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CONTENTS

Changing weather conditions during summer and early monsoon season in the *Tarai* region of Uttarakhand

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ABSTRACT: As climate change continues to cause havoc worldwide, it is important to study the local meteorological parameters to understand their impact. The summer and early monsoon season ranging between 10-23 standard meteorological weeks (SMWs) is very important for the *kharif* crops in the *Tarai* region. The current study was performed on the maximum-minimum temperatures, morning and evening relative humidity, rainfall and rainy days patterns in Pantnagar, Uttarakhand. A simple trend analysis was done for a time period from 2010-2024. The results showed a decreasing trend in evaporation since 2019-2024 at a rate of 1.7 mm/year. The early monsoon season during previous years observed moderate to heavy rainfall patterns, but due to daily temperature variations the rainfall has become extremely irregular in recent years (2019-2024). Continuous dryness, high temperatures and *El Nino* impact caused very low rainfall of 2.4 mm during 2024 which was extremely lower than the previous years as well as the normal rainfall of the region. Though the rainfall pattern indicates an increase in rainfall over the years during 2020, 2021 and 2023 but with decreased rainy days leading to heavy downpours in a very short period of time. All these steep variations in recent years during summer and early monsoon season have created difficult situations, particularly for the spring and *kharif* crops of the *Tarai* region thus, such local study could help to understand the weather patterns and its impact so that weather preparations could be made well in advance.

Keywords: Early monsoon season, rainfall, rainy days, summer season, *Tarai* region

The vagaries of weather have continuously caused problems for the livelihood of the public and food security. Uttarakhand, a small state situated in the mid-Himalayan region, has faced many such weather aberrations which are not only impacting the everyday life of the people but their cropping patterns as well. The hills of Uttarakhand are mostly dependent on rainfed farming except in the valleys and the Tarai region, but the change in weather patterns have created difficult situations for the farmers living in the hills. Either erratic and timely rains do not arrive or they are of high intensity/heavy rains causing heavy losses. Scientists have predicted the state to observe high temperatures of 1.6-1.9°C by 2050, particularly this temperature rise would be observed at higher elevations as reported in an article by Das (2021). The weather changes being observed in the state, have caused major shifts in the cropping seasons and cultivation zones of the state leading to an increase of fallow land in the state. Tripathi (2024) in India Today reported a significant shift in the horticultural production in the hills, which, as per the Horticulture Department, Government of Uttarakhand was 54% and 44% in area and production, respectively. An article published in Carbon impacts (2023) reports that Uttarakhand has observed a steep decline in apple production and the fruit which was earlier grown at an altitude of 6000 ft has now been forced to grow at a height of 6500-7000 ft with optimum snowfall. Even the orange and apricot cultivation area have also been shifted from 4500 to 6000 ft.

Break in monsoon and erratic rainfall have always been a common phenomenon, but the rising temperatures have caused warming and resulting in more evaporation and water vapour which is ultimately causing heavy or extremely heavy rainfall events in the Himalayan regions of the North (Deccan Herald, 2021). Similar changing patterns have been experienced by the *Tarai* region of Uttarakhand where Goel *et al.* (2024) reported an increase in the maximum and minimum temperature, respectively by 0.002°C and 0.003°C and a decrease in the rainfall rate, sunshine hours and evaporation, respectively by 0.043 mm, 0.004 hr and 0.024 mm on an annual basis for the time period 1981-2020.

Previously, Haseen (2015) reported trend where an increase was observed in the maximum & minimum temperatures, rainfall and relative humidity while a decrease was observed in the rainy days and wind speed on a monthly basis. These changing climate patterns clearly indicate and highlight the need to study the local climate pattern of the region. The meteorological parameters of the station are dependent and their relationship controls the weather and crop growing in the region. The meteorological observatory established by the India Meteorological Department (IMD) at different Agromet Field Units (AMFUs) reports different weather parameters i.e., maximum & minimum temperatures, morning &evening relative humidity, wind speed &direction, evaporation, rainfall, cloud cover. Jhajharia *et al.* (2009) investigated the direct relationship of wind speed with pan evaporation at Agartala which revealed a highest correlation of 0.77 showing an exponential relationship. Similarly, Samui *et al.* (2011) reported strong correlation ranging 0.35 to 0.82 between the evaporation and wind speed which clearly explained that the decrease in evaporation over India was due to the decrease in daily average wind speed in the region.

