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Spatiotemporal Variations and Trends in Minimum and Maximum Temperatures of Pakistan

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ABSTRACT

To assess variations and trends in mean minimum and maximum temperatures of Pakistan, data from 30 meteorological observatories for a period of 30 years (1976 to 2005) were acquired across the country. We found that climate zones located in high elevation in North, North West and the West of the country i.e. Hindukush Himalayan regions showed 0.01 degree change per year, whereas most of the plain and coastal areas showed a notable increase in mean maximum and minimum temperatures. As a whole on country level, a positive trend of 0.11°C/decade in mean temperature, 0.1°C/decade in minimum temperature and 0.12°C/decade in maximum temperature were found during the entire study period. This calculated temperature trend in Pakistan (0.11°C per decade) is less than the global temperature trend (0.6°C), but it has significant impacts on the society as observed during the recent years and therefore policy makers should be reluctant for any such change in the future.

KEYWORDS: Climate change, Minimum and Maximum temperatures, Trends and variability.

1. INTRODUCTION

Studies on long-term variations in surface air temperature for the entire globe [1-3] as well as for the hemispheres [4] have shown a rising trend during the last few decades. Pakistan is no exceptions, where climate change is an arising issue and its impacts can be felt severely in the form of droughts, sever cold/ heat waves, and flash flooding. The observed increase in temperature has great implications on food productions, natural eco-systems, loss of biodiversity, fresh water supply and quality and increase health risks [5-8]. Different studies [9-12] have been conducted on the occurrence and intensities of the extreme weather events and most of them have reported that temperature rising and frequent rainfall are the main factors of economic damage in the world. Mozaharul, et al., (2007) [13] reported an increase in the intensities and frequencies of extreme weather events, which will further lead to hunger, diseases spread, and economic losses on a larger scale. Similarly IPCC (2001) [14] report shows that due to human activities the greenhouse effect has been intensified in the later part of the 19th century and global climate will remain warm over the next few decades of the 21st century [15].

In the context of Pakistan, the most significant environmental effects includes, extreme weather events such as heat waves in June 2007 and May 2010 in many parts of the Punjab, Sindh and Baluchistan, and heavy torrential rains across Pakistan in Jul – Aug 2010 leading to heaviest floods and landslides in the history of the country. Although, Pakistan contributes very little in GHG emission (up to 0.43%) but rated as the 12th most vulnerable country in the world in terms of effects of climate change [16]. Agriculture sector is one example where reduced productivity, water shortage and different crop management practices are further worsening the situation. Agriculture is the largest income and employment-generating sector of Pakistan's economy with two third populations of the country living in rural areas and earning livelihood directly or indirectly from agriculture and cattle farming [17]. Agriculture contributes about 24% to the GDP of Pakistan and provides an employment to 48% of the labour force , whereas industries and 80% exports are almost agro-based with low forest cover (4.5%) and high deforestation rate i.e., 0.2- 0.4 % per annum [18]. The reports of Pakistan Agricultural Research Council (2003) shows that temperature increase in winter months (Dec-Mar) have negative impacts on wheat, sugarcane and fruits production. The production volume and quality have been adversely affected because of temperature changes in reproductive periods (Spring/late winter season), irrigation water requirements and its supply for Kharif and Rabi crops [19]. Pakistan is now considered among the 17 countries that are already facing water shortages and is among the 36 countries where there is a serious threat of food crisis.

Another important challenge imposed due climate change is water availability. As demand for water has been steadily increasing and due to shortening of the winter season or increase in the minimum temperature snow/glacial melting is likely to start early. This phenomenon not only affects the hydropower generation but

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also affect urban water supplies and agricultural sectors negatively [20]. Similarly reduction in river flow will also negatively affect the hydroelectric power generation. Pakistan which, is already infested by the worst load shedding of the history, will lead to an increase in fossil fuel combustion and hence more GHG emissions. In addition, higher temperature, particularly in the summer season has already increased demand for electricity for air-conditioning and refrigeration in domestic and commercial sectors. This demand is likely to go further up and hence necessitates additional generation capacity.

