TEMPERATURE AND RAINFALL FLUCTUATION

(A Case Study of Udigram, Swat Valley, Northwest Pakistan)

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Abstract

A study of temperature and rainfall fluctuation of Udigram, Swat, reveals decrease in annual rainfall during the past 15 years. As a result climate has become sub-humid in 2000, as compared to the humid in 1980. The valley receives both summer and winter rainfall, but the annual share of winter rain is higher than summer season. January is the coldest month when the temperature falls to freezing point, and June is the hottest month when the temperature exceeds 30 degree Celsius. There are four rainy seasons i.e. winter, pre-monsoon, monsoon, and the post monsoon. The temperature of the valley increases at the rate of 1^{o}C per year since 1995. The summer rain shows little decrease, whereas the average winter rainfall declined at the rate of 7.3cm per year during the past six years since 1995. If the rainfall of the valley decreases at this rate, then the climate of the area will be semi-arid by 2020. This climatic fluctuation may be the result of the changes in the air pressure, wind speed and direction, and deforestation on global level, and the Gulf-Afghan crises that cause a northward shift in the western disturbances. However, due to rapid increase in temperature and decrease in pressure, it is hoped that this reduction in winter rains of the area will be recovered upto 2005 and may be reversed spell till 2010.

1. Introduction:

Udigram, a historical place of evergreen land of Swat Valley, Northwest Pakistan, is located at 72°-18` east longitude and 34°-47`north latitude, at an altitude of 961m above the sea level. The Population of the village was 4402, in 1981, and increased to 12497, in 1998. The village is bounded by Balogram in the north, Raja Gira mountains in the east, Gogdara in the south and the Swat river in the west. The tributaries of Swat and Murghazar rivers cover the whole drainage of the tract (Figure-1).

The present paper deals with the rainfall and temperature variation of the Udigram valley during the past fifteen years (1986 to 2000), and its possible causes in the background of the global climatic changes.

A number of workers have studied the fluctuation of temperature and rainfall on regional level in the past, including Kazi (1951), Kazi and Khan (1959), Shamshad (1966), Nasrullah (1968), Khan (1990), and Khan (1993) etc. The present study is aimed at Udigram only, where the reduction of rainfall has caused a number of environmental problems.

2. Methods and Data:

The work is based on the daily as well as monthly weather data, covering time duration of fifteen years i.e. 1986-2000, published by Water Management Department, Agriculture University Peshawar, and Agriculture Research Station, Takhta Band, Mingora, Swat. The variables studied, are temperature and rainfall.

The monthly and annual averages have been calculated for the study. For each parameter, deviation from the mean and regression has been calculated, which provides a trend of annual as well as monthly fluctuation of rainfall and temperature. The year has been divided into two main seasons i.e. summer and winter. Months of the year having positive deviation from the mean condition of maximum and minimum temperature have been considered as summer months, otherwise winter. The two main seasons are further sub-divided into four sub-seasons i.e. winter rainfall (Mid-November to Mid-April), pre-monsoon season (Mid-April to June), monsoon season (July to Mid-September), and the post-monsoon season (Mid-September to Mid-November). The time duration of each season has been decided on the basis of positive and negative deviation from the mean condition. April, September, and November show increase, therefore, the total rainfall of these months have been divided by two, and each half of the value is added to the both seasons.

3. Temperature Fluctuation:

The temperature condition of Udigram is the representative of the plain strip of land at the foot of the Hindu Raj mountains in the Swat valley. The area is extremely cold in winter, when the mean maximum temperature falls to 18^{o}C, and the minimum temperature to 6^{o}C (Graph and table-1). The area is characterized by pleasant warm summer with maximum temperature of above 30^{o}C, and a minimum temperature of 18^{o}Celsius. The coldest month of the valley is January, when the deviation of maximum temperature falls to –10^{o}C and that of minimum temperature to -9^{o}C (Graph-2). The extreme highest temperature of the area is 43.6^{o}C, recorded on 1st June 1988, whereas, the lowest is -3^{o}C, recorded on 3rd January 1987.

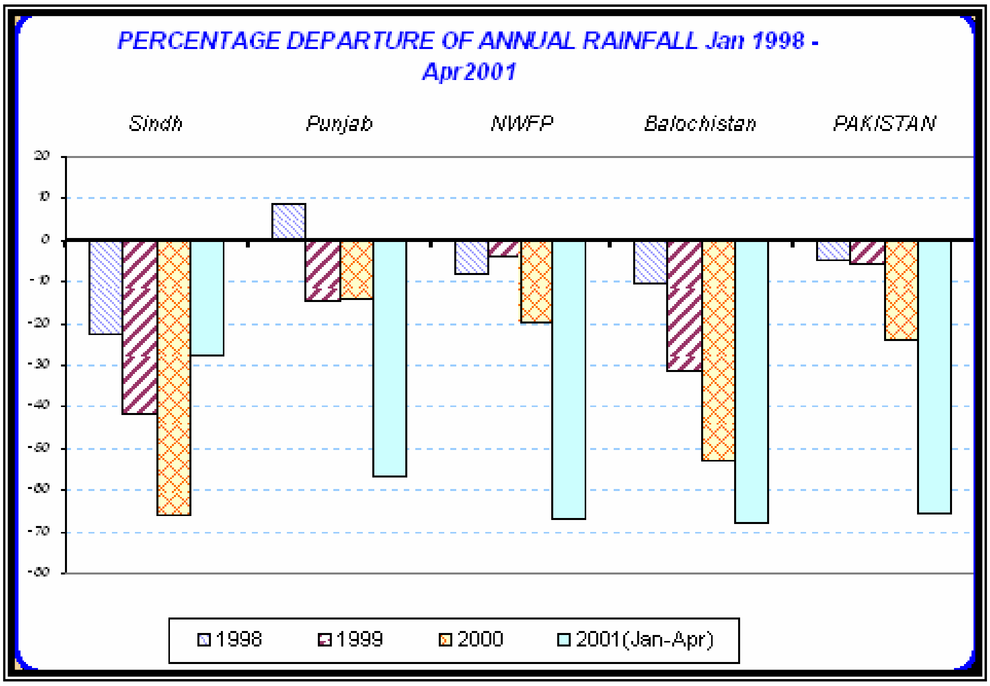
From January to April, the temperature of the valley rises up, while the highest value reaches in June, when the hot season is at its climax. In this month, the mean maximum temperature exceeds 32^{o}C, and the minimum temperature to 18.4^{o}C (Graph-1) and constitutes as the hottest month of the area. The mean daily maximum temperature falls to 30^{o}C on the onset of monsoon lows, and the minimum temperature decreases to 18^{o} Celsius. Rapid cooling of air in the valley starts in October, when the maximum temperature decreases to 24^{o}C, and the minimum temperature drops to 10^{o} Celsius. The maximum and minimum temperature in December is close to that of January, however, it is less than October and November.

The area is wet by July with rainfall above 13 centimeters. The driest month of the year is November. When proceed northward to Kalam, Murghazar, Miandam and Jambil valleys, the temperature in winter and summer falls considerably with altitude. Therefore, the climates of these valleys are different from one another.

The annual variation of temperature reveals a gradual increase/decrease of maximum and minimum temperature from the mean value during the whole period. The temperature of the area shows rises and falls from 1986 to 1994. During the period between 1994-97, it is below the mean condition, and onward to 2000, it shows positive deviation with increasing trend of 1^{o}C per year (Table-4). This decreasing trend in the beginning of the period, and then sudden increase in the last three years, generally, caused change in the pressure pattern of the area that produced change in the direction of westerly currents toward north and effected the winter rainfall of the valley. This climatic fluctuation not only influenced the human activities but also caused change in the evapotranspiration as well as relative humidity of the area.

