurred during the Southwest Monsoon season (June–September). A slight decline in total annual rainfall was noted in 2022 and 2023, suggesting a possible drying trend. The coincidence of extreme rainfall events with major landslides highlights the role of heavy rainfall in triggering slope failures. The observed decline in rainfall in some years may have implications for water resources and agricultural productivity.

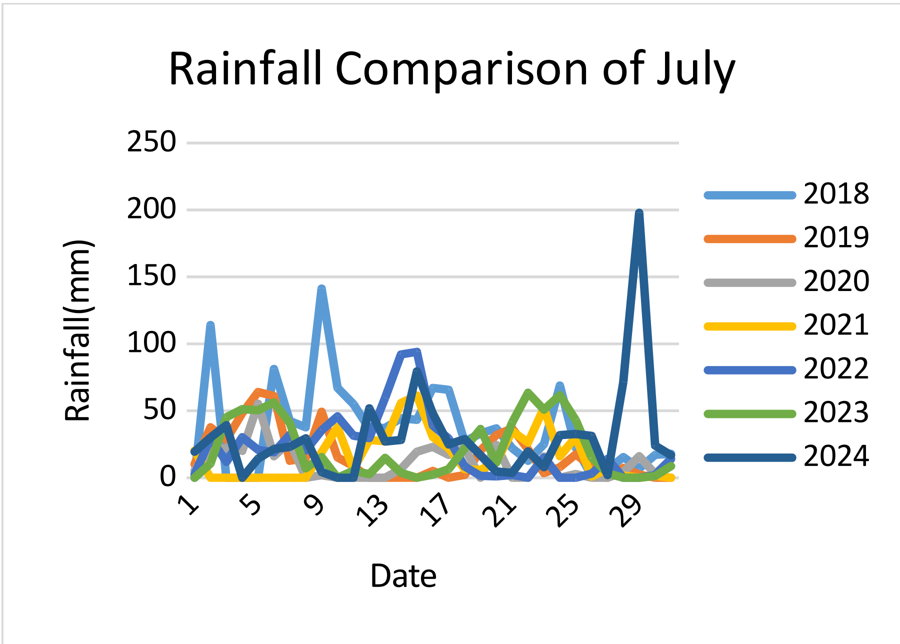

Fig. 3. The rain fall comparison of the month July from the year 2018 to 2024.

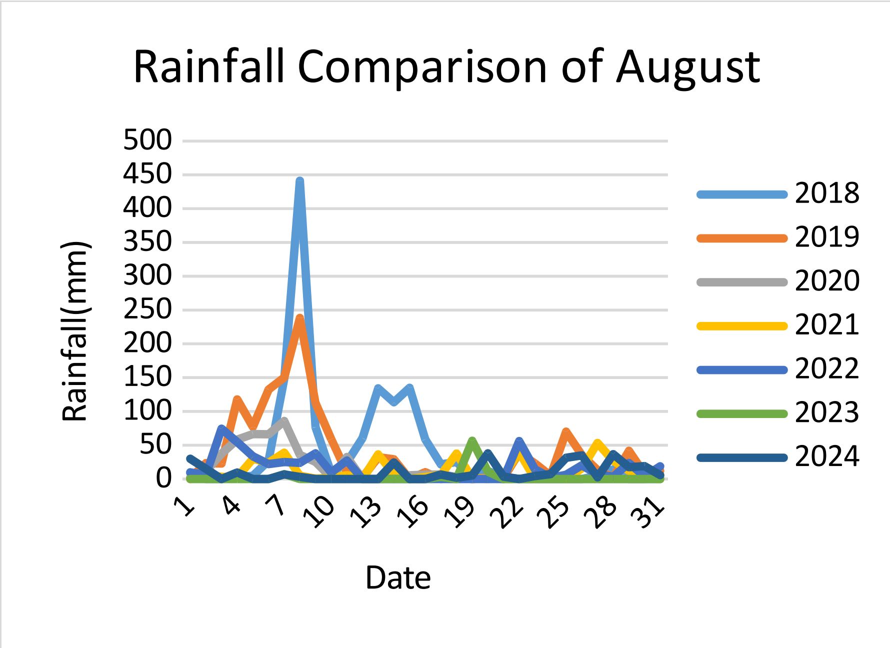

Fig. 4. The rain fall comparison of the month August from the year 2018 to 2024.