Farooqi et al., (2005) [21] have also identified ecological impacts on wetlands and mangrove forests. Pakistan could face the loss of mangrove forests - a vital source of fuel wood and seafood for local consumption and export. Accelerated melting of glaciers and seasonal snow cover in Himalayas, Karakoram and Hindu Kush ranges is threatening the natural habitat of rare animals such as the Markhor and Ibex and hence, hundreds of rare plants and animals are in danger of extinction [22]. The glaciers present in the Himalayan region are reported to be melting faster than in any other part of the world and fears have been expressed that they might disappear till 2035 [23, 24]. Further, the studies of National Institute of Oceanography indicate that the sea level along the coast of Pakistan has been rising approximately at 1.2 mm per year since 1960. Besides these, weather related disasters hit the countries regularly like cyclones, hurricanes like Katrina and Nargis, heat waves, super floods, droughts and intense rainfall. According to a World Bank Report (2006), the country loses nearly $4.5 billion annually from environmental disasters.

Over last couple of decades, in Pakistan rainfall patterns have become very unreliable and unpredictable, making it difficult for communities to make necessary arrangements for their safety, crops and livestock. For instance, on one hand the super flood of 2010 was caused by intensive and extended rainfall and on the other hand droughts have become more evident with the worst drought in the south. From the above facts and perceived threats it becomes imperative to protect the country from such adverse impacts of climate change before they strike. According to Hussain, et al. (2010) [25] that due to climate change events in Pakistan about 40% of population of Pakistan is highly prone to frequent and multiple disasters due to variations in rainfall patterns, storms, floods and drought. For this purpose the present study has been designed to determine the existence of any significant trends in the minimum, maximum and mean temperatures in Pakistan. In terms of meteorological variable, atmospheric temperature plays an important role in assessing the climate of particular area. Therefore, minimum and maximum temperatures are considering the main indicators for the determination of trends in climatic variables.

2. MATERIALS AND METHODS

3.1. Study area: Pakistan

This study focus on country level climatic changes, as Pakistan experiences diversified climate due to its large latitudinal extent from north to south and also due to large variations in the topography. Pakistan is geographically situated approximately between 24-37^o N latitudes and 62-75^o E longitudes in the western zone of south Asia. The country occupies a total geographical area of 803943 km^2. The plains of Pakistan, drained by the river Indus and its tributaries, are surrounded by many mountain ranges in the North, Northwest and the West [26]. High mountain ranges comprise of Himalaya and Karakoram with a small part of the Hindukush located in the north of the country. Pakistan is the only country where these three great mountain ranges meet. Most of the areas in the central and southern Pakistan are arid, while the northern part of the country is humid except the extreme northern mountains where it is dry. During the summer months (April to September), the mountainous north is pleasant and temperate, while the Indus Valley has temperatures in the range of 40ºC or more. In late summer the southern region experiences monsoon weather systems, particularly along the coastal belt and in winter season, the low-lying areas cool down to a range of 10-25ºC [26]. The dominant component of climate variations was spatial shifts in the rainfall patterns [26], like the monsoon winds that bring rainfall in summer. The Western Depression originating from the Mediterranean region and entering Pakistan from the west brings rainfall in winter.

3.2. Zonal classification of the country

It is difficult to consider the whole country as one region because different stations have different topography and complex microclimates. Therefore the study area is divided into five zones based on geographical features (Fig. 1).

