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Analyzing Temperature and Precipitation Regimes in Hilly Terrains of Betalghat Development Block, Kumaun Lesser Himalaya

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Abstract

Temperature and rainfall are important factors in determining a place's weather and climate. These determinants are subject to significant change following the prevailing unsustainable developmental practices. Therefore, the present study analyses the temperature and precipitation conditions in the hilly terrain of one of the fastest-growing regions in the Lesser Himalayan region. The study makes it clear that the maximum temperature of the study area shows a decreasing trend at a rate of 0.02°C/year, while the minimum temperature showed an increasing trend at a rate of 0.03°C/year. However, the region has observed a decreasing rainfall trend over the past four decades. These climatic variations have threatened subsistence farming systems, food and livelihood security, and human health in the densely populated rain-fed Lesser Himalayan region.

Keywords: Climate Change, Kumaun Lesser Himalaya, Temperature, Precipitation, Ecological Imbalances, Development Block Betalghat

1. Introduction

Climate change is a severe threat that affects natural ecosystems, natural resources, and socio-economic aspects of human beings on the earth's surface (Wafae et al., 2020; Nand, 2023), and temperature and precipitation are the major determinants in a bio-ecological region (ICIMOD, 2010; Tiwari & Joshi, 2014; Huddleson et al., 2003; Nand et al., 2022 and 2023; Kumar et al., 2023). It is observed that the changing climatic condition has affected the earth's surface significantly over the last century (NOAA, 2020; IPCC, 2021 and 2022; Nand, 2023; Nand et al., 2023). Climate change is causing ecological imbalances by increasing the average global surface temperature, glacier recession, altered precipitation pattern, increased frequency and intensity of extreme weather events (Dimri et al., 2021; Donat et al., 2013; IPCC, 2012, 2014, 2018, and 2021; Tiwari and Joshi, 2012, 2014 and 2015; Nand et al., 2023). The previous decades (2011- 2020) were one of the warmest decades in this century (WMO, 2020). Over the last 50 years, human activities, particularly burning fossil fuels, have released sufficient quantities of carbon dioxide and other greenhouse gases that are trapping additional heat in the lower atmosphere and affecting the global climate (UNDP, 2006; IPCC, 2013; WMO, 2020; IPCC, 2021). In the last 140 years, the world has warmed by approximately 0.99ºC, and each of the previous four decades has been successively warmer than any preceding decade since 1850 (IPCC, 2021). Likewise, the last 40 years have been the warmest in the northern hemisphere since 1400 (IPCC, 2021; Kumar et al., 2023), and the global surface temperature has increased by about 0.99°C (ranges from 0.84-1.10°C) in the first two decades of the twenty-first century, which is greater than the temperature rise between 1850 and 1900 (IPCC, 2014 and 2021). Further, global warming has been projected to increase from 1.4° to 5.8°C from 1990 to 2100 (Kumar et al., 2023). Sea levels are rising, glaciers are melting, precipitation patterns are changing, and extreme weather events are becoming more intense and frequent. Moreover, climate and climate variability, particularly weather extremes, affect the environment, providing clean air, food, water, shelter, and security (IPCC, 2014 and 2021; Tiwari and Joshi, 2012, 2013 and 2014; Nand, 2023; Nand et al., 2023; Khalid et al., 2017). There is a strong connection between the climate system and ecological changes (WHO, 2005 and 2014; IPCC, 2014 and 2021; Hess et al., 2012; Tiwari and Joshi, 2012, 2013 and 2014), and climate and weather have always influenced natural environment and human health (IPCC, 2014; WHO, 2005 and 2014). Therefore, the study region Betalghat development block, Kumaun Lesser Himalaya, being densely populated and economically underdeveloped, is highly vulnerable to the impacts of these changes that may cause a substantial decrease in the availability of water for drinking, sanitation, and food production and consequently increase the proportion of health-insecure populations both in highland and lowlands (Nand el al., 2022). Moreover, changing climatic conditions are expected to increase extreme weather events' severity and frequency, causing droughts, landslides, and flash floods (WMO, 2020; WHO, 2014; IPCC, 2014; ICIMOD, 2012; Tiwari and Joshi, 2010, 2013 and 2014). This may lead to catastrophic scarcity of freshwater for drinking and agriculture, thus decreasing agricultural productivity and undermining human health (Nand et al., 2022).

