Long term analysis of Temperature Extremes over Punjab and Himachal Pradesh, India (1951-2013)

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Abstract

Any significant change in intensity and frequency of temperature extremes affects key sectors of economy of a region. This research paper provides along-term analysis of temperature extremes over Punjab and Himachal Pradesh, India (1951-2013). Monthly and annual changes to temperature extremes indices were studied using homogenized gridded daily minimum and maximum temperature series. Fourteen extreme temperature indices were selected from the list of core climate extreme indices by World Meteorological Organization (WMO)- World Climate Research Program. Rclimdex 1.1 software was used in this study for calculation of climate extremes and a quality control of each grid (1°*1°) was performed to identify errors caused by data processing.

A large number of stations show non-significant warming of monthly maximum and minimum temperatures. There is an increase in warm days and significant increase in warm nights as opposed to cool nights that are experiencing cooling. Warm spell duration indicator shows significant increase in frequency of warm spells while cold spell duration indicator shows non-significant increase in cold spells. An increase in warmest days suggests an increase in warming in the region but with decreased growing seasons length (GSL)it could have a negative impact on crop production and harvest.

KEYWORDS: Temperature Extremes, Warm Spell, Cold Spell, Growing Season Length

1. Introduction

Changes in the frequency of extremes (increases or decreases) are often the most sensitive aspects of climate change for ecosystem and societal responses (Katz 1999). Extreme events pose serious problem to natural as well as socio-economic environment and is an important theme of enquiry for both developed and underdeveloped world. Temperature extremes are a major aspect that has been undertaken by climate researchers. Frich et al. (2002) has found a statistically significant reduction in the difference between annual extremes of daily maximum and minimum temperatures during the latter half of the 20thcentury. In China, Zhai and Pan (2003) observed strong increase in the absolute minimum temperature, with decrease in the one-day seasonal extreme maximum temperature since 1950s. Kunkel et al. (1996) and Karl and Knight (1997), Kunkel et al. (2008) analysed trends of short duration episodes of extreme hot or cold weather during 20thcentury in the United States and found no significant changes in frequency or intensity. In an extensive assessment of the change in frequency of heat waves during the latter half of the 20th century, Frich et al. (2002) and Jones et al. (2013) found some evidences for an increase in heat-wave frequency across the globe except for Africa and South America. During the 1997-98 El Nino events, global temperature records were broken for sixteen consecutive months from May 1997 through to August 1998. Karl et al. (2000) and Morak et al. (2013) describe this as an unusual event and such a monthly sequence is unprecedented in the observational records. De and Mukhopadhyay

(1998), Kawahara and Yamazaki (1999), Zhai (1999), Lal and Harasawa(2001), Zhai and Pan (2003), Ryoo (2004), Batima (2005), Tran (2005), Cruz (2006), Morak et al. (2013) observed significantly longer heatwave duration in many countries of Asia, as indicated by pronounced warming trends and several cases of severe heatwaves. Sillmann et al. (2013) reported that South East Asia is one of the two regions (other Amazon) where the number of heat extremes is expected to increase strongly even under a low-emission scenario of greenhouse gases.

Due to large geographical extent and variations in climate within the Indian continent, extreme weather has been projected to vary spatially. De and Mukhopadhyay (1998), Lal (2003) found that the frequency of hot days and multiple-day heatwaves has increased in past century and there has been an increase in deaths due to heat stress in recent years. IPCC (2013) has reported that with an increase in temperature by 4%, the monsoon rainfall will not be uniform and would witness 10% increase in inter-annual and intra-seasonal variability. Rupa et al. (1992) and Srivastava et al. (1992) found that decadal trends of diurnal temperature range over India is quite different from those observed over other parts of the globe because of the comparatively large increase in maximum temperature (Tmax) over a large part of India. Recently there has been an increasing trend in annual mean temperature and an increase of temperature of 0.68°C per century has been observed. The warming has been observed to be more pronounced during post monsoon and winter (Savelieva et al. 2000; Izrael 2002; Gruza and Rankova 2004). Tripathi and Singh (2013) found that maximum temperature variability for wet and dry periods decreased in most of summer months and increased in most of winter months.

This paper focuses on evaluating the long-term patterns and trends of climate extremes for the period 1951-2013 with an emphasis on highlighting the spatial and temporal variability. A study on these aspects of temperature extremes is relevant as it not only reveals the general trend of occurrence of extremes but also helps identifying change in amount, intensity, direction and the mechanisms that has prompted changes in the past.

