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Climatic trends over the past three decades in Lunglei district, Mizoram

C A Iragar[1] & S M Feroze[2]*

[1] *Department of Forest Sciences, Tharandt, Technische Universität Dresden, Germany*

[2] *ICAR–National Academy for Agricultural Research Management, Hyderabad – 500 030, Telangana, India*

Email: ferozendri@gmail.com

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Abstract

This study examines long-term trends in temperature and rainfall in Lunglei district of Mizoram over a 30-year period from 1990 to 2019. Climatic data were analyzed to assess variability, drought occurrence and directional changes in rainfall and temperature. The highest frequency of drought months was observed in December (73.33%). Statistically significant increasing trends in monthly maximum temperature were found in nine months of the year. The month of May showed both a significant decline in rainfall and an increase in maximum temperature, suggesting increasing climatic stress during the pre-monsoon period. Seasonal analysis also indicated a significant reduction in pre-monsoon rainfall, while monsoon and post-monsoon rainfall trends were negative but not statistically significant. These findings document warming trends and increasing rainfall variability in Lunglei district, providing essential baseline climatic evidence to support future impact assessments and location-specific adaptation planning for turmeric cultivation in Lunglei, Mizoram.

Keywords: Lunglei, temperature, rainfall, Mizoram, turmeric

Recent decades have provided increasing evidence of climate variability in Mizoram, marked by changes in rainfall patterns and the frequency of extreme events. Long-term climatic records indicate a significant decline in annual rainfall in the state, along with a reduction in the number of rainy days across several districts. Between 1986 and 2017, Mizoram experienced a decline in total rainfall at a rate of 5.22 mm year $^{-1}$, suggesting a persistent shift in regional precipitation regimes (Lallianthanga *et al.*, 2018). Within this broader context, Lunglei district has experienced notable changes in rainfall characteristics. Along with other districts of Mizoram, Lunglei has witnessed a decline in the number of rainy days, indicating increasing rainfall irregularity. The district has been identified as one of the 100 climate- and water-stress-vulnerable districts in India (Venkateswarlu *et al.*, 2011), underscoring its sensitivity to climatic fluctuations.

Seasonal analyses from the region show that rainfall decline is not uniform across the year. Significant reductions in August and September rainfall have been reported in nearby locations, reflecting weakening late-monsoon precipitation patterns. In addition, dendrochronological studies from forest ecosystems in Mizoram indicate the occurrence of multiple drought years, notably during 1994, 1999, 2006 and 2008 (Upadhyay *et al*., 2020), highlighting the increasing frequency of moisture stress events. Together, these observations point to increasing rainfall variability and climatic stress in Lunglei district, emphasizing the importance of district-level analyses of long-term temperature and rainfall trends to better understand ongoing climatic changes.

The study area, Lunglei, is located in the Mizoram's southern region at 22° 54′ 36″N and 92° 45′ 36″E. Myanmar borders it on the east, Bangladesh on the west, Mamit and Serchhip districts on the north, and Lawngtlai and Saiha districts on the south (Lallianthanga, 2014). The tropical monsoon climate prevails in Mizoram throughout the year, neither too hot nor too cold due to southwest monsoon. As a result, the district receives an adequate amount of rainfall, resulting in a humid tropical climate with short winters and lengthy summers marked by heavy rainfall (GoI, 2021).

The study utilized secondary datasets on climate parameters to achieve its objectives. Daily rainfall (0.25° × 0.25° grid) and temperature (1° × 1° grid) data for the 30-year period (1990–2019) pertaining to the study area were obtained from the Indian Meteorological Department (IMD). From these datasets, the monthly and seasonal (*i.e*., June to September – monsoon; October to December – post-monsoon; and January to May – pre-monsoon) rainfall and temperature were analyzed. The total number of drought months and drought seasons was estimated. A drought month was defined as one in which the actual rainfall is less than half of the average monthly rainfall (Sharma *et al*., 1979), while a drought season was defined as one in which the seasonal rainfall is less than twice the season's mean deviation (Marathe *et al*., 2001). The data related to monthly maximum temperature, minimum temperature and trend analysis during 1990-2019 are presented in Table 1.

