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Trend Detection of Temperature, Diurnal Temperature Range and Rainfall in Amritsar by using Mann Kendall Test

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***Abstract*:** The analysis of diurnal temperature range (DTR) for Amritsar from 1970–2023 was done. Daily minimum and maximum temperature were analyzed for additional consideration of DTR trend by using time series. DTR change of the Amritsar and seasonal variations of maximum and minimum temperature, rainfall by separating into *Rabi* and *Kharif* season. Diurnal temperature range (DTR) steadily decreased at the rate of -0.042°C/yr, -0.033°C/yr and -0.046°C/yr during annual, *Kharif* and *Rabi* season in the past 50 years. The yearly maximum averaged temperature indicated marginal decreasing trend but the yearly mean least temperature is increasing more rapidly, 0.028 °C/yr, 0.029 °C/yr and 0.028 °C/yr during annual, *Kharif* and *Rabi* season. The significantly expanding pattern of mean least temperature adds to the reduction of mean DTR. Annual and *Kharif* total rainfall has decreasing trend at the rate of -0.039 mm/yr and -0.223 mm/yr but the total rainfall during *Rabi* showed slightly increasing trend with 0.026 mm/yr.

Keywords: Diurnal temperature, Rainfall, Variability, Amritsar

Climate change studies in Punjab and India have gained significant attention in recent years due to the growing recognition of the region's vulnerability to climate-related changed. Rising temperatures can have adverse effects on agricultural productivity, water resources, and human health. Climate change poses significant risks to agriculture in Punjab and India, which heavily rely on the monsoon season. Studies have assessed the impact on crop yields, changes in pests and diseases, and the need for adaptation strategies to ensure food security. Changes in rainfall patterns and increased temperatures affect water availability, particularly in regions dependent on glacial melt water and monsoon rainfall. Climate change contributes to an increase in extreme weather events like floods, droughts, and heat waves. This includes assessing the feasibility and effectiveness of renewable energy, energy efficiency, sustainable agriculture practices, and resilient infrastructure development. Climate change has socio-economic implications, particularly for vulnerable communities and marginalized groups. Research investigates the differential impacts and explores strategies to enhance resilience and reduce inequalities. Climate change eludes to a significant difference in either the mean condition of the atmosphere or in its changeability, enduring for a completeperiod.The global mean surface temperature is expected to increase by 1.16.4°C by 2100, according to the intergovernmental panel on climate change (IPCC 2007).

Global warming is consequence of climate change that is most commonly acknowledged. The mean temperature has risen by a little over 1°C since 1880, with the majority of hotness occurring after 1975, at an estimated rate of 0.15 to 0.20°C per decade, according to scientists at NASA's Goddard Institute for Space Studies (GISS) (Anonymous 2020a). However, accompanying climate changes and unpredictability in meteorological parameters may result in either an increase or decrease in the net productivity of an ecosystem.

Punjab, the bread basket of the country, is that it is mainly agrarian economy which will be most affected by climate change. Kaur et al. (2016) reported that under A1B scenario, minimum and maximum temperature are expected to boost by 2.9 and 4.9 ˚C, respectively during 2021-50 and by 5.8 and 7.4 ˚C, respectively during 2071-2100. Kaur and Hundal (2010) reported gradual increase in minimum temperature at Ludhiana over last 30 years. The aim of this study is to analyze the diurnal temperature range and trends of variation in weather parameters by using Mann Kendall Test.

MATERIAL AND METHODS

Climate and location: Amritsar station is located at latitude of31°38'N and longitude of 74°52'E with an altitude of 234 m above mean sea level, which is located in the Majha region of Punjab under Trans-Gangetic agroclimatic zone of India. The general climatic condition is classified as semi-arid with mean annual rainfall of about 681 mm out of which 75% rainfall is received during monsoon (June to September). The summer temperature exceeds above 38°C and reaches upto 49°C with dry summer spell.

Weather data: The meteorological parameters i.e. daily

maximum and minimum temperature and rainfall of Amritsar was obtained from Indian Meteorological Department for 1970-2023 was analyzed for diurnal temperature range. Time series of daily maximum temperature and minimum temperature were also analyzed for further understanding of DTR trend. DTR change were analyzed first, and then impact on seasonal variations of maximum and minimum temperature; rainfall; DTR trends by separating into *Rabi* and *Kharif* season.

Mann-Kendall test: This test is used to determine whether a time series has a monotonic upward or downward trend. It does not require that the data be normally distributed or linear. It does require that there is no auto correlation. The null hypothesis for this test is that there is no trend, and the alternative hypothesis is that there is a trend in the two-sided test or that there is an upward trend (or downward trend) in the one-sided test.