2. Study Area

The study region is roughly a quadrilateral shaped area situated between 29°30′N to 33°12′N latitudes to 73°55′E to 79°04′E longitudes. This region is a part of Himalayan system and adjacent Punjab plains that is divided into 4 broad physiographic zones: Punjab Plains, the Siwaliks, the Inner Himalayas (Dhauladhar and PirPanjal ranges) and the Great Himalayas. Situated between the hot desert in southwest and the cold desert in northeast, the study area has wide altitudinal range between 200-7000 meters. Punjab and Himachal Pradesh forms a physically contiguous natural region; these two states as one geographic unit have been selected for this study for their strong physiographic, climatic and hydrological links.

The region’s geography is climatically pivotal; the Himalayas in the north and east bar the infiltration of frigid katabatic winds from the Tibetan plateau and the Central Asia. The Punjab Plains and the Thar Desert of Rajasthan in the south west plays a significant role in determining summer and winter temperature regimes in addition to attracting moisture-laden southwest summer monsoon winds that provide over 60 per cent of this region’s total annual rainfall. The region has several topographic contrasts giving rise to number of microclimates. The Punjab region experiences dry-arid, tropical and subtropical climate, while Himachal Pradesh experiences great variation from hot and sub-humid tropical in the southern tracts to cold and alpine climate in the northern and eastern mountain (Map 1). The climate of the Punjab and Himachal

Pradesh due to its geographical position is subject to great climate variability and extremes. The annual range of temperature is over 50 degrees Celsius (maximum of 48°C in Amritsar, Punjab and minimum temperature of -15°C in Keylong in Lahaul-Spiti district, Himachal Pradesh) making this region climatically diverse.

3. Data Quality and Control

Daily maximum and minimum surface temperatures were taken from high resolution daily gridded temperature datasets from India Meteorological Department (IMD), Pune between 29.5°E-33.5°N and 73.5°E-79.5°E for the period 1951-2013. This period has been selected to maximize the number of stations with data available for calculation of indices. Gridded datasets have been used because averaging over all stations in an area will not reduce trend but will reduce the effect of natural variability and thus increase detection probability. Also, gridding of datasets reduces or eliminate effects if in homogeneities are not systematic because in homogeneities at different locations may appear at different times. In addition, gridding puts less weight on individual stations, as a result of which trend estimates are much less affected by outliers. When stations are irregularly distributed over a region, areas with a higher density of stations are overrepresented in the regional averages.

An exhaustive data quality control was conducted because indices of extremes are sensitive to changes in location, exposure, equipment and observer practice (Haylock et al., 2006). Data quality control is an important prerequisite before calculation of extreme indices. A quality control (QC) of each grid (1°*1°) was performed to identify errors caused by data processing. For the present study, QC module of Rclimdex 1.1 software was used which perform following procedures:

(i) Replaces all missing values coded as -99.9 into an acceptable format that software recognizes as NA (Not Variable).

(ii) Replaces all unreasonable or erroneous values such as daily maximum temperature less than daily minimum i.e. Tmax<Tmin into NA.

Following Zhang et al. (2005) for identification of outliers, for every mean value of daily temperature variable it was checked that whether it falls within the range of ±4 standard deviations.

4. Methodology

The Rclimdex 1.1 software (developed by Zhang and Yang from Canadian Meteorological Service) was used in this study for calculation of climate extremes. Rclimdex 1.1 provides for calculation of 27 extreme climate indices, out of which 14 indices (Table 1) based on surface air temperature were chosen for this study. The temperature indices describe cold extremes as well as warm extremes. These indices were jointly established by ETCCDMI and World Meteorological Organization (WMO) commission for Climatology and the Research Programme on Climate Variability and Predictability (CLIVAR). The resulting series were analysed for trend detection using least square linear fit. The least-squares trends are easy to understand and are good for estimating the uncertainty in the fitted trends that arises from sampling variability. Statistically significant trends were identified at 95% confidence level. Trend for each of the temperature extremes index were assessed.

To run the Rclimdex 1.1 software, following requirements of the format was used: (a) ASCII text file (b) column sequence: Year, Month, Day, Precipitation, Tmax and Tmin (c) missing data records were coded as -99.9 and data were in calendar date order (d) Monthly (Annual) indices were calculated if no more than 3 (15) days were missing in a month (year).