C. Wind Speed Analysis

Wind speed analysis revealed higher wind speeds during the monsoon season (June–September) and lower wind speeds during the winter months (December–February). A slight increase in average wind speed was observed from 2021 onwards, potentially due to changing weather dynamics. Stronger winds during the monsoon periods of 2019 and 2024 may have contributed to landslide risks by destabilizing slopes and loosening soil layers and vegetation cover. The observed rise in wind speeds over the years may indicate changes in atmospheric circulation patterns, with potential implications for regional climate and landslide hazards.

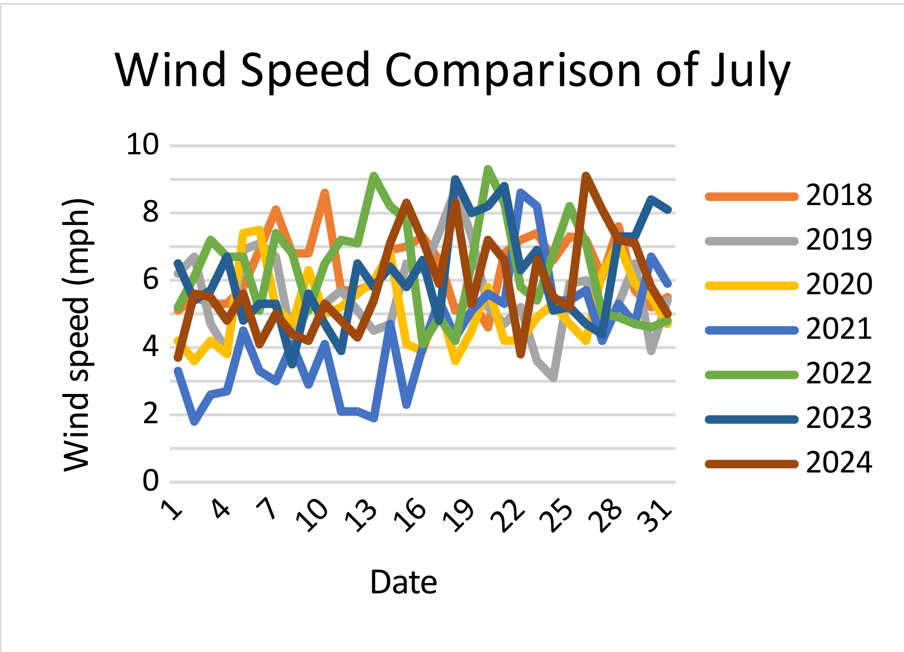

Fig. 5. The wind speed comparison of the month July from the year 2018 to 2024.

