

## Long Term Temperature Analysis during Winter Season for Some Selected Districts of Sub-Himalayan West Bengal, India

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**Abstract** Spatial trend analysis of winter temperature has attracted the attention of a group of scientists as it is directly related to the cultivation of a wide range of *rabi* crops and human comfort. Winter season in West Bengal broadly coincides with 3 months namely, December, January and February. The present study was carried out to investigate the change of winter temperature of the 4 districts (Darjeeling, Jalpaiguri, Uttar Dinajpur and Dakshin Dinajpur) of sub-Himalayan West Bengal by analyzing mean monthly maximum and minimum temperature data of these 3 months (December-February) from 1901 to 2011. The study reveals that the district Darjeeling exhibits declining trend of maximum temperature in the month of January and December while the mean minimum temperature is found to be increasing in all the winter months. District Jalpaiguri shows declining trend in winter temperature except in the month of February where increasing trend of mean minimum temperature at the rate of 0.002°C/year is observed. The trend of mean minimum and maximum temperature is positive for both Uttar and Dakshin Dinajpur.

**Keywords** Winter, Trend, Climate change, Food security.

### Introduction

In the context of global warming and climate change, assessment of temperature change will pay the attention of the scientists and the policy makers. Investigation of seasonal temperature change over an area is very crucial for studying its impact on agricultural crops and hydrological planning (Chakraborty et al. 2014).

Climate change and variability may be considered as the biggest challenge of 21<sup>st</sup> century (Kashaigili et al. 2014). Agriculturally dependent countries are the most vulnerable to the impact of climate change due to inadequate adaptation strategies, economic instability and weak governmental policy. Changing pattern of temperature and rainfall have now been considered as serious threat to sustainable development which not only affects the agricultural production and food security but also damages the economic activities of a region.

West Bengal is primarily an agrarian state of India (Pal et al. 2015). The state has diverse natural resources. Winter season in West Bengal is characterized by low temperature and abundant sunshine which present a congenial situation for cultivation of a wide range of crops (wheat, oilseeds, potato, pulses). Academic disciplines and economic sectors, such as ecology, agriculture and water resource management are interested in studying the historical trend in climatic variables (MacKellar et al. 2014). Investigation and characterization of climatic parameters are very difficult due to non availability of long-term climatic data. Besides, poor quality of data and insufficient

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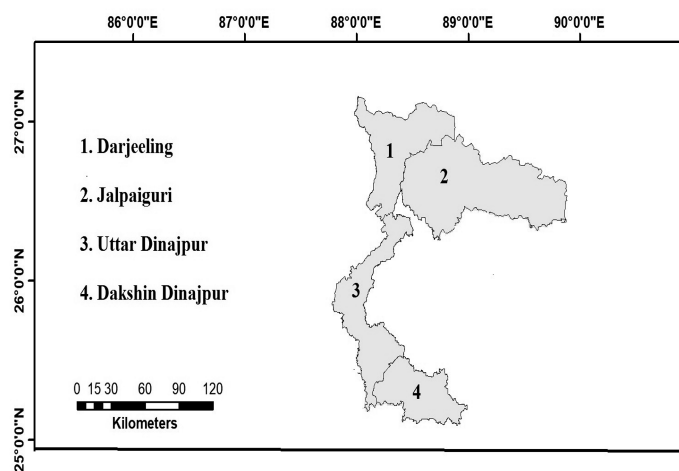
**Table 1.** Trend of maximum and minimum temperature during winter season (1901-2011).