5. Results and Discussions

5.1 Trends of Temperature Extremes

This section discusses the spatial and temporal variability of trends of temperature extremes in the region of Punjab and Himachal Pradesh analysed for the period 1951-2013. Significance of trends and decadal rates of trends of temperature indices are shown in Table 2 and Table 3.

5.2 Hottest Days (TXx)

TXx explains the monthly maximum value of daily maximum temperature representing the hottest days' temperature variations on annual scale. Hottest days' index has been increasing for the entire region (except eastern and southern Himachal Pradesh) at a rate of 0.1°C to 0.2°C per decade. The greatest increasing trend is observed in southwest Punjab where an increase rate of 0.2°C to 0.3°C per decade has been observed. A decreasing trend is witnessed only in the eastern areas and southern areas of Himachal Pradesh, where hottest days are decreasing at a rate of -0.1°C to -0.01°C per decade. The highest averaged annual days of hottest days for the region was recorded as 40.70°C in 1958, 40.69°C in 1988 and 40.59°C in 1995. The increase in intensity of the hottest days in the region suggests an increase in warming in the region particularly in dry arid southwest region of Punjab.

5.3 Hottest Nights (TNx)

The annual averaged variability and change in the monthly maximum of daily minimum temperature (TNx) during the analysis period (1951-2013) has been decreasing for the entire Himachal Pradesh and for northern and eastern Punjab at a decrease rate of -0.2°C to -0.07°C per decade. While the decrease in central and western Punjab is moderate at a rate of -0.07°C to -0.001°C per decade. A weak increasing trend is observed only in southern Punjab where an increase rate of 0.001°C to 0.02°C per decade has been observed. The highest averaged annual days of hottest nights for the region was recorded as 26.27°C in 1951, 26.46°C in 1958, 26.22°C in 1960 and 26.64°C in 1972.

5.4 Coldest Days (TXn)

The monthly minimum value of daily maximum temperature (TXn) represents the coldest days' temperature variations on annual scale. Coldest days' index has been decreasing for the entire region (except northern Himachal Pradesh) at a decrease rate of -0.3°C to -0.1°C per decade. An increasing trend is witnessed only in the upper northern areas of Himachal Pradesh, where coldest days are increasing at an increasing rate of 0.01°C to 0.1°C per decade. The lowest averaged annual days of coldest days for the region was recorded in the 5.47°C in 1957, 6.07°C in 1961 and 6.66°C in 1953. The decrease in intensity of the coldest days in the region suggests an increase in warming in the region except cold arid region of Himachal Pradesh.

5.5 Coldest Nights (TNn)

The annual averaged variability and change in the monthly minimum of daily minimum temperature (TNn) for the period (1951-2013) has been increasing for the entire region. Entire Himachal Pradesh (except a small area in southern part) and northern and eastern Punjab, coldest nights' index has been increasing at an increase rate of 0.12°C to 0.17°C per decade. While in central, western and south-eastern Punjab increase is moderate at a rate of 0°C to 0.075°C per decade. The highest increasing trend is observed only in southwest Punjab where an increase rate of 0.12°C to 0.2°C per decade has been observed. The highest averaged annual days of coldest nights for the region was recorded as 1.97°C in 1952, 1.87°C in 1958, 1.94°C in 1999 and 1.75°C in 2004.

5.6 Diurnal Temperature Range (DTR)

A slightly decreasing trend was observed for diurnal temperature range for the entire region except a small area in northern Himachal Pradesh. Sharp decreasing trend are observed in southeast Punjab and south Himachal Pradesh where the average decrease rate is in between -0.2°C to -0.12°C per decade. While the greater part of Punjab and Himachal Pradesh witnesses an averaged decrease rate of -0.12°C to -0.001°C per decade. A weaker increasing trend is noticed over a smaller area in northern Himachal Pradesh with a small increase rate of 0.001°C to 0.01°C per decade. The minimum frequency of DTR index for the region was observed during 9.20°C in 1953, 8.88°C in 1954, 8.87°C in 1957 and 8.63°C in 1961.

