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Assessing Climate Change Impacts on Land Conversion and Land Degradation in the Attappady Region of Western Ghat

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Abstract

The Western Ghats region in India, including the Attappady region in Kerala, is facing significant land degradation, which is exacerbated by factors such as deforestation, habitat loss, and erosion due to heavy monsoon rains. This degradation has led to an increased risk of landslides and loss of biodiversity, impacting the sustainable development of the area. The expansion of infrastructure, plantations, and unregulated tourism has contributed to this degradation, leading to the loss of forest cover and the spread of invasive species. Addressing these challenges requires a multi-faceted approach that includes reforestation, sustainable land use practices, and the regulation of tourism and infrastructure development to ensure the conservation of this critical ecosystem. Attappady taluk differs from the rest of the humid tropical area in the Kerala State primarily due to its unique rainfall characteristics and geographical location. The entire Attappady area has been divided into two categories; wet zone (40 percent) and dry region (60 percent). The dry region is situated on the eastern part of the taluk. The average annual rainfall in the Western region is 2500 mm, while the Eastern region receives less than 600 mm per year. The dryness in the eastern section has been attributed to the rain shadow effect of the mountains. The vegetation and land use has been completely differed from the windward side. The objective of the present study is to identify the land degradation and its impact on the Attappady, analyze the changes that Attappady's landscape has experienced over this period, and investigate the impacts of climate change. To achieve these objectives, data from the Indian Meteorological Department, the International Crops Research Institute for the Semi-Arid Tropics, SOI toposheet (1:50K), Sentinel-2 data, and Landsat Imagery were utilized. Remote Sensing and GIS techniques have been employed to analyze land use and land cover changes and land degradation using geo spatial technology These analyses help in identifying areas of land degradation, potential hotspots for disasters, and changes in land use over time. This evaluation assists in understanding where improvements are needed in the region and how to bring sustainable development.

Key Words: ***Land Degradation, Climate Change,*** **Geospatial technology,** ***Sustainable Development,***

1.Introduction

according to the data from the Attappady block panchayat in 1951, 90.26% of the population in the region were tribal people. In 2011, the tribal population here was reduced to 44% while the immigrant population became 56%, turning the tribal communities into a minority. Currently, there are 192 tribal hamlets in Attappady, consisting of Irular, Mudukar and Kurumbar tribes. "At one point, the whole of Attappady was just tribal land. Haseena (2020) reveals that generations ago, the Adivasis in Attappadi region were the original inhabitants, cultivating and consuming a diverse range of foods including 69 types of grains, 60 varieties of leafy vegetables, forest fruits, honey from different bees, and fish from local rivers. This traditional method involved communal labor for land preparation, sowing, crop protection, and harvesting every two years, emphasizing a collective moral economy. They protect agricultural land from wildlife, showing their strong sense of community and connection to nature. Additionally, the tribal community rears cattle not for milk consumption but for the calves, highlighting their deep respect for all living beings. The older generation attests that they did not encounter diseases or infant mortality issues during that time, reflecting a period of sustainable living and health within the community. The forest of Attappady was first disturbed in 1932 through clear felling to make a way for plantations, and wood for railway sleepers and plywood industry. But, the process of deforestation in Attappady became extensive with the influx of non-indigenous settlers from low and mid lands of Kerala, Tamil Nadu between 1951 and 1981. The forest cover in Attappady has declined from 81.51 per cent in 1959 (60729 hectare) to 19.7 per cent (14616 hectare in 1994. This shows a drastic decline of forest coverage in Attappady. Agricultural extensification, largely by settlers, is one of the major reasons for this large-scale deforestation in Attappady region (Manikandan and Mathew K., 2016). In Attappady, tribal land encroachment is a significant issue where non-tribal individuals and companies seize tribal lands without valid reasons. Factors such as timber exploitation, health improvements, and long-term leases with non-tribes have led to an influx of migration to Attappady, resulting in the displacement of indigenous tribes. The encroachment of tribal lands has been underscored of land conversion. The absence of individual property ownership among the adivasis in Attappady has adversely affected their development (Manjusha., Bipin, Jojo., 2022). Reports indicate that various entities, including real estate companies and individuals, have been involved in purchasing tribal lands illegally www.thenewsminute.com(2022). The authorities have historically maintained the Adivasis as a labor force, exacerbating the land question in the region (Moula et al., 2018. The conversion of agricultural land has negative impacts on food and fiber supply and the degradation of natural habitats (Wang, Hao., 2013) and (Elizabeth et al., 2019). However, due to changes in land use patterns and economic pressures, swidden cultivation of millet has been gradually replaced by cash crops like banana, cotton, coconut, and spices, impacting the traditional agricultural practices and landscape composition in the region (Kozhisseri D, 2020). The extensive deforestation and land conversion in Attappady have led to environmental and ecological impacts, such as shrinking water sources and adverse effects on traditional agriculture practiced by the Adivasis www.onmanorama.com (2021). These environmental changes further compound the challenges faced by the Adivasi community in sustaining their livelihoods.

