Minimum Temperature Analysis and Trends in Pakistan

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Abstract

In this study single station and zonal data sets from 1976 to 2005 have been analysed to examine the changes and trends in winter mean minimum temperatures of Pakistan. Statistical tests were applied to determine trends in data for different zones of the country. The student's t – test was used to find the significance of the variation. The variations were found different for different locations and regions but generally the trend of minimum temperatures was found to be increasing, especially in the big cites of Pakistan. Zone-1 that comprises of the hilly stations show an increasing trend in the minimum temperature, while Parachinar which also lies in the zone-1 shows significant decreasing trend. Zone-2 includes stations between 31°N-34°N. Increase in minimum temperature has been observed for this region. Zone-3(a) located in the south western border of the country. Most of them are mountainous stations with high elevations from mean sea level. In zone-3(a) minimum temperature shows slightly increasing trend, although negligible. Zone-3(b) includes the station with high maximum temperature. All the stations except Barkhan and Sukker show an increasing trend in minimum temperature. In Zone-4 the variation in temperature is not significant except for the Karachi station. Country wide analysis shows that there is slight increase in mean minimum temperature; however the increasing trend is weak. Increase in the mean minimum temperature is an indicator of climate change. It is evident that in the big cities and plain areas of the country changing behaviour of winter will bring in to action different health and agro-environmental challenges.

Introduction

Climate of an area can be defined as conditions of atmosphere of that particular area over a long period of time, (From one month to many years, but generally 30 years). Climate is the sum of many meteorological variables and their variations. Main constituent are temperature and precipitation and their variability especially in terms of current global climate change or global warming (IPCC report 2001). Temperature can be generally defined as the degree of hotness or coldness of a body or environment or a measure of the average kinetic energy of particles in certain matter. In an meteorological observatory, atmospheric temperature is observed every synoptic hour. Daily maximum temperature, minimum temperature and mean temperature plays an important role in assessing the climate and atmosphere of a certain area. Diurnal Temperature Range (DTR) is a difference of daily maximum and daily minimum temperature is universally used as indicator for climate change.

Houghton et al. (2001), in his studies revealed that warming in daily minimum temperature is stronger than that for maximum temperatures. Given these identifiable changes, it is expected that there would also be changes in extreme temperature events, such as the frequency of days with extremely low or extremely high temperatures. Studies have revealed that there is a significant decrease in days with extremely low daily temperatures but no significant increase in the days with extremely high temperatures. (De Gaetano,1996 and Bonsal et al.,2001) respectively showed a significant decrease in the number of days with extreme low temperature during winter in the north eastern United States of America (USA) and over Canada. (Zhai et al., 1999) showed that the number of days with extreme low temperature has been decreasing in northern China. (Yan et al., 2002) investigated comprehensively the changes in extreme temperature over Europe and China. A decrease in the cold extremes and a warming trend in the minimum temperature over China during the last few decades were observed. These changes were related to recent aspects of large-scale circulation fields: milder Siberian-high air masses in winter, a weakening of the Meiyu phenomenon and/or greater dominance of the western Pacific subtropical high in summer according to a recent study by (Gong and Ho, 2004). Although the Siberian high appears as a quasi-permanent feature in the Eurasian continent,

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during the winter season, migratory anticyclone cells often break away from the Siberian high and move eastward or south eastward, causing sudden outbreaks of cold air in the affected regions (Chang and Lau, 1980). Mean annual minimum and maximum temperatures have warming trends over Jordan during the period of mid-sixties to late nineties (Bani-Domi, 2005). In a study conducted by (Sohrabi et al., 2009) revealed that significant changes in temperature and precipitation extreme have been detected during 1961 to 2004. The results of a recent study conducted by (Dash et al., 2007) show that there is an increase of about 1°C to 1.1°C in the mean temperature of India during the last century, during winter and post monsoon months respectively. The increase of 1.15°C, 0.56°C, and 0.09°C in mean temperature has been observed in Baluchistan, Punjab, and Sindh respectively during the period 1960 to 2007 (Chaudhry et al., 2009). (Afzaal et al., 2009) revealed that daily minimum and maximum temperature have increased throughout Pakistan during winter and summer seasons.

The maximum temperature also indicates the same rising trend. On the other hand minimum temperatures have an increasing trend in post monsoon and winter season and a decreasing trend in the monsoon season. The decrease in the minimum temperatures during summer monsoon season and increase in post monsoon seasons creates a difference of about 0.8°C in the seasonal temperature anomalies which may eventually alter the distribution of heating sources and hence atmospheric circulation patterns.

Extreme weather and climate events have wide range impacts on society as well as on biophysical processes. Sometimes society is unable to cope with these extreme events, many scientists from different parts of the world have linked increasing extreme weather events to global warming and it is assumed that intensities and occurrences of extreme weather will increase with the increase in global temperatures as in IPCC report. McGregor (2005) in his studies for occurrence of extreme weather events in Europe writes that even these changes can occur at relatively small time scale.

