The Livelihoods Programme Hindukush

Climate Change Scenarios and Possible Adaptation Measures

Districts Chitral and DI Khan - Khyber Pakhtunkhwa

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Credits

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List of acronyms

CGCM3	Coupled Global Climate Model
GDD	Growing Degree Days
GHGs	Green House Gases
GLOFs	Glacial Lack Outburst Floods
GSL	Growing Season Length
HYVs	High Yielding Varieties
IC	Intercooperation Pakistan
IPCC	Intergovernmental Panel on Climate Change
KP	Khyber Pakhtunkhwa
P&DD	Planning and Development Department
PMD	Pakistan Meteorological Department
SDC	Swiss Agency for Development and Cooperation
SRES	Special Report on Emissions Scenarios

Foreword

Climate change is a phenomenon which has remained in experts' domain for quite some time now. In recent years however, people from all spheres of life have started to recognize that an emergency like situation is arising which has started affecting their lives in many ways. Where climate change has been a slow and consistent process, variability has gained wider attention with more frequent hot and cold years and extreme climatic events such as floods and hurricanes in recent years.

In case of Pakistan which is situated in a heat surplus zone, we have a higher frequency of hotter years and rising temperatures over the last couple of decades than in the whole century. Rains are far more erratic, more torrential and arrive in uneven patterns in various geographical locations. All these events are observed by our farmers who wonder how to deal with the situation. Climate change affects all walks of life, however being an agrarian economy and a largely populated country, our major concern lies with food security for our people. In order to cater to these it is extremely important to first understand these changes over the past and build likely scenarios on which to base certain decisions. Without which farmers will not be able to deal with the impact of change whether in terms of new opportunities or challenges.

Climate change is a serious and exceptional threat and none of us has the capacity to deal with it alone. Due to its challenging behaviour, we need to engage together and try to join forces to make use of climate change scenarios for a better course of action.

We are happy to pilot this first study on climate change scenarios for two selected districts of Chitral and DI Khan in Khyber Pakhtunkhwa where the Livelihoods Programme Hindukush funded by Swiss Agency for Development and Cooperation (SDC) operates. We believe that the scenarios built in this report serve as important base for the planners to suggest future strategies for adaptation to change, mainly in the field of food production. This set of information is particularly useful for agricultural researchers and extension agents so that they can provide a right set of guidance to the farmers and ensure that practices are adjusted according to the change and losses are consistently minimized at farmers' but also at national level for the benefit of all.

1. Introduction

The purpose of this paper is to document the impact of climate change on agriculture and water resources under different climate change scenarios that are likely to occur in districts Chitral and DI Khan of Khyber Pakhtunkhwa. District Chitral has a mountainous geography with temperate and cooler weather while DI Khan consists of arid planes with hotter weather. An understanding of likely scenarios in climate change is essential before embarking on appropriate adaptation strategies to adjust to the adverse and/or positive impacts of climate change on agriculture and water resources. We hope that this report will also be useful in application of climate and weather forecasting for the benefit of local communities as well as agricultural extension workers. We also hope that the agriculture researchers will benefits from the report in their effort to evolve appropriate varieties, technologies and practices for timely adaptation by farmers to climate change.

The Coupled Global Climate Model (CGCM3) data defined on a spectral grid (T47) with 31 vertical ETA15 levels has been used to develop the climate scenarios for two cities of Pakistan (DI Khan and Chitral). The CGCM3 T47 historical simulation and future runs together covering the entire period from 1961 to 2100, and the datasets for the future period following two scenarios A2 (heterogeneous world) and A1B (A1 scenarios are of a more integrated world, and its subset of A1B is a balanced emphasis on all energy sources) have been considered in this report. These scenarios are based on Special Report on Emissions Scenarios (SRES) that was prepared for the region by the Intergovernmental Panel on Climate Change (IPCC) and used in the IPCC Fourth Assessment Report 2007 (IPCC 2007).

Regional scenarios were constructed from raw global model data with low resolution to prepare the precipitation and temperature scenarios. This transformation was done by dynamical or statistical downscaling with the assumption that the relationship between the large-scale variables and small-scale surface variables do not vary under climate change conditions. A web-based statistical downscaling portal developed by ENSEMBLES has been used to prepare the seasonal precipitation and temperature scenarios at regional scale. (Reference: DAI CGCM3 Predictors, 2008: "Sets of Predictor Variables Derived from CGCM3 T47 and NCEP/NCAR Reanalysis", version 1.1, April 2008, Montreal, QC, Canada, 15 pp).

The finer resolution scales at the regional level would help in assessing regional specific climate change implications and in devising regional specific recommendations for dealing with these implications. We invite researchers to suggest suitable adaptation measures based on projects made in this report. This report only hints at a few measures based on field experiences in the Livelihoods Programme Hindukush funded by SDC and implemented by IC in collaboration with P&DD, KP.

2. Climate Change and Pakistan

According to the assessment reports of the Intergovernmental Panel on Climate Change (IPCC), average global temperature has increased by about 0.6 °C since the industrial revolution, and future change in global average temperature in between 2 – 4.5 °C is almost inevitable by the end of the 21st century (IPCC 2007). The increases in temperature are mainly as a result of increasing concentrations of Green House Gases (GHG) in the atmosphere as caused by burning of fossil fuels for industrial use, land use change and population pressures.

While climate change is happening at the global level, its impacts, both positive and negative, will be felt at the local level depending upon the region. In South Asia, average annual temperature could rise to a maximum of 3.5 – 5.8 °C by the end of 21st century because the region falls in arid and semi-arid zone (IPCC 2001). Two degrees centigrade is widely considered the maximum temperature increase to avoid irreversible damage to the global climate and ecosystems. The resultant climate change effects will therefore be more pronounced in the South Asia region. The increase in temperature will be associated with changes in rainfall patterns and will impact (positive and negative) various socio-economic sectors e.g., water, agriculture, health, forestry, biodiversity and human health. In Pakistan most of these impacts are already visible especially since 1990 (meteorological data records).