4. Rainfall Fluctuation:

Udigram had sub-humid climate with annual rainfall of 98.9cm (39.6inches) in 2000, as has been shown in table-3. The area is highly moist in March, when the rainfall increases upto 17cm, followed by the decrease in the rainfall, but in May an increase in the rainfall above 5centimeters. The area receives both summer and winter rains, but the contribution of winter rains is higher as compared to summer (Graph-1).



Graph-7: Percentage Departure of Annual Precipitation in Pakistan, Pakistan Meteorological Department, 2001.

The recent fluctuation of rainfall, plotted on graph-3 and 4, shows a gradual decrease in rainfall during the past fifteen years (1986-2000). The precipitation during 1986-90 shows a decreasing trend. The area recorded 17.6cm rainfall in 1986 that dropped to –5.4cm, in 1990. In the period between 1991-95, the rainfall reveals a rapid increase from 9.3cm to

15.1cm, with negative deviation anomalies in 1993 and 1994 and then falls to –27cm, in 2000. As shown in graph-4 and 7, the rainfall of the valley in the last five years (1995-2000) decreased at the rate of 7.3cm per year (Table-4). This rapid reduction in rainfall not only influenced the crop growth and yield, but it also affects the human activities of the area. Inspite of this, from 1931 to 1970, the average rainfall of the valley was above 40inches (100cm), and the area had a humid climate. But the reduction of rainfall in 1986 to 2000 that is in the past fifteen years (7.3cm/year) put the area in sub-humid climate. If the rainfall decreases at this rate continuously, then the climate of the valley will change from sub-humid to semi-arid by 2020 i.e. during the next twenty years.

Swat valley receives both summer and winter rains, and the annual rainfall is the average of these two seasons. The deviation of rainfall from the mean condition of the seasons, plotted on graph-5, shows that from 1986 to 1990, the summer rains increased from 11 to 18cm, and the winter rains from 12 to 18centimeters. From 1991-95, the summer rain reveals positive deviation of 14 to 20cm, and the winter rainfall from 0.6 to zero centimeters, with little increase of 7 to 9cm, in 1991 to 1992. From 1995 to 2000, the summer rains decreased from 20 to 5cm, while the winter rains dropped from zero to –26centimeters (Graph-5). In the last five years (1995 to 2000), the summer rains of the area decreased at the rate of 3cm/year, whereas, the fall in winter rain is -4.9cm/year (Table-4). The decrease in the winter rains of the valley is higher than summer, and due to this rapid decrease, the area is continuously going towards aridity.

Based on annual cycle of rainfall, these two seasons have further been divided into four sub-seasons i.e. winter, pre-monsoon, monsoon, and the post-monsoon seasons. The general description of each season is as follow.

4.1. Winter Rainfall:

The winter rainfall is associated with the passage of western disturbances, moving eastwards from Iran and Afghanistan during Mid-November to Mid-April (Figure-2 and 3). An active western disturbance can induce fairly heavy rain. In some of the heaviest falls in winter, amount as high as 10.2cm has been recorded on 2nd February 1980.

The total rainfall of the area recorded in winter is 46centimeters. The rains, in this season start with its lowest amount in December (5.1cm), and increase upto 17.4cm in March.

Figure-2: Map showing Western Disturbance, 3rd December, 2008, by Google, Earth

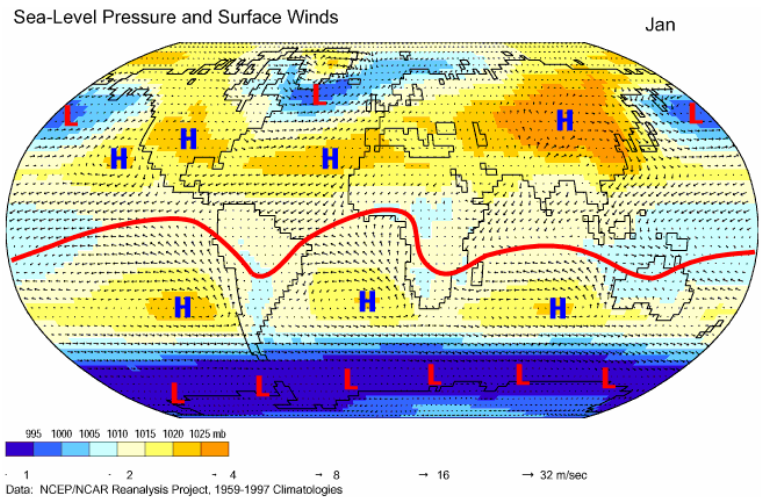


Figure-3: January (Winter Season), NCEP/NCAR, Reanalysis Project 1959-1997.

The rainfall variation plotted on graph-6, shows that the total rainfall of the area was 56.5cm in 1986, and dropped rapidly to 32.5cm in 1989. In 1990, the winter rains increased to 70.2cm, and then decreased continuously to 25.2cm in 2000. In winter, the rainfall shows a mark decrease, which may be the result of change in atmospheric circulation, temperature, and air pressure. However, the rapid increase in temperature in the last five years (1995 to 2000) will cause high rains due to low pressure in the area, which may recover the deficiency in rains of winter quota upto 2005 and may be fall again till 2010.

4.2. Pre-Monsoon Rainfall:

The season generally lasts from Mid-April to June, when the temperature of the valley reaches to its extreme. These rains are mostly the result of the ascending air currents, due to local heating, and therefore, they are also designated by the name, “local thunderstorms”. The total rainfall of the season is 15.8cm, with high rainfall of 10.2cm in April, and lowest is 5.6cm in May.

The rainfall recorded in the pre-monsoon season is 30.6cm in 1986, which decreased to 2.5cm in 1990. Again there is an increase in the next 10 years and by the year 2000, it has increased to 14.4centimeters. The variation of rainfall, generally, shows very minor decrease, but the rate of decreases is less as compared to 1986. This minor fluctuation in the area results in the increase in temperature particularly in May and June, and the mountain slopes, help to activate the warm moist air parcels to condensation level and bring rains.

4.3. Monsoon Rainfall:

The monsoon precipitation is associated with the convergence of the Arabian sea and Bay of Bengal currents in upper troposphere when a tropical depression is developed over central part of the Indo-Pakistan sub-continent. The monsoon winds reach to the area in the first week of July and are well-established upto mid of that month. The major share of summer rains from these winds is 24.4cm, which is one-half of the winter rains. July, with 13.7cm rainfall, is the leading month of the season, while it decreases to 6.3cm in September, when the monsoon currents reverse from land to Arabian sea (Graph-6).

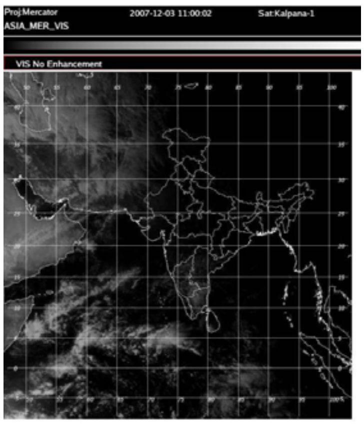


Figure-4: Summer (Southwesterly Monsoon) Clouds Flow towards Indian Sub-Continent by NASA, 2007.