5.7 Summer Days (SU25)

The index SU25 refers to as annual count of days when maximum temperature of the day exceeded 25°C. Overall, there is an increasing trend of summer days for the region except southern and western Punjab. An increase in summer days was observed for entire northern and eastern Punjab and for southern, western and eastern Himachal Pradesh at an increase rate of 0.01 days to 0.9 days per decade. The sharpest increase is recorded for northern Himachal Pradesh where the increase rate accounts to 0.9 days to 1.3 days per decade. Southern and Western Punjab witnesses a decrease of SU25 index at a rate of -0.3 days to -0.01 days per decade. An increasing trend of SU25 index particularly in northern and north-eastern Himachal Pradesh suggests warming of the cold and alpine climate regime. Maximum summer days for the region was observed during 1953, 1974, 2001 and 2010.

5.8 Tropical Nights (TR20)

The index TR20 refers to the annual count of nights when minimum temperature exceeded 20°C. Overall, there is an increasing trend of tropical nights for the region with highest increase in southwest Punjab and eastern Himachal Pradesh. North and south Himachal Pradesh experiences a moderate increase in tropical nights at an increase rate of 0.3 days to 1 days per decade. Entire Punjab and eastern Himachal Pradesh witnesses a highest increase of TR20 index at a rate of 1.01 days to 1.6 days per decade. An increasing trend of TR20 index particularly for entire Punjab and eastern Himachal Pradesh suggests severe warming of the tropical and sub-tropical climate regime of Punjab, and hot and sub-humid tropical climate regime of Himachal Pradesh. Maximum topical nights for the region was observed during 1958, 1998, 2006 and 2013.

5.9 Growing Seasons Length (GSL)

Growing season length is defined as the number of days between the start of the first spell of warm days in the first half of the year, and the start of the first spell of cold days in the second half of the year. Spells of warm days are defined as six or more days with mean temperature above 5°Celsius; spells of cold days are defined as six or more days with a mean temperature below 5°Celsius. A slightly increasing trend was observed for GSL for the greater part of the northern and western Punjab and for northern and eastern Himachal Pradesh at a rate of 0.001 to 0.04 days per decade. Weaker decreasing trend are observed for rest of the region where the average decrease rate is in between -0.03 days to 0.001 days per decade. The maximum frequency of GSL index for the region was observed during in 1976, 1988, 1996 and 2000. The maximum and minimum air temperatures have shown increasing trends (table 2) which may result in elevated evapotranspiration rate during the growing season. As a result, irrigation activities during the growing season will contribute to greater water losses. A decreased GSL along with a warmer growing season could have a negative impact on crop production and could decrease harvests and seasonal yields.

5.10Warm Days (TX90p)

TX90p represents the annual averaged changes in the percentage of days when the daily maximum temperature exceeds its 90^{th} percentile. A linearly decreased trend was observed in southern and eastern region of Himachal Pradesh and central and southeast Punjab with an average decrease rate of -0.8 days to -0.001 days per decade. Southwest and northern region of Punjab and northern region of Himachal Pradesh experienced an increasing trend of warm days with an average increase of 0.001 days to 0.4 days per decade, while northwest Himachal Pradesh witnessed maximum increase of 0.4 days to 1.1 days per decade. The most frequent number of cool days were experienced during 1951, 1987, 1998 and 2001.

5.11 Warm Nights (TN90p)

TN90p explains the annual averaged frequency changes in frequency of nights when daily minimum temperature falls above its 90^{th} percentile. Analysis reveals a linearly increasing and statistically significant trend of warm night's frequency index for the entire region of Punjab and Himachal Pradesh. Greater parts of Punjab (except southern and western) and Himachal Pradesh witnesses an average increase rate of 0.17 days to 1 days per decade. Southern and western Punjab witnesses highest increase of 1 days to 2 days per decade. The region experienced the maximum percentile of hot nights during 1953, 2002, 2004 and 2006.

5.12 Cool Days (TX10p)

Cool days refers to annual averaged changes in the percentage of days when the daily maximum temperature fall below its 10^{th} percentile. Trends of cool days' frequency index shows a linearly decreasing trend in upper parts of Himachal Pradesh particularly northern and eastern region with an average decrease rate of -0.19 days to -0.01 days per decade. Greater parts of Punjab and south western Himachal Pradesh experienced an increasing trend of cool days with an average increase of 0.1 days to 0.3 days per decade, while southeast Punjab witnessed maximum increase of 0.3 days to 0.5 days per decade. The most frequent number of cool days were experienced during 1982, 1983,1986 and 1997.