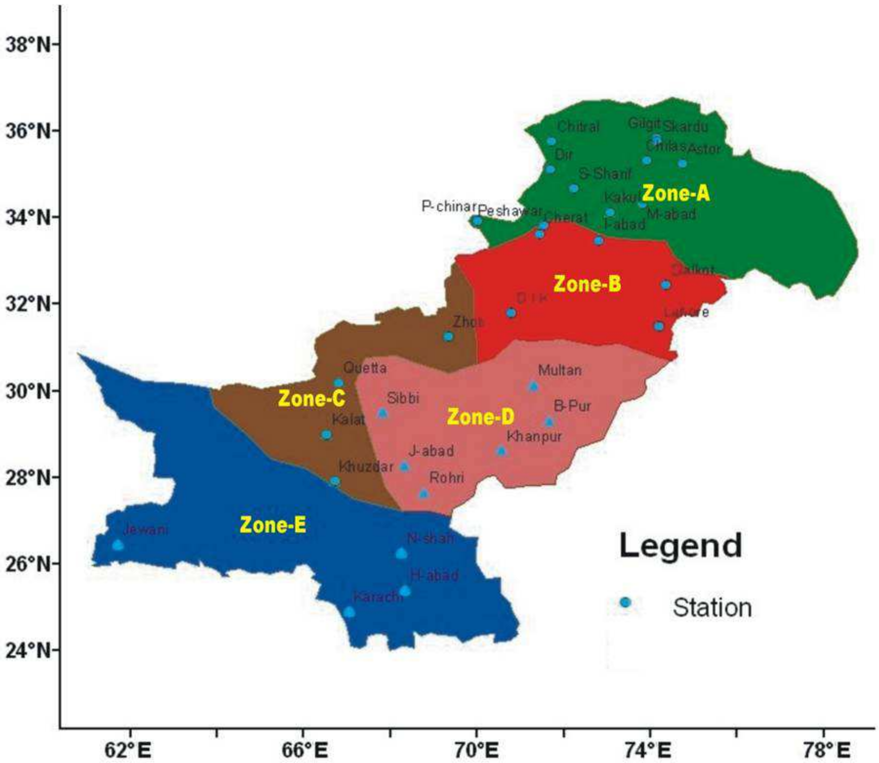

Fig. 1. Map of Pakistan Showing different climate zones of Pakistan along with their latitude and longitude.

Zone A: This Zone comprises of the stations having cold climate and high mountains, situated in the North of Pakistan. These stations are Chitral, Gilgit, Muzaffarabad, Said-u- Sharif, Skardu, Astor, Dir, Chilas, Parachinar and Kakul, shown in the green part of Fig. (1) in North. These are hilly stations located between 34^{o}N to 38^{o}N in the Himalayan Hundukush region.

Zone B: This zone has mild cold climate and sub-mountains, located between 31 to 34^{o}N. The stations are Sialkot, D.I. Khan, Islamabad, Peshawar, Cherat and Lahore shown with the red color in Fig. 1.

Zone C: Here climate is cold in winters and hot in summers. Most of them are mountainous stations with high elevations from mean sea level and laying between 27 to 32^{o}N and 64 to 70^{o}E. Stations included in this zone are Quetta, Zhob, Kalat and Khuzdar.

Zone D: This is the hottest and dry zone of the country, where highest maximum temperatures are recorded in stations of Sibbi and Jacobabad. Stations included are Sibbi, Jacobabad, Bahawalpur, Khanpur, Multan and Rohri.

Zone E: Zone E is a big zone (blue part of the map in the south) having many stations and coastal cities, near to Arabian Sea. The coastal part comprises only a small part of this region and climate above coastal parts in Balochistan as well as in Sindh province is arid. The selected stations from this zone are Hyderabad, Karachi, Nawabshah and Jewani.

Table 1. List of Meteorological stations along with their geographical features

S.N.	Station	WMO*	Altitude (m)	Latitude	Longitude	Zone and Climate
1.	Astor	41520	2168	35° 20'N	74° 54'E	**Zone A, Cold climate and high mountains**
2.	Chilas	41519	1250	35° 25'N	74° 06'E	
3.	Chitral	41506	1499	35° 51'N	71° 50'E	
4.	Dir	41508	1375	35° 12'N	71° 51'E	
5.	Gilgit	43516	1459	35° 55'N	74° 20'E	
6.	Kakul	41535	1308	34° 11'N	73° 15'E	
7.	Muzafarabad	43532	701	34° 22'N	73° 29'E	
8.	Parachinar	41560	1725	33° 52'N	70° 05'E	
9.	Said-u- Sharif	41523	961	34° 44'N	72° 21'E	
10.	Skardu	43517	2209	35° 18'N	75° 41'E	
11.	Cherat	41565	1372	33° 49'N	71° 33'E	**Zone B, Mild cold climate and sub-**

