Spatio – Temporal Analysis of Aerosol Optical Depth (Aod) During Southwest Monsoon Over Kerala Using Qgis

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***Abstract*—The Southwest monsoon plays a crucial role in shaping Kerala's climate, with aerosol optical depth (AOD) being a significant factor influencing health risk factor (lung respiratory disease) and poor air quality. Satellite-derived AOD data from MODIS Aqua and Aeronet station positioned in Kerala were analysed for the period 2014-2023. Our objectives were to investigate AOD patterns and variability during the Southwest Monsoon, analyse the spatial distribution of AOD, identify potential sources of aerosols, and evaluate trend variations during the study period. The results reveal significant spatial and temporal variations in AOD across Kerala, with high AOD values observed during the monsoon months. The study also identifies areas with high AOD hotspots (Kannur, Kasaragod, Kozhikode) and potential aerosol sources. It was observed from the study that; the aerosol deposition is found to be very high during the month of June since the starting of the decade for all districts of Kerala. It deposition rate is identified to be drastically shifted to the month of July towards the mid of the decade and again it attains the high level of AOD deposition over june month at the end of the decade. This study also revealed that the major source of AOD is due to the high deposition of sea salt in the coastal regions of Kerala which has made the AOD values to be peaked to 0.7.**

***Index Terms*—Southwest monsoon, MODIS Aqua, Spatio-temporal AOD patterns, high AOD hotspots, AOD Kerala.**

1. INTRODUCTION

Aerosols, tiny solid and liquid particles suspended in the atmosphere, originate from various sources, including windblown dust, sea salts, volcanic ash, wildfire smoke, and industrial pollution. Their impact on the Earth's climate is complex, as they can both cool and warm the surface, influence cloud formation, and affect air quality and human health [1]. Aerosols can both cool and warm the surface, influence cloud formation, and affect air quality and human health. The Southwest Monsoon period in India is characterized by high levels of aerosol optical depth (AOD), making it an ideal time to study aerosol properties and their impacts. During this period, aerosols can influence cloud formation [2], precipitation patterns [3], and atmospheric circulation, which in turn can affect air quality and human health. The interplay between aerosols and monsoon dynamics is a critical area of research [4]. Kerala, with its unique geography, high population density, and significant economic activities, is vulnerable to aerosol-related health risks. The state's geography, influenced by the Western Ghats Mountain range, can also influence aerosol transport and deposition [5]. Kerala has a high population density, making it an ideal location to study the impacts of aerosols on human health and air quality. Kerala is an economically significant state, with major industries such as agriculture, tourism, and IT. Kerala has a well-established network of weather stations, air quality monitoring stations, and research institutions, providing access to reliable data for this study. Studies have shown that aerosol loading can exacerbate respiratory problems, particularly in densely populated regions [6]. Existing studies on AOD over Kerala are limited, with significant knowledge gaps. Previous research has explored AOD in other parts of India [7-9], but region-specific studies like this one are crucial. This study aims to address the knowledge gaps regarding AOD during the Southwest Monsoon in Kerala by analyzing spatio-temporal AOD patterns, identifying aerosol sources, and evaluating trends over a decade. The study will also contribute to a better

understanding of the relationship between AOD and the unique meteorological conditions of the Southwest Monsoon in Kerala [10].

2. METHODOLOGY

A. Data Collection

The study utilized satellite-derived AOD data from MODIS Aqua and ground-based data from AERONET stations in Kerala. MODIS Aqua data was obtained from the Giovanni website. https://giovanni.gsfc.nasa.gov/giovanni/

The following parameters were used:

1	Measurements	Aerosol Optical Depth
2	Platform/instruments	MODIS AQUA
3	Spatial resolution	1^0
4	Temporal resolution	Monthly
5	Wavelength	550