5.13 Cool Nights (TN10p)

TN10p represents the annual averaged changes in the frequency of nights when the tail of daily minimum temperature falls below its 10^{th} percentile. Analysis reveals a linearly decreasing and statistically significant trend of cool night's frequency index for the region of Punjab and Himachal Pradesh. Greater parts of Punjab (except southeast and northwest) and western Himachal Pradesh witnesses an average decrease rate of -1.2 days to -1 days per decade. Northern and eastern Himachal Pradesh witnesses a decrease of -0.8 days to -0.6 days per decade while southern part is experiencing the lowest decreasing rate of -0.6 days to -0.4 days per decade. The region experienced the maximum percentile of cool nights during 1965, 1975, 1983 and 1989.

5.14 Warm Spell Duration Indicator (WSDI)

WSDI refers toan annual count of days with at least six consecutive days when the tail of maximum temperature falls above its ninetieth (90^{th}) percentile. Overall, there is an increasing trend for the WSDI index for the entire region (except a few areas in southern and eastern Himachal Pradesh). Greater parts of central Punjab and central Himachal Pradesh experiences a moderate increase is of 0.001 days to 0.5 days per decade. Southern Punjab and lower part of northern Himachal Pradesh experiences an average increase of 0.5 days to 1.5 days per decade. The upper northern Himachal

Pradesh recorded highest occurrences of WSDI index of 1.5 days to 3 days per decade. Maximum WSDI for the region were recorded in 1987, 1998 and 2010.

5.15 Cold Spell Duration Indicator (CSDI)

CSDI refers to an annual count of days with at least six consecutive days when the tail of minimum temperature falls below its tenth (10^{th}) percentile. Overall, there is an apparent decreasing trend for the CSDI index for the entire region. The sharpest decline is in the southwest and northeast part of Punjab where the average decrease is of -2.5 days to -1.3 days per decade. Eastern and northern part of Punjab and western Himachal Pradesh experiences an average decrease of -1.9 days to -0.9 days per decade. Entire Himachal Pradesh (except western part) recorded declining occurrences of CSDI index of -0.09 days to -0.001 days per decade. Maximum CSDI for the region were recorded in 1964, 1972, 1983 and 1984.

6. Conclusions

Indicators of temperature extremes determines the direction and magnitude of warming or cooling of the region, and provides a generalized picture regarding any major climatic shift in climatic parameters. The study region exhibits a wide range of temperature regimes strongly influenced by altitudinal zones. Overall there is an increasing trend of hottest days (TXx) and significant increasing trend in coldest nights (TNn), and decreasing trend in hottest nights and coldest days which is reflected in an increasing trend in diurnal temperature range (DTR).

High increasing trend of summer days (SU25) and tropical nights (TR20) suggest an overall warming of the region particularly cold arid and semi-arid climatic region of Himachal Pradesh. An increasing trend of warm spell duration indicator (where tail of maximum temperature lies above 90^{th} percentile) and decreasing trend of cold spell duration indicator (where tail of minimum temperature falls below 10^{th} percentile) indicates warming of the entire region. The entire study region for the period 1951-2013 was affected by warm extremes based on nights time indices rather than cold extremes based on day time indices.

In light of the above discussion, it appears that region exhibits overall warming and thus it becomes necessary to undertake the issues as how and to what extent this warming has potential to have implications on agriculture, ecosystems, water resources, wildlife and human development. Such an attempt would further strengthen the understanding of thermal regime behaviour in the region.

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TABLES

Table 1: List of Indicators of Temperature Extremes

S. No	ID	Indicator name	Definitions
1	**TXx**	Max Tmax	Monthly maximum value of daily maximum temperature
2	**TNx**	Max Tmin	Monthly maximum value of daily minimum temperature
3	**TXn**	Min Tmax	Monthly minimum value of daily maximum temperature
4	**TNn**	Min Tmin	Monthly minimum value of daily minimum temperature
5	**DTR**	Diurnal Temperature Range	Monthly mean difference between TX and TN
6	**SU25**	Summer Days	Annual count when TX(daily maximum)>25ºC
7	**TR20**	Tropical Nights	Annual count when TN(daily minimum)>20ºC
8	**GSL**	Growing Season Length	Annual (1st Jan to 31st Dec in NH, 1st July to 30th June in SH) count between first span of at least 6 days with TG>5ºC and first span after July 1 (January 1 in SH) of 6 days with TG<5ºC
9	**TX90p**	Warm Days	Percentage of days when TX>90th percentile
10	**TN90p**	Warm Nights	Percentage of days when TN>90th percentile
11	**TX10p**	Cool Days	Percentage of days when TX<10th percentile
12	**TN10p**	Cool Nights	Percentage of days when TN<10th percentile
13	**WSDI**	Warm spell duration indicator	Annual count of days with at least 6 consecutive days when TX>90th percentile
14	**CSDI**	Cold spell duration indicator	Annual count of days with at least 6 consecutive days when TN<10th percentile