12.	D .I. Khan	41624	173	31° 49'N	70° 55'E	**mountains**
13.	Islamabad	41571	507	33° 37'N	73° 06'E	
14.	Lahore	41640	213	31° 33'N	74° 20'E	
15.	Peshawar	41530	359	34° 01'N	71° 35'E	
16.	Sialkot	41600	255	32° 31'N	74°32'E	
17.	Kalat	41696	2015	29° 02'N	66o 35'E	**Zone C, Cold climate in winter and hot in summer**
18.	Khuzdar	41744	1231	27° 50'N	66° 38'E	
19.	Quetta	41660	1719	30° 15'N	66 ° 53'E	
20.	Zhob	41620	1405	31° 21'N	69 ° 28'E	
21.	Bahawalpur	41700	110	29° 20'N	71° 47'E	**Zone D, Hottest and dry zone, where highest max temp are recorded**
22.	Jacobabad	41715	55	28° 18'N	68° 28'E	
23.	Khanpur	41718	87	28° 39'N	70° 41'E	
24.	Multan	41675	122	30° 12'N	71° 26'E	
25.	Rohri	41725	66	27° 40'N	68° 54'E	
26.	Sibbi	41697	133	29° 33'N	67° 53'E	
27.	Hyderabad	41764	28	25° 23'N	68° 25'E	**Zone E, Warm humid sub-tropical climate mostly coastal cities**
28.	Jiwani	41756	56	25° 04'N	61° 48'E	
29.	Karachi	41780	21	24° 54'N	67° 08'E	
30.	**Nawabshah**	**41749**	**37**	**26° 15'N**	**68° 22'E**	

*World Meteorological Observatory reference

3.3. Data collection

The dataset used in this study consisted of daily minimum and maximum temperatures records obtained from the Climate Data Processing Centre (CDPC) of Pakistan Meteorological Department (PMD). The dataset spreads over a period of 30 years (1976-2005) covering the whole country. The stations included in this study were selected on the basis of their latitudinal position, elevation from sea level, length of record, completeness and reliability of data so that a synoptic view of the entire country could be obtained. List of Meteorological stations along with their location and climate are shown in Table 1. An additional factor controlling the choice of stations was that they were not changed/ displaced in last 30 years, as some of the meteorological stations were re-established or relocated to new sites. Spatial and temporal changes in temperature trends are sometime complicated due to missing values, seasonal and other short-term fluctuations or climate variability and lack of homogeneity of the data e.g. due to changes in instrument and observation techniques and location change of the station. The time series used have been chosen according to the PMD data quality check and in function of the length of the period of records and homogeneity of time series. All time series used are continuous from 1976 to 2005, as the PMD has estimated the missing values.

3.4. Data Analysis

The first step of the analysis includes the understanding of the climate variables not only for time series of each individual station, but also for the zonal or regional averages. For this purpose, average values were compiled carefully for the entire period 1976-2005, for fifteen year periods for each station, zone and for the whole country. The reliability of data and homogeneity of means were statistically tested by applying Analysis of Variance (ANOVA) along with Duncan Multiple Range test, using SPSS version 20. ANOVA test is designed to obtain a significant value and difference among the means of more than two groups (with and within the groups) by assuming equal variances or normal distribution of the data. Now worldwide for the detection of the temperature trend, mostly ANOVA test is applied. In this sense, the application of statistical test makes it easy to compare the means of different periods and to assess the significance of the changes for each station, zone and for the overall country. Further, for the visualization of the data, ArcGIS software is applied which is used for all mapping and editing tasks as well as for map-based query and analysis.

3. RESULTS AND DISCUSSION

Analysis of the temperature trends spatially and temporally across the country has been summarized based on zonal classification of the study area and two time periods. Changes between 1976 and 1990 referred as Period1, while changes between 1991 and 2005 referred as Period2. The following section discusses the spatial changes in temperature trends:

3.5. Single station analysis

In six different locations, we observed high increase in minimum temperature in the second period i.e., between 1991 and 2005 compared to period1. Fig.2 A & B and Table 2 give the detailed account of the changes observed.