Districts	Months					
	January		February		December	
	Maximum temperature (°C)	Minimum temperature (°C)	Maximum temperature (°C)	Minimum temperature (°C)	Maximum temperature (°C)	Minimum temperature (°C)
Darjeeling	Moderate decline	Moderate increase	Moderate increase	Sharp increase	Moderate decline	Moderate increase
Slope (°C/year)	-0.006	0.002	0.003	0.013	-0.005	0.004
Jalpaiguri	Sharp decline	Moderate decline	Moderate decline	Moderate increase	Sharp decline	Moderate decline
Slope (°C/year)	-0.019	-0.009	-0.001	0.002	-0.018	-0.006
Uttar Dinajpur	Sharp increase	Moderate increase	Sharp increase	Sharp increase	Sharp increase	Sharp increase
Slope (°C/year)	0.012	0.001	0.023	0.022	0.018	0.020
Dakshin Dinajpur	Moderate increase	Slight decline	Sharp increase	Moderate increase	Sharp increase	Sharp increase
Slope (°C/year)	0.005	-0.001	0.014	0.001	0.014	0.011

coverage of the surface weather instruments make the representation of regional climatic characteristics restricted. Some countries have also restricted the use and sharing of meteorological data. Despite these short comings, a number of studies have been carried out by the researchers to investigate the recent trend of atmospheric temperature (Safari 2012,

Chakraborty et al. 2014, Chattopadhyay and Edwards 2016, Rsahmstorf et al. 2017, MacKellar et al. 2014). So, Keeping the above points in view, the present paper has investigated the trend of winter temperature of some selected districts of sub-Himalayan West Bengal (Fig. 1).

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**Fig. 1.** Location map of the study area.

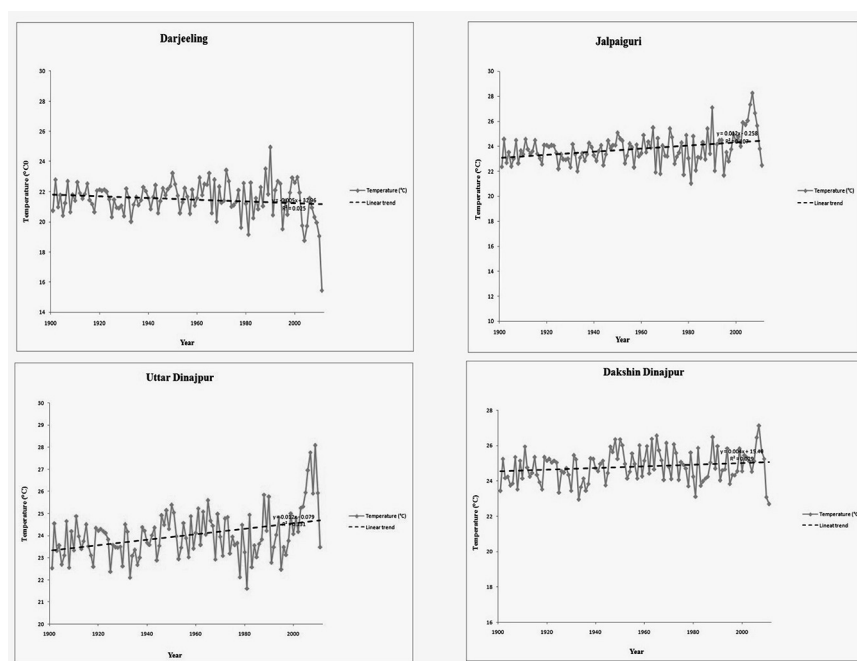


Fig. 2. Trend of maximum temperature in January (1901-2011).

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### Materials and Methods

The present study deals with both maximum and minimum temperature data of winter season i.e. from December to February. Maximum and minimum temperature data of these four districts have been collected from Agricultural Meteorology Division of the State Agriculture Department, Government of West Bengal, NCEP and India Meteorological Department through the Indian water-portal website (<http://www.indiawaterportal.org/>) for the time period of 1901 to 2011. The data were analyzed on monthly basis and statistical parameters like mean and slope

were determined with the MS Excel 2007 software. Linear trends have been used to show the sequential change of maximum and minimum temperature over the time period of 111 years (1901-2012) during winter season.