Source: Compiled from WMO/CLIVAR List for Climate Extreme Indices.

Table 2: Significance of Trends of Indicators of Temperature Extremes

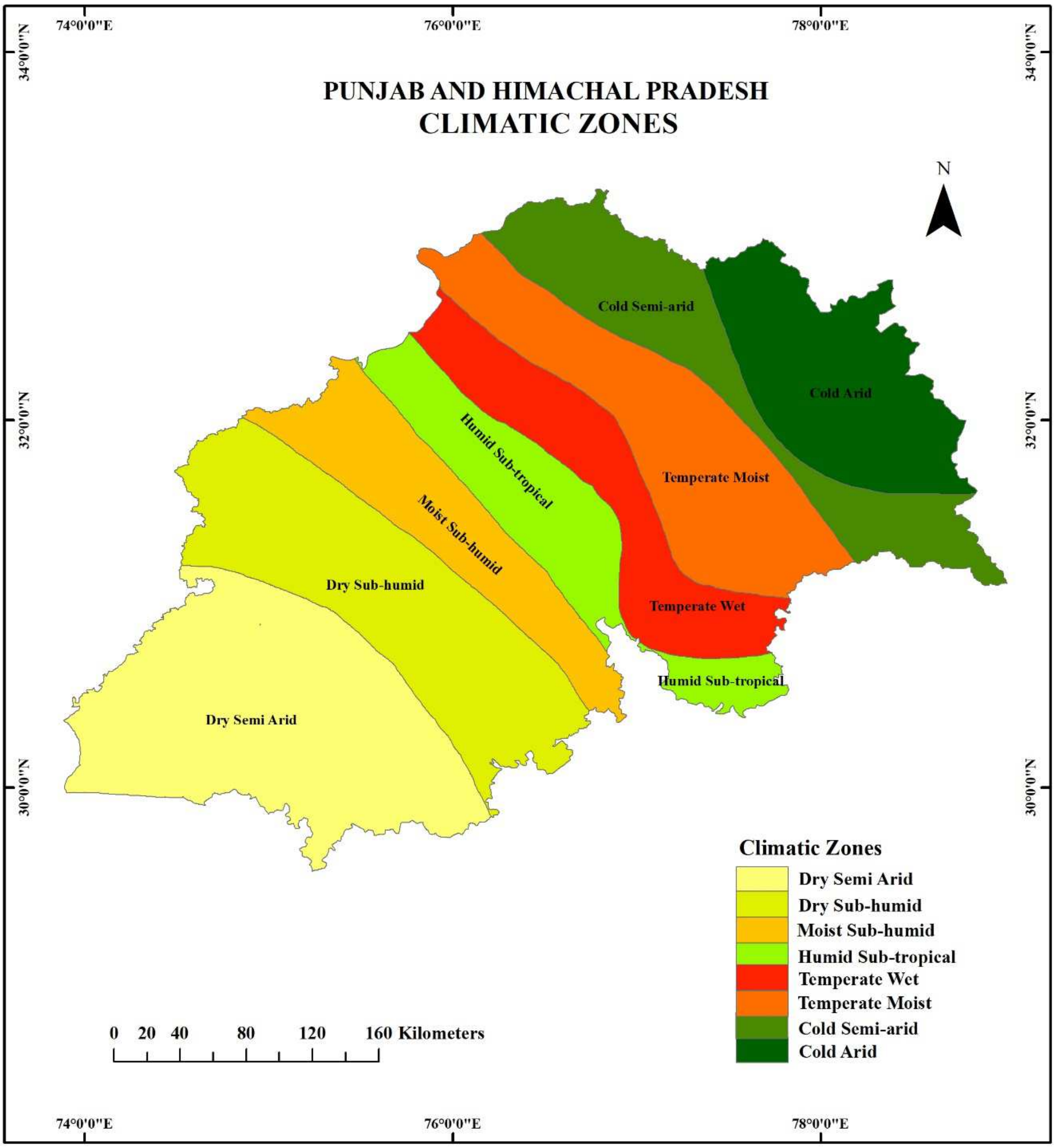
	Indicators	Positive Significant (%)	Positive Non-Significant (%)	Negative Significant (%)	Negative Non-Significant (%)
1	**TXx**	5.56	44.44	0.00	50.00
2	**TNx**	0.00	5.56	16.67	77.78
3	**TXn**	0.00	38.89	16.67	44.44
4	**TNn**	5.56	88.89	0.00	5.56
5	**DTR**	44.44	22.22	0.00	33.33