The fluctuation of monsoon rainfall for Swat valley shows that in 1986, the area recorded a total rainfall of 25.9cm that reduced to 18.8cm in 1990. From 1991, it reveals an increasing trend of 35.8cm and 38.9cm till 1995. Onward, the rainfall shows gradual decrease to 23.3cm in 2000, with 3cm falls per year (Figure 4 and 5).

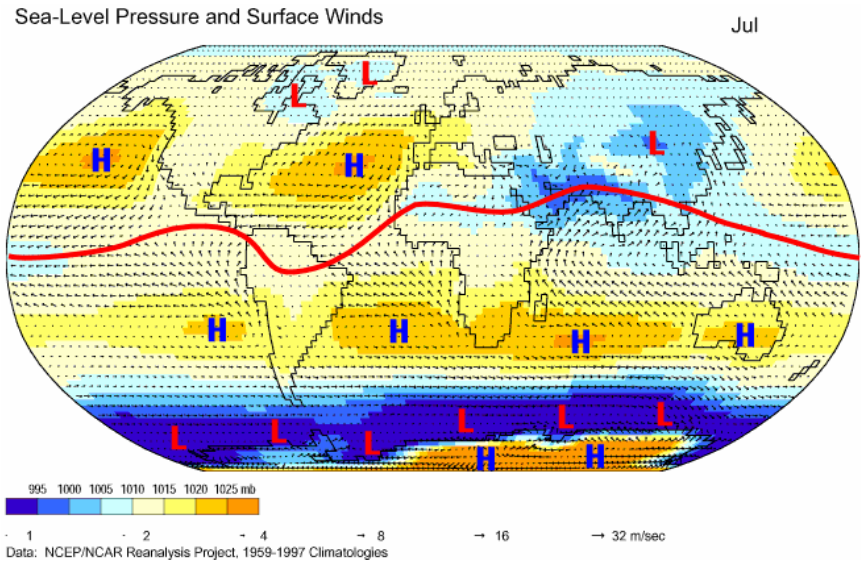


Figure-5: July (Summer Season), Surface NCEP/NCAR, Reanalysis Project 1959-1997.

4.4. Post- Monsoon Rainfall:

In September, when the summer convergence zone shifts southwards, there is a marked decrease in rainfall of the area. Rainfall decreases further, after the withdrawal of the monsoon, and November is usually the driest month of the year. The post-monsoon season remains from Mid-September to Mid-November. During this season, the total rainfall of the area drops to 7.6cm, with 3.1cm in October and 0.5cm in November.

The area recorded 4.5cm rainfall in 1986, which decreased to 2cm in 1990, and then increased to 7cm in 1995, and 9cm in 2000. The fluctuation in the 1986 to 2000 show a marked increase in rainfall, but it is many times less than the decrease in winter rains and does not fill the reduction of winter quota (Graph-6).

5. Causes of Temperature and Rainfall Fluctuation:

The following are the possible causes of climatic change in the Swat valley.

1. The recent climatic fluctuation (1986 to 2000) seems to be the result of change in the atmospheric pressure on global scale, particularly, between equator, tropics, and polar region. According to Khan (1960), "*The annual pressure was rising in the South Asian low pressure belt and the Equatorial trough and falling in the Siberian high pressure, since the beginning of the period from 1881 to 1915. After this period the trend changed to one of the increase in the Siberian high pressure and decrease in the South Asian low pressure and the Equatorial trough. This trend continued upto 1941-50, after which it showed signs of reversal to the previous trend*." This change in the pressure gradient on global scale may be responsible for the present fluctuation of rainfall in the area.
2. Another main cause of low winter rain in Swat valley may be the change of speed and direction of westerly currents (Western Disturbances). Khan (1960) is of the opinion that, "*The rainfall condition has been improving over the southwest monsoon regime during the period of 1931-50 and has shown deterioration over the northeast monsoon regime. The rainfall had been persistently decreasing over Middle East and increasing over the Soviet Republics of Central Asia. The trend seems to be most probably connected with a northerly shift of the track of western disturbances. The deterioration of rainfall in the arid and semi-arid zone of West-Pakistan and Baharat may also be due to a reduction in the winter quota of the annual precipitation.*" This northerly shift in the wind direction of westerly currents may have increased the share of winter rain in Central Asia and decreased it continuously in Indo-Pakistan sub-continent.
3. Deforestation is another main human activity, and most of the natural vegetation of the valley has been cut for lumbering or farming, without immediate replanting of new trees. The mountains slopes are barren and completely exposed to rain and wind erosion. Such exposed terrain, generally, reflects high amount of incoming radiation back to space and causes change in the atmospheric temperature of the area.
4. The Middle East, Indo-Pakistan, and Afghanistan are the war zones for the past 36 years. These crises created serious problems due to the use of highly explosive devices and burning of oil wells in Kuwait and Iraq, which produced a

huge amount of un-burned methane and ethane gases, particularly during Gulf war that caused ozone depletion. Consequently, the rate of ultraviolet radiation increased on the earth surface and this may be one of the causes of the temperature fluctuation in the Indo-Pakistan sub-continent.

6. Recommendations:

The following are the suggestions to ameliorate the climate condition of the region.

1. The global climatic change is mainly the result of various human activities like, exhaust gases from industries, wars, deforestation, chloroflorocarbons, and the use of fossil fuels. Therefore, it is needed to initiate programs to create awareness among the people about the effects of these atmospheric pollutants on the physical environment of the area.
2. Legislation is needed to prevent sever cutting of forests and also to ensure the immediate replanting of trees, cut for lumbering or farming and also to provide alternate sources of energy e.g. bio-gas, and natural gas for the domestic use. However, the plantation of eucalyptus is not recommended, as it evaporates more than 50liters of the groundwater into atmosphere per day and is more dangerous to watertable of the mountainous region (Khan SU, USEPAM International Conference, Hanoi, Vietnam, 26th March 2007).
3. Contourwise ploughing of the hill slopes should be carried out at right angle to the hill slopes. This impedes the downward flow of the rainwater and checks soil creep so that gullying does not develop. Much of water is also retained by the furrows and absorbed by the plants that are grown in a contourwise pattern, improving the crop. Therefore, for the proper surface run-off and control of soil erosion, the awareness of people about the contourwise ploughing in the catchments areas should be created.
4. For extensive afforestation, it is necessary to provide facilities to the inhabitants of the mountainous areas and to encourage the community reforestation.
5. Further study is needed to findout the causes of modification in temperature, pressure, wind speed and direction, and precipitation on global scale so that by proper planning, the problems arising due to the shortage of water may be met with.

6. The increase in temperature causes the melting of glaciers in the catchments areas of different rivers in Pakistan that enhancing flood disaster in the Indus Plains and effect agriculture production, industries, land and properties etc. So that it is necessary to cover the banks of rivers with metals sheets or embankments and to make sure the safety of land degradation and damages to the human lives in the area during high floods in the Indus, Jhelum, Chanab, Ravi, and Kabul rivers.
7. The decline in precipitation at Swat valley show signs of sever Agriculture, Meteorological, and hydrological droughts in the region and will be effected the human life, economical, and physical environment etc of Pakistan. So it is recommended to craft proper planning for the safety of the human and livestock lives, economical development, availability of water for domestic use etc especially in the dry (desert) areas of Balochistan, Sind, and Punjab and also to arrange environmental research for how to combat desertification and drought in Pakistan.
8. Hypothesis is made here that the drying of springs and precipitation fluctuation are also an evidence of plate tectonic moment in the area and after each 3 to 4 years of sever drought, the area hit by the earthquake disaster caused by tectonic moment, especially at the mountainous north that also caused changes in the weather and climates of the area, however it is needed further research to find out the correlation between drought, drying of springs, decline in water table, and tectonic moment. May be it provides a positive signs and base for the forecasting of tectonic moment before its activation for the safety of the locals.