### Results and Discussion

The average maximum temperature of these four districts is found to be 24.87°C during winter season which ranges from 22.85°C (lowest) over Darjeeling to 26.19°C (highest) over dakshin Dinajpur, and the average minimum temperature of the study area is 10.88°C. District Darjeeling records the lowest mean minimum temperature of 9.53°C whereas highest mean minimum temperature (12.24°C) during winter is recorded by Dakshin Dinajpur. The study area, on an average, experienced low minimum and maximum temperature in 1903, 1908, 1918, 1951, 1965, 2011 and 1905, 1952, 1970, 1978, 2007, 2010 respectively. Analysis of mean maximum and minimum temperature data of individual month from December to Feb-

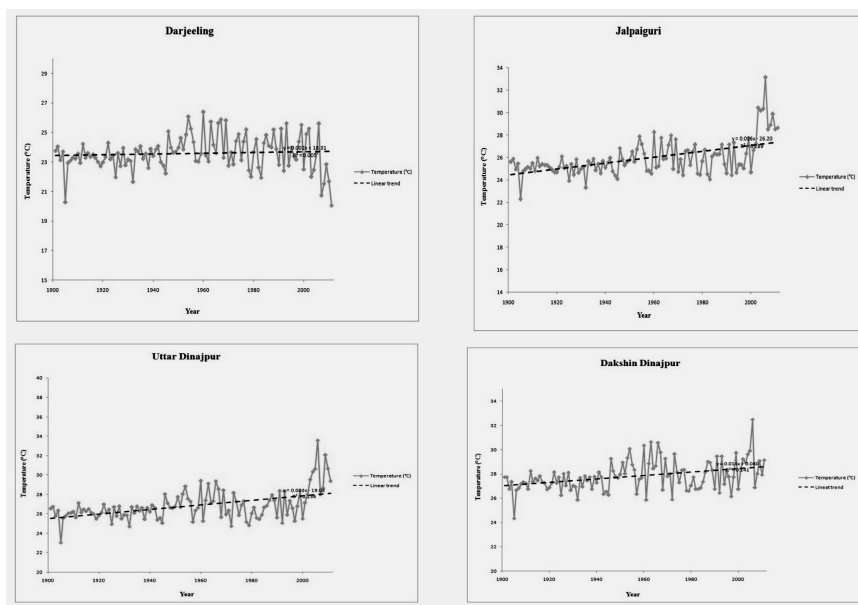


Fig. 3. Trend of maximum temperature in February (1901-2011).

ruary revealed that the study area experienced lowest mean minimum temperature ( $8.34^{\circ}\text{C}$ ) in the month of January followed by Uttar Dinajpur ( $9.29^{\circ}\text{C}$ ) and

Jalpaiguri( $10.06^{\circ}\text{C}$ ) whereas mean maximum temperature ranges from  $27.81^{\circ}\text{C}$  over Dakshin Dinajpur to  $21.5^{\circ}\text{C}$  over Darjeeling in the month of February