Data and Methodology

In order to conduct this study dataset of daily winter minimum temperature (Dec, Jan, Feb and Mar) of 30 years (1976–2005) from 30 meteorological stations was selected for analysis. This data is obtained from

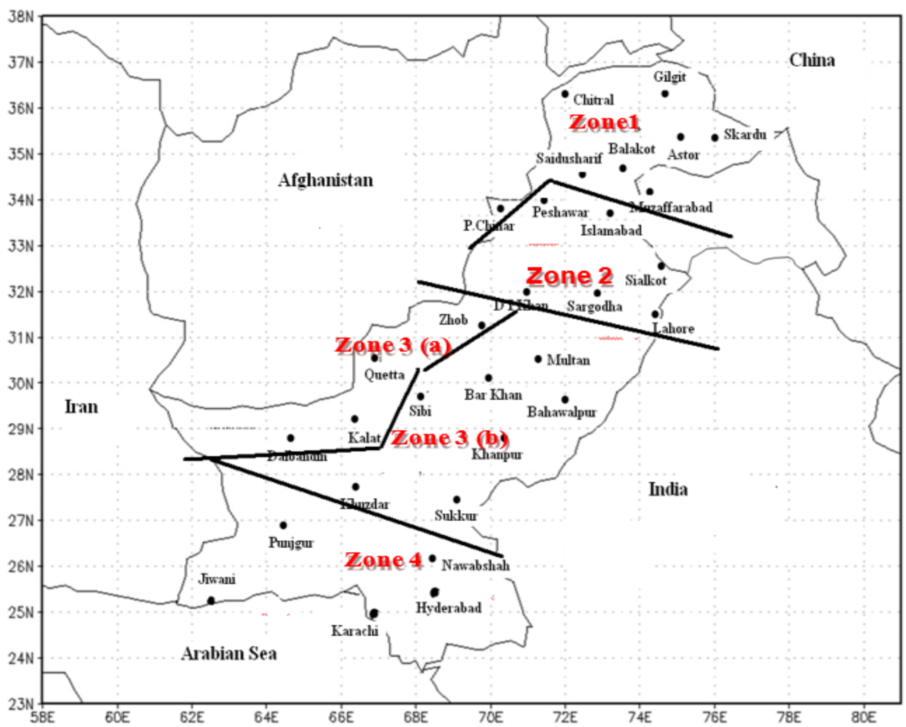

Figure 1: Location of Meteorological Observatories and Climatic zones of Pakistan.

Climatic Data Processing Centre (CDPC) of Pakistan Meteorological Department. According to international standard data is recorded to the nearest 0.1°C. These stations were selected taking into account the length, completeness and reliability of the records, so that major portion of the country was covered by the corresponding data.

Location of the observatories and proposed zones are shown over the map of Pakistan in Figure 1. Meta data of all the stations used in this study is given in Table 1.

Zonation Criteria

All of the stations are divided into groups to make five different zones. These zones are formed keeping in view the climate characteristics of the stations. Koppen climate classification were considered to determine the type of climate of each station.

Zone 1

Zone 1 consists of seven stations, Balakot, Chitral, Gilgit, Muzaffarabad, Parachinar, Saidusharif and Skardu. These are mostly hill stations located between 34°N to 38°N in the Himalaya, Hindukash and Koh-e-sufaid mountain ranges. The analysis of zone 1 shows mixed results.

Zone 2

Zone 2 comprised of six stations, Dera Isamil Khan (to be referred as DIKhan), Islamabad, Lahore, Sargodha and Sialkot. The stations of zone 2 are mostly plain sub mountain areas located between 31°N and 34°N.

Zone 3(a)

This zone includes five stations, Dalbandin, Quetta, Zhob, Kalat, and Khuzdar, located in the south western border of the country. Most of them are mountainous stations with high elevations from mean sea level.

Zone 3(b)

This zone includes six stations Bahawalpur, Barkhan, Khanpur, Multan, Sukker, Sibbi. This is the hottest zone of the country where highest maximum temperatures are recorded (Sibi and Jaccobabad, not considered for this study).

Zone 4

Five stations, Hyderabad, Jewani, Karachi, Nawabshah and Punjgur are included in zone 4.