7. Conclusion:

The area is cold in winters, and warm in summers. January is the coldest month, when the minimum temperature drops to below freezing, whereas, June is the hottest month, when the maximum temperature exceeds 30^{o}C. The variation of temperature shows marked increase of 1^{o}C per year, particularly from 1995 to 2000.

The area receives both summer and winter rains. The summer rains are the result of pre-monsoon and monsoon season, while the winter rains are the sum of the post-monsoon and western depressions. The annual total rainfall of the area is 98.9cm (39.6inches) currently and the climate has changed from humid (>40inches) to sub-humid. The highest rainfall of the area is received in March (17.4cm), which decreases to 3.3cm in November. The total winter rainfall of the valley is 82.9cm, whereas, that of summer as 57.5centimeters. Thus the major share of rainfall in the area is from winter season. The rainfall of the valley recorded in pre-monsoon season is 15.8cm, while from monsoon it is 24.4cm, and from post monsoon it is 7.6centimeters. The pre-monsoon period shows very little fluctuation, while the other three rainy seasons lead to rapid decrease in rainfall from 1986 to 2000. The deviation of rainfall from the mean condition falls to negative deviation from 1986 to 1990, and then it increased from 1990 to 1995, and again fell to negative deviation upto 2000 at the rate of 7.3cm per year. The winter rains decreased continuously for the last five years up to –29cm, while the summer rains decreased from 1995 to 1999, and then increased to 4.6cm in 2000 with average increase of 2.9cm. In general, the winter rains of the area continuously decreased as compared to summer rainfall. However, the rapid increase in temperature is a hopeful sign for the recovery of winter rains upto 2005. This variation of rainfall generally triggers to change in air pressure, wind speed and direction, increase in temperature, chloroflorocarbons, exhaust gases from industries, and deforestation on global scale.

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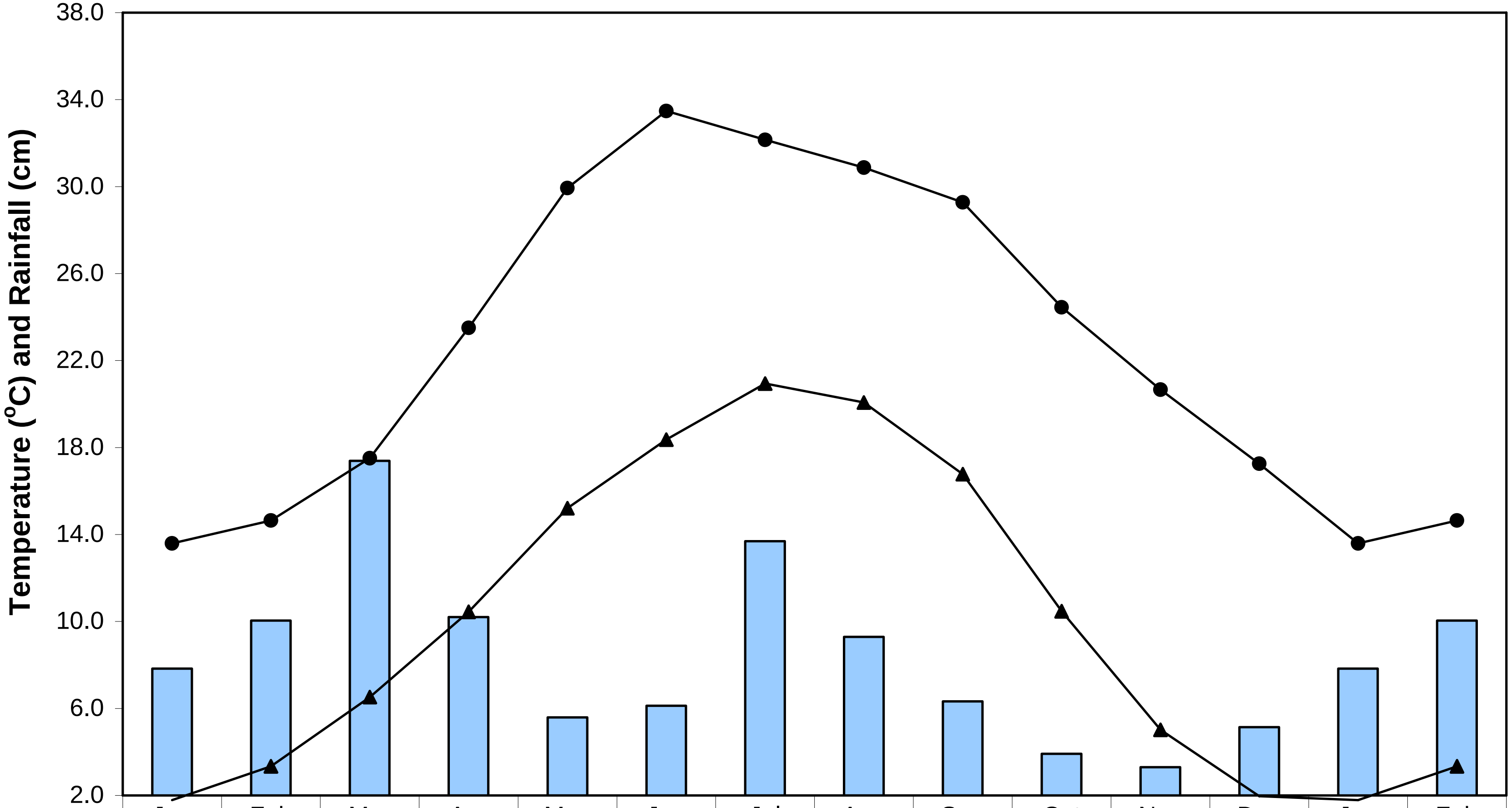
Figure: 1 **SWAT District Political**

Graph: 1

Udigram
Mean Monthly Maximum, Minimum Temperature and Rainfall (1986-2000)



