DIURNAL TEMPERATURE RANGE (DTR) ASSESSMENT IN MAJOR CITIES OF PUNJAB, PAKISTAN

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ABSTRACT: Present study was conducted for the assessment of diurnal temperature range (DTR) in major cities of Punjab. Diurnal temperature range is the difference between the Monthly Maximum and Minimum temperature. This study provides more information than mean temperature. The purpose of the study was to calculate the spatial distribution of minimum and maximum temperature over Punjab and to assess the Diurnal Temperature range for annual and seasonal variation over the period of last 6 years (2010 to 2015). The first step in this research was to set up a new database of mean yearly maximum and minimum temperature from 6 stations of Punjab (Pakistan) which was Bahawalpur, Bahawalnagar, Sargodha, Jhelum, Faisalabad and Lahore. For this, the data was collected by secondary data collection method. The secondary data of all the indicators was obtained from Bureau of statistics and Metrological department of Pakistan. The data of three indicators which are maximum temperature, minimum temperature and population of the selected cities of Punjab was taken for the same period of time. Different tools such as correlation, regression, scatter diagram and interpolation were used to tabulate the data. The analysis revealed that the selected 6 cities of Punjab showed decrease in diurnal temperature range in recent six years. It is found that when mean temperature is increased then the diurnal temperature range is decreased. In future it is compulsory to take positive steps for the plantation. Congested buildings can boost up minimum temperature more rapid then maximum temperature if there is any green belt or park present in it can help to control the extreme temperature.

Keywords: Climate change, sustainability, Environment, Diurnal range of temperature, Punjab, Pakistan.

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INTRODUCTION

Diurnal Temperature Range (DTR) is welldefined as the daily maximum minus the daily minimum temperature. So, the consideration of DTR is delimited to land areas, where the DTR is far more vibrant than over the seas. DTR of Over land regions differs largely both seasonally and geologically (Wang and Dillon, 2014). The nature of DTR changeability is significant from a speculative viewpoint for many causes, comprising the considerate impacts of microclimate, variations in stratification tendency, and the kind of changes within the deeper boundary layer (McNider et al., 2012). It is potentially a factor between forcing that have dissimilar short wave and long wave radioactive fingerprints. It may otherwise be alike (Jackson and Forster, 2013). Trends and unevenness in DTR also have significant due to practical effects for health of humans (Paaijmans et al., 2010). The daily maximum temperature inclines to happen in a few hours after the maximum emergent solar radiation. The border layer is well assorted. On the other hand, the daily minimum temperature has a tendency to happen around dawn, as and when surface radiation cooling is pulling near. Records of the Meteorology have been assumed at the observing stations which spread back to the late 18th century nationally and to the late 19th century at globally (Rennie et al., 2014). Struggles have been made since many decades to organize this data, applying the similarity assessments, and to determine the kind of changes over the air temperatures of the land surfaces on the globe (Hawkins and Jones, 2013). Nowadays, there exist many such data sets internationally and locally (Rohde et al., 2013; van der Schrier et al., 2013). Besides the DTR has been deliberated as part of a more universal analyses internationally (Donat et al., 2013) and locally, examination of global DTR data and its homogeneousness was created (Vose et al., 2005). The Intergovernmental Panel on Climate Change (IPCC) at the very most contemporary employed group one examination noticed that there was the only "medium

confidence" (Hartmann *et al.*, 2013). This research paper tries to find out the benefits of these methodological and innovations of the data, to produce a new estimation of long-term changes in DTR regionally. A later research equated these results to a broader range of observation based results (Thorne *et al.*, 2016). Such consequent analyses allow an investigation of sensitivity to both structural and parametric reservations for estimation of the DTR. Therefore, this research was aimed to studying the spatial distribution of minimum and maximum temperature over Punjab and to assess the diurnal temperature range for annual and seasonal variation over the period of last six years (2010 to 2015).

MATERIAL AND METHODS

Study Area: Punjab has an area of about 205,344 km² and its population is about 82 million. It consists of 56% population of the country. The capital of Punjab province is Lahore. Punjab is located between 31°N to 72°E. Punjab is bordered with Azad-Jammu and Kashmir in the north-eastern side. In Indian, Punjab and the state of Rajasthan is located in east. In south Punjab border with Sindh province of Pakistan. Punjab bordered with

Pakistani provinces Baluchistan and Khyber Pakhtun Khaw in west. Islamabad and Azad Kashmir lies in its north. Province Punjab is mostly comprised of fertile land. Punjab is called five rivers land like, Chenab, Indus, Jhelum and Ravi. Punjab has 36 districts, But in this research work we worked on 8 districts which are Lahore. Faisalabad, Rawalpindi, Multan, Sialkot, Sargodha, Jhelum and Bahawalpur (Figure 1). Stations of study were include Lahore, Faisalabad, Sargodha and Northern highlands like the Karakoram range, Himalayas and Hindu Kush. This area consists on some other mountains like the second highest peak in the world are Mount K-2 with its height 8,611 meters and Nanga Parbat with 8,126 meters high, the 20th highest peak. One-half of the conferences over 4,500 meters, and the fifty peaks reach above 6,500 meters. Punjab is lies in monsoon Climate Belt. The temperature of Punjab is generally hot and has a very large number of variations in summer and winter. Usually, summer is hottest and winder is coldest in Punjab. The annual Rainfall is low, excluding in sub-Himalayan and Northern areas and it decreased from north to south or south east. Punjab province is knowledge able one of the coolest winters in the last 70 years.