Various studies have reported a rainfall decline with an increase in the premonsoon showers which often cause damage to agricultural crops due to water logging. Alam *et al*. (2018) reported a significant increase in the premonsoon rainfall at 10% significance level in Haridwar, Nainital, Tehri Garhwal and Udham Singh Nagar districts. This clearly depicts rainfall pattern shifts in Uttarakhand

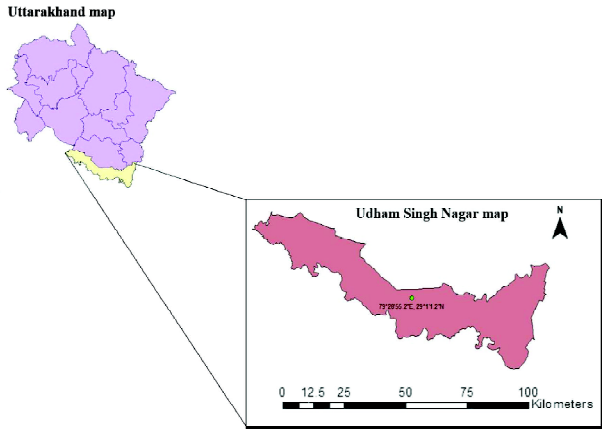

Fig. 1: Udham Singh Nagar map showing the study location

state. Nowadays, large variations in weather pattern were observed during the summer season in the *Tarai* region of Uttarakhand. The present study has been proposed to investigate the different patterns in major meteorological parameters *i.e.* maximum & minimum temperatures, morning & evening relative humidity, evaporation and rainfall during the summer and early monsoon months varying between the standard meteorological week (SMW) 10 to 23 in the *Tarai* region of Uttarakhand.

MATERIALS AND METHODS

Study location

The study has been conducted at the Department of Agrometeorology, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, which lies in the *Tarai* region of Uttarakhand, having 29.10°N and 79.28°E at an elevation of 243.84 m above the mean sea level (Fig. 1). The area is popularly known as the *Tarai* region of Uttarakhand as the area experiences a subtropical humid climate with an annual rainfall of 1560 mm. The daily weather data was obtained from the Agrometeorological Observatory situated at the Norman E. Borlaug Crop Research Centre in Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. The daily, weekly, monthly and annual weather data has been maintained by the Department of Agricultural Meteorology, College of Agriculture.

Analysis of the weather data

Analysis of weather data was done for the time period (2010-2024) during the summer and early monsoon season coinciding with the SMW 10 to 23. The current analysis of trend has been done for the important weather parameters playing an important role in crop growth i.e., maximum and minimum temperatures, morning and evening relative humidity, rainfall and number of rainy days. A rainy day, as per the India Meteorological Department (IMD) is the day which receives rainfall of more than 2.5 mm. The summer and early monsoon season have been selected to understand the changing pattern of different meteorological parameters over a period of fifteen years. The trend and regression analysis was done for the mean weekly data

parameters on annual basis.

RESULTS AND DISCUSSION

The observed weather patterns over the region show steep changes during the summer and early monsoon months for SMW 10 to 23. The study has been done to determine how the changing weather parameters have caused major shifts in the regional weather conditions.

Maximum-minimum temperatures and rainfall pattern against normal during summer and early monsoon season

The analysis of the 15-year weather data showed that during the SMW 10 to 23 the maximum-minimum temperatures respectively, ranged between 32-37°C and 17-20°C while the rainfall amount ranged from 2-245 mm against normal rainfall ranging 90-180 mm on an annual basis. The annual average maximum-minimum temperature analysed over the years during the mentioned meteorological weeks did not show much variations against the normal (Fig. 2a & b). However, the rainfall showed significant variations, where it was observed to be lowest during 2024 i.e. 2.4 mm. The year 2024 was already declared as a strong *El nino* (IMD, 2024) year where the winter months did not observe significant rainfall, leading to dry and cold winters. Fig. 3 clearly shows an increase in the rainfall amount over the 15 years period against the normal with significantly high rainfall (>200 mm) against the normal during 2020, 2021 and 2023. Though, Udham Singh Nagar region has observed significant rainfall over the years during the considered SMW but, the current year 2024 observed extremely low rainfall as marked by red in the graph. A recent report by Jayshree Nandi (2024) reported a decline in the pre monsoonal showers that plays an important role in the monsoonal rainfall during June months. The continuous increase in daily temperatures during summer months is due to reduced or no rainfall during winter months. The trend line in Fig. 3 shows that the increase in rainfall amount was at the rate of 6.01mm/year, though no significant weekly temperature changes (Fig 2a & b) have been observed during this period. The graph for maximum-minimum temperature and rainfall clearly depict the non-significant changes in the temperature patterns and significant changes in rainfall pattern reaching to a low annual rainfall amount of 2.4 mm during 2024. Similarly, a study by Alam *et al.* (2018) reported the rainfall trends in Uttarakhand which indicated an increase, significant at 10% in the pre-monsoonal rainfall in Garhwal, Haridwar, Nainital, Tehri Garhwal and Udham Singh Nagar. The studies clearly show a shift in the rainfall patterns. Haseen (2015) reported an increase in rainfall over a 33 year time period by 2.04 mm on a monthly time scale