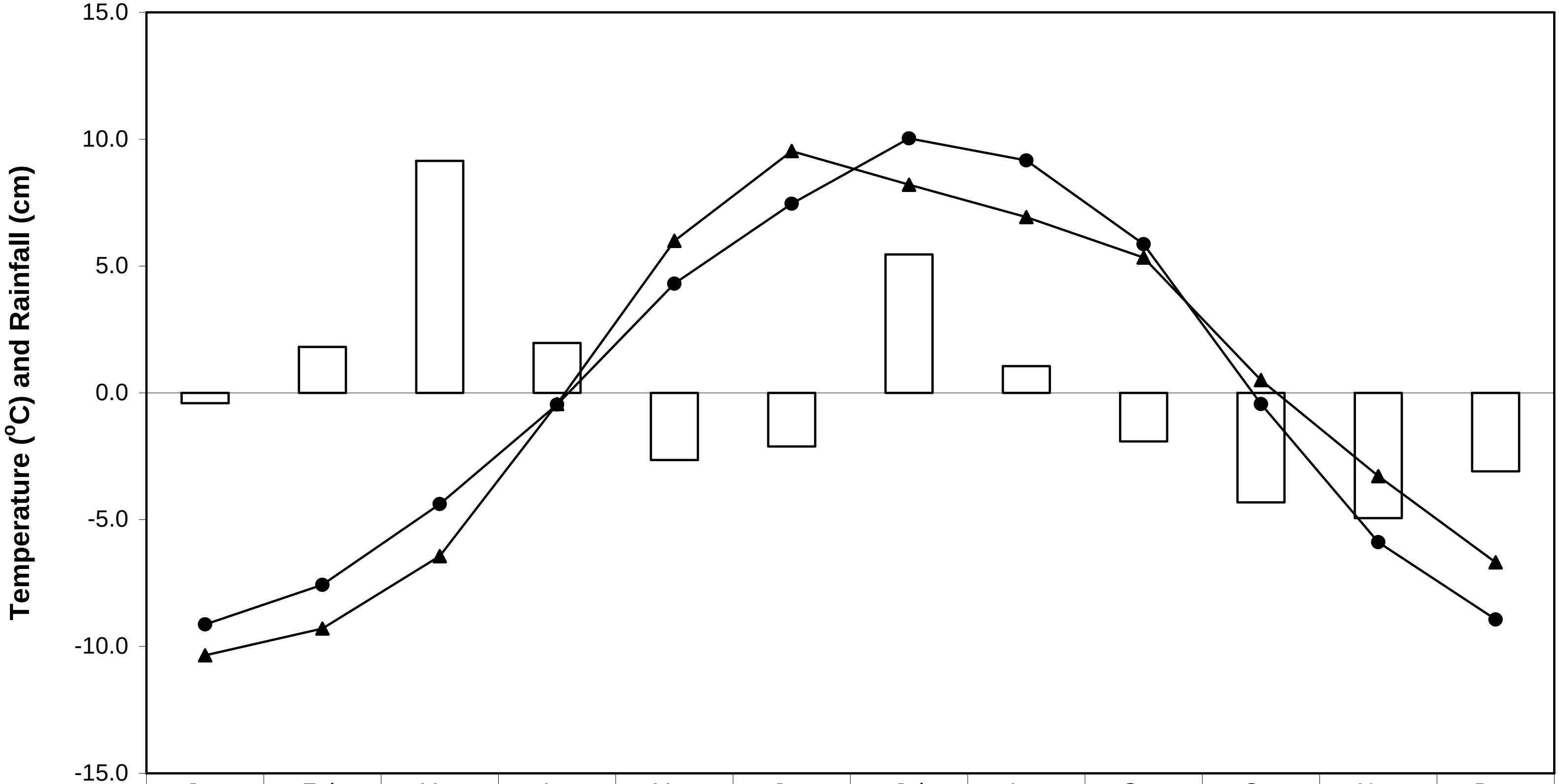
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Rainfall	7.8	10.0	17.4	10.2	5.6	6.1	13.7	9.3	6.3	3.9	3.3	5.1	7.8	10.0
Maxi.T.	13.6	14.6	17.5	23.5	29.9	33.5	32.2	30.9	29.3	24.4	20.7	17.3	13.6	14.6
Mini.T.	1.8	3.3	6.5	10.4	15.2	18.4	20.9	20.1	16.8	10.5	5.0	2.0	1.8	3.3

Months

Graph: 2

Udigram

Deviation of Mean Monthly Maximum, Minimum Temperature and Rainfall



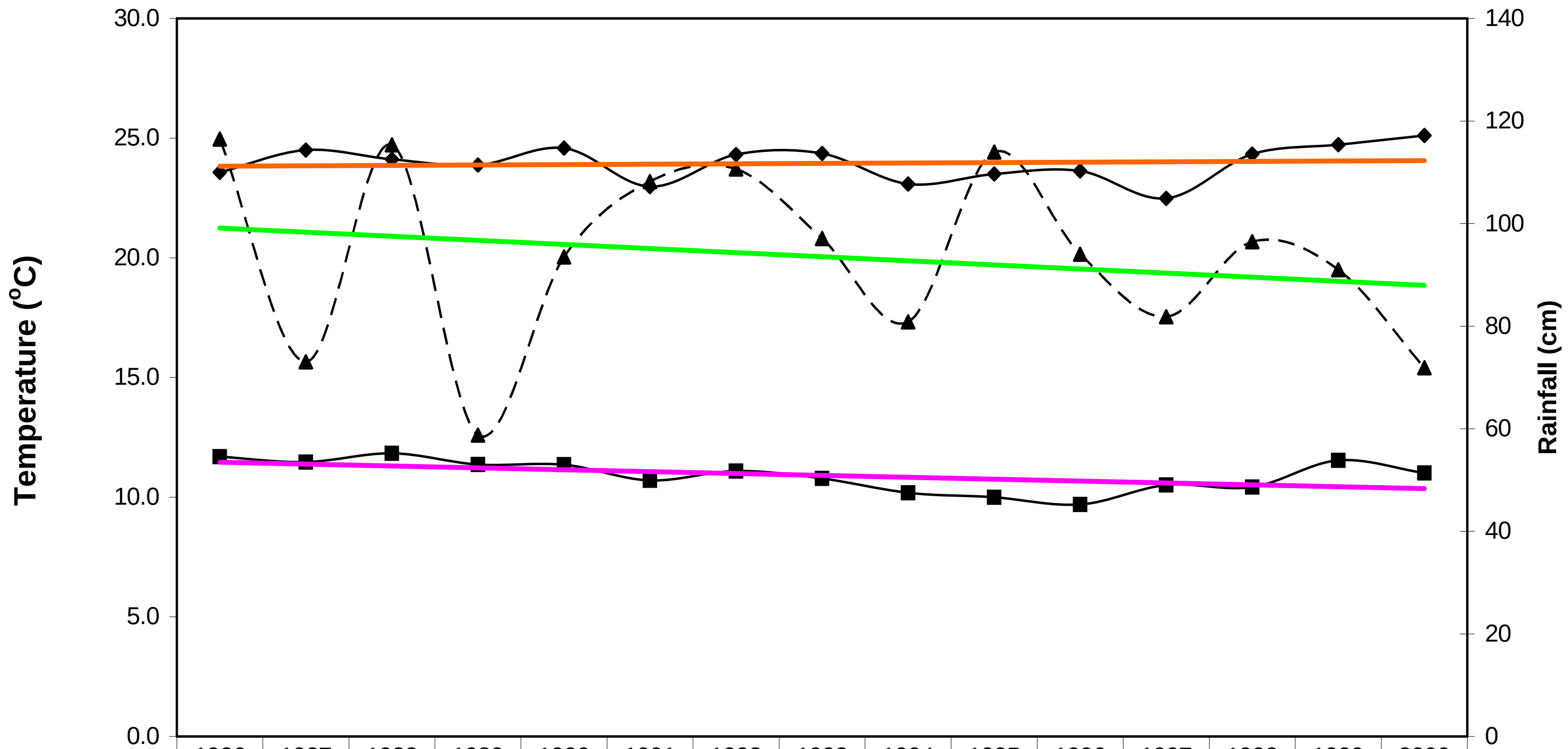
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	-0.4	1.8	9.1	2.0	-2.6	-2.1	5.5	1.1	-1.9	-4.3	-4.9	-3.1
Maxi.T.	-10.4	-9.3	-6.4	-0.4	6.0	9.5	8.2	6.9	5.3	0.5	-3.3	-6.7
Mini.T.	-9.1	-7.6	-4.4	-0.5	4.3	7.5	10.0	9.2	5.9	-0.4	-5.9	-8.9