Figure 1: Map of Punjab showing study areas



Figure 2: Methodological Flow Chart

Data Collection and Manipulation: The research is based on multiple methods and techniques such as correlation and Scatter Diagram of temperature data. For this purpose number of research techniques and methods has been used. Our research methodology consists of couple of phases (Figure 2), the first phase was to gather and collect the appropriate required data which is monthly mean temperature and monthly mean minimum temperature from different six metrological stations of Punjab for the period of 2010-2015, the second phase of research was to process the statistical data. Processing of data is one of the critical stages of the research. In this research. temporal data of monthly maximum temperature and monthly mean minimum temperature is used. Therefore, we find correlation of all data and find seasonal effects by using scatter plot method.

Analysis of the Data: Correlation is an important technique which can be used to organize, manipulate and analyze geospatial data in every discipline of social sciences (Figure 3 and 4). Correlation can be helpful in decision making process. The correlation analysis of the meteorological data, and related literature was consulted which lead towards the fulfillment of the research objectives. The result of data analysis achieved in accordance with the aims and objectives of this research are summarized here. Station data collected on Monthly maximum and minimum temperature for all first order data from meteorological department. At the end, the diurnal temperature range was found by subtracting maximum temperature from minimum temperature values for whole year.

X	Y
1 .	10
2	20
3	30
4	40
5	50

Figure 3: X and Y components for positive correlation

RESULTS

Diurnal Temperature Range (DTR) Variations: Diurnal temperature range is different in different parts of Punjab province in degrees Celsius (Figure 4). Highest diurnal temperature range was seen in Jhelum district which was 14.23. Here maximum diurnal temperature range was high as compared to night time minimum temperature. The gap between maximum and minimum was high in Jhelum therefore it shows high rate of DTR as compared to other districts of Punjab and very low diurnal temperature range can be seen in Lahore. The diurnal temperature range was 11.4 in Lahore urban area



Figure 4: Linear diagram of positive correlation

while we go away from the urban area then the DTR range increased and reached to 12 in surrounding areas. In Punjab the second lowest DTR can be seen in Sargodha, it ranges from 12 to 12.4. Mostly part of Rawalpindi and Faisalabad divisions show diurnal temperature range 13.1 to 13.4, it is considered moderate diurnal temperature range in Punjab. Other districts of four divisions in middle and southern Punjab which were Bahawalpur, Dera Ghazi Khan, Multan and Sahiwal showed diurnal temperature range between 12.8 to 13.1. This group of diurnal temperature range comprised large land area of Punjab. Northern Punjab showed variation in DTR while the diurnal temperature range was moderate.



Figure 5: DTR variations in study areas of Punjab

	Maximum	Minimum	Mean	DTR	
Cities	Temperature (°C)	Temperature (°C)	Temperature (°C)	(°C)	
Lahore	30.12	18.78	24.45	11.45	
Sargodha	31.17	18.56	24.85	12.63	
Bahawalnagar	32.47	19.5	25.99	13.09	
Faisalabad	30.83	17.69	24.27	13.38	
Bahawalpur	32.48	18.86	25.67	13.78	
Jhelum	30.67	16.85	23.77	14.23	

Table 1: V	Variations in	temperature	and DTR	of different stations
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Figure 6: Variations in temperature and DTR of different stations

Lahore has showed minimum gap between maximum temperature and minimum temperature which were called diurnal temperature range. Lahore has maximum population as compared to the other cities due to urban heat island the night time temperature was not decreased at a high rate. Their gap was low between night time temperature and day time temperature.



Figure 7: Correlation of mean temperature and DTR of Bahawalpur

The behavior of mean temperature and DTR was highly correlated and showed negative trend. DTR and T(mean) are inversely proportional to each other, when mean temperature increases the DTR decreases on the other hand. Maximum DTR was 16.20 for the month of November and the minimum Diurnal temperature range can be seen 9.57 for the month of August. The linear diagram of pre-monsoon season for Faisalabad showed decrease in diurnal temperature range from year to year. Reduction can be seen during 2010-2015 simultaneously. Large number of reduction can be shown in pre-monsoon season, DTR dropped down from 15.80 to 13.60.