2. Research Methodology

2.1 Study Area

Development Block Betalghat situated in the Lesser Himalayan ranges of district Nainital in the state of Uttarakhand has been selected as the area of study. Betalghat Block is located between 29°26'30" and 29°32'00" North Latitudes and 79°14'00" and 79°30'30" East longitudes and encompasses a geographical area of nearly 315.7 sq. km (Fig. 1).

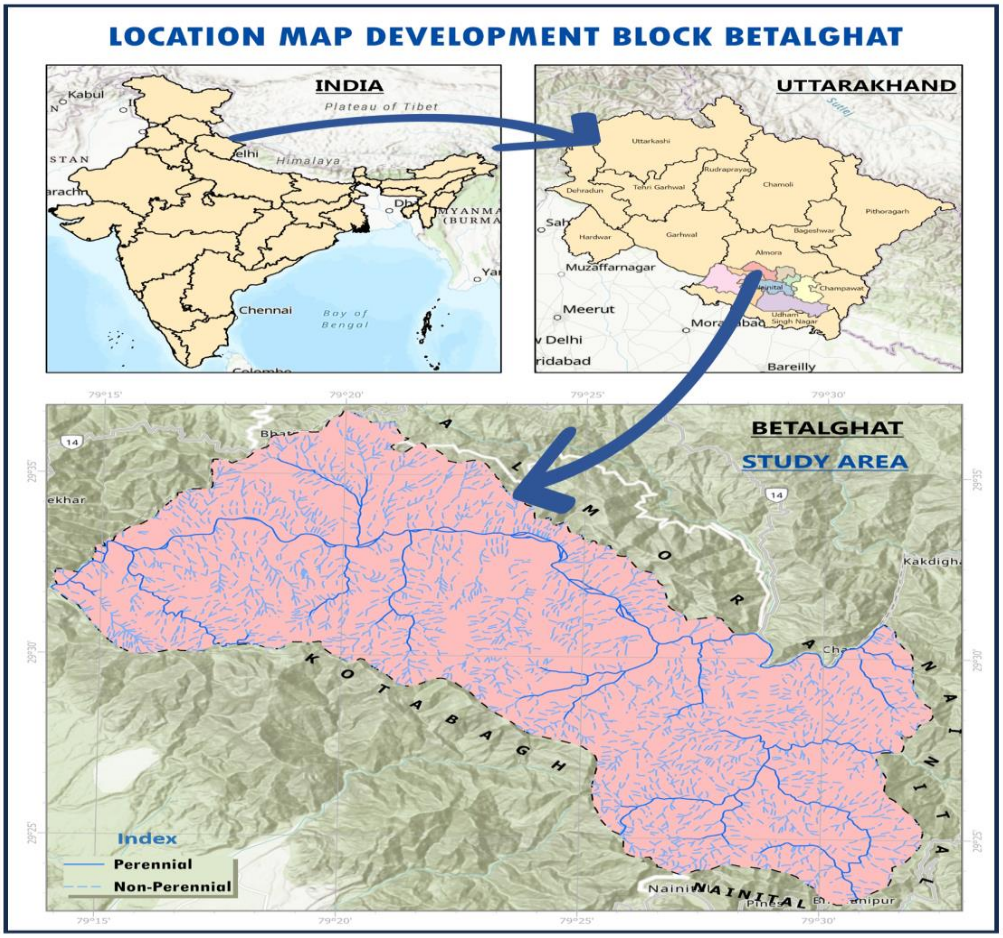


Fig. 1: Development Block Betalghat situated in the Lesser Himalayan ranges of district Nainital in the state of Uttarakhand, India

The study area is densely populated and agriculturally colonized region of Kumaun Lesser Himalaya. According to the 2011 census, total population of this region is 41535 and the calculated density of population is 131 persons/sq. km. River Kosi, one of the major rainfed rivers of Kumaun Himalaya, drains through Betalghat Block, which is one of the major tributaries of the Ganges system in its hilly terrain. The area is characterized by diversified terrain and geomorphic landscape which are clearly reflected in varying magnitudes of slopes and their aspects, variety of soils, natural vegetation and hydrological parameters, and the climatic complexities. As in other parts of Kumaun Himalaya, the traditional resource use structure is changing fast mainly in response to growth of population and resultant increased demand of food, fodder, and energy resources. Consequently, the activities of cultivation, grazing and deforestation are extended over large areas of the region.