Pakistan is a land of great topographic contrasts and therefore the climate of the country has large spatial and temporal variations. The northern and western mountain ranges in the country add to the wide climatic variation in the climate of places located in the same latitudinal belts. Most of the areas of Pakistan are very sensitive to the changes in both temperature and precipitation. Some of the regions of the country over higher latitudes are short of heat and therefore may benefit from rising temperatures due to climate change. These areas are vulnerable to flash floods, whilst most of the southern regions are extremely vulnerable to droughts and heat stresses.

Of particular concern is the occurrence of climate related extreme events (shocks) such as heat waves, storms, droughts and floods. The frequency and intensity of these climate related disasters have considerably increased during the last two decades which have displaced thousands from their homes, destroying livelihoods and causing losses of lives among vulnerable populations. Monsoon is the major rainy season of Pakistan, which yields nearly 60% of total rainfall during the season (Jun-Sep), and therefore stands critical for agriculture, industry, drinking water and human health. In the future, the pressures of an increasing population will bring additional stresses on society and the environment, with serious implications for water resources, health and food security. The precipitation distribution, especially monsoon rainfall, may become less stable (erratic but intensive) as a result of climate change. This will have serious consequences for Pakistan in the form of flash and riverine flooding that have already increased in recent years.

The agricultural and water resources in Pakistan are highly vulnerable to climatic changes. In particular, as the prevailing temperatures are close to the tolerance limits for most crops any further increase in temperature will have serious implications for agricultural production throughout arid and semi-arid areas in the country. It could especially alter bio-physical relationships by changing growing periods of the crops, altering scheduling of cropping seasons, increasing crop stresses (thermal and moisture stresses), changing irrigation water requirements, altering soil characteristics, and increasing the risk of pests and diseases, thereby negatively affecting agricultural productivity. In the dry western mountainous regions, the increase in temperatures could enhance the process of de-glaciations thereby affecting our water resources upon which the country depends for agriculture and energy production.

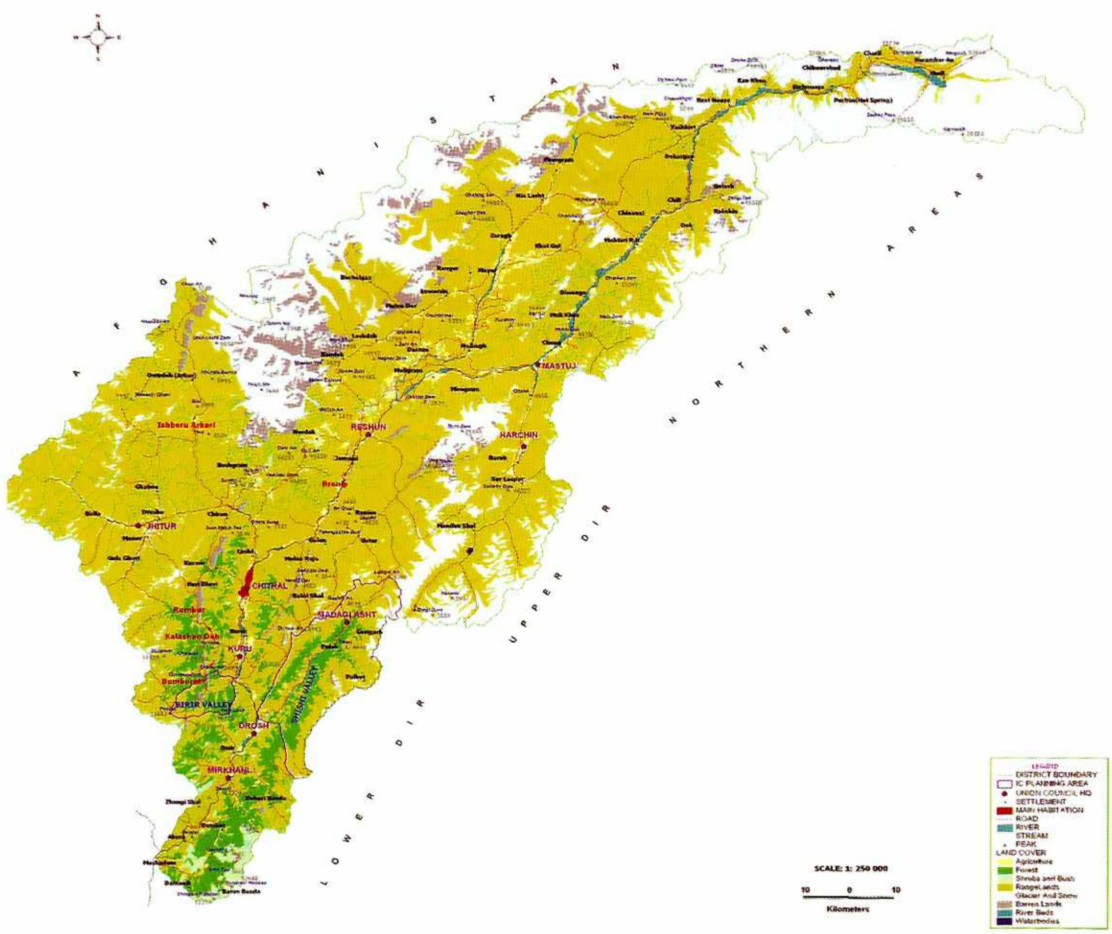
The increase in temperature in the high mountainous regions including Chitral district is expected to have positive impacts on crop yields (Hussain and Mudaser 2006). This is mainly because these areas are short of temperatures and any increase due to climate change in this region can enhance crop growth by allowing earlier planting, faster maturation and earlier harvesting of the winter crops, and this may enhance yields and expansion of the area. Double cropping utilising both winter and summer seasons may also be possible in the high mountainous areas.

3. Study area

The study covered two districts, Chitral (in the Hindu Kush mountain ranges) in the northern region and DI Khan in the southern region of KP.