Months

Graph: 3

Udigram

Mean Monthly Maximum, Minimum Temperature (^oC) and Rainfall (cm)



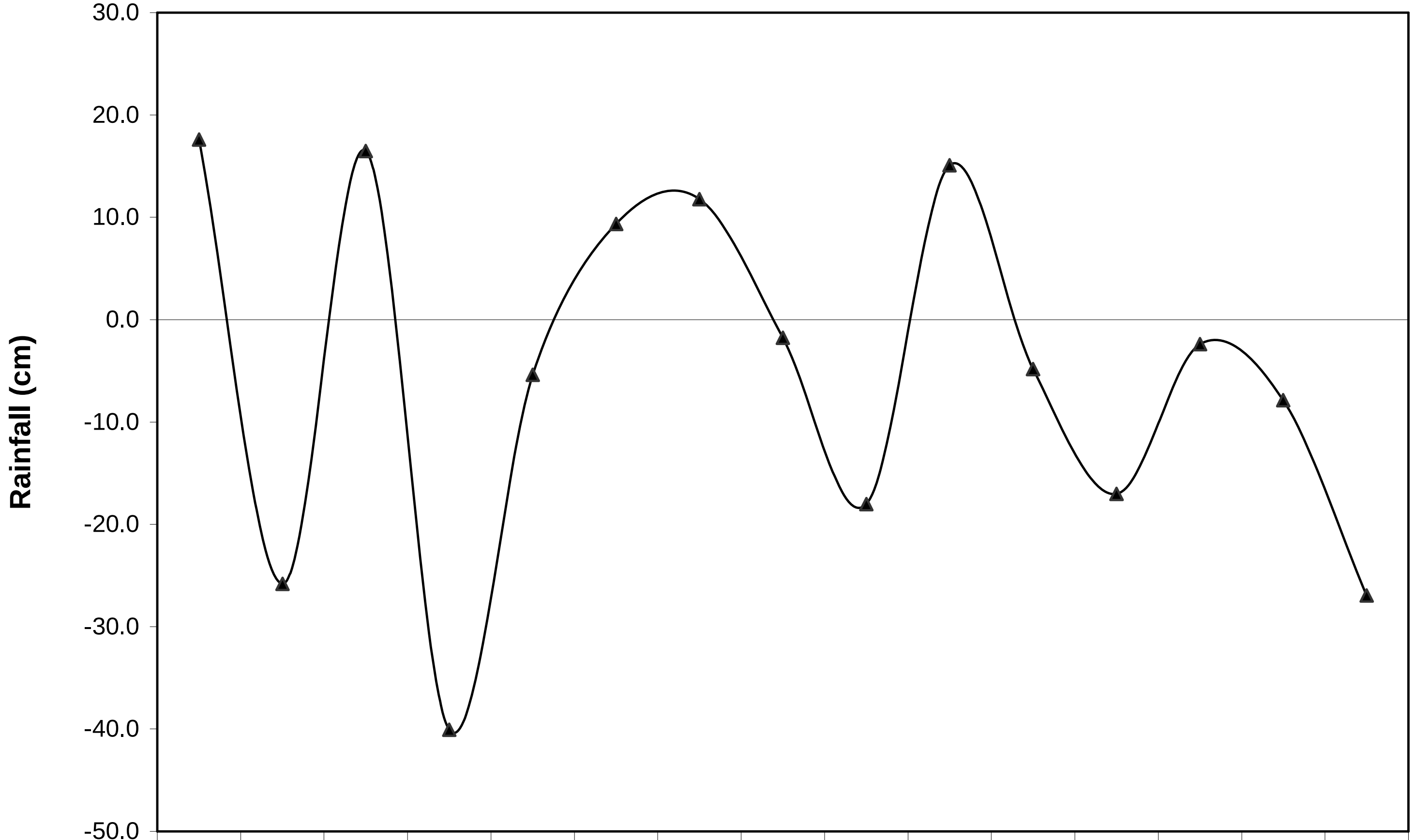
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Maxi.T.	23.6	24.5	24.1	23.9	24.6	23.0	24.3	24.4	23.1	23.5	23.6	22.5	24.3	24.7	25.1
Mini.T.	11.7	11.5	11.8	11.4	11.4	10.7	11.1	10.8	10.2	10.0	9.7	10.5	10.4	11.5	11.0
Rainfall	116.47	73.05	115.35	58.78	93.48	108.21	110.65	97.11	80.85	113.94	94.05	81.84	96.47	90.99	71.9

Months

Graph: 4

Udigram

Deviation of Mean Monthly Rainfall (1986-2000)



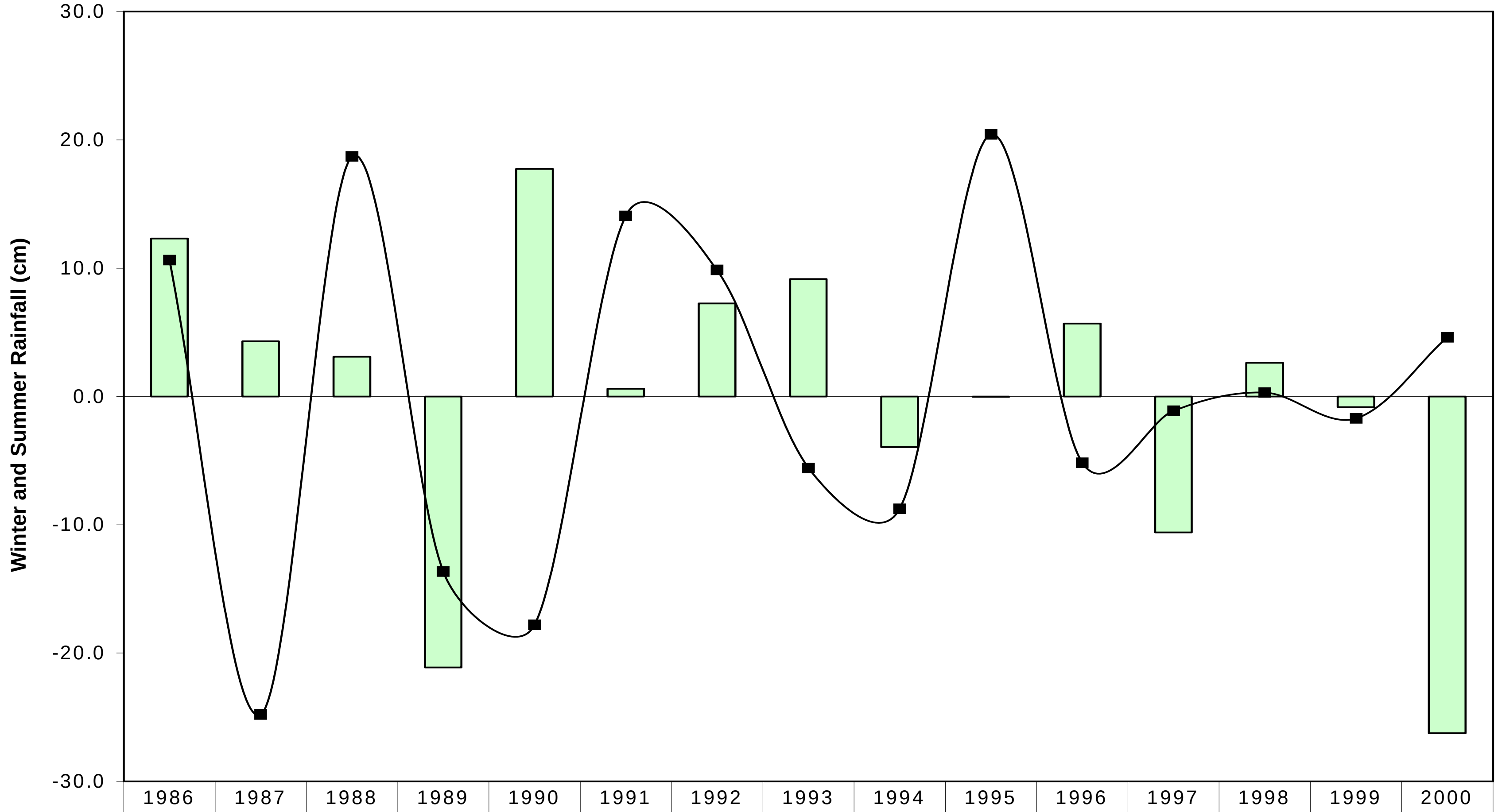
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Rainfall	17.6	-25.8	16.5	-40.1	-5.4	9.3	11.8	-1.8	-18.0	15.1	-4.8	-17.0	-2.4	-7.9	-27.0