2.2 Data Collection Methods and Analysis

The climate of the study area has been captured by using available data from the Indian Council of Agriculture Research, National Bureau of Plant Genetic Resources and Regional Station (ICAR- NBPGR RS) Bhowali, Niglat, Nainital, Uttarakhand, India [1983-2022] and recently published reports. Since the weather station is located within the Betalghat development block, the climatic data obtained from the station has been considered as base information for analyzing the study area's annual and seasonal temperature and rainfall trends. Furthermore, the India Meteorological Department criteria were used to examine the high-intensity rainfall events and drought occurrences (2015). Table and multiple-line graph have been used to demonstrate and analyze the temperature and precipitation data.

3. Results and Discussion

3.1 Variation in Temperature

Temperature is the significant physical factor influencing any region's climate system characteristics. A comprehensive assessment has been carried out based on the ground-observed daily temperature data of the Indian Council of Agriculture Research, National Bureau of Plant Genetic Resources and Regional Station (ICAR- NBPGR RS) Bhowali, Niglat, Nainital, Uttarakhand, India [1983-2022] to understand the changing pattern of temperature in the Betalghat development block. Since this section includes yearly and seasonal analyses of maximum, minimum, and mean temperature, the daily maximum and minimum temperature data were obtained by ICAR- NBPGR RS from 1983 to 2022. The maximum and minimum temperature data are calculated by the arithmetic average of daily maximum and minimum temperature data, and the mean temperature has been calculated by taking the arithmetic average of daily maximum and minimum temperature. The annual and seasonal time series of all parameters under mean maximum, mean minimum and mean temperature are compiled in this study.

3.1.1. Observed Changes in Temperature

The fluctuations in temperature and rainfall at the National Bureau of Plant Genetic Resources Niglat, Bhowali have been analyzed for the 40 years from 1983-2022 [Fig. 2, 3 (A) and (B), 4 (A) and (B)]. The mean value of the average annual maximum temperature (T_{max}) and the average annual minimum temperature (T_{min}) in the study area are 22.4ºC ± 0.12ºC and 9.9ºC ± 0.09ºC, respectively, which demonstrate significant change in the annual average temperature. The T_{max} presents a decreasing trend of 0.02ºC/year and T_{min} reveals an increasing trend of 0.03ºC/year, respectively (Fig. 2).

