

# Climatic Trends in Faisalabad (Pakistan) Over the Last 60 Years (1945 - 2004)

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## ABSTRACT

Meteorological data of 60 years recorded from meteorological observatory main campus, University of Agriculture Faisalabad was analyzed by taking average of daily data of each month. These monthly means of 60 years were used for trend analysis. A line  $Y = mX + c$  was fitted to find the trend of change of temperature and rainfall of each month in 60 years. Two normals from 1945 to 1974 and 1975 to 2004 were calculated and compared. Analysis show that the mean temperature of November, December, January, February and March is rising. It means winter is getting warmer; particularly November and December are warming more rapidly. The winter temperature has increased by 0.55°C. The temperature of April, May and October is also increasing. The average temperature of June, July and September is decreasing, while the average temperature of August is increasing. The summer temperature as a whole has decreased by 1°C during last thirty years. The trend analysis shows that summer season is getting cooled, so climate of Faisalabad is getting mild. Overall increase in temperature is 0.22°C, which becomes only 0.9%. Rainfall during summer is increasing particularly in June the rate of increase of rainfall is very high. Rainfall during summer has increased by 68.7 mm. Rainfall for the months of December, January and March is decreasing, while rainfall for the months of November and February is increasing. Trend of rainfall for the months of April, May and October is also increasing. As a whole trend of rainfall is increasing and it has increased by 90.4 mm (from 1975 to 2004) The Normal temperature of Faisalabad on the basis of WMO definition of normal (from 1975 to 2004) is calculated as 24.5°C and normal rainfall is calculated as 408 mm.

**Key Words:** Temperature; Rainfall; Climatic trends

## INTRODUCTION

Faisalabad is located just out-side the tropics at latitude 31°26', longitude 71°06' and altitude of 184.4 m. Here the sun's rays do not slant much especially in the summer therefore high temperature prevails during the summer months. Many scientists have predicted that rising global temperatures are making our weather and climate not only warmer, wetter and windier but more un-predictable and violent (Rajindra & Pachauri, 2005). Temperature has a direct affect on the plant growth rate and temperature above optimum results in reduced growth rate and may cause severe stresses at critical stages of development (Salimi, 1985). In Faisalabad, rainfall does not occur through out the year, most of the rainfall occurs in two seasons namely summer, from July to September and winter, from December to March. Winter rainfall accompanies the western disturbances. A small quantity of rainfall occurs during thunderstorm (dry summer & calm interval).

The climate of the whole planet earth is under transition, no analysis of the meteorological data is reported so far for Faisalabad region. Maximum and minimum temperatures and rainfall have been recorded in Meteorological Observatory, University of Agriculture, Faisalabad during the last 60 years. The present effort was therefore carried out to analyze the trends in temperature

and rainfall during the last sixty years and suggest the present and up-coming climatic changes in Faisalabad.

## MATERIALS AND METHODS

Meteorological data has been recorded daily from Meteorological Observatory, University of Agriculture, Faisalabad. Monthly means of this data were entered in Microsoft Excel sheet for analysis and graphs.

The word climate is often used as "average weather" over very variable periods of time, which may vary from a few months to millions of years. However Ahrens (1998) define weather as "Condition of the atmosphere at any particular time and place". Whereas climate has been defined by him as "The accumulations of daily and seasonal weather over a long period of time". But according to World Meteorological Organization the climate normal is considered a period of 30 years. So in this write up 30 years normals of Faisalabad temperature and rainfall are calculated. The latest normals from 1974 to 2004 are very important for agricultural scientific community and research fellows. A trend line  $Y = mX + c$  is fitted on 60 years temperature data and trend of each month of the year is calculated, which is more suitable as compared to divide 60 years data in to intervals. Similarly a trend line is fitted on 60 years rainfall data and trend of rainfall for each month as

well as trend of rainfall per year was calculated. Also data has been analyzed for Trend analysis of two seasons. In order to calculate % increase in rainfall and temperature, the data is divided in to two normals i.e., average from 1945 to 1974 and 1975 to 2004 are calculated. In order to make the results more understandable the graphs are drawn.