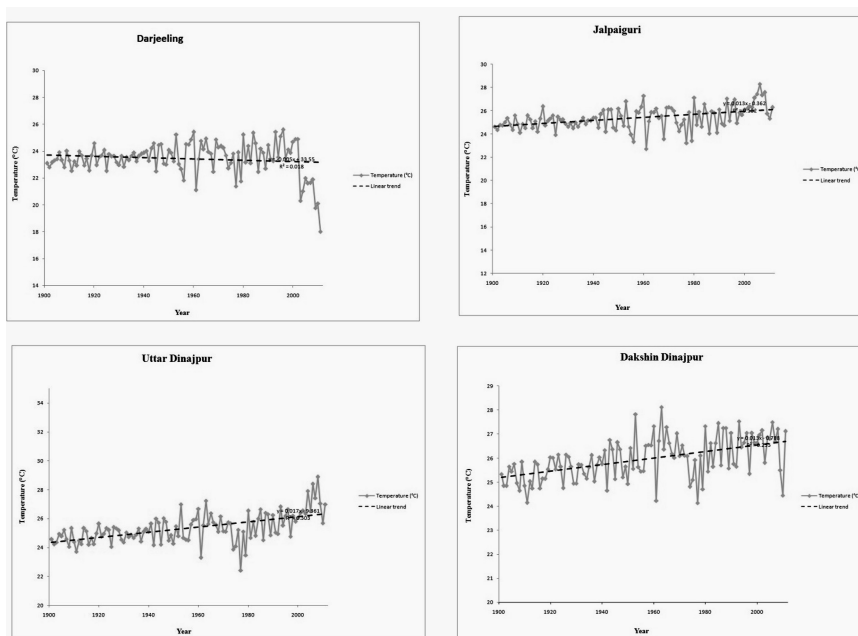


Fig. 4. Trend of maximum temperature in December (1901-2011).

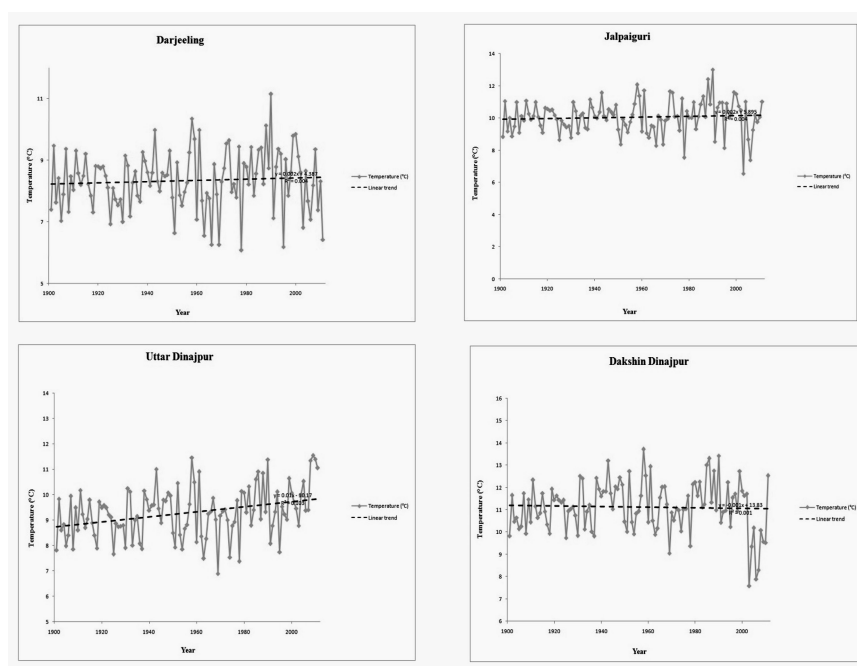


Fig. 5. Trend of minimum temperature in January (1901-2011).

and January respectively (Table 1).

Mean maximum temperature in the month of January shows a rising trend in Uttar and Dakshin Dinajpur ( $0.012^{\circ}\text{C}$  and  $0.005^{\circ}\text{C}/\text{year}$  respectively) whereas declining trend is noticed for Darjeeling ( $-0.006^{\circ}\text{C}/\text{year}$ ) and Jalpaiguri ( $-0.019^{\circ}\text{C}/\text{year}$ ). The situation changes in the month of February. All the districts except Jalpaiguri ( $-0.001^{\circ}\text{C}/\text{year}$ ) exhibit clear rising trend of maximum temperature at the rate of  $0.003^{\circ}\text{C}$  (Darjeeling),  $0.023^{\circ}\text{C}$  (Uttar Dinajpur) and  $0.014^{\circ}\text{C}/\text{year}$  (Dakshin Dinajpur), Mean maximum temperature is found to be increasing over Uttar Dinajpur and Dakshin Dinajpur at the rate of  $0.018^{\circ}\text{C}$  and  $0.014^{\circ}\text{C}/\text{year}$  respectively while declining trend at the rate of  $-0.005^{\circ}\text{C}$  and  $-0.018^{\circ}\text{C}/\text{year}$  is noticed over Darjeeling and Jalpaiguri respectively (Figs. 2–4).