The highest average monthly maximum temperature of 30.71°C was recorded in the

Table 1. Descriptive statistics for monthly rainfall in Lunglei district during 1990-2019

Month	Maximum temperature			Minimum temperature		
	Average	Trend	p-value	Average	Trend	p-value
January	22.60	0.030	0.110	9.57	-0.010	0.568
February	25.56	0.068**	0.017	12.26	0.001	0.964
March	28.86	0.058**	0.034	16.30	0.005	0.824
April	29.95	0.032	0.222	19.49	0.023	0.245
May	30.30	0.042**	0.014	21.71	0.025**	0.033
June	30.51	0.040***	0.004	23.48	0.026***	0.004
July	30.38	0.037***	0.001	23.67	0.020***	0.007
August	30.71	0.037***	0.001	23.62	0.021***	0.005
September	30.42	0.055***	0.000	22.96	0.032***	0.000
October	29.46	0.038***	0.004	20.52	0.011	0.449
November	27.18	0.032***	0.002	15.67	-0.025	0.192
December	24.07	-0.0001	0.993	11.19	0.010**	0.486

Note: **and *** indicate $p<0.05$ and $p<0.01$, respectively month of August and the lowest maximum temperature of 22.60°C was registered in January. The highest average monthly minimum temperature of 23.67°C was registered in the month of July whereas the lowest of 9.57°C was recorded in January. The linear trends are positive and significant for 9 months in a year for maximum temperature *i.e.*, the months of February and May (p<0.05) and June to November (p<0.01) and for 5 months for minimum temperature *i.e.*, May to September (p<0.01) and December (p<0.05).

received no rainfall in some of the years. The CV was found to be highest in the month of December (191.19%) whereas, lowest in July (31.00%). Within the monsoon period, the CV of August was found to be highest. Higher value of CV indicates inconsistency in monthly rainfall across the years. Highest monthly drought was observed in December (73.33%), followed by January and February. Three drought months were observed in each of the four monsoon months (June, July, August and September) in Lunglei during the study period

Table 2. Average, CV, linear trends for monthly rainfall and monthly droughts in Lunglei district during 1990-2019

Month	Average rainfall (mm)	Contribution (%)	CV (%)	Number and % of drought months	Trend	*p*-value
January	6.51	0.26	141.37	17(56.67)	-0.307	0.115
February	32.91	1.30	174.30	14(46.67)	-2.454**	0.040
March	46.59	3.68	97.32	13(43.33)	-5.208***	0.004
April	164.92	6.51	79.68	12(40.00)	-2.487	0.379
May	304.85	12.04	60.97	4(13.33)	-10.683***	0.004
June	456.16	18.02	42.63	3(10.00)	-2.223	0.597
July	480.04	18.96	31.00	3(10.00)	0.433	0.893
August	438.07	17.30	43.38	3(10.00)	-0.061	0.988
September	327.82	12.95	40.41	3(10.00)	-0.906	0.752
October	185.05	7.31	53.68	6(20.00)	0.036	0.987
November	28.08	1.11	134.28	13(43.33)	-1.480	0.061
December	14.02	0.55	191.19	22(73.33)	-0.239	0.680

Note: **and *** indicate p<0.05 and p<0.01, respectively

Data related to monthly rainfalls and its trends during 1990 to 2019 in Lunglei district are presented in Table 2. The average monthly rainfall was found to be highest in the month of July (480.04 mm) with contribution of 18.96% to the annual rainfall. July was followed by June (18.02%), August (17.30%), September (12.95%) and May (12.04%). The monthly rainfall was least in January (6.51 mm), followed by December (14.02 mm) which contributed only 0.26 % and 0.55 % to total annual rainfall, respectively. The months of January, February, November and December 1990 to 2019. March and May months showed significant decreasing linear trend (b=-5.208 and -10.683, p<0.01) whereas February month showed significant decreasing trend (b=-2.454, p<0.05). The linear trend is decreasing for the month of April but insignificant.