Figure 8: DTR trends of Faisalabad



Figure 9: Variations in temperature and DTR of Jhelum

The behavior of mean temperature and DTR was highly correlated and showed negative trend. Mean temperature and DTR were inversely proportional to each other, when mean temperature the DTR decrease on other hand. Maximum diurnal temperature range was 16.73 for the month of December and the minimum Diurnal temperature range can be seen 9.00 for the month of August.

The behavior of T(mean) and DTR was highly correlated and show negative trend. Mean temperature and DTR were inversely proportional to each other, when mean temperature the DTR decreased on other hand. Maximum diurnal temperature range was 14.00 for the month of April and the minimum Diurnal temperature range can be seen 7.93 for the month of August.

Linear diagram of pre-monsoon season for Sargodha showed small decrease in diurnal temperature range from year to year. Reduction can be seen during 2010-2015 simultaneously. Small reduction can be shown in pre-monsoon season, DTR dropped down from 15.37 to 13.23.



Figure 10: Variations in temperature and DTR of Lahore



Figure 11: DTR trends of Sargodha

DISCUSSION

Diurnal range of temperature has a significant impact on the climate and environment of the concerned stations. The results of the different stations have shown variations in Mean temperature and DTR. Lahore has maximum population as compared to the other cities and due to this urban heat island the night time temperature was not decreased at a high rate. Their gap was low between night time temperature and day time temperature. Kaiser et al., (2016) that due to the urban heat island and urbanization the day time temperature increases at a rate of 1°C. Pilogallo et al., (2019) conducted a study in Basilicata region (Italy) and concluded that there is a prominent association between the recorded minimum temperature and urban area expansion. A study conducted in Po Valley, Italy found that there is a decreasing Land Surface Temperature (LST) range liked with regular increase of urbanized areas. The LST in daytime conditions was an average

increase of $+1.36^{\circ}$ C in the study area (Zullo *et al.*, 2019). DTR and T(mean) are inversely proportional to each other, when mean temperature increases the DTR decreases on the other hand during 2010-2015 simultaneously. Čeplová *et al.*, (2017) found that size of settlement, and urban heat island have a great impact on biodiversity of the area. Therefore, planting of trees and green spaces are crucial to mitigate the effects of increasing temperature especially in major urban areas i.e. Lahore, Faisalabad, Multan, Sargodha etc. It is noted in a study conducted in four major cities of Asia (Jakarta, Singapore, Kuala Lumpur and Hong Kong) that greening and city configuration are determined the land surface temperature and cooling effects in urban centers (Masoudi *et al.*, 2019).

Conclusion: This research aimed to assess the variations in diurnal range of temperature and its impacts on human being. Diurnal temperature range has shown great variations. The variations in the Diurnal temperature range were due to the anthropogenic effect which is analyzed from 2010-2015 on yearly bases in the study area which consists of six major cities of Punjab. Diurnal temperature range showed reduction in this particular research work. Faisalabad, Jhelum, Bahawalpur and Bahawalnagar showed decrease in diurnal temperature range for Pre-Monsoon, Monsoon, Post-Monsoon, and western disturbance. This decrease in diurnal temperature range was more rapid in Pre-Monsoon, and in western disturbance seasons and rate of reduction was low for Monsoon and Post-Monsoon. The nature of relationship between mean temperature and diurnal temperature range showed negative relationship for Pre-Monsoon, Post monsoon, and western disturbance seasons. This is due to the inverse relationship between diurnal temperature range and mean temperature. Sargodha showed decrease in Diurnal temperature range for Pre-Monsoon, Monsoon, Post monsoon, and western disturbance. This decrease in Diurnal temperature range was more rapid in Pre-Monsoon, and in western disturbance seasons and rate of reduction was low for Monsoon and post-Monsoon. The nature of relationship between mean temperature and diurnal temperature range showed negative relationship for Pre-Monsoon, Post monsoon, and western disturbance seasons this is due to the inverse relationship between Diurnal temperature range and mean temperature. Lahore is also showed decrease in Diurnal temperature range for Pre-Monsoon, Monsoon, Post monsoon, and western disturbance. This decrease in Diurnal temperature range was more rapid in Pre-Monsoon, and in western disturbance seasons and rate of reduction was low for Monsoon and post-Monsoon. The nature of relationship between mean temperature and diurnal temperature range showed negative relationship for Pre-Monsoon, Post monsoon, and western disturbance seasons. This is due to the Inverse relationship between Diurnal temperature range and mean temperature. Overall results of this research show that the diurnal temperature range was decrease but its decrease was rapid in pre-monsoon season and in western disturbance and it was slowly increase in monsoon season and post-monsoon season. Both diurnal temperature range and mean temperature showed negative correlation. This decrease is due to increase in anthropogenic activities like Deforestation, Urban heat island. Population and Diurnal temperature range are negatively correlated with one another. As population is increase the diurnal temperature range shows decrease.

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