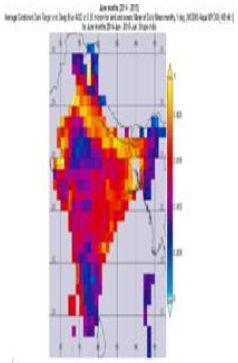

Fig 1. June month Giovanni data

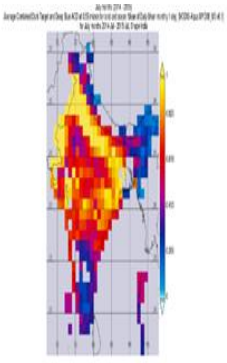

Fig 2 July month Giovanni data

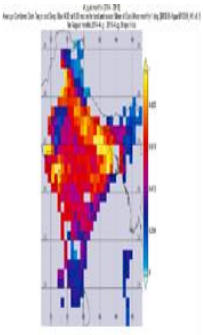

Fig 3. August month Giovanni data

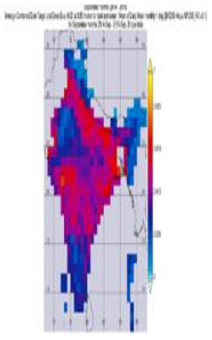

Fig 4 September Giovanni data

B. Spatial Analysis

Spatial analysis of AOD data was conducted using QGIS (version) for the period 2014-2023 to investigate the spatial distribution of AOD across Kerala.

3. RESULT AND DISCUSSION

A. Spatio – temporal AOD patterns

The spatial analysis revealed significant spatial and temporal variations in AOD across Kerala. High AOD values were observed during the monsoon months. The spatial variations are more evident and dominant when compared to temporal variations of the annual means during the 5-year period [11]. Annual mean variations in AODs in different regions do not show any significant increasing or decreasing trend as the mean AODs are found to lie within ±1s of each year during the 5-year period [11]. AODs are higher in the north and the east. High population density locations result in large aerosol sources due to fossil fuel consumption and biofuels used for cooking purposes which likely contribute in a significant way to higher AOD levels throughout the year [12]. The highest AOD deposition was observed in 2018. This could be attributed to specific meteorological events or increased anthropogenic activities during that year. During the pandemic, the AOD deposition was low from 2019 to 2020. Lockdown measures and reduced industrial activity likely contributed to this decline. After COVID-19, the aerosol deposition slightly increased, indicating a resurgence of economic activities and associated emissions. Long-term trends of AOD in the Indian subcontinent have been studied by several researchers, providing a broader context for our findings.