## RESULTS AND DISCUSSIONS

Air converging in to a low pressure center at the surface rises, leading to moisture condensation and the subsequent release of heat in to the upper atmosphere. Diverging air at the surface in a high pressure center is associated with subsiding air from the upper atmosphere and evaporation, a mechanism for energy storage. Just as energy imbalances develop between land and water surfaces, the variation in space and time of solar heating due to the earth's tilt create seasonal hemispheric energy imbalances. The hemisphere receiving the most direct radiation (during the summer months) experiences a net radiative heating (more energy is gained from the sun than is lost to space). The winter hemisphere is at the same time experiencing net radiative cooling. As part of a global compensation, heat is transported from warmer to cooler areas by ocean and wind currents. Since the areas of heat surplus and deficit change throughout the year, as in the sea breeze example, the direction of transport must change as well. Recent rapid global warming has been attributed mainly to anthropogenic activity of burning fossil fuels and deforestations. Each year CO<sub>2</sub> level in the air is increasing by 1.5 ppm causing global warming (Chaudhary, 2003).

Meteorological data of 60 years recorded from the Meteorological Observatory located at the University of Agriculture, Faisalabad campus was analyzed statistically. During the last 60 years, maximum rainfall was recorded during the month of July followed by August (Fig. 1), while maximum temperature was recorded during the month of June followed by July (Fig. 1). Climatic trends of rainfall,

maximum temperature, minimum temperature and average temperature of each month has been discussed.

Maximum temperature and rainfall of January is decreasing, while minimum temperature and average temperature is increasing (Table I). In February the maximum temperature is decreasing and minimum temperature, average temperature and rainfall are increasing (Table I). During March temperature trend is increasing and rainfall trend is decreasing (Table I). Average rainfall of 30 years (from 1975 to 2004) is greater than average rainfall of 30 years (from 1945 to 1974) (Table I) reason behind might be that if 60 years data is divided in to 6 decades, the average rainfall of each decade is calculated as 17.3 mm, 23.4 mm, 17.3 mm, 38.0 mm, 23.7 mm and 12.0 mm reveals that the average rainfall of 4<sup>th</sup> decade (1975 - 1984) is 38 mm, which is very high as compared to other five decades. In April the temperature and rainfall are both increasing (Table I). The trend of May is same as that of April but rate of increase of rainfall in April is more as compared to May. An important result is seen during month of June that the maximum, minimum and average temperature is decreasing, while rainfall is increasing more significantly. The average rainfall for 30 years from 1945 to 1974 is 22 mm, while the average rainfall for 30 years from 1975 to 2004 is 38.9 mm. The Rainfall has increased by 16.9 mm at the rate of 76.8% and the average temperature has decreased by 0.42°C.

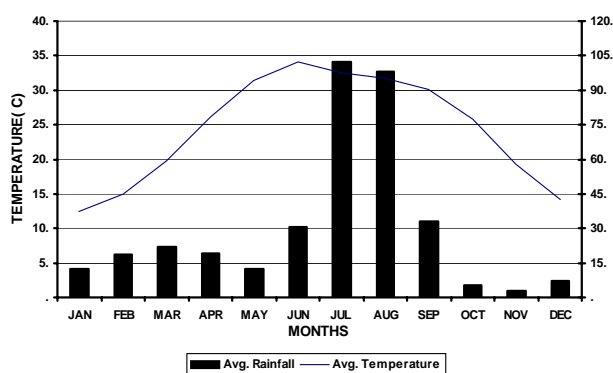
In July the maximum, the minimum and average temperature is decreasing with an increase in rainfall. The rainfall has increased by 21.6%. The average rainfall of July is 112.5 mm (from 1975 to 2004) per year, which is highest among all months. Trend analysis shows that average temperature of August is rising, while rainfall is decreasing at the rate of 24.3% but Table I show that average rainfall of 30 years (from 1975 to 2004) is greater than average rainfall of 30 years (from 1945 to 1974) (Table I). The reason is that if 60 years data is divided in to 6 decades, the average rainfall of each decade is calculated as 99.4 mm, 93.3 mm