Table 1: Meteorological observatories and their meta data

S. No	Station	WMO Ref	Altitude (m)	Latitude	Longitude
1	Astore	43520	2167	35°22´ N	74°54´ E
2	Bahawalpur	41700	116	29°24´ N	71°47´ E
3	Balakot	41536	980	34°23´ N	73°21´ E
4	Barkhan	41685	1097	29°53´ N	69°43´ E
5	Chitral	41506	1499	35°51´ N	71°50´ E
6	Dalbandin	41712	848	28°53´ N	64°24´ E
7	Dera Ismail Khan	41624	173	31°49´ N	70°55´ E
8	Gilgit	43516	1459	35°55´ N	74°20´E
9	Hyderabad	41765	40	25°23´ N	68°25´ E
10	Islamabad	41571	507	33°37´ N	73°06´ E

11	Jiwani	41756	56	25°04´ N	61°48´ E
12	Kalat	41696	2015	29°02´ N	66°35´E
13	Karachi	41780	21	24°54´ N	67°08´ E
14	Khanpur	41718	87	28°39´ N	70°41´ E
15	Khuzdar	41744	1231	27°50´ N	66°38´ E
16	Lahore	41640	213	31°33´ N	74°20´ E
17	Multan	41675	122	30°12´ N	71°26´ E
18	Muzaffarabad	43532	701	34°22´ N	73°29´ E
19	Nawabshah	41749	37	26°15´ N	68°22´ E
20	Panjgur	41739	980	26°58´ N	64°04´ E
21	Parachinar	41560	1725	33°52´ N	70°05´ E
22	Peshawar	41530	359	34°01´ N	71°35´ E
23	Quetta	41660	1600	30°15´ N	66°53´ E
24	Saidusharif	41523	961	34°44´ N	72°21´ E
25	Sargodha	41594	187	32°00´ N	72°07´ E
26	Skardu	43517	2209	35°18´ N	75°41´ E
27	Sialkot	41600	251	32°30´ N	74°32´ E
28	Sibbi	41697	133	29°33´ N	67°53´ E
29	Sukkur	41725	66	27°42´ N	68°54´ E
30	Zhob	41620	1405	31°21´ N	69°28´ E

In the next step, seasonal series (DJFM) were drawn for whole Pakistan. The monthly and seasonal mean minimum temperatures, standard deviations, medians and standard errors were computed for each individual station, zone and then averages for the country. The monthly and seasonal means computed for individual stations, zones and country, of minimum temperatures were plotted for time series of thirty years, fifteen years and ten years to find out any possible trend, using the Excel software. To observe the changes, the magnitude of the trend was analysed for the slope of the regression line using least squares method. Statistical student's t – test is used to compare the means of different periods and to assess the significance of the changes for individual stations, zones and country. Although the length of the data span (30 years) is not sufficient as compared to the other similar studies conducted for the same purpose however it provides a base for assessing variations in minimum temperatures of the country.

Results and Discussions

The linear trend value represented by the slope of simple least square regression line with time as the independent variable gives the magnitude of rise or fall in temperatures. The results of zones and whole country are included in this study.

Zone 1

The analysis of zone 1 shows mixed results. To find the variations in temperature of zone 1, the seasonal mean of minimum temperature of all individual stations were averaged to obtain zonal means. The analysis of zone 1 revealed a decrease in the mean minimum temperature. Some time in zonal average, data of single station dictates the results. In order to check whether or not the result is representative of zone as a whole? Trend lines of individual stations were also checked. Behaviour of Parachinar is dominant over the whole zone. Its decrease in the temperature is very sharp and the whole zone may be affected by results of this station, showing a different pattern of temperature analysis. Therefore the analysis was performed again after excluding the data of Parachinar from the rest of the zone. Figures 2 (a) and 2(b) show analysis for the zone including the station of Parachinar, and figures 2(c) and 2(d) represent the analysis of the zone excluding its data. In the first analysis (see figure 2 (a)) the regression line is showing a decreasing trend whereas in the second analysis instead of downward trend it shows an upward trend (see figure 2(c)).