Due to changes in agricultural practices, the significant transition in Adivasi food culture, highlighting the shift from self-sustained, diverse diets to reliance on market-bought staples like rice. This transition, influenced by factors like government policies and environmental regulations, has led to drastic shift in food culture, driven by changes in agricultural practices, has had profound physical and mental impacts on individuals, particularly in tribal communities. The transition away from traditional grains and towards market-bought food items like rice has led to nutritional deficiencies and unhealthy repercussions. Additionally, the reduction in meat consumption due to wildlife protection laws, coupled with the rise in alcohol consumption, reflects complex socio-economic and cultural challenges faced by these communities, impacting their freedom of choice and well-being (Haseena, 2015).

Soil moisture stress is a significant factor in Attappady. It can lead to extreme moisture regimes such as water surplus (flood, water-logging, over-moistening) or water deficiency (drought) Gy., Várallyay. (2009). The effects of water stress on plant growth, yield, and physiological characteristics have been studied in pigeonpea genotypes, with significant differences observed among the genotypes under moisture stress and control conditions (Suraj et al., 2018). Water stress in Attappady is a significant issue that has led to severe land degradation and ecological degradation in the region (Subha et al., 2012). The combination of severe land degradation, poverty, and a tribal population has made Attappady hydrologically and socially unique (Franke et al., 2005).

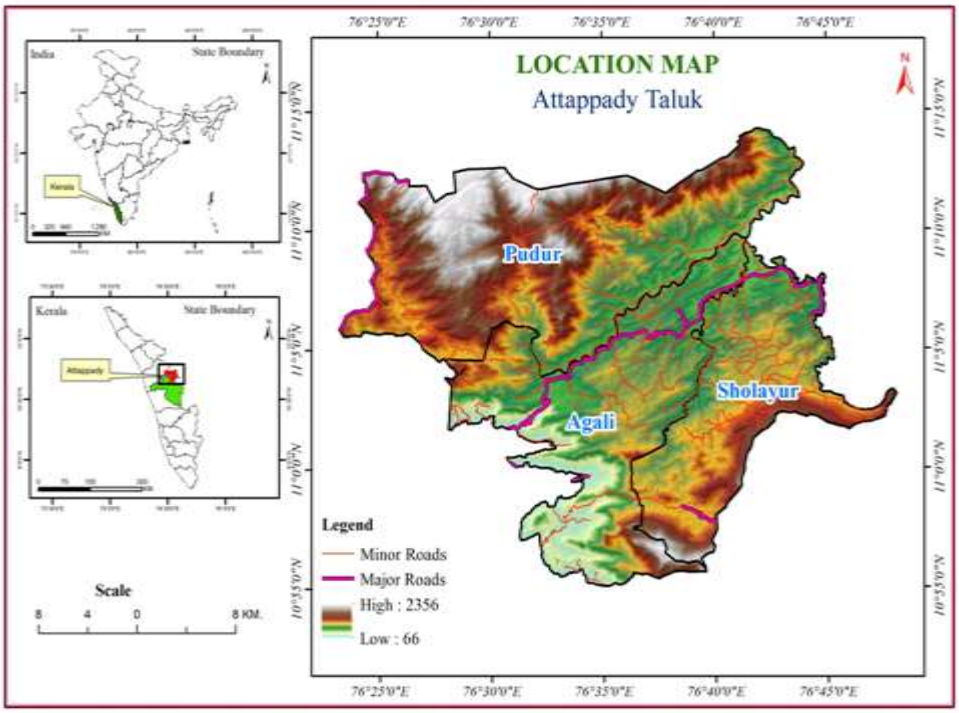
The objective of the present study is to identify the land degradation and its impact on the Attappady, and analyze the changes that Attappady's landscape has experienced over this period, and investigate the impacts of climate change.