**Table I. Analysis of temperature and rainfall data**

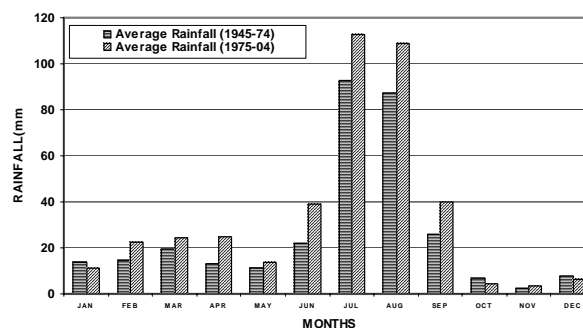
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Maximum Temperature Trend	-0.007	-0.009	0.009	0.004	0.011	-0.014	-0.0021	0.014	0.0003	-0.001	0.014	0.017
Minimum Temperature Trend	0.040	0.036	0.015	0.014	0.013	-0.004	-0.0001	0.006	-0.0011	0.020	0.053	0.054
Average Max-min Temperature trend	0.015	0.008	0.004	0.004	0.014	-0.012	-0.0034	0.011	-0.0034	0.014	0.033	0.032
Rainfall trend	-0.145	0.231	-0.063	0.261	0.073	0.636	0.0308	-0.140	0.2437	-0.058	0.029	-0.008
Average Maximum Temperature	19.28	22.19	27.03	33.85	39.00	40.70	37.61	36.42	35.98	33.20	27.41	21.65
Average Minimum Temperature	5.62	7.99	12.79	18.51	23.68	27.54	27.59	26.99	24.43	18.22	11.31	6.76
Average Max-min. Temperature	12.41	15.03	19.83	26.13	31.36	34.09	32.58	31.72	30.18	25.75	19.35	14.16
Average Rainfall	12.46	18.56	21.97	19.01	12.42	30.43	102.49	96.4	32.97	5.49	2.88	7.19
Average lowest Rainfall	0	0	0	0	0	0	0	0.3	0	0	0	0
Average Highest Rainfall	63.5	97.7	83.1	78	104.7	160	480.1	268.6	161.6	39.12	29.97	50.29
Avg. Temperature (1945-1974) 30 Yrs.	12.17	14.93	19.99	26.16	31.11	34.32	32.76	31.66	30.33	25.54	18.79	13.58
Avg. Temperature (1975-2004) 30 Yrs.	12.7	15.1	19.7	26.1	31.6	33.9	32.4	31.8	30.	26.	19.9	14.8
Average Rainfall (1945-1974) 30 Yrs.	13.8	14.7	19.4	13.2	11.3	22.	92.5	87.5	26.	6.6	2.3	7.9
Average Rainfall (1975-2004) 30 Yrs.	11.2	22.4	24.6	24.8	13.6	38.9	112.5	105.3	40.	4.4	3.4	6.5
Deviation of rainfall (mm)	-2.6	+7.7	+5.2	+11.6	+2.3	+16.9	+20	+17.8	+14	-2.2	+1.1	-1.4
Deviation of temperature (°C)	+0.53	+0.17	-0.29	-0.06	+0.49	-0.42	-0.36	+0.14	-0.33	+0.46	+1.11	+1.22

Normal Rainfall of 30 years (1975-2004) is 408mm; Normal Temperature of 30 years (1975-2004) is 24.5°C.