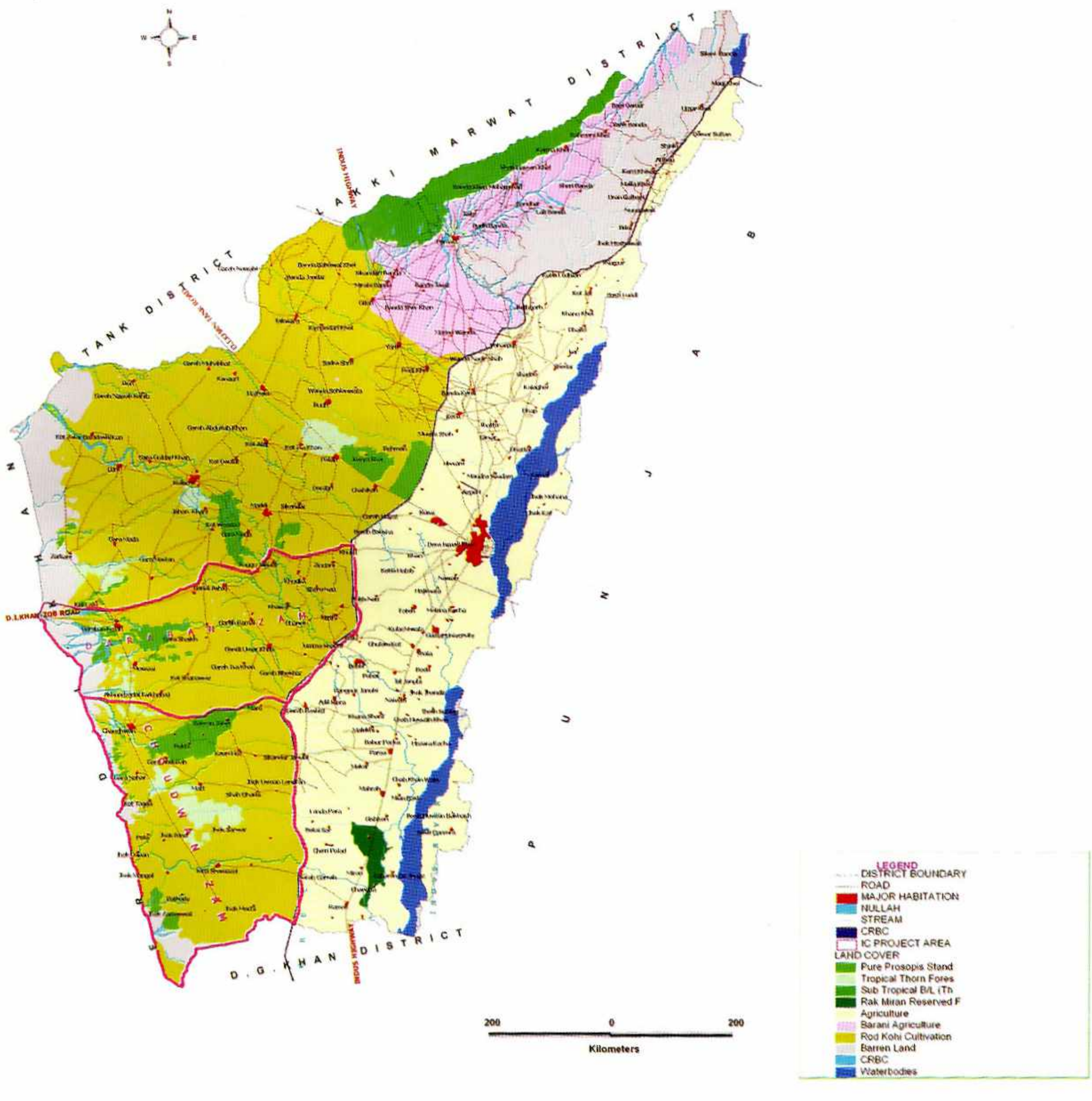
Chitral

Chitral is a closed valley at an altitude of 1500 meters above sea level (in the valley bottom) with a latitude and longitude of approximately 35_ 51 ˚N and 71_ 50 ˚E, respectively. The weather in Chitral is temperate and dominated by a winter weather pattern with rains caused by western disturbances that occur in the period of December–March. The mean annual temperature in Chitral district is 16 ˚C, minimum average temperature reaches to 8 ˚C and maximum average temperature is 24 ˚C. Temperatures in the winter season drop to freezing. The district receives an annual total rainfall of 451 mm with heavy snow fall in winter, more in the surrounding mountains. The main source of livelihood is subsistence agriculture and natural resources. Land holdings are small. Main crops are Wheat, Maize, Pulses, Potato, Rice and fodder. In addition, high value fruits such as Apple, Apricot, Pomegranate, Walnut, Grapes and Pears are also grown. About 60 percent of the area is mono-cropped (wheat/or maize) as the prevailing low temperatures during the crop growing season do not allow two crops to mature in time. The remaining 40 percent of the area lies in the valley, dependent upon irrigations from springs and is usually double cropped. The region is also rich with natural resources, including forests, wildlife and minerals. The area has high potential for tourism that can enhance livelihoods of the local economy. The district is prone to frequent hazards of flash floods, soil erosion, avalanches, landslides, earthquakes, drought and other climatic extremes.



Dera Ismail Khan

DI Khan district is in the southern part of Khyber Pakhtunkhwa with a latitude and longitude of approximately 35_56 °N and 70_56 ˚E, respectively. The district lies in the arid zone where summers are hottest and winters are mild. The mean annual temperature in the district is 24 ˚C, with a minimum average temperature of 17 ˚C and maximum average temperature of 32 ˚C. Major source of livelihoods in the district is agriculture based. The district can be classified into four agro-ecological sub-regions, (i) part of the area is irrigated through Chasma right bank canal, where intensive agriculture is practiced with wheat, sugarcane, cotton and vegetables as the major crops. The irrigated area is prone to severe water logging and salinity. (ii) An extensive area is still rainfed where traditional crops like wheat, gram and pulses are grown. The rainfed area is prone to the hazards of wind erosion and droughts. (iii) In the foothills of Suleman ranges hill torrent water is used for irrigating the cultivated area under the traditional Rod Kohi spate irrigation system. This area is prone to droughts especially in case of no rains in the mountain ranges. The Rod Kohi system is currently highly prone to the hazard of flash floods and soil erosion because of increasing population density, raised bunds and water diversions. (iv) In the Kacha area along the Indus river bed, major crops grown are wheat, rice and cotton. The Kacha area is frequently affected by riverine floods.