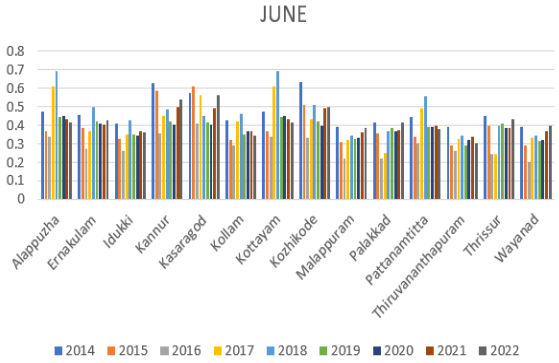

fig 2. June month analysis

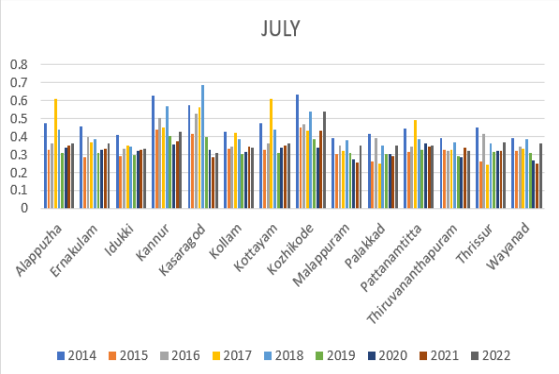

Fig 3. July month analysis

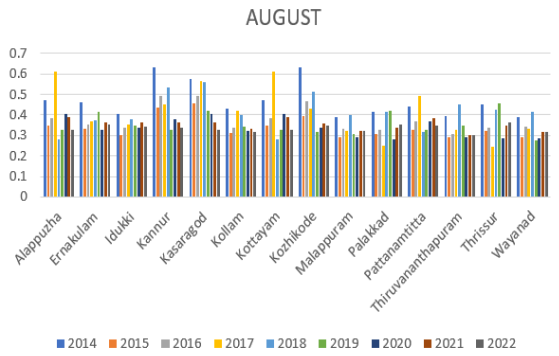

Fig 4. August month analysis

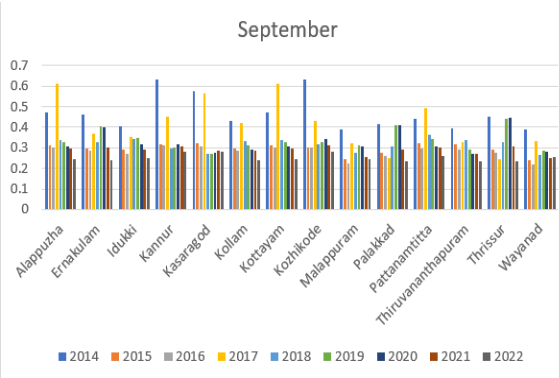

Fig 5. September month analysis

B. High AOD Hotspots

Kasaragod, Kannur, and Kozhikode districts exhibited high AOD levels, indicating significant aerosol loading and poor air quality. Kottayam also recorded high AOD in certain years. These coastal areas experience high AOD due to marine aerosol deposition. High AOD levels are recorded at coastal areas like Kasaragod, Kannur, Kozhikode due to marine aerosol deposition. Low AOD levels are recorded at hilly areas like Wayanad, Palakkad. The Western Ghats play a crucial role in orographic lifting and cloud formation, which can influence AOD distribution.