**Fig. 1. Average temperature and rainfall vs months**

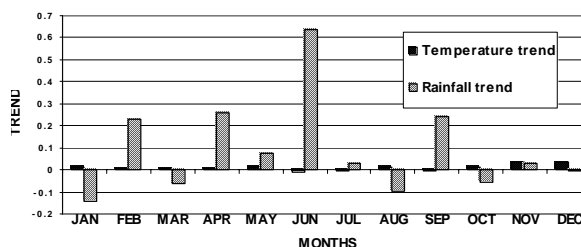


**Fig. 2. Two normals of rainfall verses months**



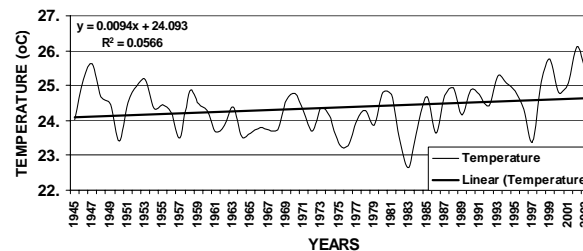
69.8 mm, 149.4 mm, 71.4 mm and 95.1 reveals that the average rainfall of 4<sup>th</sup> decade (1975 - 1984) is 149.4 mm, which is very high as compared to other five decades. During September maximum temperature has slightly increasing trend while minimum temperature and average temperature has decreasing trend. Rainfall is increasing at the rate of 53.8%. Trend analysis of October shows that maximum temperature and rainfall are decreasing, while minimum temperature and average temperature are increasing. During November both average temperature and rainfall are increasing. Trend of temperature for the month of December is increasing, while rainfall is decreasing.

**Fig. 3. Average temperature and rainfall trend vs months**



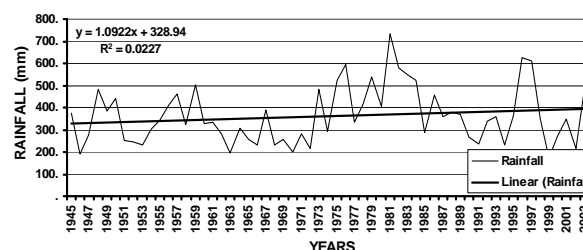
Comparison of two normals of rainfall are more clear from Fig. 2. Fig. 3 shows the trend comparison of rainfall and temperature of 60 years. In Fig. 4 trend line shows that average temperature of 60 years is increasing. This trend is also reported by Siddiqui A (1960) and later on by Ch. Dr. Qamar-uz-zaman (2003). The increasing trend of rainfall is clear from Fig. 5. This trend is also reported by Haider *et al.* (1991).

**Fig. 4. Average temperature vs years**



During, whole winter season (Nov., Dec., Jan., Feb., & March) average temperature has increased by 0.55°C at the rate of 3.5% and during summer, temperature has decreased by 0.97°C at the rate of 3% and during thunderstorm (Apr., May & Oct.) the temperature has increased by 0.89°C at the rate of 3.7%.

**Fig. 5. Total rainfall vs years**



Rainfall for the months of December, January and March is decreasing, while rainfall for the months of November and February is increasing. Rainfall of February on the average has increased by 7.7mm at the rate of 52.4%. During summer season (June, July, August & September) rainfall has increased by 68.7 mm at the rate of 30%. During thunderstorm season rainfall is also increasing except October.

increasing and it has increased by 90.4 mm. During the period from 1975 to 2004 (30 years) normal temperature of Faisalabad is 24.5°C and normal rainfall is 408 mm.

The present study suggests that summer season is getting cooled, so climate of Faisalabad is getting mild. Rainfall during summer is increasing particularly in June the rate of increase of rainfall is very high, while it is decreasing during the months of December, January and March. Rainfall during February, April, May October and November is also increasing. As a whole trend of rainfall is

**CONCLUSIONS**

The analysis of weather records of Faisalabad for 60 years revealed that the winter season has been shorting and warming, while the temperature of March is decreasing due to greater amount of rainfall. The winter temperature has

increased by 0.55°C. The summer temperature as a whole has decreased by 1°C during last thirty years due to greater amount of rainfall. The Trend of rainfall is increasing. Trend analysis shows that summer season is getting cooled, so climate of Faisalabad is getting mild.

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