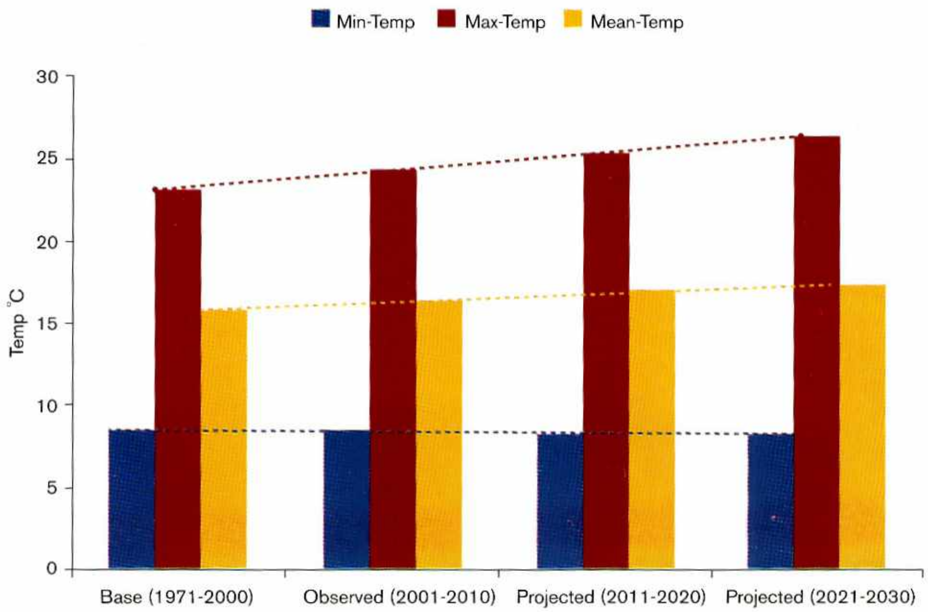
4. Temperature Scenario for Chitral

Decadal temperature scenarios for Chitral district are shown in Table 1. These are analysed for the four seasons and presented graphically in Figure 1- 5.

The results reveal that the annual maximum temperatures are at an increasing trend and annual minimum temperatures are at a decreasing trend compared to the base period of 1971-2000 (Figure 1). This implies that days are getting hotter while nights are getting cooler. On average the increase in annual mean temperatures is about 0.6 °C per decade.

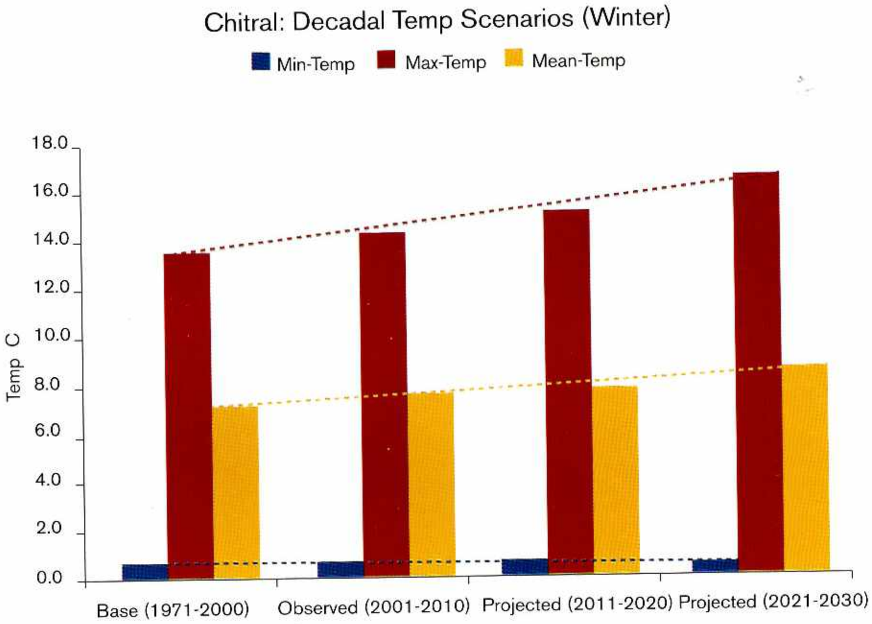
This pattern of increasing trend for maximum temperature (hotter days) and a decreasing trend of minimum temperature (cooler nights) has also been observed for all the seasons in Chitral during the year except spring season (see Figure 2-5). For the spring season both maximum and minimum temperatures are showing an increasing trend implying that days and nights are both getter hotter during the spring season. The rate of change in temperatures is higher in the winter and spring compared to the summer and fall seasons. Winter mean temperature is increasing with 0.45°C per decade, with day temperature increasing with 1.0°C per decade, indicating warmer winter days than normal in the future whereas the night temperatures are slightly decreasing indicating that nights are likely to further get cooler during the winter season. Spring mean temperature is increasing with 0.7°C per decade, indicating that spring is likely to become warmer. Summer mean temperature is increasing with 0.3°C per decade, also indicating warmer summers in the future. No significant change was found in the mean temperature of fall season.