2. Materials and Methods

2.1 Study Area

Attappady is the largest tribal taluk, located in the Western Ghats situated in Palakkad district of Kerala. The terrain of Attappady is marked by hills and valleys. The taluk extends from north latitudes 10^0 55' 36.16"N to 11^o 14'13.27''N and east longitudes from $76^0$23'13.96''E and $78^0$48'8.57''E. covers an area of 829.45 Km^2. Attapady taluk consists of seven villages, and three panchayats namely, Agali, Puthur and Sholayur. (Fig: 1).

(Fig: 1). **Location Map of Attappady**



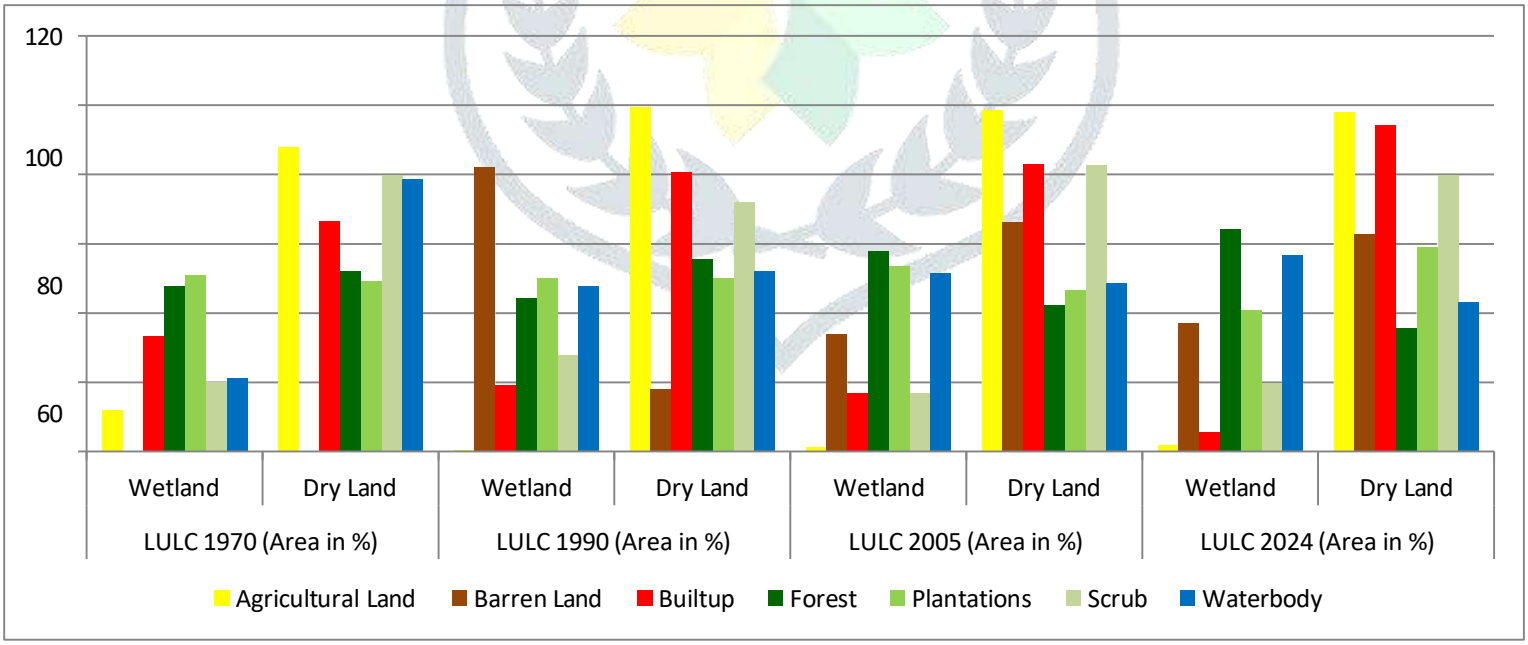
2.2 Data Collection and Analysis

To achieve these objectives, data from the Indian Meteorological Department, the International Crops Research Institute for the Semi-Arid Tropics, SOI toposheet (1:50K), Sentinel-2 data, and Landsat Imagery were utilized. Remote Sensing and GIS techniques have been employed to analyze land use and land cover changes and land degradation using Analytic Hierarchy Process (AHP) Multi-Influencing Factor (MIF) techniques.