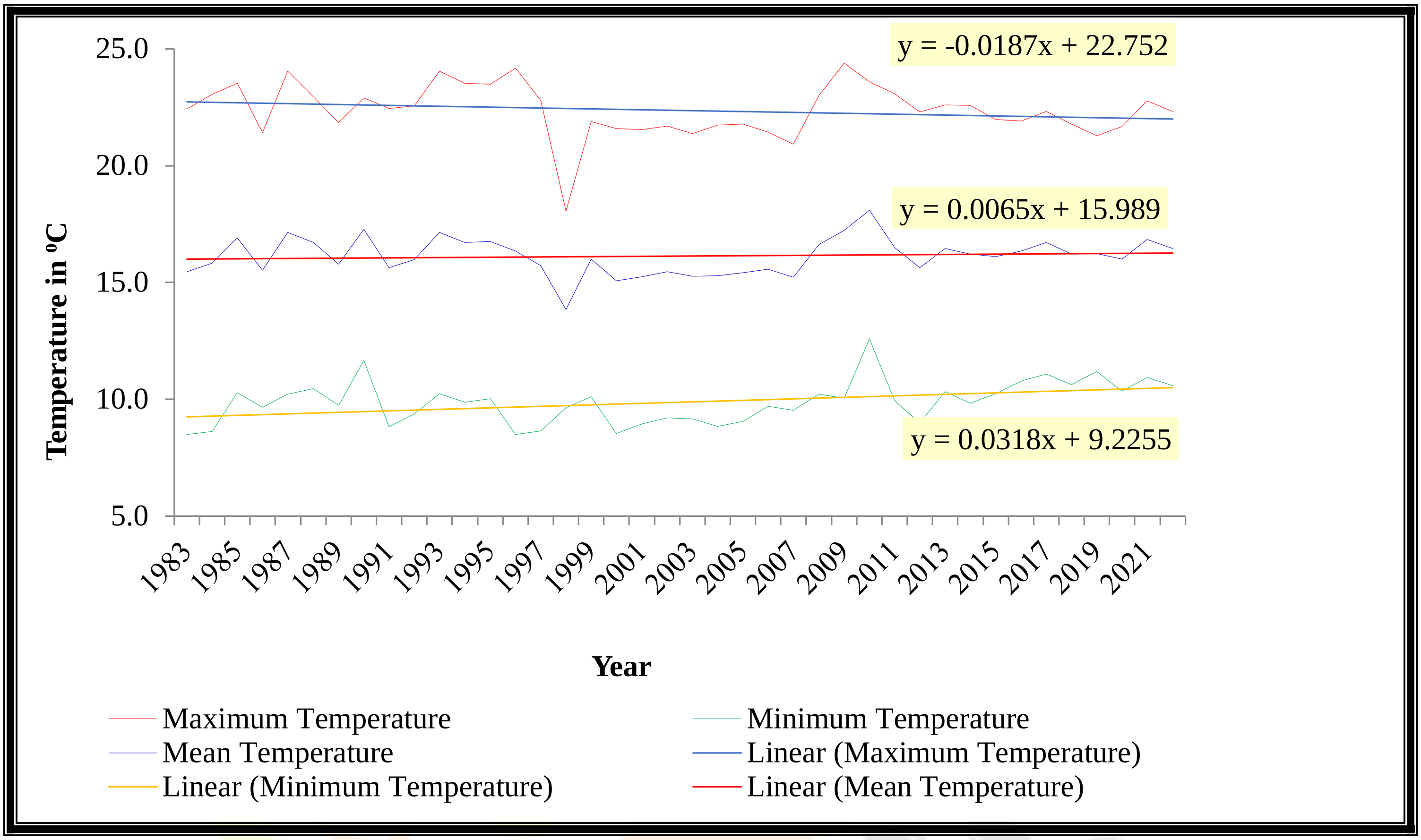