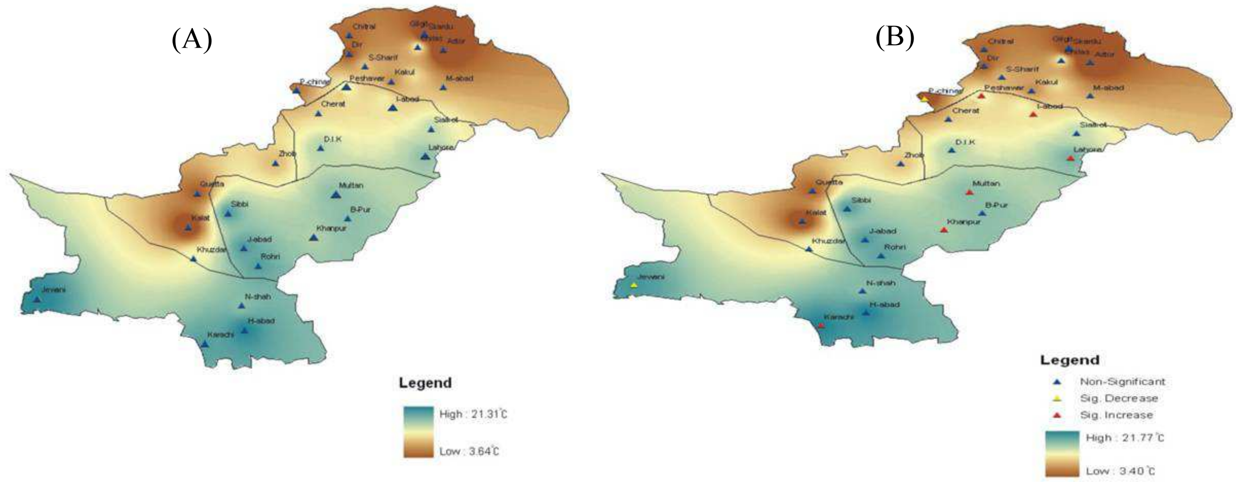

Fig. 2. Map of Pakistan showing significant increase, decrease and no change in the minimum temperature. (A): For period 1976-1990; (B): For period 1991-2005

Table 2. Stations are showing significant increase, decrease, and no change in mean minimum temperature.

Station	Mean (1976-1990)	Mean (1991-2005)	Mean Diff	Std. Error	Zone
Increase in minimum temperature					
Islamabad	14.18	14.73	0.55	0.20	2
Lahore	17.97	19.01	1.04	0.20	2
Peshawar	15.7	16.36	0.67	0.30	2
Khanpur	16.92	17.55	0.63	0.30	3b
Multan	18.02	18.42	0.4	0.20	3b
Karachi	19.68	21.77	2.09	0.20	4
Decrease in minimum temperature					
Parachinar	9.55	5.46	-4.09	0.60	1
Jewani	21.15	20.69	-0.46	0.10	4
No change in minimum temperature					
Astor	3.63	3.39	-0.24	0.30	1
Chilas	14.52	14.57	0.05	0.20	1
Chitral	8.76	8.67	-0.09	0.20	1
Dir	7.88	8.05	0.17	0.30	1
Gilgit	7.66	7.78	0.12	0.20	1
Kakul	10.56	10.45	-0.11	0.30	1
Muzaffarabad	13.46	13.62	0.16	0.20	1
Skardu	5.21	5.08	-0.13	0.30	1
Saidu Sharif	12.28	12.02	-0.27	0.20	1
Cherat	12.69	12.81	0.13	0.20	2
DIK	16.71	17.03	0.32	0.30	2
Sialkot	16.23	16.49	0.27	0.30	2
Khuzdar	14.87	14.8	-0.07	0.20	3a
Quetta	8.34	8.48	0.14	0.20	3a
Zhob	12.18	12.7	0.51	0.20	3a
Bahawal Pur	18.05	18.4	0.35	0.20	3b
Rohri	19.7	19.85	0.14	0.30	3b
H-bad	21.32	21.75	0.43	0.20	4
Kalat	5.03	5.8	0.76	0.40	3a
Jacobabad	19.94	20.27	0.32	0.20	3b
Sibbi	19.8	20.16	0.36	0.20	3b
Nawab Shah	18.03	18.38	0.35	0.30	4