Districts Darjeeling and Uttar Dinajpur exhibit increasing trend of mean minimum temperature at the rate of  $0.002^{\circ}\text{C}$  and  $0.001^{\circ}\text{C}/\text{year}$  respectively in the month of January whereas the trend is negative for Jalpaiguri ( $-0.009^{\circ}\text{C}/\text{year}$ ) and Dakshin Dinajpur

( $-0.001^{\circ}\text{C}/\text{year}$ ).

Mean minimum temperature is found to be increasing over all the studied districts of sub-Himalayan West Bengal in the month of February. Districts Darjeeling, Uttar Dinajpur and Dakshin Dinajpur exhibit clear rising trend in the mean minimum temperature at the rate of  $0.004^{\circ}\text{C}$ ,  $0.020^{\circ}\text{C}$  and  $0.011^{\circ}\text{C}/\text{year}$  respectively while the trend is negative for the district Jalpaiguri ( $-0.006^{\circ}\text{C}/\text{year}$ ) (Figs. 5–7).

The entire time span of 111 years (1901-2011) has been divided into two parts i.e. from 1901 to 1955 and from 1956 to 2012. In the first 55, years (1901-1955), the average maximum temperature of these four districts were found to be  $22.85^{\circ}\text{C}$ ,  $24.98^{\circ}\text{C}$ ,  $25.89^{\circ}\text{C}$  and  $24.62^{\circ}\text{C}$  for Darjeeling, Uttar Dinajpur, Dakshin Dinajpur and Jalpaiguri respectively which increased to  $25.82^{\circ}\text{C}$ ,  $26.49^{\circ}\text{C}$  and  $25.42^{\circ}\text{C}$  over Uttar Dinajpur, Dakshin Dinajpur and Jalpaiguri respectively except in the case of Darjeeling where the maximum temperature decreased by  $0.01^{\circ}\text{C}$  in the second half (1956-2012). The change of mean

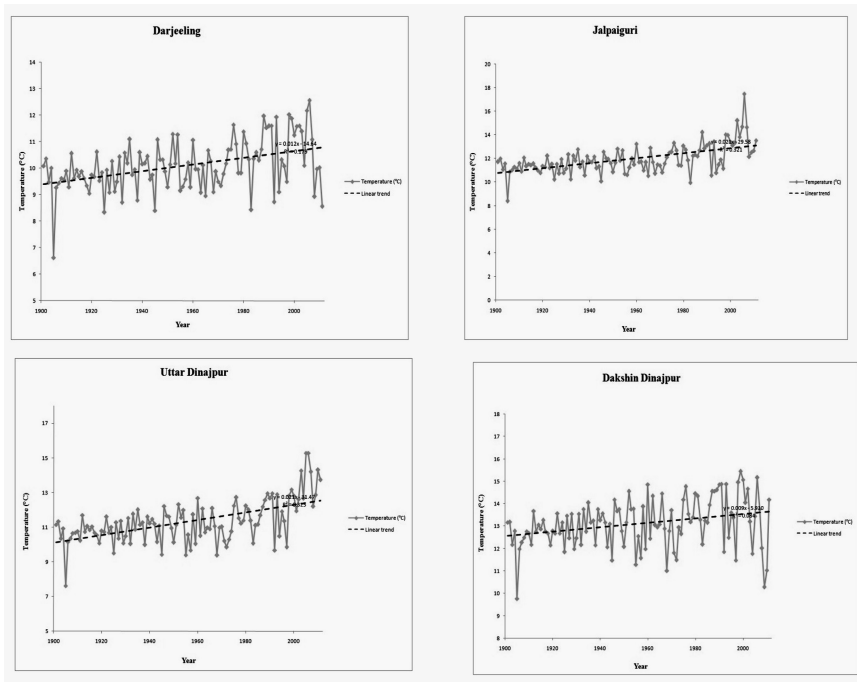


Fig. 6. Trend of minimum temperature in February (1901-2011).