RESULTS AND DISCUSSION

Mann-Kendall test: Most of the time, the time series data show quite strong patterns, with the Mann-Kendall trend either increasing or decreasing (Table 1). H0 is disregarded if the p value is less than the significance level of (alpha) = 0.05. Accepting H0 means no trend was observed whereas rejecting H0 means there is a pattern in the time series. On rejecting the null hypothesis, the result is said to be statistically significant. Null Hypothesis was accepted for maximum temperature and rainfall data over the last 53 years. Similar trend were observed for *annual, rabi* and *kharif* seasons for 1970-2023. Frimpong et al. (2022) analyses temperature indices revealed an increase in warm days and a general rise in the minimum temperature compared to maximum temperatures. Mann Kendall and Sen's slope revealed significant change in the annual and seasonal (dry and wet seasons) in minimum temperature in Ghana.

Temperature: Despite year-to-year changes due to numerous climate causes significant downward trend in diurnal temperature range, with a slope of -0.042 °C/yr. The annual mean maximum temperature declined at -0.013 °C/yr, but the annual mean lowest temperature is rising significantly faster, at 0.028 °C/yr. The significantly increasing trend in the mean lowest temperature adds to a drop in the mean DTR. Because seasonal trends exist in temperature change, time series of seasonal average DTR, Tmax, and Tmin of the Amritsar were analyzed to explore seasonal aspects of DTR change (Figs. 1, 2, Table 2) DTR variation demonstrates

Table 1. Mann-Kendall test statistics on maximum, minimum temperature and rainfall of *rabi, kharif* and annual in Amritsar district of Punjab

Weather parameters	Tau	p value	Alpha	Test interpretation
Annual (1970-2023)				
Maximum temperature	-0.17	0.09	0.05	Accept H0
Minimum temperature	0.21	0.03	0.05	Reject H0
Rainfall	-0.01	0.91	0.05	Accept H0
Kharif season (1970-2023)				
Maximum temperature	-0.12	0.23	0.05	Accept H0
Minimum temperature	0.20	0.04	0.05	Reject H0
Rainfall	-0.003	0.98	0.05	Accept H0
Rabi season (1970-2023)				
Maximum temperature	-0.09	0.37	0.05	Accept H0
Minimum temperature	0.26	0.009	0.05	Reject H0
Rainfall	-0.002	0.99	0.05	Accept H0

Table 2. Regression equations of meteorological parameters of Amritsar

Seasons	Diurnal temperature range	Mean maximum temperature	Mean minimum temperature	Annual rainfall(mm)	Number of rainy days
Annual	y = -0.042x + 99.63 R^2 = 0.421	y = -0.013x + 57.71 R^2 = 0.127	y = 0.028x –41.91 R^2 = 0.264	y = -0.039x + 798.4 R^2 = 7E-06	y = -13.2x + 430.4 R^2 = 0.520
Kharif	y = -0.033x + 60.61 R^2 0.266	y = -0.003x + 42.27 R^2 = 0.005	y = 0.029x –37.03 R^2 = 0.220	y = -0.223x + 1024 R^2 = 0.000	y = -8.6x + 293.6 R^2 = 0.435
Rabi	y = -0.046x + 108.0 R^2 = 285	y = -0.018x + 60.61 R^2 = 0.098	y = 0.028x –47.44 R^2 = 0.219	y = 0.026x + 90.80 R^2 = 2E-05	y = -7x + 145.8 R^2 = 0.147

seasonal patterns. DTR exhibits a declining trend in both seasons, with kharif having the largest decrease rate and Rabi having the lowest decrease rate. Tmax has a slightly decreasing trend of -0.003°C/yr in *Kharif*, but TMIN has the highest increasing rate, 0.029°C/yr than *Rabi*, therefore DTR has the most dramatically declining trend, at -0.033 °C/yr. Similarly, in *Rabi*, Tmax has a slightly decreasing trend of -0.018 °C/yr and TMIN has an increasing trend of 0.028 °C/yr, hence DTR has a slightly decreasing trend of -0.046 °C/yr. A downward trend in mean DTR was observed particularly in recent decades, the DTR has decreased. As the yearly mean most extreme temperature of the Amritsar has a marginally expanding pattern, the yearly mean least temperature is increasing at a lot quicker rate, which might make sense of the lessening of mean DTR. The patterns of normal DTR, greatest temperature and least temperature have huge occasional contrasts. Mehta and Yadav (2019) showed significant increase in temperatures and decreases in monsoon rainfall in most parts of the Rajasthan state and climate in Rajasthan state is growing warmer, especially in summer.