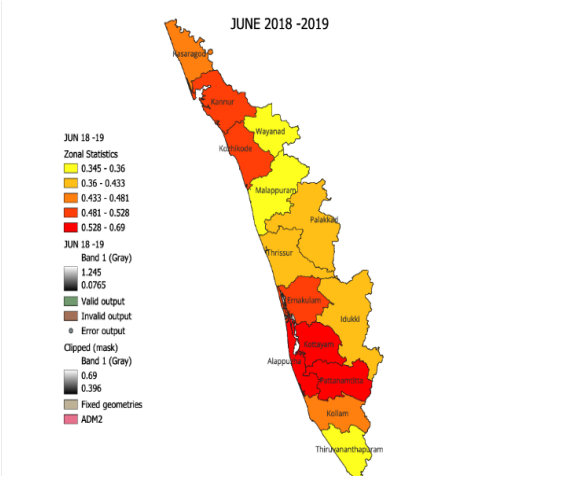

Fig 6.2018 June month AOD data

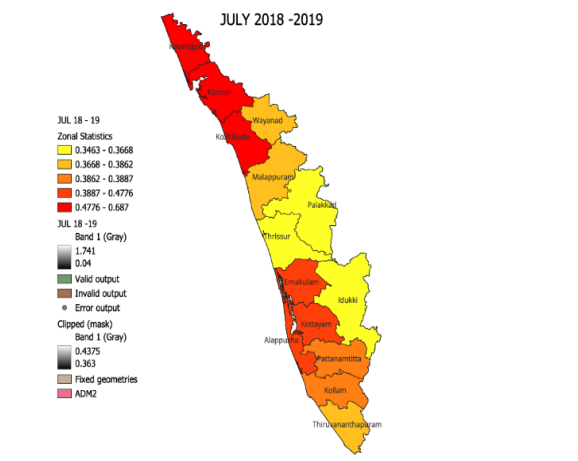

Fig 7. 2018 July month AOD data

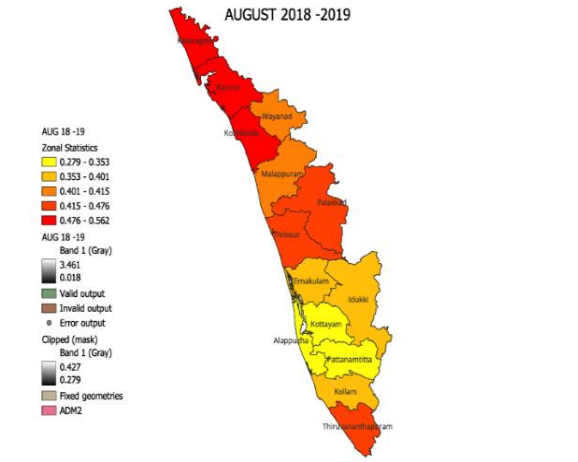

Fig 8.2018 August month AOD data

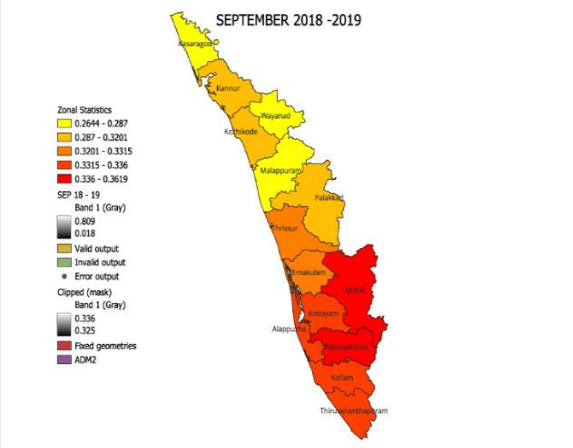

Fig 9. 2018 September month AOD data

C. Aerosol Sources

Potential sources contributing to high AOD levels include industrial activities, agricultural burning, vehicle emissions, dust from construction activities, and proximity to the Arabian Sea, leading to an influx of sea salt aerosols. The study also revealed that high sea salt deposition results in high AOD values. Sea salt aerosols are predominant in coastal areas, especially during the monsoon season, due to strong winds and ocean activities. Studies have also highlighted the contribution of long-range transport of aerosols from other regions to the overall AOD over India.

D. Trend Variations

Over the decade (2014-2023), the peak aerosol deposition shifted from June to July to June. This shift could be related to changes in monsoon onset, rainfall patterns, or agricultural practices over the years. As per trend analysis for this decade, the highest AOD deposition is observed in 2018.

Fig 9. Trend analysis

4. CONCLUSION

The study shows significant spatio-temporal variations in AOD across Kerala during the Southwest Monsoon. High AOD hotspots were identified in Kasaragod, Kannur, and Kozhikode districts. The peak aerosol deposition is maintained throughout June. The reason behind the observation of high AOD level in the month of July during Mid of the decade is because of the formation of the Asian Tropopause Aerosol Layer (ATAL) which forms during June-July-August, resulting in enhanced high aerosol concentrations [22]. High AOD levels in coastal regions are attributed to marine aerosol deposition. These findings underscore the need for targeted mitigation strategies to improve air quality and reduce health risks in Kerala. Further research could investigate the specific chemical composition of aerosols and their impact on human health in this region.

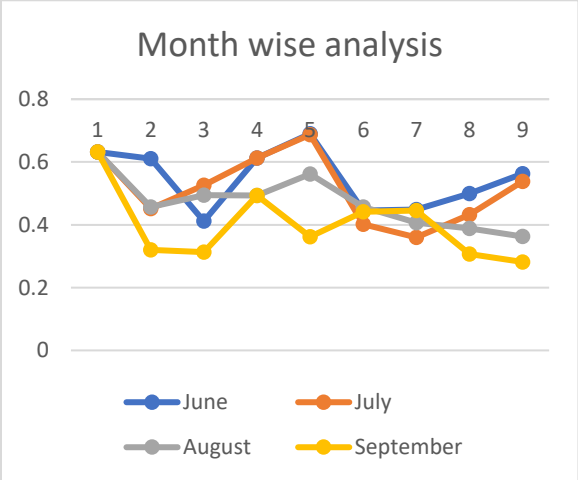

Fig 10. Month wise analysis

YEAR	HIGHEST AOD	DISTRICT
2014	0.45	Kasaragod
2015	0.46	Kasaragod
2016	0.55	Kasaragod
2017	0.69	Kottayam
2018	0.7	Kasaragod
2019	0.46	Thrissur
2020	0.45	Kottayam
2021	0.5	Kannur
2022	0.58	Kasaragod

Table 1. Highest AOD districts

YEAR	LOWEST AOD	DISTRICT
2014	0.23	Wayanad
2015	0.24	Wayanad
2016	0.2	Wayanad
2017	0.24	Thrissur
2018	0.25	Thrissur
2019	0.29	Wayanad
2020	0.26	Wayanad
2021	0.28	Wayanad
2022	0.22	Palakkad

Table 2. Lowest AOD districts

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