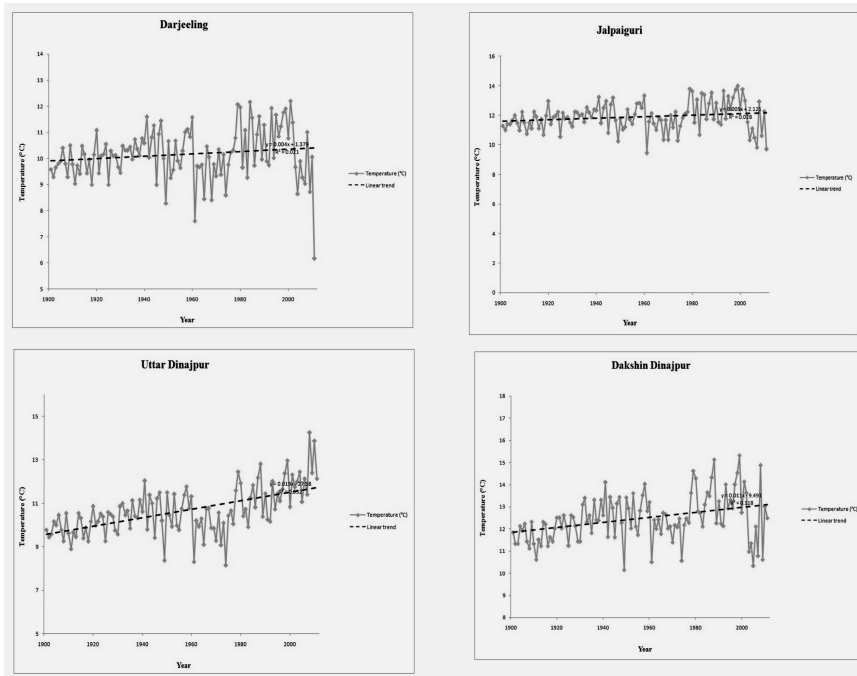


Fig. 7. Trend of minimum temperature in December (1901-2011).

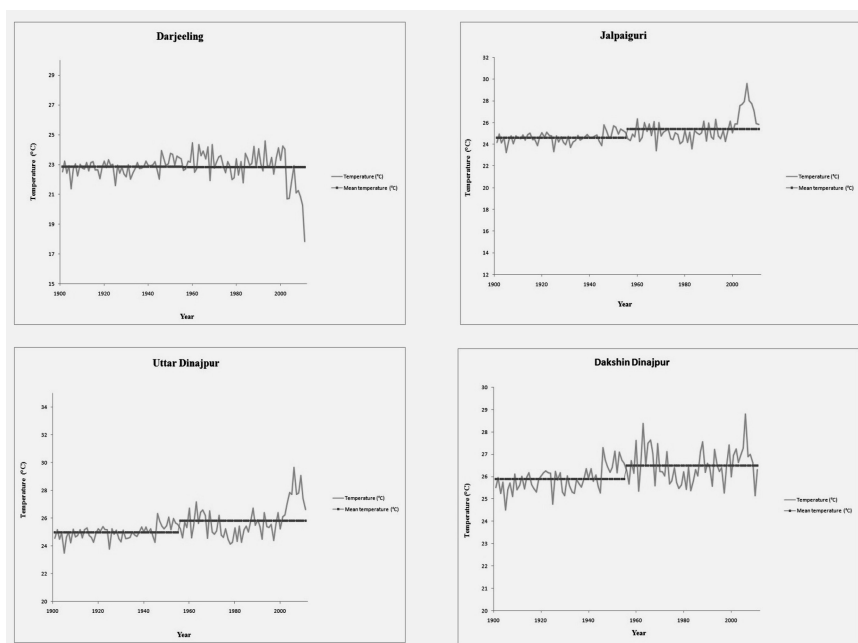


Fig. 8. Change of mean maximum temperature line during winter season (1901-2011).

minimum temperature is highest for the district Uttar Dinajpur (0.75°C), followed by Jalpaiguri (0.48°C), Dakshin Dinajpur (0.35°C) and Darjeeling (0.33°C) (Figs. 8, 9).