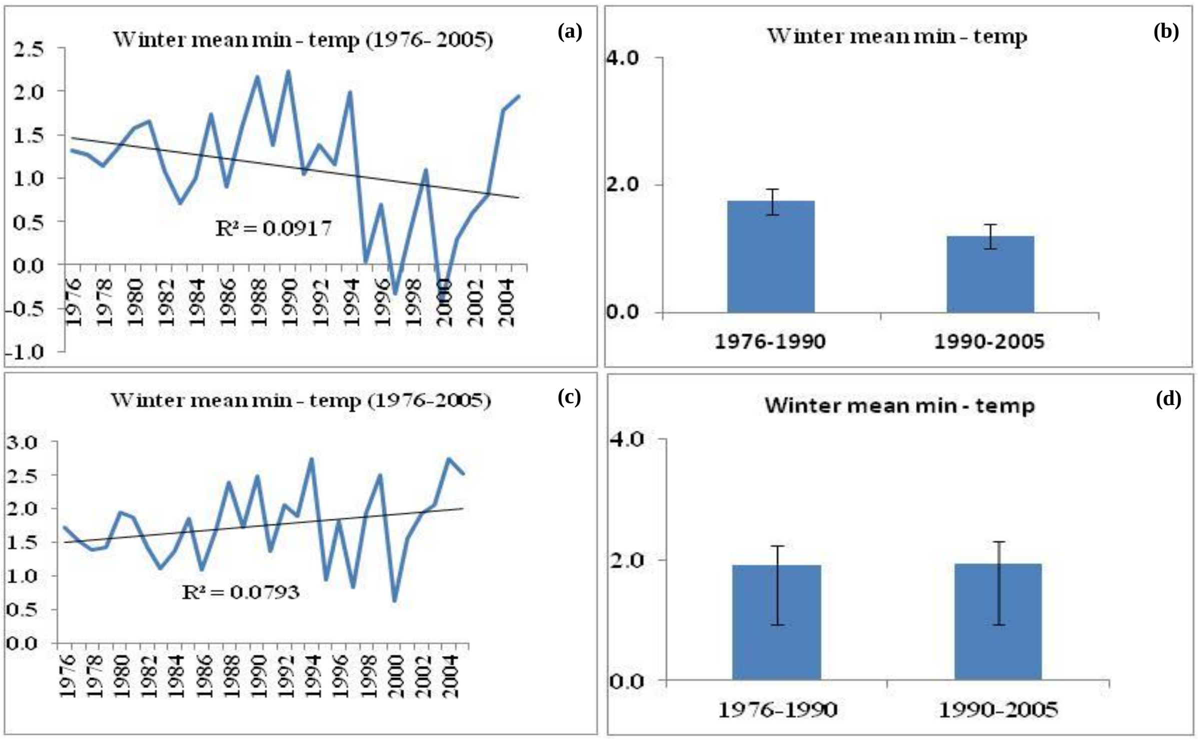

Figure 2: Analysis of mean minimum temperatures of zone 1. Figures (a) and (b) represent the analysis when the station of Parachinar was included in the zone. Figures (c) and (d) represent the analysis without the station of Parachinar

In both of the analysis the value of r^2 is less than 0.1 (figure 2 (a) and (c)). In the first analysis (figure (a) and (b)) there is a decrease of 0.4°C; standard error of the data for this analysis is 0.3°C. In the figures (c) and (d) no change in the temperature is found using simple statistics. The p value of the significance of t–test for the data of the first test (including Parachinar) is 0.05, and t value is 1.79. The t–test shows decrease of 0.43°C in mean temperature for the two periods and the standard error is 0.2°C. For the second analysis (without the data of Parachinar figure (c) and (d)) the results of the t – test are shown in the Table 2.

Table 2: t-test of zone 1 excluding the data of Parachinar

t – test for equality of means					95 % of the C I of diff	
t	df	Sig p	Mean diff	Mean S.E.	lower	upper
0.58	28	0.5	0.13	0.2	0.59	0.33

The t value of the test is 0.58 less than critical tabulated value of 1.70 and greater than zero. Significance is 0.5 > 0.05. Standard error for this analysis is 0.1°C. From the comparison of the two analyses it can be considered that the change in the temperatures of this zone is not notable. Summarized results of station wise analysis are given in the Table 3.

Table 3: Changes observed for stations of zone 1.

Station	t value	Mean (1976-1990)	Mean (1991-2005)	Difference	St. Error
Balakot	4.2	4.15	4.99	0.85	0.3
Chitral	0.59	1.07	1.21	0.13	0.3
Gilgit	0.11	0.17	0.22	0.04	0.4
Muzaffarabad	0.81	5.52	5.69	0.17	0.3
Parachinar	6.8	0.71	-3.13	-3.83	0.4
Saiusharif	0.64	4.07	3.84	-0.24	0.3
Skardu	0.31	-3.7	-3.9	-0.16	0.5

The value of t is higher than the critical value of 1.70 only for Balakot and Parachinar. The minus signs in the table for temperatures show decrease in mean temperature during the second half period of analysis. The maximum increase in mean minimum temperature is computed for Balakot (0.85°C) of this zone and highest decrease by Parachinar (-3.8°C). The changes in the mean minimum winter temperatures of the other stations are small compared to their standard errors of the data therefore they cannot be concluded as decrease or increase of mean minimum temperatures.

Zone 2

The stations of zone 2 are mostly plain sub mountain areas located between 31°N and 34°N. This zone shows an increasing trend in the seasonal mean minimum temperatures. The trend analysis of this zone is represented in Figure 3(a) and (b).