Figure 1: Annual Temperature Change in Chitral (1971 – 2030)



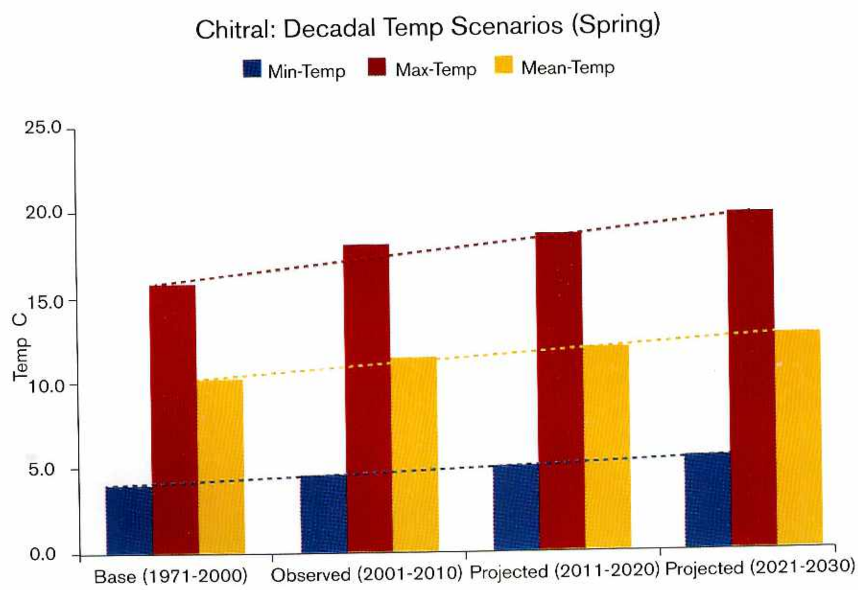
Source: Dr. Syed Sajidin Hussain

Figure 2: Winter Temperature Change in Chitral



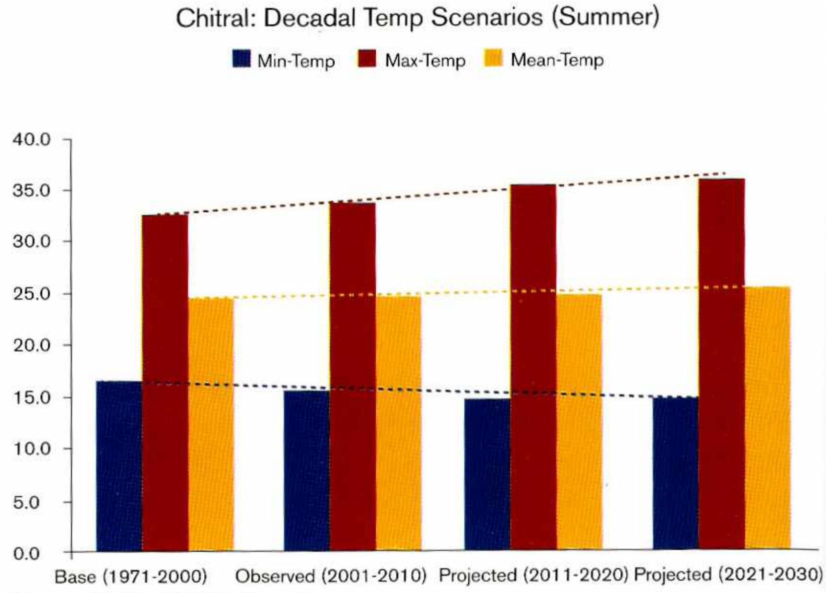
Source: Dr. Syed Sajidin Hussain

Figure 3: Spring Temperature Change in Chitral



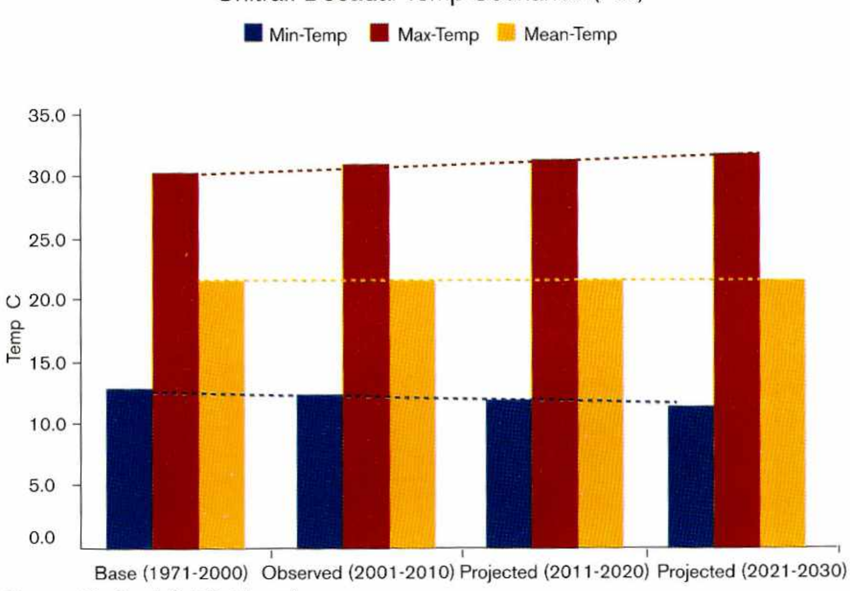
Source: Dr. Syed Sajidin Hussain

Figure 4: Summer Temperature Change in Chitral



Source: Dr. Syed Sajidin Hussain

Figure 5: Fall Temperature Change in Chitral



Source: Dr. Syed Sajidin Hussain

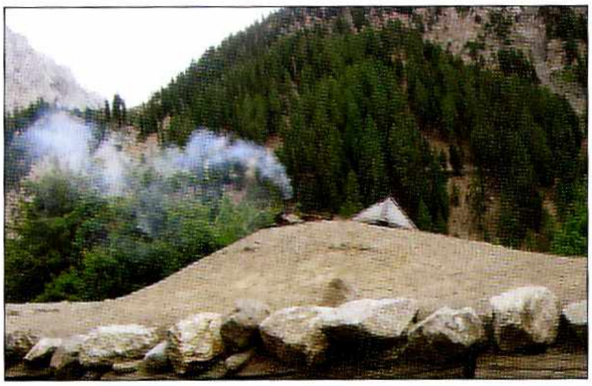


Table 1: Chitral: Decadal Temperature Scenarios (°C)