Years

Graph: 5

Udigram

Deviation of Mean Monthly Summer and Winter Rainfall (cm)



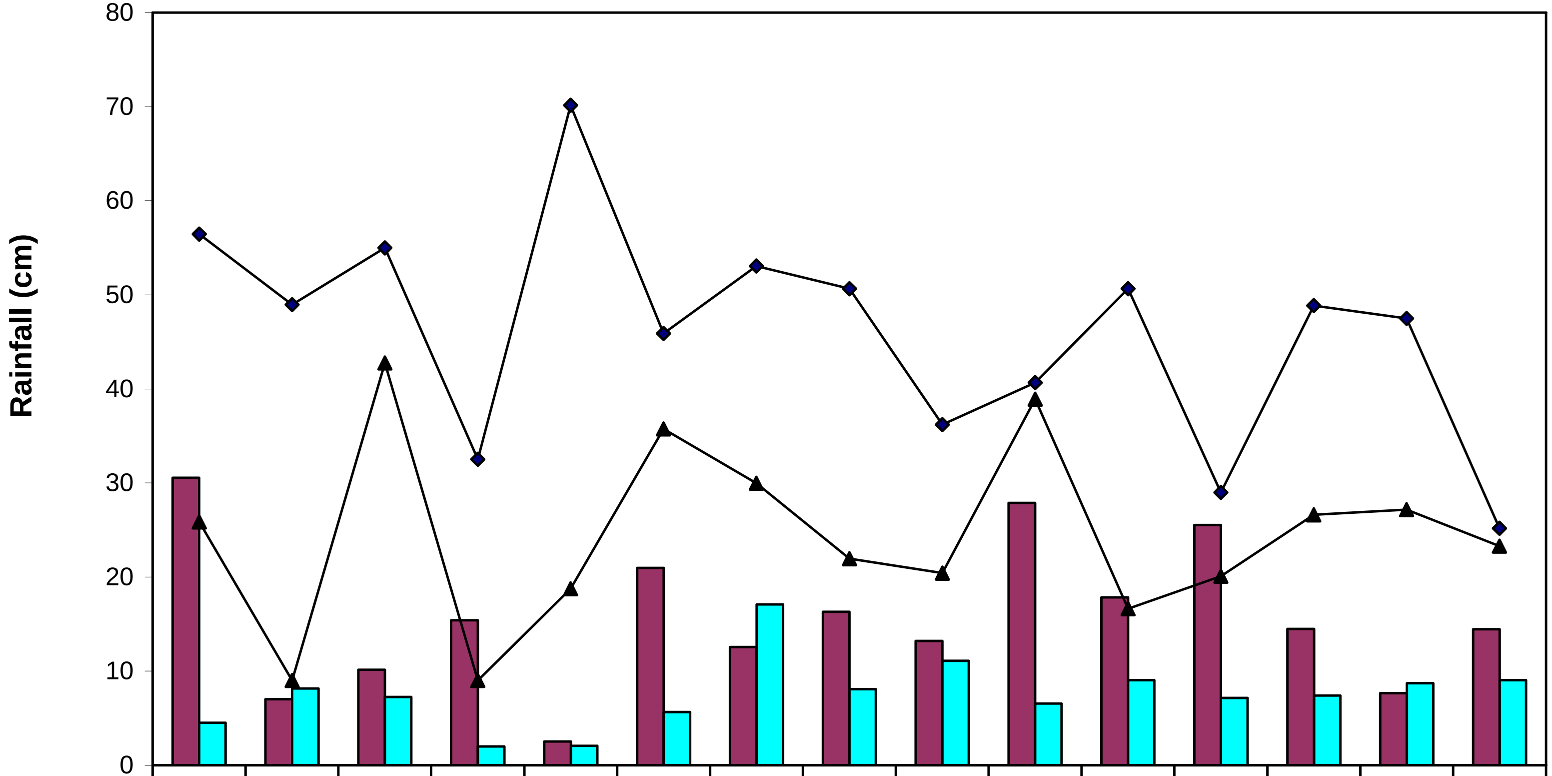
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Winter	12.3	4.3	3.1	-21.1	17.7	0.6	7.2	9.2	-3.9	0.0	5.7	-10.6	2.6	-0.8	-26.2
Summer	10.6	-24.8	18.7	-13.6	-17.8	14.1	9.9	-5.6	-8.7	20.4	-5.2	-1.1	0.3	-1.7	4.6

Year

Graph: 6

Udigram

Seasonal Variation of Rainfall (cm)



	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Pre-Monsoon	30.56	7	10.15	15.4	2.5	20.97	12.54	16.31	13.2	27.87	17.83	25.55	14.48	7.65	14.44
Post-Monsoon	4.5	8.15	7.25	1.98	2.05	5.65	17.08	8.1	11.1	6.55	9.02	7.15	7.41	8.72	9.05
Winter	56.45	48.95	55	32.5	70.15	45.89	53.06	50.66	36.2	40.68	50.65	28.99	48.86	47.49	25.17
Monsoon	25.9	9.0	42.8	9.0	18.8	35.8	30.0	22.0	20.4	38.9	16.6	20.1	26.6	27.2	23.3