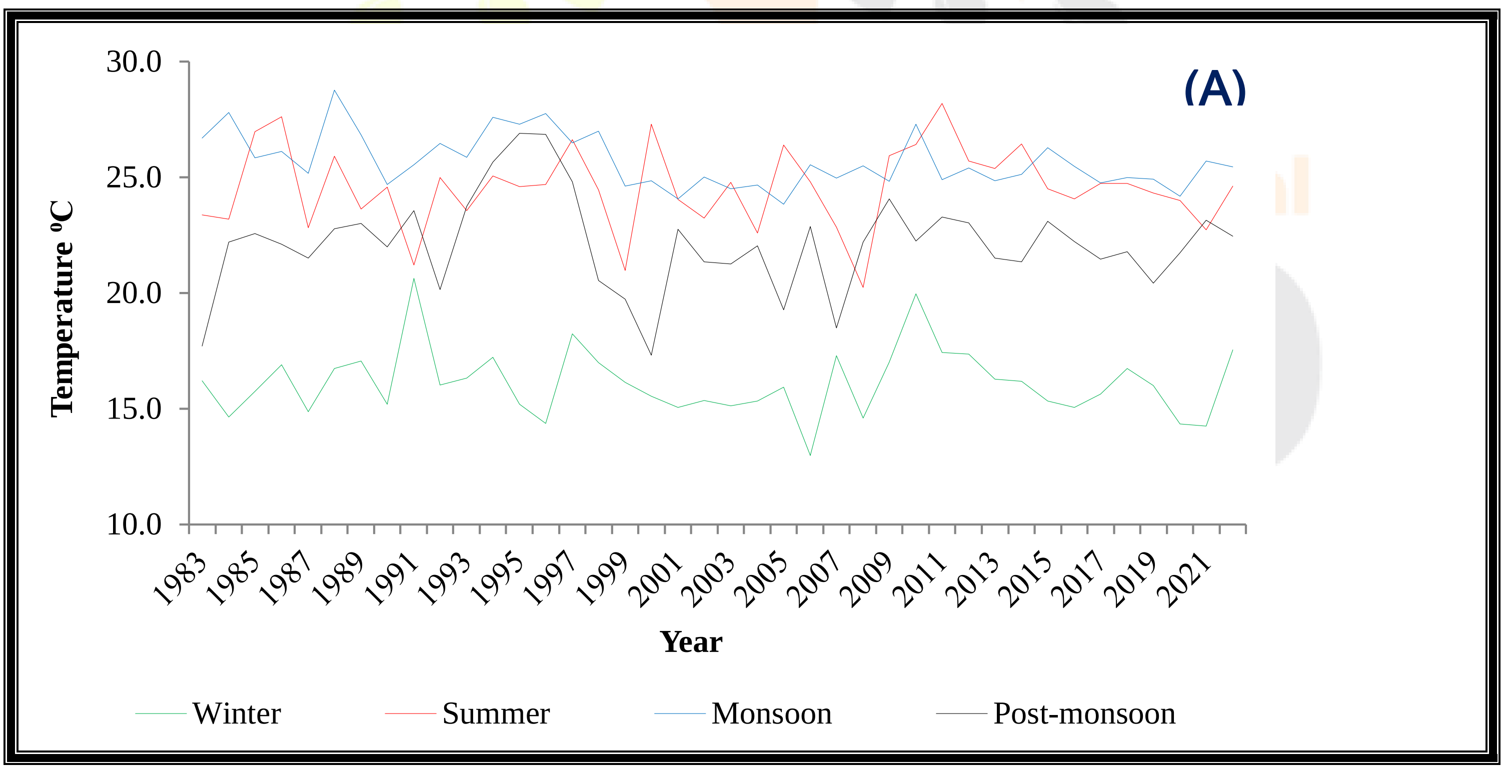