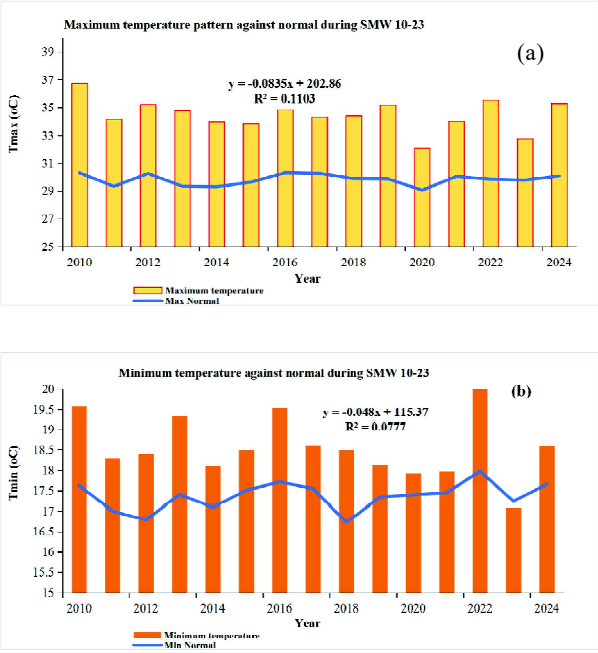

Fig. 2: (a) Maximum and (b) minimum temperatures against normal during summer and early monsoon

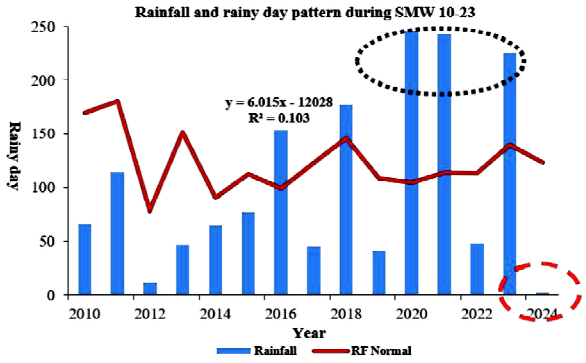

Fig. 3: Rainfall pattern against normal during summer and early monsoon

while the mean increase in maximum and minimum temperature, respectively, was very minor i.e. 0.002 and 0.033°C.

Evaporation and Relative Humidity pattern during summer and early monsoon season

The analysis of the 15-year weather data showed that during the SMW 10-23, the relative humidity and wind speed respectively, ranged between 47-59% during the year. The annual average relative humidity analysed over the years during the 10-23 SMWs didnot show much variations. The evaporation has observed a significant decline from the range 88-116 mm to the range 80-90 mm from 2020 to 2024. The bargraph (Fig. 4) for evaporation shows the decline during recent years. A study conducted by Jhajharia *et al.* (2009) at Agartala concluded that the wind speed and mean temperature had a positive influence on the evaporation rate. Samui *et al.* (2011) reported strong correlation between evaporation and wind speed ranging 0.35 to 0.82. A trend study in Australia by Rayner (2007) reported a daily average wind speed decline as an important reason of decrease in evaporation. A study by Wirangga *et al.* (2023) reported the wind speed impact on the evaporation rate in a desalination chamber and concluded that the highest rate of evaporation occurred at a wind speed of 18kmph and the lowest at a wind speed of 0 kmph. Singh *et al.* (2021) reported that the decrease in evaporation with increasing temperatures could be contributed to decreasing wind speed in the region. Haseen (2015) studied the climate change, trend and variability in the *Tarai* region where the wind speed decreased slightly by 0.03 kmph over a 33 year time period on a monthly time scale while the mean morning and evening relative humidity, respectively increased by minor values of 0.05% and 0.09%.