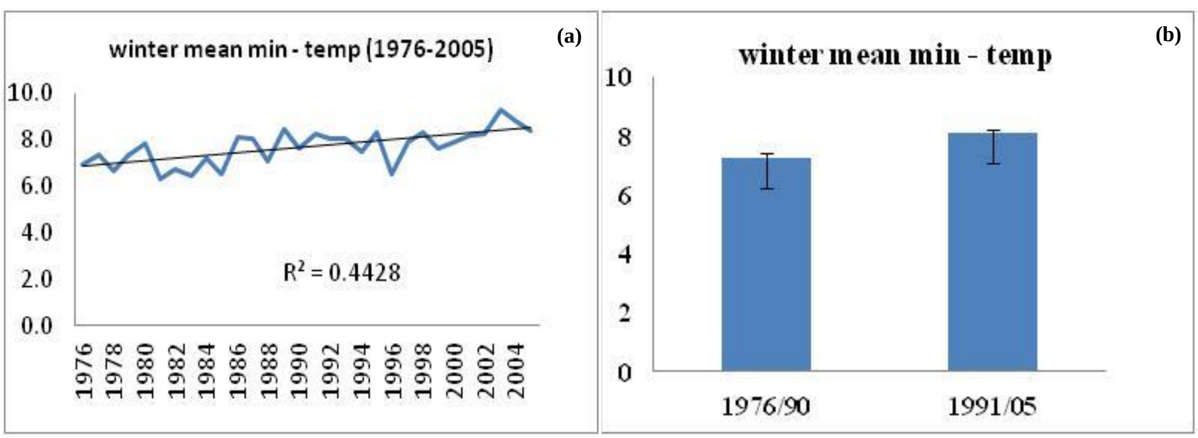

Figure 3: Analysis of winter mean minimum temperatures of zone 2

Figure 3(a) is the linear regression analysis for 30 years; the magnitude of the r^2 for regression line is 0.44 which indicates that variations can be explained as function of time. The analysis of two 15 years period indicates an increase of 0.8°C for this zone with a standard error of 0.2°C for the data of 30 years. The results of t–test are very clear for this zone. The value of t is 3.6 which show that the null hypotheses for the equality of means can be rejected with significance 0.01. Standard error computed for the data is 0.3. Station wise changes of mean minimum temperature between the two time periods can be summarized as given in Table 4

Table 4: Changes observed for stations of zone 2

Station	t value	Mean (1976-1990)	Mean (1991–2005)	Difference	St. Error
Sialkot	1.73	7.46	7.94	0.48	0.3
D I Khan	1.5	7.33	7.97	0.64	0.3
Islamabad	3.1	5.45	6.15	0.69	0.3
Peshawar	2.5	6.46	7.34	0.88	0.3
Lahore	5.6	9.25	10.74	1.48	0.3
Sargodha	2.8	7.48	8.32	0.82	0.3

Table 4 indicates that the results of the t–test for the zone and individual stations are very good for the null hypotheses to be rejected. Five stations out of six are showing the value of t to be greater than the critical value of t (1.70). The t value of D.I. Khan is just below the critical value. Although probability to reject null hypotheses is less than critical value of 90 %, but is on higher side (87 %). So the null hypotheses can be rejected for this zone. From the table, it is evident that maximum increase occurred in the temperatures of Lahore which shows a value of 1.5°C. In the time series analysis the increase in temperatures shows a good strength with time with the value of $r^2 = 0.64$. It could be worth mentioning that Lahore is second biggest city of Pakistan following Karachi. There are some big industrial units in Lahore. It is one of the atmospheric polluted cities of Pakistan as per study of Pakistan Council for Scientific and Industrial Research (PCSIR), a scientific organization of Pakistan working in the field of water and atmosphere quality (www.pcsir.gov.pk).

Zone 3(a)

Kalat have the highest altitude of 2015 metres from mean sea level and Dalbandin the lowest with an altitude of 848 metres. This zone covers an area between 27°50´N to 32°N and 64°E to 70°E. In the thirty years' time series analysis the trend line shows very low values for r^2 (0.05) which cannot be explained as a function of time. The analysis of zone 3 (a) is shown in figure 4 (a) and (b).

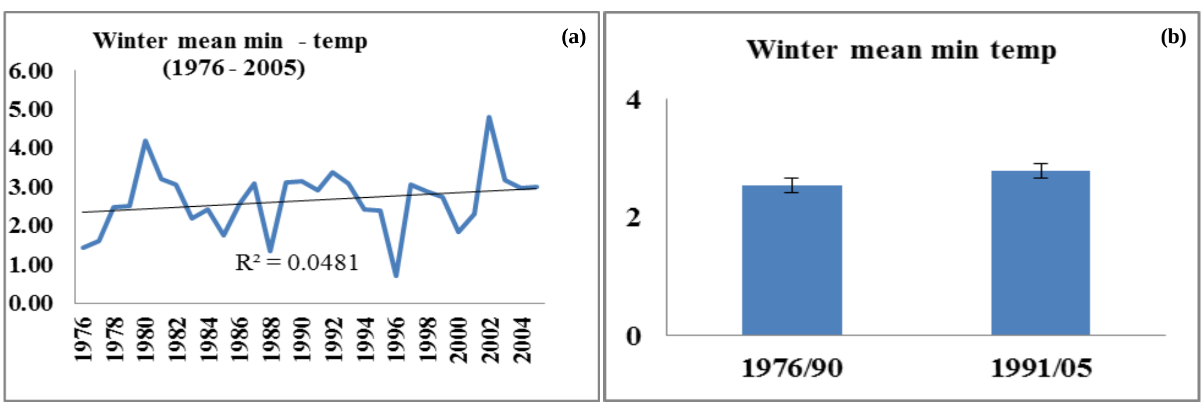

Figure 4: Analysis of winter mean minimum temperatures of zone 3(a).