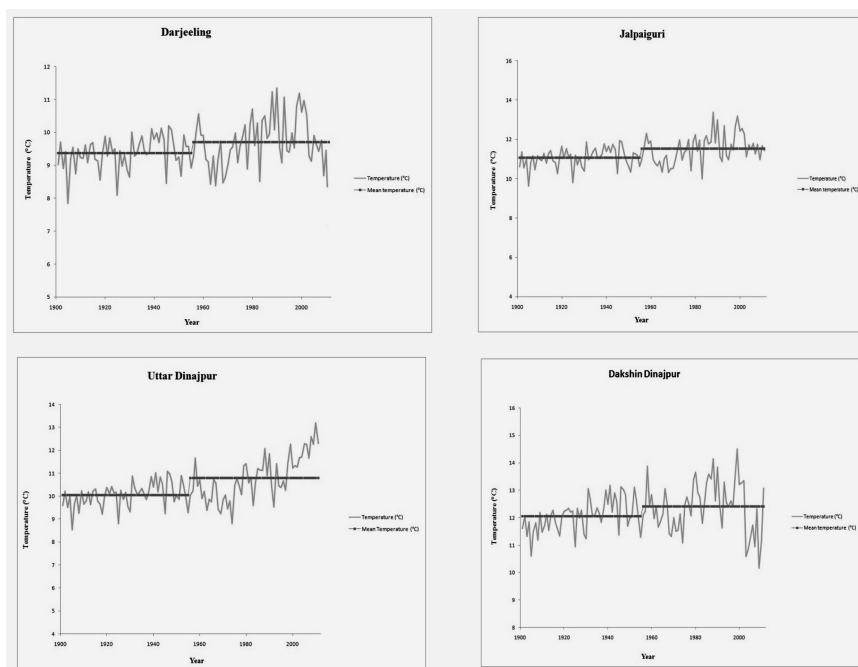


Fig. 9. Change of mean minimum temperature line during winter season (1901-2011).

## Conclusion

Indian agriculture is largely controlled by the variability of temperature and rainfall. Success of *rabi* crops cultivation in the state largely depend on the favorable temperature regime during winter season. So, an investigation of spatio-temporal trend and fluctuation of temperature will be helpful for the planning of agricultural activities and efficient management of water resources. The study area, on an average, depends on agricultural activities for their livelihood. So, a minor fluctuations in winter temperature may hamper the cultivation of a wide range of *rabi* crops. The crops grown in this area during winter season are sensitive to the temperature change. The present study has investigated the trend of maximum and minimum temperature during winter season for the timeperiod of 111 years i.e. from 1901 to 2011 using a large data set. From the present study, it can be clearly indicated that the winter season is experiencing high warming.

The study reveals that the district Darjeeling shows a declining trend of maximum temperature in the month of January and December while the mean minimum temperature is found to be increasing in all the winter months. District Jalpaiguri exhibits declining trend in winter temperature except in the month of February where increasing trend of mean minimum temperature is noticed. The trend of mean minimum and maximum temperature is positive for Uttar and Dakshin Dinajpur. It is also revealed from the present study that the mean minimum and

maximum temperature increased in the recent 56 years (1956-2011) compared to the past 55 years (1901-1955) except for the district Darjeeling where the maximum temperature increased in the second half (1956-2011).

It is hoped that the study in general will be helpful for the geographers, agricultural policy makers and scientists so that they can suggest suitable measures for the growth of winter crops in this region.

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