Tempera-ture	Base	Observed	% change from	Projected	% change from	Projected	% change from
	1971-2000	2001-2010	Base	2011-2020	2001-2010	2021-2030	2011-2020
Annual							
Average	15.9	16.3	2.52	16.9	3.53	17.3	2.52
Minimum	8.6	8.3	-3.49	8.2	-1.20	8.1	-1.22
Maximum	23.2	24.3	4.74	25.3	4.12	26.4	4.35
Winter							
Average	7.1	7.5	5.63	7.7	2.67	8.5	10.39
Minimum	0.7	0.7	-5.07	0.6	-16.48	0.5	-12.28
Maximum	13.4	14.3	6.10	15.0	5.16	16.5	10.00
Spring							
Average	10.1	11.4	12.87	11.9	4.36	12.7	6.75
Minimum	4.2	4.7	12.11	5.2	9.48	5.7	9.23
Maximum	16.0	18.0	12.90	18.6	3.37	19.8	6.22
Summer							
Average	24.6	24.7	0.41	24.9	0.81	25.5	2.47
Minimum	16.5	15.7	-4.86	14.8	-5.47	14.7	-0.81
Maximum	32.8	33.8	3.17	35.0	3.48	36.2	3.43
Fall							
Average	21.7	21.6	-0.46	21.5	-0.46	21.5	0.00
Minimum	12.9	12.3	-5.09	11.8	-3.87	11.3	-4.24
Maximum	30.4	30.9	1.67	31.3	1.14	31.8	1.60

Source: Dr. Syed Sajidin Hussain

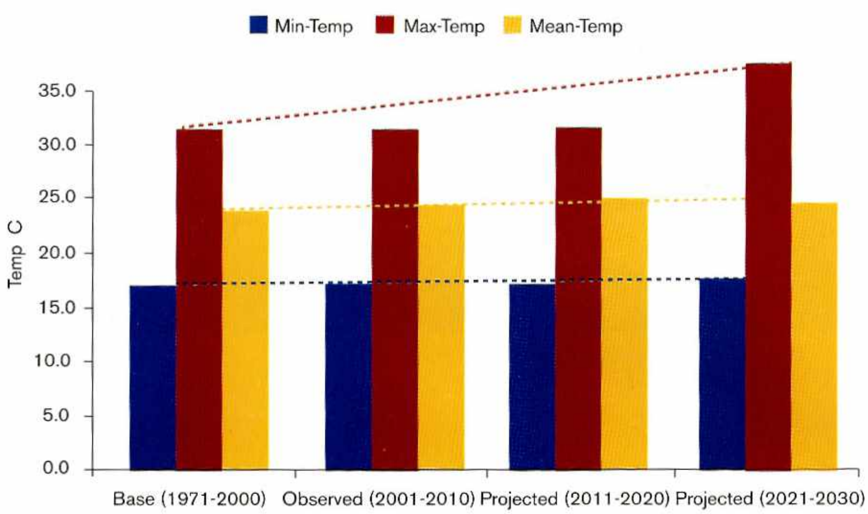
5. Temperature Scenario for DI Khan

The decadal temperature scenarios for DI Khan District are shown in Table 2. These are analysed for the four seasons and presented graphically in Figure 6 - 10.

Similar trends in the annual mean temperature (on average an increase of 0.4°C per decade) may also be seen for DI Khan (Figure 6) but the rate of increase in temperature especially during the day time is less than that of Chitral district. This implies that high latitudes (e.g. Chitral) will experience greater increases in temperatures than the lower latitudes (e.g. DI Khan).

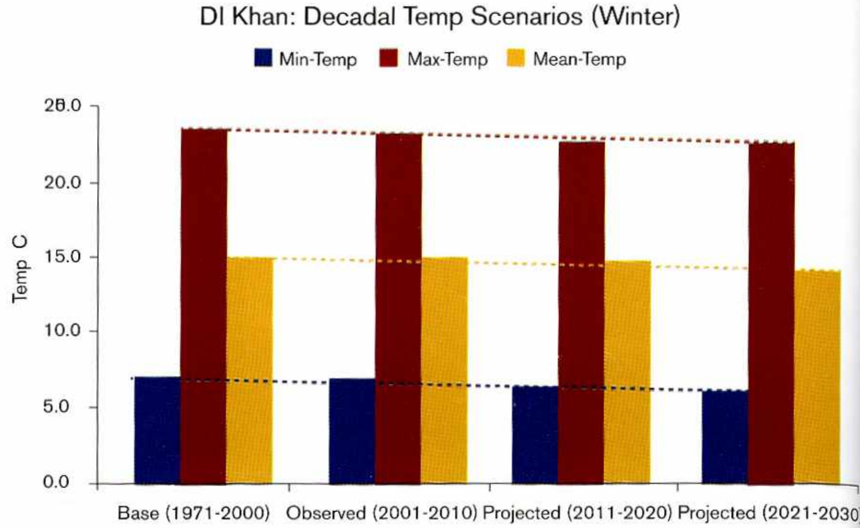
The seasonal patterns for temperature change (as shown in Figures 7-10) indicate that winter will become cooler falling by about 0.3 °C on average per decade. Springs will become hotter by about 0.7 ° C per decade that may also imply early summers. The summer and fall temperatures trend show insignificant change with only a slight increase in maximum temperatures (day temperature) but a declining trend for minimum temperatures (night temperature).

Figure 6: Annual Temperature Change in DIK (1971 – 2030)