Rainy days against the rainfall pattern during summer and early monsoon season

The analysis of the 15-year weather data showed that during the SMW 10-23 the rainfall amount ranged from 2-245 mm on an annual basis while the rainy days ranged from 0-15 days. The annual average rainfall analysed over the years during the mentioned meteorological weeks showed variations as discussed above. However, the analysis of the rainfall and rainy days together showed significant changing patterns. The bar and the line graph in Fig. 5 respectively, for rainfall and rainy days, showed a significantly large increase in rainfall with a slight decline in the number of rainy days. The graph marks where the rainfall has increased significantly with the decline in the number of rainy days, during 2018, 2020, 2021 and 2023. Previously during the years 2010-2014, the rainy days were more, which clearly showed the variability of rainfall over the days but in later years the rainfall variability over the days has decreased and the intensity and amount of rainfall within a few days has increased. This trend has been observed to be more frequent during recent years due to the higher daily temperatures existing in the state, which has caused significant heating, thus, leading to large amount of water vapour and ultimately large amount of rainfall within shorter intervals. These rains cause low groundwater

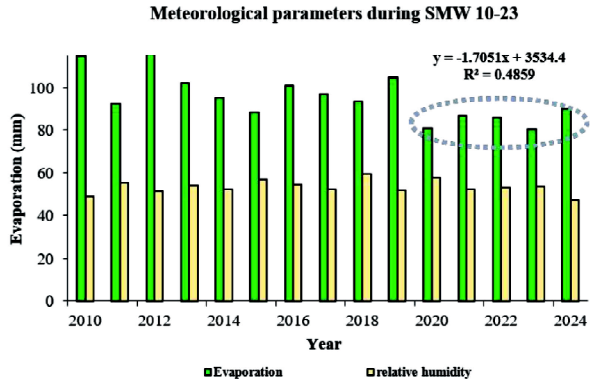

Fig. 4: Evaporation and Relative Humidity pattern during summer and early monsoon

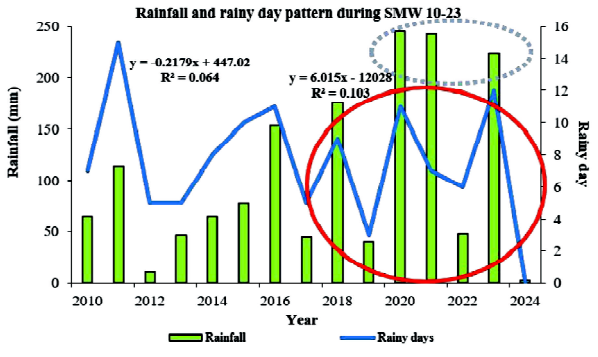

Fig. 5: Rainfall against Rainy days pattern during summer and early monsoon

recharge, higher runoff and damaging impacts on the crop. However, during 2024 the extreme *El Nino* conditions led to lower rainfall of 2.4 mm, which could not be counted as a significant rainy day. Kaur and Vatta (2015) mentioned in their study that the sudden heavy downpour in a short span of time contributed to declining crop water productivity and hampered recharge of groundwater aquifers. These events have increased in recent decades though low intensity rainfall acts as a crop growth booster as well as groundwater recharge. Haseen (2015) reported an increase in rainfall over a 33 year time period by 2.04 mm on a monthly time scale and a slight mean decrease in the number of rainy days by 0.01 day. A similar recent study by Goel *et al.* (2024) on the weather parameters, namely maximum-minimum temperature, rainfall, sunshine hours and evaporation annually for a time period 1981-2020 reported a decline in the rainfall and evaporation amount, respectively by 1.46 mm/year and 0.03 mm/year while the maximum-minimum temperature, respectively would increase by 0.0004°C/year and 0.0180°C/year. Thus, the considered research studies clearly show the increasing rainfall pattern on monthly scale and a decreasing rainfall pattern on annual scale. Sandhu and Prabhjyot-Kaur (2023) in a case study of Punjab, reported abrupt changes of 13, 33, 36 and 18%, respectively in monthly monsoonal rainfall amount for June, July, August and September, while rainfall was less during June and July which is a major cause of draining of ground water resources .The increase in rainfall extreme events have increased with global warming and if greenhouse gases continue to be emitted, particularly carbon dioxide, it would enhance the water holding capacity of air thus, during a break in monsoon, the air would release huge water vapour amounts as rainfall resulting in heavy or extremely heavy rainfall events which have been a frequent phenomenon recently (Deccan Herald, 2023).