Fig. 2: Annual Mean Temperature Trends between 1983 and 2022 (**Source:** ICAR- NBPGR RS)



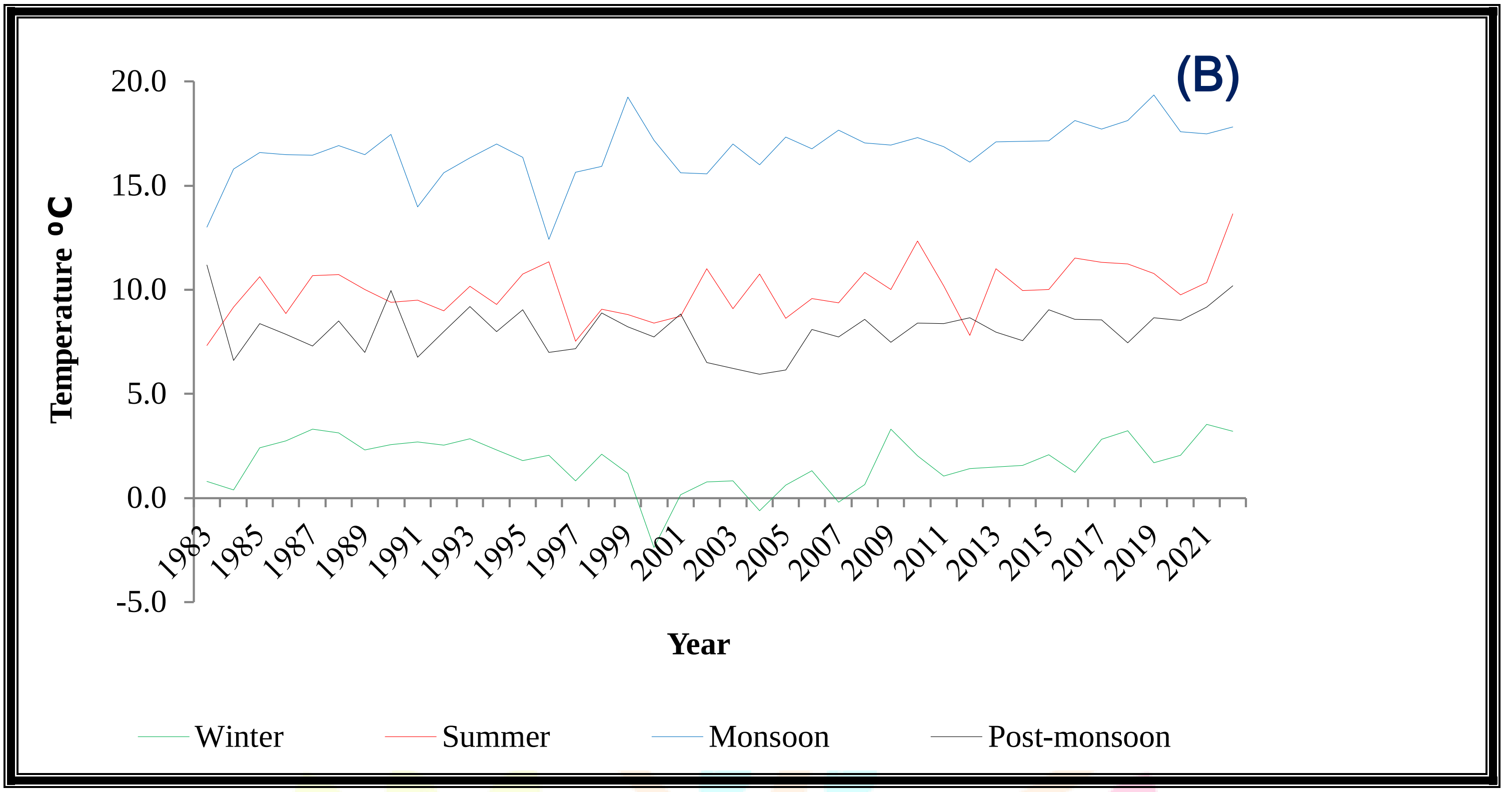


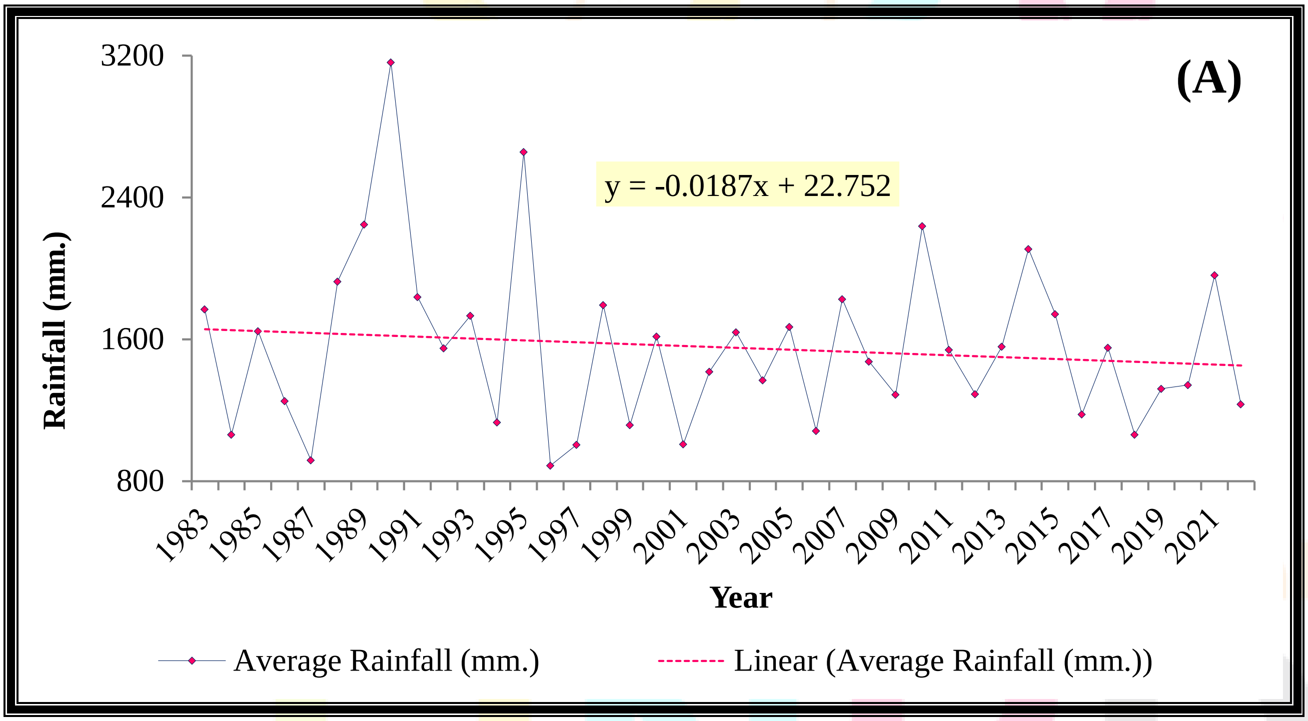
Fig. 3: Seasonal Temperature Trends: [**A**] Maximum Temperature and [**B**] Minimum Temperature between 1983 and 2022 (**Source:** ICAR- NBPGR RS)