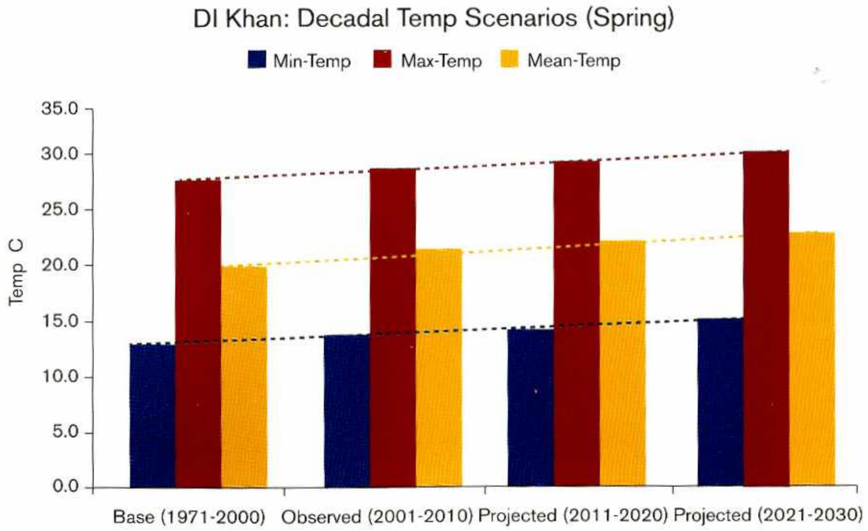
Source: Dr. Syed Sajidin Hussain

Figure 7: Winter Temperature Change in DI Khan



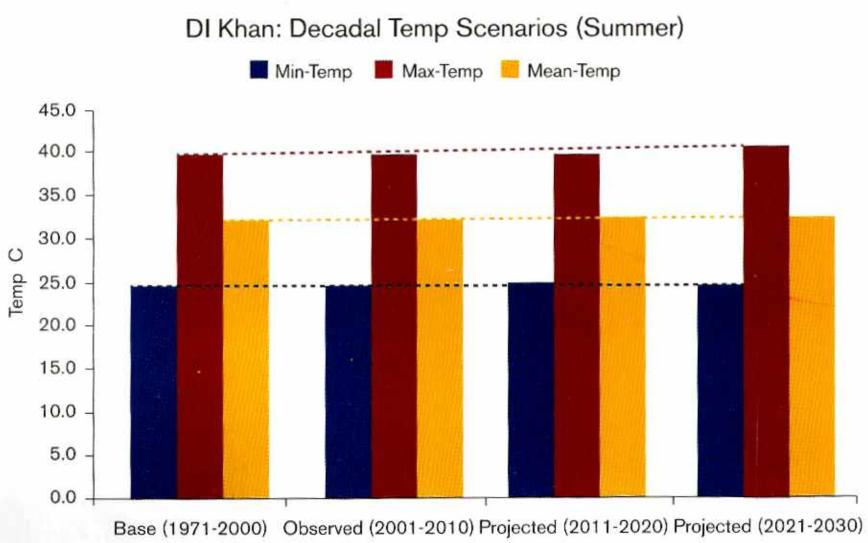
Source: Dr. Syed Sajidin Hussain

Figure 8: Spring Temperature Change in DI Khan



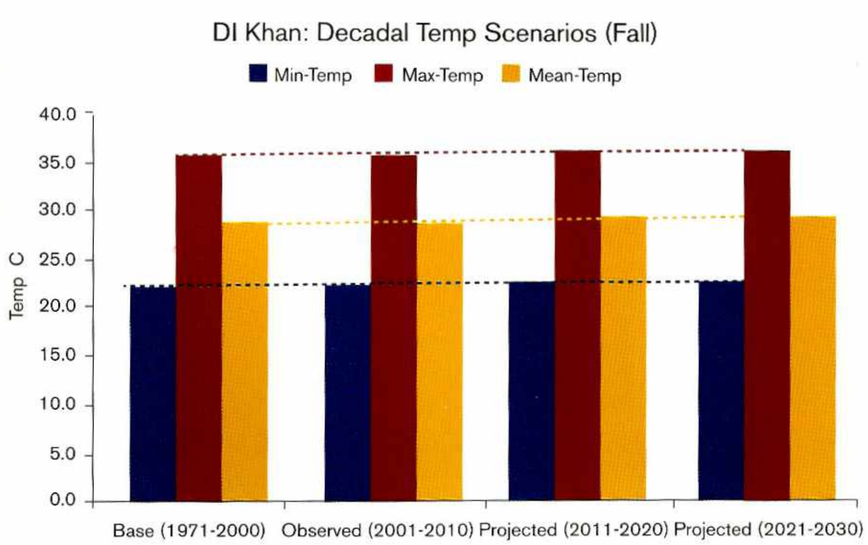
Source: Dr. Syed Sajidin Hussain

Figure 9: Summer Temperature Change in DI Khan



Source: Dr. Syed Sajidin Hussain

Figure 10: Fall Temperature Change in DI Khan

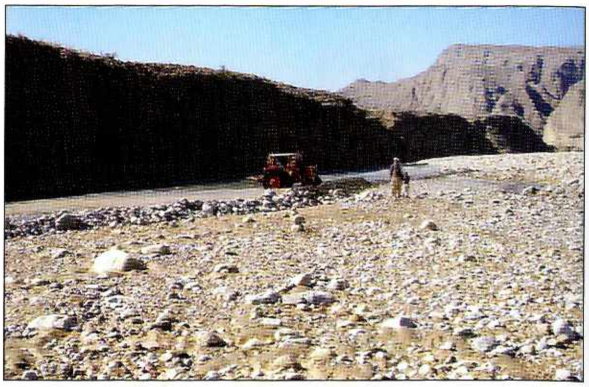


Source: Dr. Syed Sajidin Hussain

Table 2: DI Khan: Decadal Temperature Scenarios (°C)

Temperature	Base	Observed	% change from	Projected	% change from	Projected	% change from
	1971-2000	2001-2010	Base	2011-2020	2001-2010	2021-2030	2011-2020
Annual							
Average	24.2	**24.4**	0.83	24.8	1.6	25.2	3.31
Minimum	16.9	**17.1**	1.18	17.5	2.3	17.6	4.73
Maximum	31.5	**31.7**	0.63	32.0	0.9	32.5	2.54
Winter							
Average	15.2	**15.0**	-1.32	14.7	-2.0	14.3	-5.26
Minimum	7.0	**7.0**	-0.43	6.5	-7.1	6.2	-13.94
Maximum	23.4	**23.1**	-1.52	22.8	-1.1	22.5	-3.51
Spring							
Average	20.1	**21.2**	5.47	21.9	3.3	22.7	11.94
Minimum	12.8	**13.7**	6.73	14.3	4.4	15.2	18.46
Maximum	27.4	**28.8**	5.07	29.5	2.4	30.4	8.73
Summer							
Average	32.4	**32.4**	0.00	32.5	0.3	32.7	0.62
Minimum	25.4	**25.2**	-0.54	25.0	-1.0	24.8	-1.50
Maximum	39.5	**39.6**	0.15	40.0	1.1	40.5	1.77
Fall							
Average	29.0	**29.0**	0.00	29.2	0.7	29.4	0.86
Minimum	22.3	**22.3**	0.00	22.4	0.4	22.5	1.03
Maximum	35.6	**35.7**	0.16	35.8	0.3	36.0	1.00