Year

Table-1: **Udigram**

Mean Monthly Temperature (^{0}C) 1986-2000

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1986	14.2	14.5	17.4	22.3	27.5	35.0	34.4	31.4	29.1	25.7	18.5	12.9	23.6
1987	13.7	16.0	18.5	23.3	26.2	33.7	35.0	31.8	31.5	23.8	22.5	18.0	24.5
1988	14.7	15.5	13.9	23.9	33.9	34.9	30.6	29.1	31.5	26.2	19.2	16.0	24.1
1989	14.5	14.3	19.1	22.5	32.6	35.7	33.0	29.2	31.0	19.8	19.7	15.1	23.9
1990	14.3	13.9	17.9	21.3	32.4	32.0	34.2	30.5	30.0	26.9	21.1	20.5	24.6
1991	12.7	14.0	19.8	22.0	28.7	31.0	32.6	31.2	28.9	26.8	11.5	16.5	23.0
1992	12.8	15.2	17.7	23.4	28.3	33.5	31.7	35.2	22.0	17.4	28.6	26.0	24.3
1993	13.4	18.7	16.0	26.0	31.1	32.7	28.8	30.2	29.3	26.1	21.5	18.5	24.4
1994	12.9	11.9	19.6	21.9	28.8	34.7	30.1	29.9	28.5	23.4	20.9	14.4	23.1
1995	13.5	14.6	16.3	21.3	29.5	35.9	31.7	29.8	29.2	23.9	21.9	14.4	23.5
1996	14.0	16.0	16.8	24.2	26.8	31.5	31.8	30.5	30.2	24.5	20.8	16.5	23.6
1997	14.2	14.8	17.3	21.6	26.8	30.9	32.0	30.5	29.7	19.4	18.9	13.7	22.5
1998	13.2	12.8	16.6	24.1	29.7	32.9	32.1	31.5	28.8	27.6	23.1	19.6	24.3
1999	11.8	14.1	18.2	26.8	32.9	34.0	32.3	30.9	30.1	26.9	19.7	19.0	24.7
2000	14.0	13.4	17.5	28.0	33.8	33.8	32.0	31.4	29.4	28.3	22.0	17.8	25.1
Average	13.6	14.6	17.5	23.5	29.9	33.5	32.2	30.9	29.3	24.4	20.7	17.3	23.9

Source: Pakistan Agriculture Research Station Mingora, Swat, 2000

Table-2: **Udigram**

Mean Monthly Minimum Temperature (^{0}C) 1986-200

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1986	3.7	4.1	5.3	11.3	19.3	16.2	20.6	19.3	16.6	12.6	7.3	4.0	11.7
1987	2.9	5.0	8.2	11.2	13.7	18.2	19.4	20.4	17.6	12.5	6.0	2.5	11.5
1988	3.8	4.7	6.2	12.7	15.0	20.4	22.7	19.3	17.6	10.6	5.4	3.6	11.8
1989	4.3	5.6	9.2	9.5	14.1	17.6	19.2	19.2	20.1	8.4	5.0	4.2	11.4
1990	2.5	4.3	6.0	9.6	15.8	18.1	22.1	21.6	18.0	11.9	4.1	2.3	11.4
1991	1.8	3.7	7.4	9.5	13.9	17.1	19.0	20.1	15.7	11.5	4.2	4.5	10.7
1992	3.1	3.2	7.0	11.4	14.2	18.5	20.8	20.1	16.0	9.0	6.1	3.7	11.1
1993	1.2	4.7	5.2	11.8	16.2	18.9	20.3	18.4	16.3	8.5	5.3	2.6	10.8
1994	1.0	0.9	7.5	7.6	15.2	18.9	22.2	21.2	14.3	7.9	4.9	0.6	10.2
1995	1.7	1.9	4.6	7.6	15.9	19.0	21.2	20.6	14.3	10.0	2.8	0.4	10.0
1996	-1.3	2.0	7.0	10.4	13.7	17.5	19.8	19.8	16.4	9.7	2.7	-1.4	9.7
1997	0.0	1.1	6.2	10.3	12.6	18.1	22.6	20.5	17.2	11.9	4.9	0.7	10.5
1998	-0.1	2.3	4.5	10.7	15.6	18.2	21.9	20.7	17.0	11.3	3.9	-0.9	10.4
1999	0.9	5.0	7.3	12.2	16.3	18.6	21.3	20.1	18.5	10.7	6.8	0.7	11.5
2000	1.2	1.6	6.3	10.9	16.7	20.2	21.0	19.8	16.0	10.5	5.9	2.0	11.0
Average	1.8	3.3	6.5	10.4	15.2	18.4	20.9	20.1	16.8	10.5	5.0	2.0	10.9

Source: Pakistan Agriculture Research Station Mingora Swat, 2000

Table:3 **Udigram**

Mean Monthly Total Precipitation (cm) 1986-2000

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1986	4.5	3.8	35.2	18.1	1.6	19.5	14.4	9.5	4.0	0.2	4.6	1.2	116.5
1987	4.1	11.2	15.0	5.0	4.5	0	9.0	0	0	0	16.3	8.0	73.1
1988	7.5	9.0	25.0	2.5	1.5	7.5	21.0	16.5	10.5	2.0	0	12.4	115.4
1989	9.1	2.8	12.2	2.4	10.4	3.8	0	7.5	3.0	0.5	0	7.2	58.8
1990	7.7	19.6	26.2	4.0	0	0.5	3.5	14.0	2.5	0	1.6	13.9	93.5
1991	4.3	13.2	17.9	19.3	10.3	1.0	27.2	3.2	10.7	0	0.6	0.6	108.2
1992	24.5	7.0	15.8	0	8.6	3.9	15.7	8.7	11.2	9.4	2.1	3.7	110.7
1993	4.1	4.4	31.5	16.4	2.7	5.4	14.0	5.4	5.2	3.2	4.6	0.2	97.1
1994	4.6	5.8	7.7	12.4	4.9	2.2	10.8	7.5	4.3	8.8	0.3	11.8	80.9
1995	1.1	11.8	14.6	17.7	2.0	17.0	29.0	9.1	1.6	4.0	3.5	2.6	113.9
1996	8.2	22.0	15.3	6.7	8.5	6.0	7.8	6.8	4.1	6.8	0.4	1.5	94.1
1997	3.2	2.1	11.3	19.5	8.1	7.7	6.5	12.3	2.5	4.8	2.3	1.5	81.8
1998	7.2	23.8	11.3	12.1	6.9	1.1	10.5	12.1	8.0	3.3	0.3	0	96.5
1999	18.7	8.6	14.2	6.5	1.4	3.0	14.9	7.3	10.0	1.0	5.4	0	91.0
2000	8.8	5.7	7.6	0.6	7.0	7.2	7.5	10.3	11.0	3.1	0.9	2.4	71.9
Average	7.8	10.0	17.4	10.2	5.6	6.1	13.7	9.3	6.3	3.9	3.3	5.1	98.9

Source: Pakistan Agriculture Research Station Mingora Swat, 2000

Table:4 **Udigram**

Average/Sum of Increase/Decrease in

Mean Monthly Total Precipitation (cm), and Temperature (^{0}C) 1995-2000

Year	Precipitation (cm)		Average Fall	Mean Maximum Temperature (^{0}C)			Mean Minimum Temperature (^{0}C)			Mean Monthly Temperature (^{0}C)			Seasonal Decline in Precipitation (cm)			
	Annual Total	Mean Deviation		Mean	Mean Deviation	Average Increase	Mean	Mean Deviation	Decrease	Mean	Mean Deviation	Increase	Winter	Av.Fall	Summer	Av.Increase
1995	113.9	15.1	-7.3	23.5	0.98	1.00	10.00	-0.52	0.00	16.75	0.97	1.00019	0.0	-4.9	20.4	2.89
1996	94.1	-4.6		23.6	0.99		9.70	-0.82		16.65	0.97		5.7		-5.2	
1997	81.8	-17		22.5	0.94		10.50	-0.02		16.50	0.96		-10.6		-1.1	
1998	96.5	-2.4		24.3	1.01		10.40	-0.12		17.35	1.01		2.6		0.3	
1999	91	-7.9		24.7	1.03		11.50	0.98		18.10	1.05		-0.8		-1.7	
2000	71.9	-27		25.1	1.05		11.00	0.48		18.05	1.05		-26.2		4.6	
Sum /Average	**549.2**	**-43.8**	**-7.3**	**23.95**	**6.00**	**1.0**	**10.52**	**0.00**	**0.00**	**17.23**	**6.00**	**1.00019**	**-29.4**		**17.3**	