Moreover, the seasonal temperature pattern for T_{max} exhibit declining trend, viz., 0.01ºC/year (winter season), 0.05ºC/year (monsoon season), and 0.01ºC/year (post-monsoon season) whereas the rising trend was observed at the rate of 0.023ºC/year during summer season [Fig. 3 (A)]. Furthermore, the T_{min} is increasing all the seasons at the rate of 0.002ºC/year (winter season), 0.05ºC/year (summer season), 0.06ºC/year (monsoon season) and 0.01ºC/year during post monsoon season [Fig. 3 (B)].

3.1.2. Variability in Rainfall Pattern

The Betalghat development block is located in the Lesser Himalayan ranges. The rainfall is the most important form of precipitation in this region as most of the precipitation in the developmental block is received through rainfall. The distribution of rainfall in the region mainly depends upon, altitude, slope aspect and alignment of ridges. Physiographic diversities and altitudinal variations play important role in determining the quantity of rainfall at different locations. Study region falls in sub-tropical and temperate climatic regimes and the total average rainfall in the region has been recorded to be 1555 mm during the last 40 years. Thus, based on this absolute rainfall value, the entire region falls under moderate rainfall zones. The rainfall pattern is governed by the southwest monsoon, and nearly 80% of the total annual rainfall occurs during the monsoon season normally between 15 June and 15 September. The rainfall data have been obtained from the Indian Council of Agriculture Research, National Bureau of Plant Genetic Resources and Regional Station (ICAR- NBPGR RS) located at Bhowali, Niglat in Betalghat development block. Besides analyzing the daily rainfall pattern, the arithmetic average has been used for the construction of monthly mean rainfall data in the region. The daily rainfall data has been used for determining the number of total monthly and annual rainy days. The temporal pattern of rainfall is reflected by its annual, monthly and seasonal variability, and the number of rainy days. This section comprised annual and seasonal rainfall and rainy days analysis over the Betalghat development block from 1983 to 2022.

Fig. 4 [A] indicates that over the past forty years, the average annual rainfall in the study area has been steadily decreasing at a rate of 0.02 mm/year. After a comprehensive analysis of seasonal rainfall data, it was observed that the monsoon season has recorded the highest and the winter season has received minimum rainfall amount. However, Fig. 4 [B] shows that the seasonal rainfall of the study area illustrates a slightly increasing trend; respectively, 0.29 mm/year (summer season), 0.94 mm/year (post-monsoon), and 0.94 mm/year (winter season) whereas monsoon season shows decreasing trend with the rate of 4.30mm/year.