Two stations namely Parachinar and Jewani have been observed with significantly decreasing trend i.e. -4.09^{o} C and -0.46^{o} C with standard error 0.60 and 0.10respectively, while rest of the stations have shown no significant change. Parachinar and Jewani are situated in different zones (Zone A and Zone E) and completely different in terms of their latitude, longitudes and atmospheric conditions. Jewani is a coastal area situated at comparatively low altitude in the southwest bordering the Arabian Sea while Parachinar is a town situated in the Kurram Agency (Federally Administrated Tribal Area) in north-western part of the country in Koh-e-Sufaid mountain range along Pak-Afghan border. The sudden drop of temperature in both stations indicates their abnormal behaviour. Hence, further research is needed to investigate other meteorological variables such as humidity, sunshine, precipitation and cloudiness etc. in detail. The intensity of the colours on the map Fig. 2B from high to low temperatures shows the range of minimum temperature i.e., from 3.4 to 21.8^{o} C. Similarly for the mean maximum temperature illustrated in Fig. (3 A & B) depicts a greater rising trend for Karachi, Quetta and Nawabshah, while Parachinar, Kalat, Hyderabad, Khuzdar and Zhob showed variation from 0.5^{o} C to 0.7^{o} C in the period2 i.e. 1991-2005. The stations, with maximum variation in temperature are located in different parts of the country, mainly from Zone A, C and E. Table 3 lists all the stations showing maximum increase in temperature and display significant increasing trend. Quetta is the capital city of Balochistan province and considered as one of the atmospherically polluted city while Kalat, Khuzdar and Zhob are mountainous towns of the province with less environmental pollution. Karachi and Hyderabad (Zone E) are big urban centers with heavy industry and transport vehicles. All these environmental factors could be the causes of rising trend of temperatures in these cities [27, 28]. According to Shirazi and Ali (2009) [28], many of the world's cities are home to around 50% of the world's population with rapid growth trend, using 75% of the world's energy resources and are responsible for 75% of global greenhouse gas emissions (GHG) and global warming. Similarly Munich Report (2004) [27] estimates approximately 80% of GHG emission from urban areas. Based on present warming trends, World Energy Outlook predicts a 53% increase in global energy demand by 2030, with 70% of that coming from developing countries. Therefore, various studies with different approaches have documented the climate variation as well as the warming trend in the country [29-31].

(A) (C)