In the graph (a) the value of $r^2 = 0.05$ which means that variability in mean minimum temperature during the winter season is almost negligible. The difference between the means of two periods (1976-1990 and 1991–2005), is 0.24°C which is comparable to the standard error, 0.2°C for the data set. The t value is low, 0.77, compared to the critical tabulated value of 1.70 for a level of significance of 0.10. The standard deviation is 0.8°C. This variation in mean minimum temperature cannot be clearly attributed as rise in temperature because the value of the variation and standard error are comparable to each other. For the individual stations the changes can be summarized as given in the Table 5.

Table 5: Changes observed for stations of zone 3(a)

Station	t value	Mean (1976 – 1990)	Mean (1991 - 2005)	Difference	St. Error
Dalbandin	0.1	5.2	5.2	0.0	0.3
Quetta	0.5	0.3	0.6	0.3	0.3
Zhob	1.2	1.9	2.5	0.6	0.4
Kalat	3.24	-2.7	-1.1	1.6	0.4
Khuzdar	0.94	6.1	6.4	0.3	0.2

Comparing the values of changes occurred with standard error of the data and the values of t test of the stations, the variance cannot be clearly explained, as these differences are very low. The t values are very low except for Kalat which is greater than critical value (1.70) and this is the only station of the zone indicating clear increase in the temperature. Population wise Quetta is the biggest city of this zone, and is capital of Baluchistan.

Zone 3(b)

This is the hottest zone of the country where highest maximum temperatures are recorded (Sibi and Jaccobabad, not considered for this study). Most of the stations of this zone show an increasing trend of temperature except for Barkhan and Sukker. Barkhan shows a decreasing trend in temperatures. The decreasing trend in the mean minimum temperature is unusual for this zone and especially for this station when all surrounding stations are indicating an increasing trend. The data was rechecked and reanalysed but the result came out to be the same. The data set of this station is only for 25 years and it needs to be studied separately in details. The analysis for the zone is represented in the Figure 5 (a) and (b)

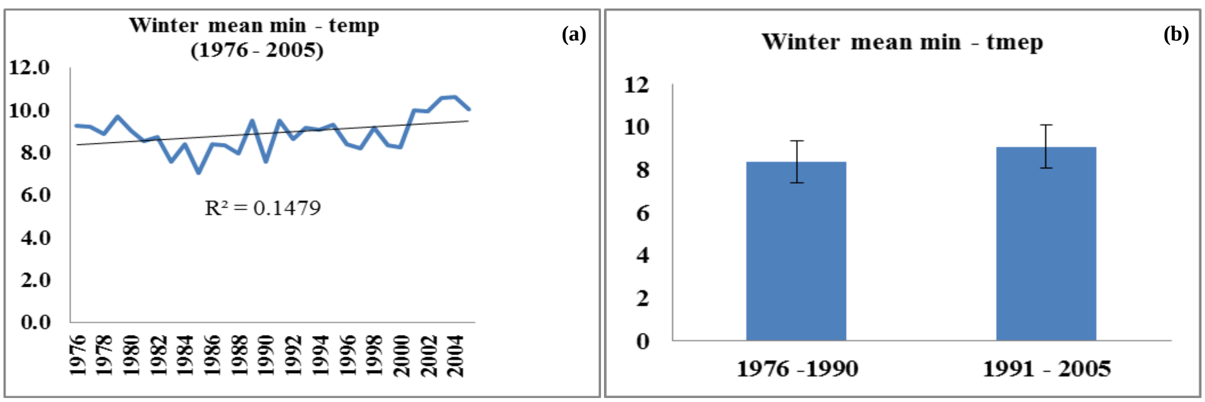

Figure 5: Analyses of winter mean minimum temperatures of zone 3(b)

Figure 5 (a) shows a value of $r^2 = 0.15$ which indicates that variation (increase) in mean minimum temperature is very low. The results of the analysis show a rise of 0.8°C in mean minimum temperature during the second period of time (1991–2005). The standard error computed for the data of this zone is 0.2°C. The value of t is 2.6 for this zone and its significance value p is 0.02. At this level the null hypotheses can be rejected for the equality of means of the two periods. Station wise analysis can be summarized as in Table 6.

Two stations Khanpur (1.4°C) and Sibi (0.9°C) are showing significant increase whereas Barkhan is showing a decreasing trend. In terms of population, industries and urbanization Sukker is one of the bigger cities of the zone but its increase in mean minimum temperatures is not as much significant as shown by Sibi, Khanpur and Multan. Population of Sibi and Khanpur are not much bigger i. e. 0.17 million and 0.15 million respectively and there are no big industrial units in these cities and urbanization effects are also low. Therefore there must be some other factors contributing for the increase in minimum temperatures of these stations.