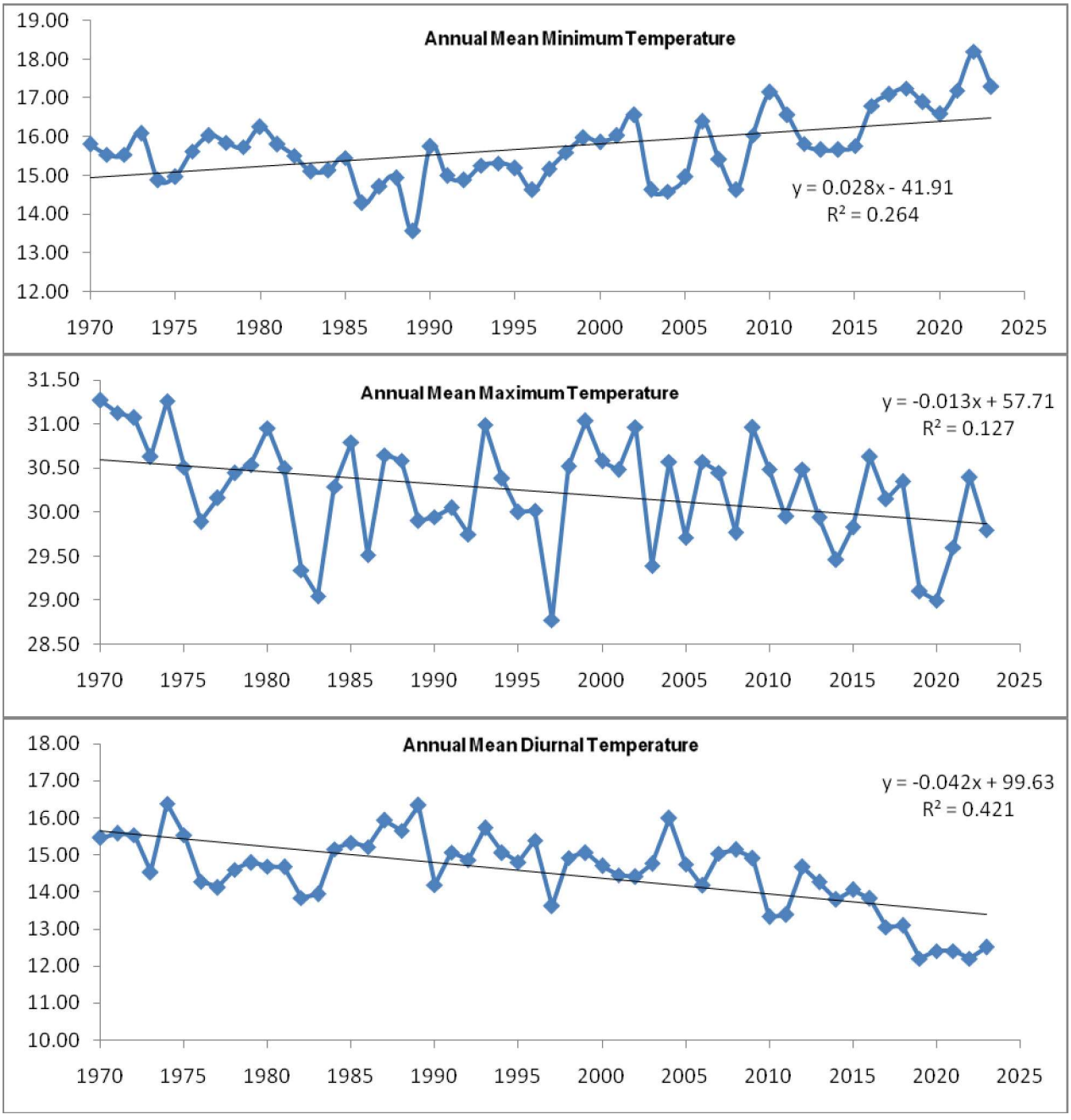

Fig. 1. Annual mean diurnal, maximum and minimum temperature at Amritsar

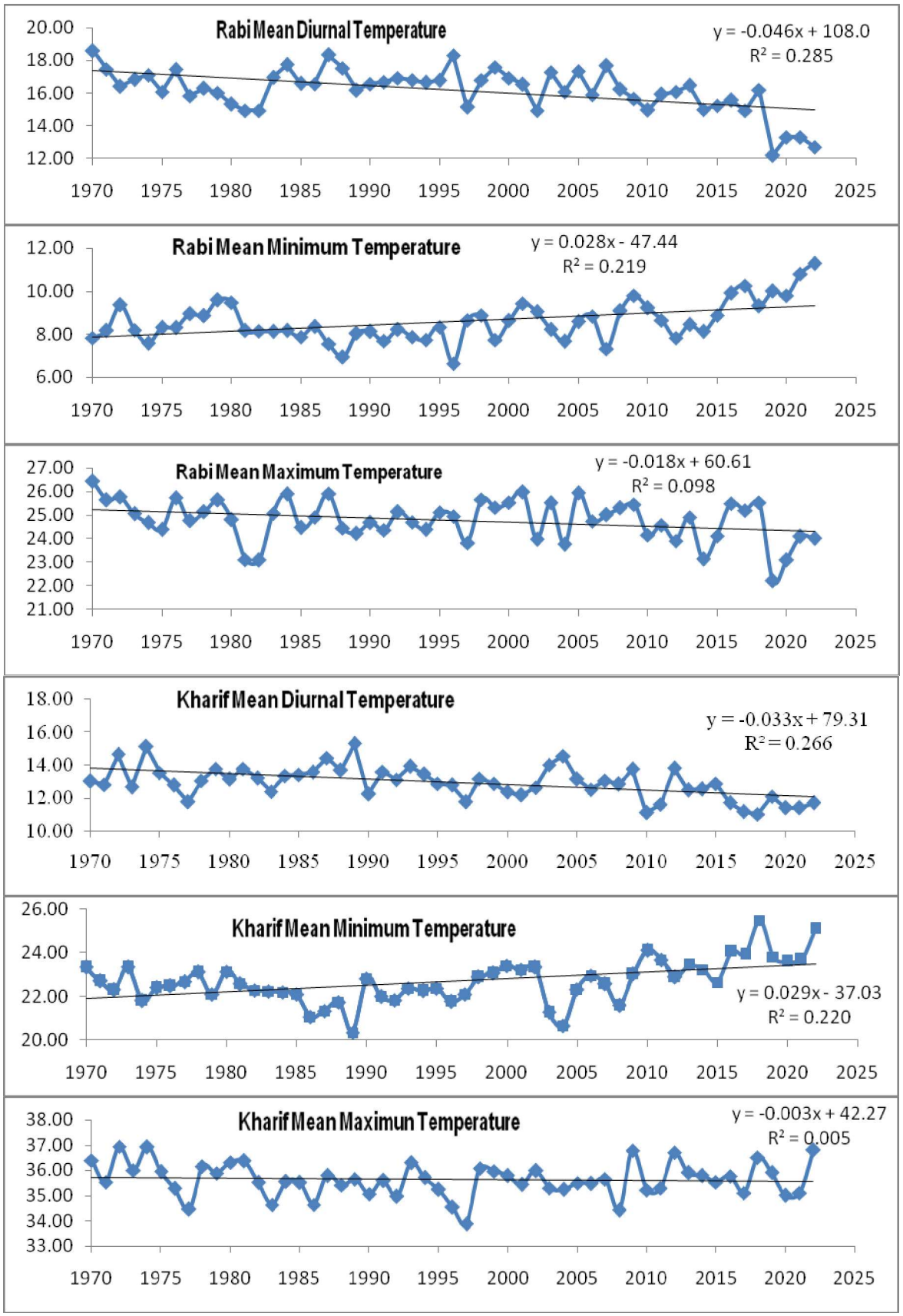

Fig. 2. *Rabi* and *kharif* mean diurnal, maximum and minimum temperature at Amritsar

Rainfall: Along with the temperature rainfall represents the most important parameter of meteorology for any particular region. There was not a significant change. The Annual and *Kharif* total rainfall indicated decreasing trend at the rate of -0.039 mm/yr and -0.223 mm/yr but the total rainfall during *Rabi* has slightly increasing trend with 0.026 mm/yr. During recent decades, the decreasing trend is more significant. The decreasing rate of change in number of rainy days were observed as -13.2 days/yr, -8.6 days/yr and -7 days /yr during annual, *kharif* and *Rabi* season, respectively at Amritsar (Table 2).

Decadal shift: The maximum temperature (T_{max}) decreased from 1970-79 to 2010-18 by -0.46°C, -0.09°C and -0.67°C for annual, *Kharif* and *Rabi* season, respectively. However, the (T_{min}) minimum temperature increased by 0.77°C, 1.02°C and 0.54°C during annual, *kharif* and *Rabi* season, respectively from1970-79 to 2010-18. On contrary , The perusal of diurnal temperature data has significant decreasing shift of -1.4°C, -1.3°C and -0.6°C for annual, *Kharif* and *Rabi* season, respectively from1970-79 to 2010-18. The similar trends of mean maximum and mean minimum temperature were observed by Prabhjyot-Kaur *et al* (2012).

CONCLUSION

The yearly maximum averaged temperature has a marginal decreasing trend but the yearly mean least temperature is increasing more rapidly in the past 53 years. Thus, the significantly expanding pattern of mean least temperature adds to the reduction of mean DTR.

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