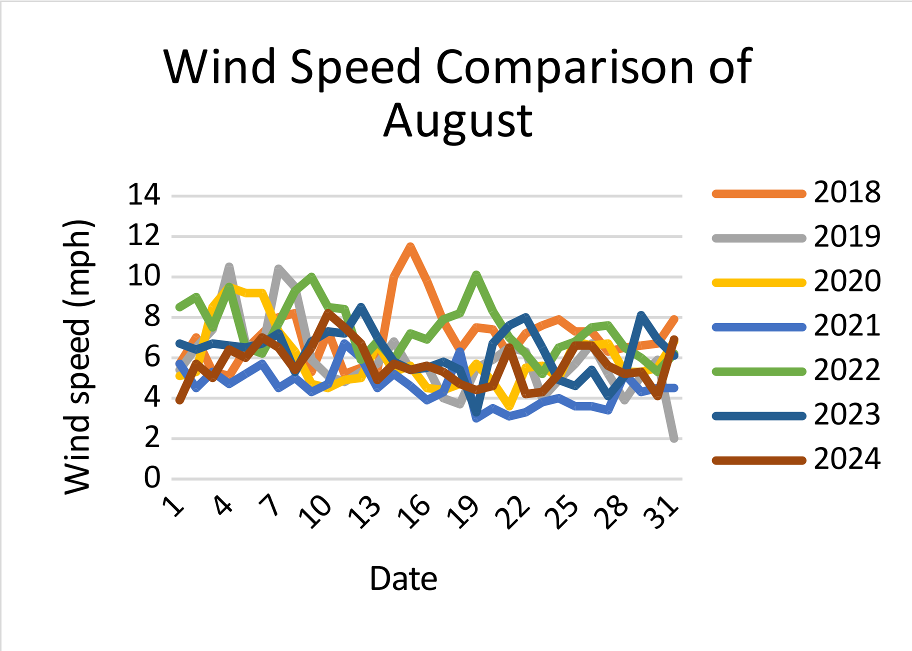

Fig. 6. The wind speed comparison of the month August from the year 2018 to 2024.

D. Landslide Correlation with Weather Patterns

The Kavalappara landslide, which occurred on August 8, 2019, was preceded by anomalously high temperatures during the first week of August, exceeding those of other years as shown in the fig.2. From the fig.3 and fig.4 it is clear that heavy rainfall was observed on August 7-8, although the intensity was lower compared to the rainfall events in 2018. Notably, on analyzing the fig.6 it is found that high wind speeds were recorded in the first week of the August, potentially contributing to the destabilization of the slope.

Similarly, the Chooralmara landslide event on July 30, 2024, followed a period of intense monsoon rainfall[8] from July 28-30 as shown in the fig.3. On analyzing fig.5 it is revealed a high wind activity during the landslide period, while temperature analysis (fig.1) indicated elevated temperatures from July 24-29.

The flood event in Kerala on August 8, 2018, was characterized by exceptionally high rainfall, surpassing all other years as shown in the fig.4. Temperature analysis (fig.2) showed elevated temperatures during the first week of August 2018. The wind speed data indicated an increment during the flood but relatively low wind speed that of 2019 during the same period, which is shown in the fig.6.

A comparative analysis of these events reveals a consistent pattern of increased temperature and co-relative action of the climate variables preceding both landslides and floods. On analyzing the role of parameters like temperature, rain fall and wind speed during the events (flood in August 2018, Kavalappara land slide in August 2019 and Chooralmala land slide in July 2024) it is found that an upraised temperature was found just before the land sliding or flood occur [9]. Furthermore, the Table 1 reveals that the three variables adhere to a consistent relationship during these events [10], wherein the logarithm of their product yields a threshold value, expressed as:

$$\log (T \times R \times W) = N$$

Where, T is the temperature in fahrenheit, R is the rain fall in mm, W is the wind speed in mile per hour and N has a threshold value (which is a constant in a particular region). If the the value of N is greater than or equal to the threshold value (constant) there will be a bigger chance for land slide or flood in the region. Specifically from the Table 1, it is clear that in Kerala the threshold value constant is at $N = 5.28 \pm 0.10$, above which there is a high risk of landslide or flood in the region.

Table 1: logarithm of product of peak points of the variables temperature (T), rainfall (R) and wind speed (W).

Year	Month	log (T x R x W)
2018	July	3.95
2018	August	**5.39**
2019	July	3.75
2019	August	**5.29**
2020	July	3.91
2020	August	4.75
2021	July	2.71
2021	August	4.19
2022	July	2.8
2022	August	4.7
2023	July	2.82
2023	August	2.75
2024	**July**	**5.15**
2024	August	4.34

4. Conclusion

This study investigated long-term trends in climate variables, including temperature, rainfall, and wind speed, in regions proximal to Kavalappara and Chooralmala, two landslide-prone areas in Kerala. A comparative analysis of landslide and flood events in these regions revealed a consistent pattern of increased temperature and correlative action of climate variables preceding these disasters, suggesting a potential linkage between these factors in forecasting such events. Based on this analysis, a predictive equation was formulated to forecast floods and landslides in the region, which may have broader applicability to other regions worldwide. These findings have significant implications for the development of early warning systems and disaster risk reduction strategies, potentially enhancing resilience to climate-related hazards.

Acknowledgment:

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