3.Result and Discussion

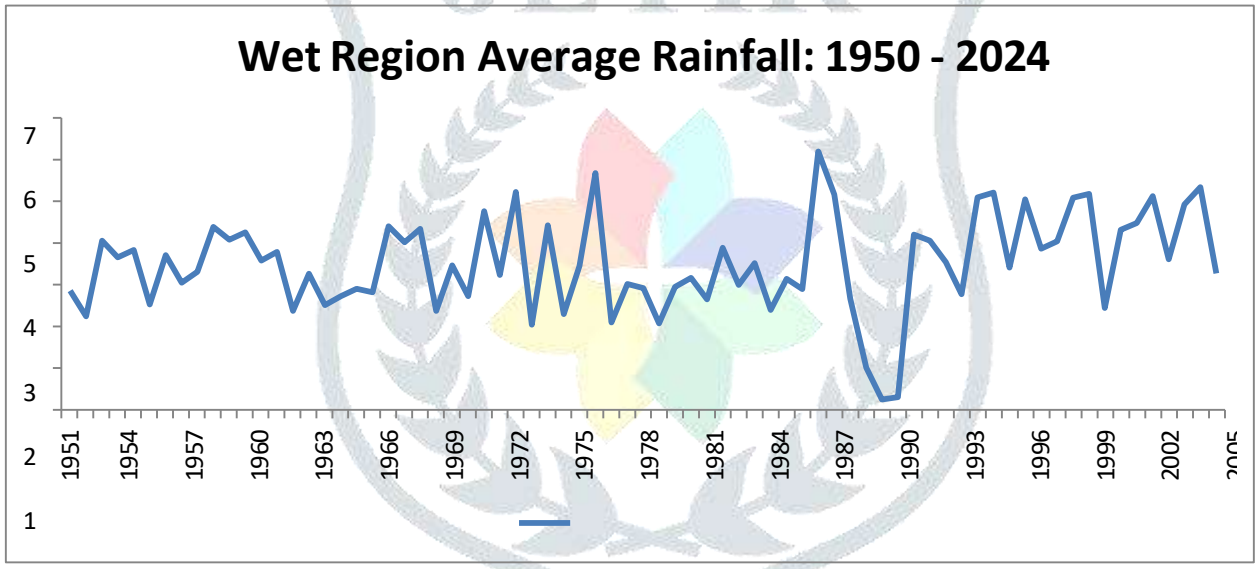
3.1 Comparison of the Land Use and Land Cover Statistics for the Dry and Wet Regions of Attappady Across the Years: 1970 – 2024

Sl.No	LULC Name	LULC 1970 (Area in %)		LULC 1990 (Area in %)		LULC 2005 (Area in %)		LULC 2024 (Area in %)	
		Wetland	Dry Land	Wetland	Dry Land	Wetland	Dry Land	Wetland	Dry Land
1	Agricultural Land	11.93	88.07	0.44	99.56	1.25	98.75	1.88	98.12
2	Barren Land	0.00	0.00	82.01	17.99	33.85	66.15	37.20	62.80
3	Built-up	33.33	66.67	19.18	80.82	16.99	83.01	5.71	94.29
4	Forest	47.93	52.07	44.34	55.66	57.81	42.19	64.27	35.73
5	Plantations	50.86	49.14	50.00	50.00	53.46	46.54	40.88	59.12
6	Scrub	20.01	79.99	27.79	72.21	17.00	83.00	19.91	80.09
7	Waterbody	21.24	78.76	47.89	52.11	51.44	48.56	56.69	43.31