6	**SU25**	0.00	72.22	0.00	27.78
7	**TR20**	11.11	88.89	0.00	0.00
8	**GSL**	0.00	11.11	0.00	88.89
9	**TX90p**	0.00	55.56	11.11	33.33
10	**TN90p**	33.33	61.11	0.00	5.56
11	**TX10p**	0.00	50.00	0.00	50.00
12	**TN10p**	0.00	0.00	33.33	66.67
13	**WSDI**	5.56	72.22	0.00	22.22
14	**CSDI**	0.00	0.00	5.56	94.44

Table 3: Decadal Trend of Indicators of Temperature Extremes

	Climatic Regions of Punjab and Himachal Pradesh						
Indicators	**Dry Semi -arid**	**Dry Sub-humid**	**Moist Sub-humid**	**Humid Sub-tropical**	**Temperate Wet**	**Temperate Moist**	**Cold Semi -arid and Arid**
TXx (°C)	0.2 to 0.3	0 to 0.1	0 to 0.1	0 to 0.1	0 to 0.1	0 to 0.1	-0.1 to -0.01
TNx (°C)	0.02 to 0	0 to -0.07	-0.12 to -0.7	-0.12 to -0.7	-0.12 to -0.7	-0.12 to -0.7	-0.07 to 0
TXn (°C)	-0.3 to -0.25	-0.25 to -0.15	-0.25 to -0.15	-0.15 to 0	-0.15 to 0	0 to 0.02	0 to 0.02
TNn (°C)	0.12 to 0.17	0 to 0.07	0.07 to 0.12	0.07 to 0.12	0.07 to 0.12	0.07 to 0.12	0.07 to 0.12
DTR (°C)	-0.06 to 0	-0.06 to 0	-0.06 to 0	-0.06 to 0	-0.06 to 0	0 to -0.01	0 to -0.01
SU25 (days)	-0.3 to 0	-0.3 to 0	0 to 0.45	0.45 to 0.9	0.45 to 0.9	0.9 to 1.3	0.9 to 1.3
TR20 (days)	0.1 to 0.2	0.1 to 0.2	0.1 to 0.2	0.8 to 0.1	0.8 to 0.1	0.8 to 0.1	1.4 to 1.6
GSL (days)	-0.3 to 0	0 to 0.04	-0.3 to 0	-0.3 to 0	0 to 0.04	0 to 0.04	-0.3 to 0
TX90p (days)	0.4to 0	-0.01 to 0	-0.01 to 0	-0.01 to 0	-0.01 to 0	-0.8 to -0.4	-0.8 to -0.4
TN90p (days)	1.2 to 1.6	0.5 to 1	0.5 to 1	0.5 to 1	0.5 to 1	0.5 to 0.17	0.5 to 0.17
TX10p (days)	0.1 to 0.3	0.1 to 0.3	0.1 to 0.3	0.1 to 0.3	0 to -0.01	-0.2 to -0.05	-0.2 to -0.05
TN10p (days)	-1 to -0.8	-1 to -0.8	-1 to -0.8	-1 to -0.8	-0.8 to -0.6	-0.8 to -0.6	-0.8 to -

							0.6
WSDI(days)	0 to 1.5	0 to 0.5	0 to 0.5	0 to 0.5	0 to 0.5	0.5 to 1.5	0.5 to 1.5
CSDI (days)	-2.5 to -2.1	-1.3 to -0.9	-1.3 to -0.9	-1.3 to -0.9	-0.9 to 0	-0.9 to 0	-0.9 to 0



Map 1