CONCLUSION

The summer and early monsoon months are important, particularly for the *kharif* sown crops. In recent years, there have been changes in the major weather parameters impacting crop growth. The maximum and minimum temperatures and morning and evening relative humidity did not show any significant increasing/decreasing trend since 2010, but the daily variation in temperatures has significantly impacted the evaporation amount, rainfall and rainy days during the recent years from 2019-2024. The evaporation rate has significantly declined during recent years (2019 to 2024) which could be contributed to decreasing wind speed in the region. Evaporation and wind speed are very important parameters impacting the climate of a place and a declining trend in the wind speed may be an indicator of uneven warming of the area, urbanization and changes in the land use pattern. A decline in wind speed directly affects the evaporation rate. The rainfall showed steep variations during recent years (2020 to 2024) where a decline in rainy days with the increase in rainfall amount has been observed. These variations are leading to extreme events like floods, cloudbursts, etc. in the region. The summer and the early monsoon season have always experienced significant rainfall which was nil during 2024 due to *El Nino*. The *El Nino* impact resulted in no rainfall during winter months, leading to excessive heating and high temperatures in the region, causing negative impacts on crops like the shrivelling of sweetcorn. Thus, it is important to understand such sharp local changes in weather that mostly impact the sensitive crops in the region, leading to crop loss.

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REFERENCES

Alam, N.M., Jana, C., Barman, D., Sharma, B.,

Singh, D., Mishra, P.K. and Sharma, N.K. (2018). Twentieth century rainfall trends of Uttarakhand, India: A spatio-temporal analysis. *Climate Change and Environmental Sustainability*, 6(2): 104-113. DOI: 10.5958/2320-642X.2018.00013.3.

Carbon impacts (2023). Climate Change: Uttarakhand grapples with declining food production.https://carbonimpacts.info/article/climate-change-uttarakhand-grapples-with-declining-food-production-657acfb98dd02

Das, K. (2021). Climate change is already forcing farmers in Uttarakhand to migrate. Scroll.in. https://scroll.in/article/995283/climatechange-is-already-forcing-farmersin-uttarakhand-to-migrate

Deccan Herald (2023). https://www.deccanherald.com/environment/climate-change-triggered-monsoon-fury-in-uttarakhand-himachal-2652873

Goel, S., Dhami, J. and Singh, R.K. (2024). Climate and its variability over the *Tarai* region of Uttarakhand. *Mausam*, 75 (1): 47-60. DOI :https://doi.org/10.54302/mausam.v75i1.5015

Haseen, A. (2015). Monthly trend analysis and variability of climatic variables. *International Journal of Scientific Research*, 4(7): 685-690.

IMD (2024). ENSO-IMD update bulletin. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://mausam.imd.gov.in/ClimateInformation/imdweb/CLIMATE_FCST/Bulletin/ENSO_IOD_Update_Bulletin.pdf

Jayshree Nandi (2024). Drier June, wet Sept? Data points to shift in monsoon. https://www.htsyndication.com/hindustan-times/article/drier-june,-wet-sept—data-points-to-shift-in-monsoon/82453154

Jhajharia, D., Agrawal, G. and Sevda, M.S. (2009). Influence of meteorological parameters on pan evaporation at Agartala. *Journal of Agricultural Engineering*, 46 (1): 23-26.

Kaur, S. and Vatta, K. (2015). Groundwater depletion in Central Punjab: pattern, access and adaptations.*Current Science*, 108: 485-490.

Rayner, D. P. (2007). Wind run changes: the dominant factor affecting pan evaporation trends in Australia. *Journal of Climate*, 20: 3379-3394.

Samui, P., John, G., Ransure, S.P. and Pachankar, M.A. (2011). Factors affecting the trends in evaporation during different crop growing seasons over India. *Mausam*, 62 (3): 391-402.

Sandhu, S.K. and Prabhjyot-Kaur (2023). A case study on changing pattern of monsoon rainfall duration and its amount during the recent five decades in different agroclimatic zones of Punjab state of India. *Mausam*, 74 (3): 651-662. DOI :https://doi.org/10.54302/mausam.v74i3.5331

Singh, D., Senthil Kumar, A.R., Goyal, V.C., Arora, M., Rao Allaka, N. (2021). Characteristics of meteorological variables and their implications on evaporation in Roorkee (India). *HydroResearch*, 4: 47-60.

Tripathi, S.K. (2024). Uttarakhand's apple orchards shrink as climate change hits India's fruit basket. *India Today*. https://www.indiatoday.in/environment/story/uttarakhands-apple-orchards-shrink-as-climate-change-hits-india-fruit-basket-2545653-2024-05-30

Wirangga, R., Mugisidi, D., Sayuti A.T., Heriyani, O. (2023). The impact of wind speed on the rate of water evaporation in desalination chamber. *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*, 106 (1): 39-50. https://doi.org/10.37934/arfmts.106.1.3950.

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