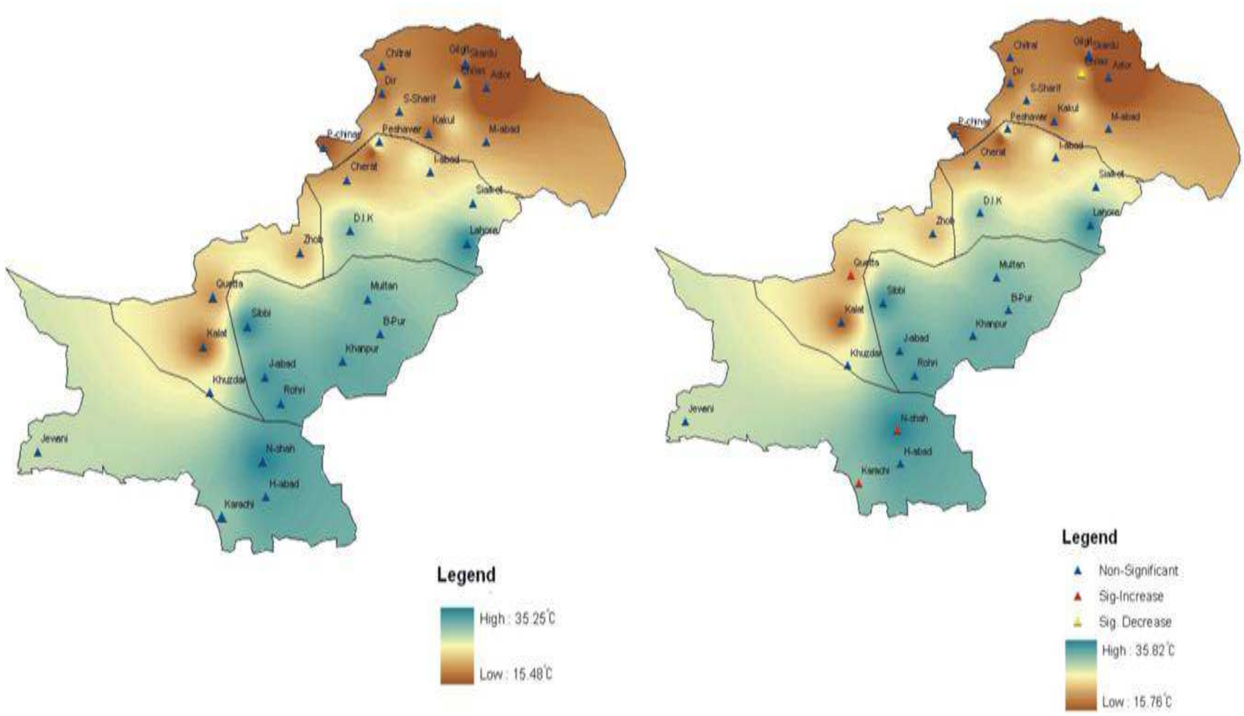

Fig. 3. Map of Pakistan showing significant increase, decrease and no change in the maximum temperature. (A): For period 1976-1990; (B): For period 1991-2005.

Table 3. Stations are showing significant increase, decrease, and no change in mean maximum temperature.

Station	Mean (1976-1990)	Mean (19912005)	Mean Diff	Std. Error	Zone
Increase in Maximum temperature					
Quetta	24.55	25.22	0.67	0.30	3a
Karachi	31.53	32.35	0.82	0.20	4
Nawab Shah	35.26	35.83	0.57	0.20	4
No change in Maximum temperature					
Astor	15.46	15.74	0.28	0.30	1
Chilas	26.58	26.11	-0.47	0.20	1
Chitral	23.46	23.61	0.15	0.20	1
Dir	22.7	23.04	0.34	0.20	1
Gilgit	24.21	24.51	0.3	0.20	1

Kakul	22.45	22.76	0.31	0.30	1
Muzaffarabad	27.11	27.62	0.51	0.20	1
Skardu	18.65	19.16	0.51	0.20	1
Saidu Sharif	25.79	26.08	0.29	0.30	1
Cherat	20.71	20.78	0.07	0.20	2
DIK	31.59	31.65	0.06	0.20	2
Islamabad	28.71	28.78	0.07	0.30	2
Lahore	34.76	35.02	0.25	0.20	2
Peshawar	29.76	29.83	0.07	0.20	2
Sialkot	29.36	29.56	0.2	0.30	2
Bahawal Pur	32.7	33.07	0.38	0.20	3b
Jacobabad	34.1	34.33	0.23	0.20	3b
Khanpur	33.39	33.52	0.13	0.20	3b
Multan	32.61	32.68	0.07	0.20	3b
Rohri	34.02	34.34	0.32	0.20	3b
Sibbi	34.73	34.92	0.19	0.20	3b
Jewani	29.92	30.28	0.36	0.20	4
Parachinar	21.16	21.62	0.45	0.30	1
Kalat	21.92	22.46	0.55	0.20	3a
Khuzdar	28.66	29.32	0.66	0.20	3a
Zhob	25.69	26.28	0.6	0.30	3a
Hyderabad	33.6	34.08	0.49	0.20	4

3.6. Zonal analysis

A general progressive increase in mean minimum temperature with inter-zonal variations can be easily recognized across the country from period 1 to period 2. The variations observed in zonal analysis showed significant increasing trend for all zones except Zone C. Zone E clearly exhibits the highest increase of 0.61^{o} C and standard error 0.20 among other zones. Although there are slight variations among the zones but the overall trend is increasing in minimum temperature.

Table 4. Zonal analysis of minimum and maximum temperatures

Zones	F-Value	Sig.	Mean (1976-1990)	Mean (1991-2005)	Mean Diff	Std. Error
Minimum Temperature						
Zone A	0.67	0.00	9.43	9.1	-0.33	0.20
Zone B	2.91	0.00	15.58	16.07	0.49	0.20
Zone C	0.23	0.64	10.11	10.44	0.34	0.30
Zone D	4.00	0.05	18.74	19.11	0.37	0.20
Zone E	3.98	0.05	20.05	20.65	0.6	0.20
Maximum Temperature						
Zone A	1.54	0.23	22.76	23.03	0.27	0.20
Zone B	0.44	0.51	29.15	29.27	0.12	0.20
Zone C	7.23	0.01	25.2	25.82	0.62	0.20
Zone D	1.32	0.26	33.59	33.81	0.22	0.20
Zone E	7.47	0.01	32.58	33.14	0.56	0.20