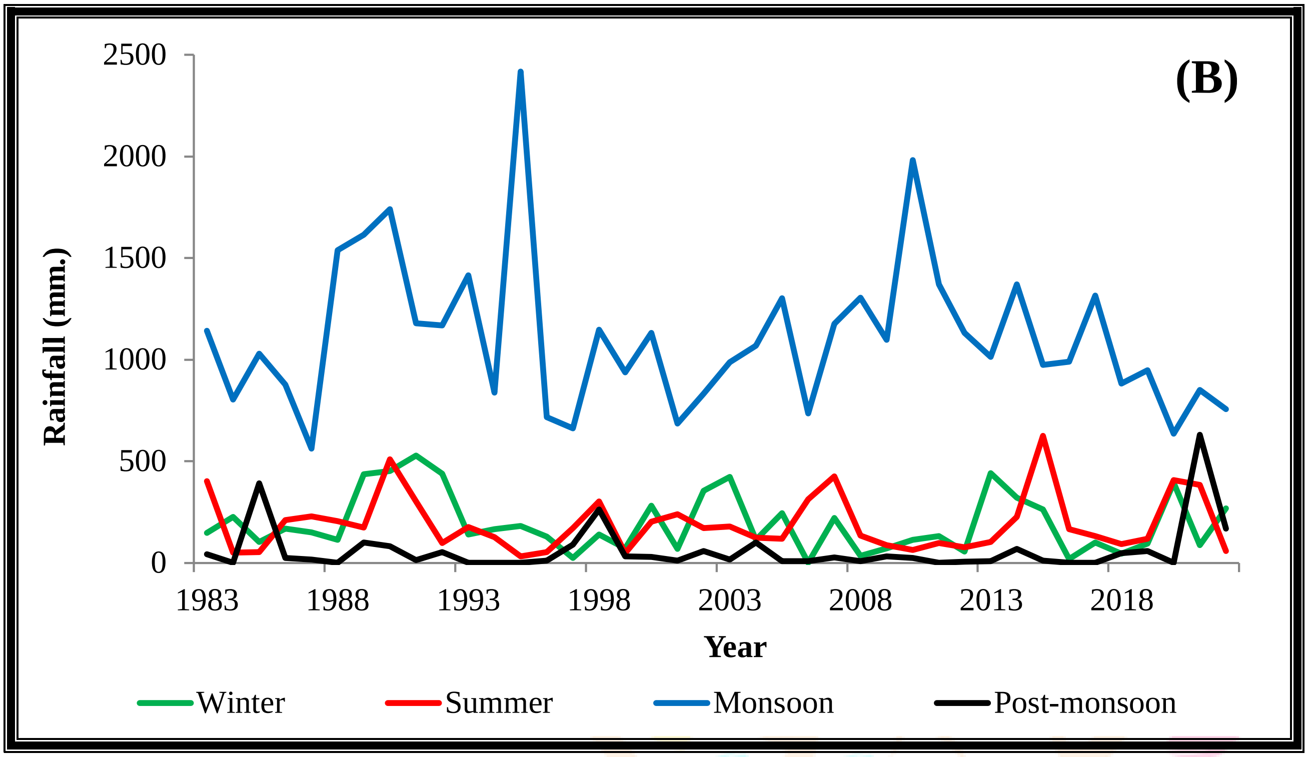


Fig. 4: Rainfall Trends: [A] Annual Trends and [B] Seasonal Trends between 1983 and 2022 (**Source:** ICAR-NBPGR RS)

Conclusion

The mean value of the average annual T_{max} and the average annual T_{min} in the study area are 22.4ºC ± 0.12ºC and 9.9ºC ± 0.09ºC, respectively, which demonstrate significant change in the annual average temperature. The T_{max} presents a decreasing trend of 0.02ºC/year and T_{min} reveals an increasing trend of 0.03ºC/year, respectively. Moreover, Betalghat development block observed an overall decreasing trend has been observed in annual rainfall at the rate of 0.02 mm/year. However, the seasonal rainfall in the study region shows a slightly increasing trend of 0.29 mm/year (summer season), 0.94 mm/year (post-monsoon), and 0.94 mm/year (winter season), whereas the monsoon season shows a decreasing trend with a rate of 4.30mm/year.

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