The results are verified by the t test as its value is 2.7. t values for Sibi and Multan are also stronger (3.3 and 2.8 respectively). But for Sukker value of significance of the t - test is 0.01 and value of t is 0.45 which is very low compared to the critical value (1.70), which indicates that the null hypotheses of equality of means cannot be rejected for this station.

Table 6: Changes observed for the stations of zone 3(b).

Station	t value	Mean (1976 - 1990)	Mean (1991 – 2005)	Difference	St. Error
Bahawalpur	-1.4	8.7	9.1	0.4	0.2
Barkhan	1.5	7.2	6.4	-0.8	0.3
Khanpur	-2.7	7.1	8.4	1.3	0.2
Multan	-3.3	8.1	8.8	0.7	0.2
Sukker	-0.5	10.98	11.24	0.2	0.4
Sibbi	-2.8	9.5	10.4	0.9	0.4

Zone 4

Out of five stations of this zone only two stations Karachi and Jewani show significant trends. The overall temperature trend of this zone is not showing any remarkable difference between the two time periods of analysis (1976 -1990 and 1991 – 2005), Figure 6 (a) and (b) represent the analysis for the zone four. The value of $r^2 = 0.03$ shows very that the variations cannot be explained as a function of time. A rise in mean temperature of 0.4°C is found for the second period of time. The standard error is 0.2°C. The results of the t–test shows significance as the t value is 1.5 and p value is 0.1, thus the null hypotheses of the equality of the means for the two periods can be rejected.

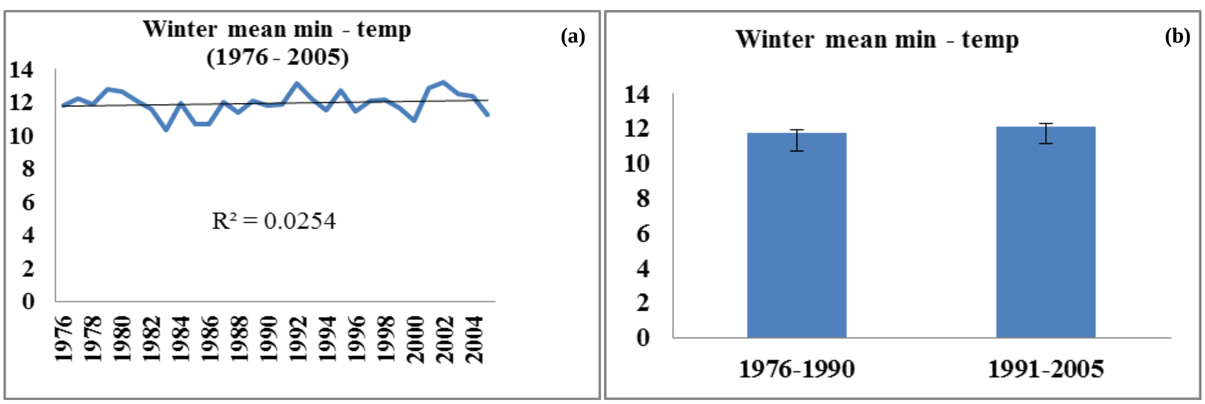

Figure 6: Analysis of winter mean minimum temperatures of zone 4.

The analysis of the other stations of the zone is summarized in Table 7. Table 7 indicates that maximum increase in mean minimum temperatures is shown by Karachi (1.8°C) followed by Punjgur (0.8°C). The remaining two stations, Hyderabad and Nawabshah show small increase of 0.1°C and 0.3°C respectively, comparable to their standard error of the data. There is only one station of Jewani of this zone which shows a decrease in mean minimum temperatures. Three stations out of five show significant value for t, they are Karachi (4.8), Punjgor (2.0) and Jewani (1.8) with the significance of more than 90 %. The t value for Hyderabad and Nawabshah has got the same value of 1.3, smaller than critical value of 1.70. The significance of the test is 0.20 for these two stations. Karachi is the biggest city of the country and second biggest city of the world (according to the list issued by UNO) having a population of 12.3 million with great urbanization effects. This city is the business and industrial capital of the Pakistan. Hyderabad is also an industrial city but with less industrial units and an estimated population of 1.4 million. Nawabshah is an agriculture district with a population of 1.1 million and Panjgur has a population of 0.35 million. Jewani is a small city of not more than 10000 inhabitants and is a coastal station bordering Arabian Sea in the south. So it can be considered from the analysis that only the station of Karachi is indicating an actual increase in the minimum temperature in this zone.

Table 7: Changes observed for stations of zone 4

Station	t value	Mean (1976 - 1990)	Mean (1991 - 2005)	Difference	St. Error
Hyderabad	1.3	14.2	14.4	0.2	0.1
Jewani	1.8	15.9	15.0	0.9	0.1
Karachi	4.8	12.9	14.7	1.8	0.3
Nawabshah	1.3	9.2	9.5	0.3	0.3
Punjgor	2.0	6.3	7.1	0.8	0.2

Country Wide Analysis

The zonal variations in mean minimum temperature (°C) for the two periods can be summarized in the Table 8

Table 8: Difference of mean minimum temperatures for the two periods.