From the data analysis shown in Table 4, it can be inferred that plain areas of the country showed a clear warming trend during the second period i.e., 1991-2005 compared to period1 (1976-1990). However the temperature variations in northern parts of the country i.e., Himalayan and Hindukush mountain ranges (Zone A) showed no significant change. Similarly in the south and southwest (Zone C) of the country variations are negligible but the southeast (Zone D) showed an increasing trend. Both these Zones C and D lies in the same latitudinal window but Zone C is mountainous region having moderate to cold climate, whereas Zone D lies near the 'Thar Desert' having hot climate. The p-value shows a decrease in the mean minimum temperature of Zone A (-0.33^{o} C) during period2, which looks anomalous when compared with the increasing trend of other zones. A similar decreasing trend has been advocated by other workers for the western Himalaya [32, 33]. The overall increase in minimum temperature of the country is 0.29^{o}C from 1976-90 to 1991-05 periods which can be inferred as 0.10^{o} C per decade.

In similar manner, the maximum temperatures of the study area have also registered a temporal increase from the first half to the second half of the study period. Zones C and E exhibit increasing trend compared to the other zones. Although variations were noticed among the five zones but generally the overall trend was found increasing. The p-value for maximum temperature of the country is significant ($p<0.05$) for 0.36^{o} C increase between the two time period or 0.12^{o} C per decade.

It is evident from this study that all climatic zones of the study area show a consistently rising trend in the minimum and maximum temperatures except certain high elevation areas situated in the northern parts of the country. This study has also demonstrated an increase of 0.1^{o} C per decade in mean minimum temperature and 0.12^{o} C per decade in mean maximum temperature. These values are higher than the globally reported mean value of 0.018^{o}C for minimum temperature and 0.050^{o} C for maximum temperature [34] but lower than 0.296^{o} C, 0.287° C and 0.296° C per decade for mean, maximum and minimum temperatures respectively as shown by Russel et al. (2004) [35]. Similarly in Pakistan, Afzaal et al., (2009) [31] have reported a sharp increase of 0.06°C per decade and a cumulative rise of 0.64° C, between 1901 and 2007 by merging datasets of the Climatic Research Unit (CRU) of University of East Anglia and Pakistan Meteorological Department real time series (PMD). In the neighbouring country India, an observational dataset compiled by Dash et al (2007) [36], found an increase of 0.25^{o}C per decade in minimum temperature of post monsoonal and winter seasons. For Nepal, Shrestha, et al. (2005) [37], found an increase of mean temperature at rate of 0.04^{o}C during the time period of 1975-2005. While, in Bangladesh Islam et al (2007) [38], obtained a variation trend of 0.61^{o}C from 1961 -1990 with comparison of observational data with PRECIS modelling data. A similar analysis was conducted by Zhou et al (2004) [39], for southeast China for period 1979-1998. They show an increase of 0.6^{o}C per decade of minimum temperature, a rate faster than that of maximum temperature. It means the results of the rising temperature trends in Pakistan are in harmony with other published work in south Asian countries as well as in the globe.

4. CONCLUSIONS

Based on CDPC daily mean minimum and mean maximum temperatures from 1976-2005, the spatiotemporal trends and variations in temperatures were studied throughout the country. Analysis revealed that all climatic zones showed a consistent rising trend in minimum and maximum temperatures except Zone A and Zone C. The overall rising trend in minimum temperature for the country is observed approximately 0.29^{o} C for the two time periods and 0.10^{o} C per decade, which is found non-significant at p-value<0.05. Similarly, for maximum temperature we observed significant increase 0.36^{o} C in temperature in the two time intervals and $0.12\ ^{o}$ C per decade. However, the average increase of 0.11°C/decade is less than the global mean (0.6°C), but its potential implications are far reaching and have been observed in the recent years. It is therefore, concluded that climate change phenomenon may be given key consideration in developmental schemes, food security, and disaster risk management sectors by the policy makers.

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