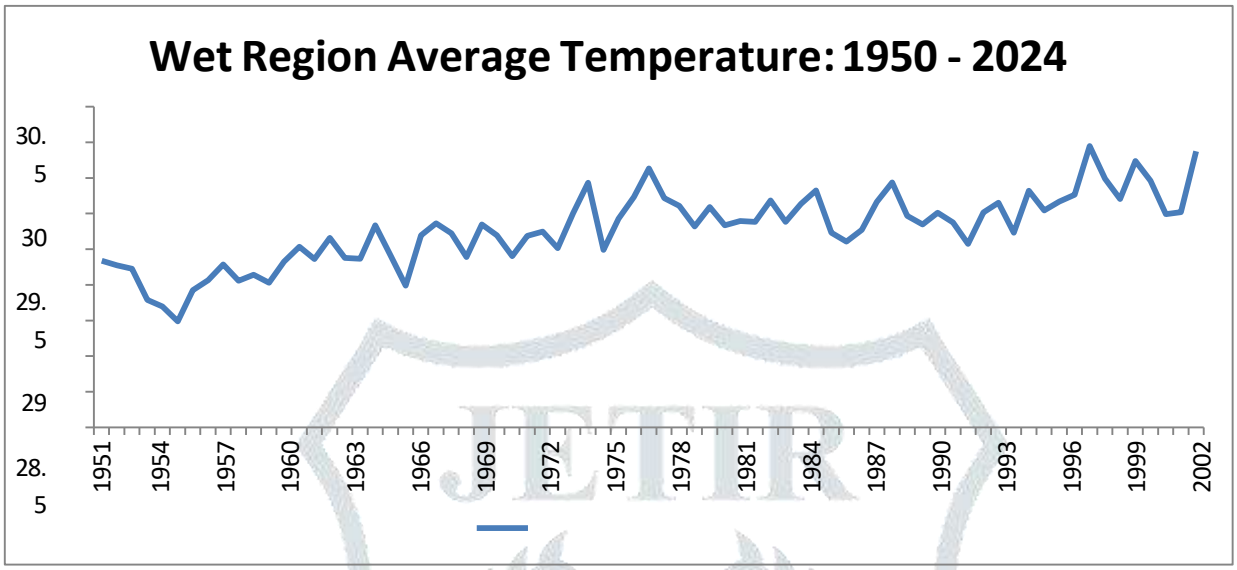


Agricultural land in dry region shows steady decrease over the years where as in wet land region remains high, with slight fluctuations. Barren land in dry region increases over the years, especially noticeable after 1990. In wet region also sees an increase but not as prominent as in the dry region. Built-up area decreasing trend, especially after 1990 in the dry region ad in wet region it shows Increasing steadily, indicating more urbanization in this region. Forest area gradually decreasing from 47% in 1970 to 35% in 2021 in the dry region but in contrast it shows increasing trend in wet region from 48% in 1970 to 64% in 2021. Plantation in the dry region increasing from 49% to 57% over the last five decades where as in wet region shows some fluctuations but remains relatively stable.

3.2 Temperature and Rainfall of Wet Region



From the IMD average annual rainfall data in the Attappady wet region over the period of 1950 to 2024, The rainfall values fluctuate over the years, indicating variability in the region's precipitation patterns. This variability could be influenced by various factors such as climate oscillations, local geography, and atmospheric conditions. By analyzing the data, we can identify any long-term trends in rainfall. For instance, we observe periods of above-average or below- average rainfall, which could be indicative of larger climatic phenomena or human-induced changes. There appear to be some years with notably high or low rainfall compared to the average. These extreme events could have significant impacts on the local ecosystem, agriculture, water resources, and infrastructure. The average annual rainfall in the Attappady Wet Region over the observed period (1950-2023) is approximately 3.634 units.The standard deviation of 1.467 units indicates variability in rainfall from year to year, suggesting that some years may experience significantly higher or lower rainfall than the average.