During monsoon and post-monsoon rainfall, there is a decreasing (b=-2.757 and -1.683) insignificant trend but in the pre-monsoon season, there is a significant decreasing trend (b=-21.139, p< 0.01) during 1990- 2019 (Table 3), which may be due to the change in climate. The

Table 3. Linear trend analysis for seasonal rainfall and temperature

Season	Rainfall		Maximum temperature		Minimum temperature	
	Trend	*p*-value	Trend	*p*-value	Trend	*p*-value
Pre-monsoon	-21.139***	0.001	0.046***	0.002	0.009	0.372
Monsoon	-2.757	0.783	0.042***	0.000	0.025***	0.0002
Post-monsoon	-1.683	0.509	0.023**	0.014	-0.0013	0.912

Note: **and *** indicate $p<0.05$ and $p<0.01$, respectively

maximum temperature showed the increasing and significant trend of (b= 0.046, 0.042 and 0.023) during pre-monsoon, monsoon and post-monsoon season, respectively. The minimum temperature showed increasing and significant trend (b=0.025, $p<0.01$) in monsoon season.

Climate change affects various spice crops in India through changes in temperature and rainfall, influencing flowering, fruit set and vegetative development. Elevated temperatures have been reported to cause spike shedding in black pepper, while prolonged dry periods can reduce pollination and induce flower abortion in cardamom (Das and Sharangi, 2018). Spice crops such as ginger, turmeric, chilli and large cardamom cultivated under the humid agro-climatic conditions of Northeast India, including Mizoram, are particularly sensitive to such climatic shifts, as their growth and productivity are closely linked to consistent rainfall distribution and moderate temperature regimes (Momin *et al*., 2018). Chetan (2023) studied effect of climate change on turmeric crop in the Lunglei district and mentions that in the recent ten years, more than 90.00% farmers reported difficulty in predicting the planting time of turmeric and increase in the incidence of pests and diseases. About 77 % of the farmers reported deterioration in the quality of the turmeric produce and about 82 % of the farmers reported decline in productivity which they felt was due to climate change, especially untimely rainfall, erosion during heavy rainfall and incidence of pest and diseases. Turmeric growers in Lunglei and Mamit districts of Mizoram reported rising temperatures, declining and erratic rainfall, and increasing climatic uncertainty, indicating substantial climate stress on livelihoods. The study showed that Lunglei recorded a higher exposure score to climate risks, while its overall vulnerability index remained comparatively lower than that of Mamit, confirming that climate change is already affecting farming households in Lunglei (Lalrinsangpuii *et al*., 2025).

Over the past decade, in the neighboring state of Manipur as well, climate change has adversely affected turmeric cultivation through irregular rainfall and rising temperatures, leading to reduced rhizome formation, shortened or prolonged crop duration, and increased pest and disease incidence. Farmers reported an overall decline of about 25% in turmeric productivity, largely linked to climatic stress (Amulya *et al*., 2024).

The study uses IMD gridded datasets (0.25° × 0.25° for rainfall and 1° × 1° for temperature), which are relatively coarse for a geographically complex and hilly district like Lunglei. Such resolution tends to smooth out micro-climatic variations caused by elevation and terrain, meaning the results may not fully represent spatial variability within the district. Confidence intervals and uncertainty estimates could not be generated due to limitations in the available long-term climatic data; therefore, the identified trends should be interpreted as indicative rather than statistically bounded estimates. The analysis also relies on a single grid point to represent the entire district, which restricts the ability to capture local climatic differences across blocks and elevations.

The results of the study indicate clear signals of climatic change in Lunglei district of Mizoram over the period 1990–2019. Monthly rainfall analysis reveals a significant decline during February, March and May, while seasonal analysis shows a significant decreasing trend in pre-monsoon rainfall. In contrast, monthly maximum temperature exhibited significant increasing trends for nine months of the year, reflecting a consistent warming pattern. The month of May was characterized by the simultaneous occurrence of declining rainfall and rising temperature, indicating increasing climatic stress during the pre-monsoon period. Overall, the observed trends highlight increasing rainfall variability and warming conditions in the district. These findings provide robust baseline climatic evidence for Lunglei district and underscore the importance of continuous monitoring of temperature and rainfall patterns to support future climate impact assessments and location-specific adaptation planning especially for spices cultivation to boost production.

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