Period	Zone 1	Zone 2	Zone 3(a)	Zone 3(b)	Zone 4	Mean	St Error
1976-1990	1.7	7.3	2.5	8.4	11.7	6.3	0.2
1991-2005	1.3	8.1	2.8	9.1	12.1	6.7	0.2

From Table 8 it can be observed that the variations shown by the zone1 and zone 3 (a) are very low in general and cannot be attributed to clear change because the values of standard error of these zones are comparable to the values of these variations. The reason for the decrease of the mean minimum temperature the zones 1 may be because of the abrupt decrease in temperatures of Parachinar which shows a significant abnormal decrease in the winter mean minimum temperatures of 1994 to 1997. The analysis for the country is shown in Figure 7 (a) and (b).

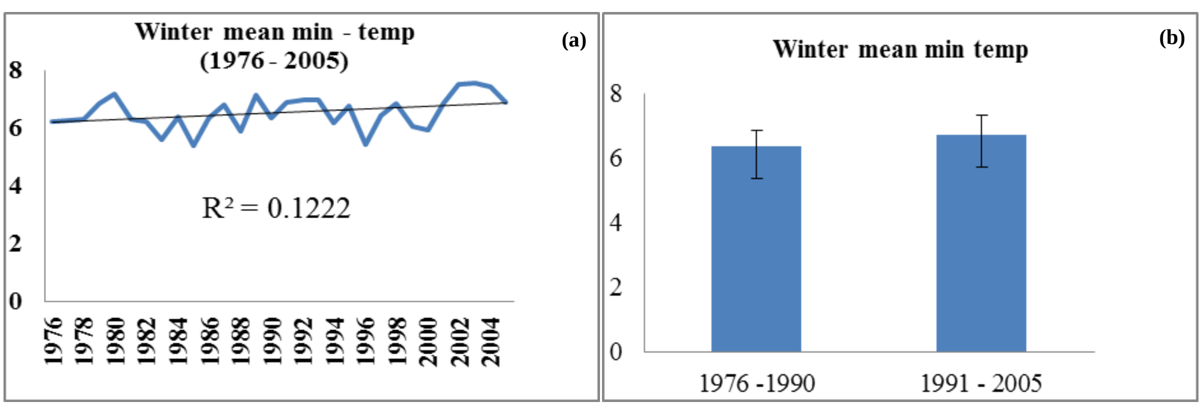

Figure 7: Analysis of winter mean minimum temperatures of whole country (Pakistan).

The country wide analysis as a whole does not indicate any alarming situation. The value of $r^2 = 0.12$ indicates that there are weak chances of the variations to be the function of time. A difference of 0.4°C between the two periods of analysis is computed for the country. The Standard error of the data is 0.2°C. The significance level of the t – test for the data of country is up to 92 %. The value of t (1.8) and p

(0.9), see table 9, indicates that the null hypotheses of the equality of means for the two periods can be rejected.

Table 9: t- test results for the country significance and difference of means.

t – test for equality of means					95 % of the C I of diff	
t	df	Sig p	Mean diff	Mean S.E.	lower	upper
1.76	28	0.09	0.36	0.20	-0.77	0.06

Standard error computed for the two periods are 0.13°C and 0.16 respectively showing a small increase during the second period of analysis.

Table 10: statistics of the country wide analysis.

Years	N	Mean	Std. Dev	Std. Error
1976-1990	15	6.35	0.50	0.13
1991-2005	15	6.71	0.61	0.16

In table 10, N is the number of years for each period. Mean temperatures for the period 1976–1990 is 6.35°C and for the period 1991–2005 is 6.71°C. Standard deviations show a slight increase for the second period.

Conclusions

From the discussions in the above section it can be concluded that the variations observed during the analysis of the data are not significant for the whole country but for the few big cities which show significant increase in the mean minimum temperatures. The variations observed for the northern parts of the country in the Himalayan and Hindukash mountain ranges are found negligible whereas some of the areas of plain regions are showing variations especially central parts of the country. In the south and south west these variations are again negligible except for one or two big cities. Few stations with less populations has shown increase in temperatures and one or two big cities like Hyderabad and Sukker are not showing any variations which need to be studied in details later on. Increase in minimum temperature can be attributed to climate change. Deforestation, rapid and unplanned urbanization can be a reason to this increase in temperature. It will shorten the maturity period (early ripening) of winter crops, especially wheat resulting into decreased crop production. Moreover certain fruits require chilling temperature to ripe properly. Rise in minimum temperature will cause to shorten the chilling period, so in the absence of required chilling hours, the production will be substandard. Rise in winter temperature will also put an extra burden on electricity demand.

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