From the IMD temperature data for Attappady, it is noted that a general increasing trend in the average annual temperature over the last five decades. This is evident from the gradual rise in temperature values over time. While there is a trend of increasing temperatures, there is also noticeable variability from year to year. Some years experience higher temperatures, while others show slight decreases or remain relatively stable. It's important to note any extreme temperature events within the dataset. These could include particularly high or low temperatures compared to the average, as well as any instances of temperature spikes or dips that may have occurred due to specific weather phenomena or climate events.

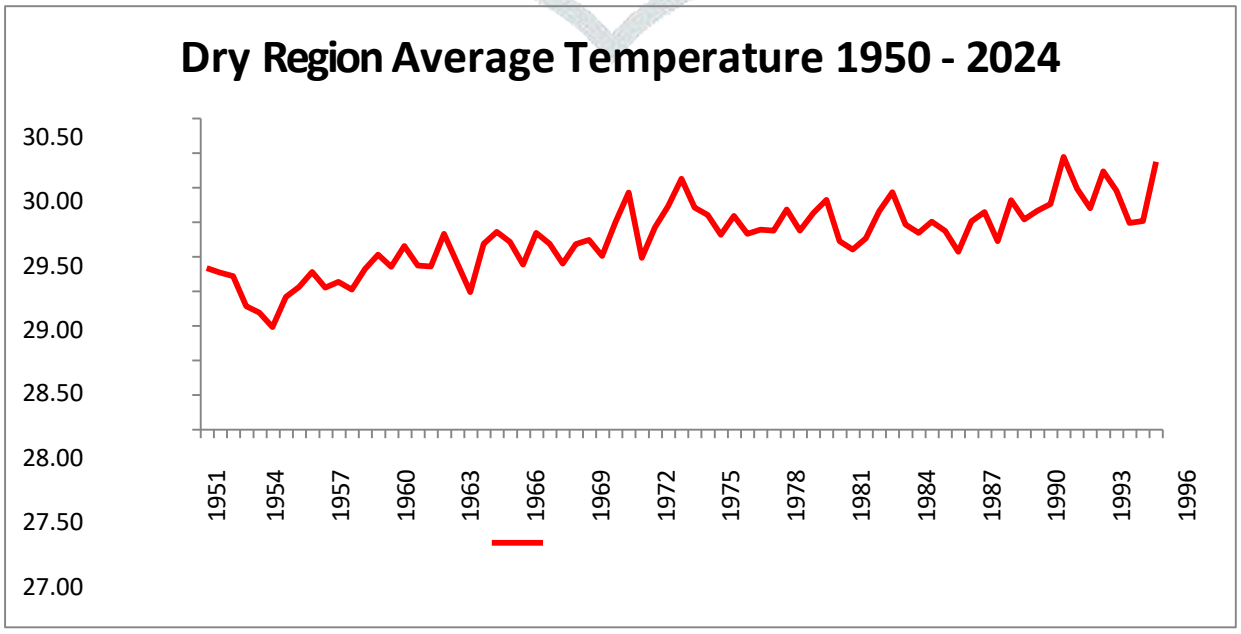
The average annual temperature in the region over the observed period is approximately 28.912 degrees Celsius. The standard deviation of 0.434 degrees Celsius suggests relatively lower variability in temperature compared to rainfall. Analyzing the provided data of average annual temperature for the Attappady Wet region from 1950 to 2023, we can draw several interpretations:

3.3 Temperature and Rainfall of Dry region

The mean rainfall also showing high fluctuation variation. In 2002 rainfall recorded very low in the last seven decades. The findings reveal decreasing rainfall trends and rising temperatures, emphasizing the urgent need for effective adaptation measures to mitigate the direct and indirect impacts on the farming community in the region. The correlation value of -0.55 indicate that the vegetation decreasing paved the way for increasing surface temperature and also over the last three years the green vegetation cover decreasing drastically whereas the land surface temperature has been increasing significantly. The average annual rainfall data for the Attappady dry region from 1950 to 2024, we can observe several trends and patterns. The IMD rainfall data shows significant variability in annual rainfall amounts over the years. Some years experience higher rainfall, while others have much lower levels. The overall average annual rainfall for the region appears to be around 2 to 3 mm, with some years falling above or below this range. There are instances of extreme rainfall events, such as the maximum value of 4.75mm and minimum value of 0.19mm, indicating years of exceptionally high and low rainfall, respectively. The amount of rainfall variation directly affects various aspects of the environment, including vegetation, water availability, and

soil moisture. It also influences agricultural productivity, with both excess and insufficient rainfall posing challenges for farming communities. Long-term changes in rainfall patterns can have profound implications for the region's ecosystem, biodiversity, and socioeconomic conditions.

To interpret the average annual temperature data for the Attappady dry region from 1950 to 2023, we can observe the following; over the last seven decades, the average temperature has been increasing from 27.5^0 to 30^0degree Celsius. The notable changes observed only after 1985. There seems to be a trend of increasing temperatures over the years. This is indicated by the generally higher average temperatures in recent years compared to earlier years. Similar to rainfall data, there is variability in annual temperatures. Some years experience higher temperatures, while others have lower temperatures. The majority of the recorded temperatures are above 27°C, indicating a consistently warm climate in the region. There are instances of particularly high temperatures, with the maximum value reaching nearly 30°C. These extreme temperatures could have implications for the region's ecology, agriculture, and human health. Rising temperatures can have various impacts on the environment, including changes in ecosystems, water availability, and the frequency of extreme weather events. Additionally, higher temperatures can pose health risks, particularly during heatwaves. Long-term increases in temperature can lead to shifts in climate patterns, affecting rainfall, vegetation, and biodiversity. These changes can have complex socio-economic implications, requiring adaptive strategies for communities in the region.



3.4. Mann-Kendall tests for the Dry and Wet regions of Attappady, focusing on rainfall and temperature.

In Dry region, the P-value of 0.10 for rainfall suggests that there is a 10% chance of observing the given data if there were no trend in rainfall over time. Generally, a P-value less than 0.05 is considered statistically significant, indicating a strong likelihood that the observed trend is not due to random fluctuations. However, a P-value of 0.10 is borderline and may not reach conventional levels of significance. The Z-value of 1.63 indicates the magnitude and direction of the trend. A positive Z-value suggests an upward trend, while a negative Z-value suggests a downward trend. In this case, the positive Z-value indicates a slight upward trend in rainfall, but it's not particularly strong.

The P-value of 0.05 for temperature in the dry region suggests a 5% chance of observing the given data if there were no trend in temperature over time. This P-value is significant at the 0.05 level, indicating strong evidence of a trend in temperature. The extremely high Z-value of 29.78 indicates a very strong and significant trend in temperature. Such a high Z-value suggests a substantial increase or decrease in temperature over time, depending on the sign of the Z-value.

In wet region the A P-value of rainfall is 0 indicates that there is no chance of observing the given data if there were no trend in rainfall over time. This is highly significant and suggests a strong, statistically significant trend in rainfall in the wet region. The Z-value of 14.89 further confirms the strength and significance of the trend. Such a high Z-value indicates a substantial and consistent trend in rainfall over time. Similar to rainfall, both the P-value and Z-value for temperature in the wet region are extremely low, indicating a highly significant and strong trend in temperature over time.

4.Conclusion

For the dry region, while there seems to be a slight upward trend in rainfall, it's not statistically significant at conventional levels. However, there is a significant and very strong upward trend in temperature. In contrast, the wet region shows highly significant and strong upward trends in both rainfall and temperature. These findings suggest potentially significant shifts in climatic patterns over time in both regions of Attappady, with the wet region experiencing more pronounced changes. This could have important implications for ecological

processes, water resource management, and community livelihoods in the area. Factors such as local geography, land use changes, and climate pattern are all affect the climatic stability conditions in the Attappady wet Region of Kerala. The IMD data suggests a warming trend in the Attappady dry region, which could have significant implications for its environment, agriculture, and residents.

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