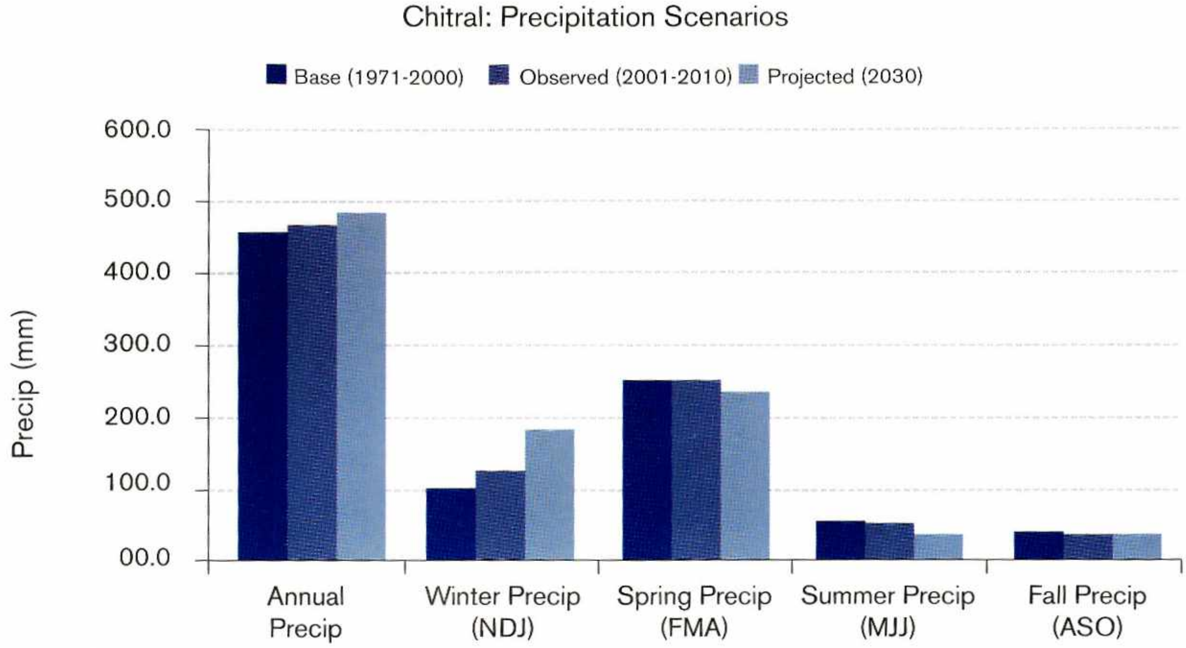
Source: Dr. Syed Sajidin Hussain



6. Precipitation Scenario for Chitral

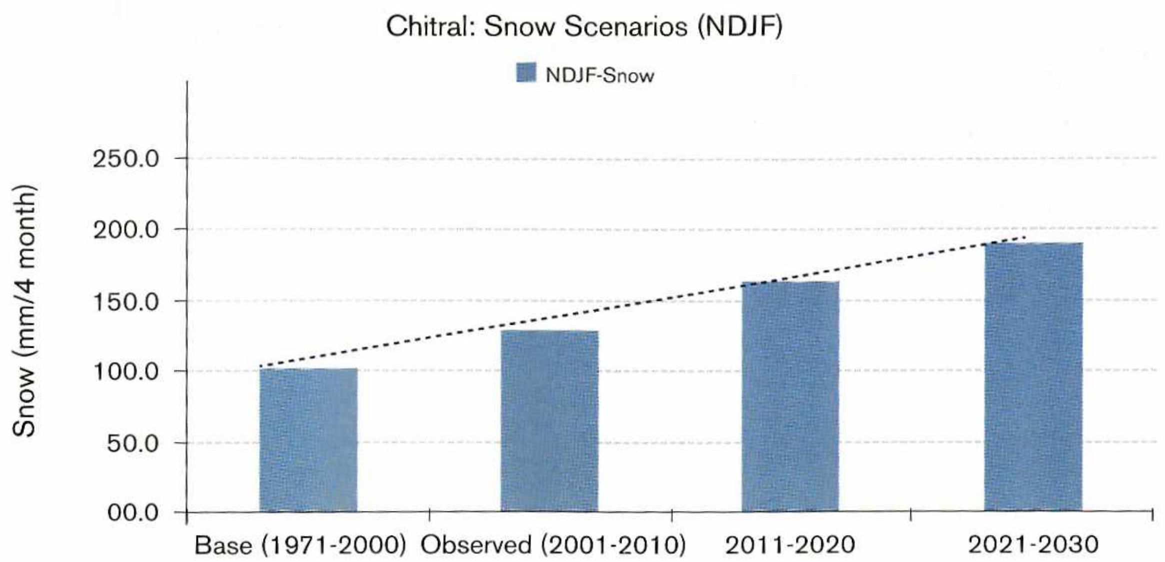
The decadal changes in precipitation (rainfall and snowfall) for Chitral district are shown in Table 3 and Figure 11-12. In Chitral annual rainfall is showing an increasing trend compared to the base (1971-2000) and projected to further increase by 2030. This is due to an increase in the winter season rainfall. For the other seasons, rainfall is showing a declining trend. Chitral also receives snow fall during the winter season which is showing a significant increase in trend (Figure 12). However, this analysis may be seen with caution because the existing simulation models do not provide consistent predictions for precipitation.

Figure 11: Trends in Annual and Seasonal Precipitation



Source: Dr. Syed Sajidin Hussain

Figure 12: Trends in snow fall during winter season

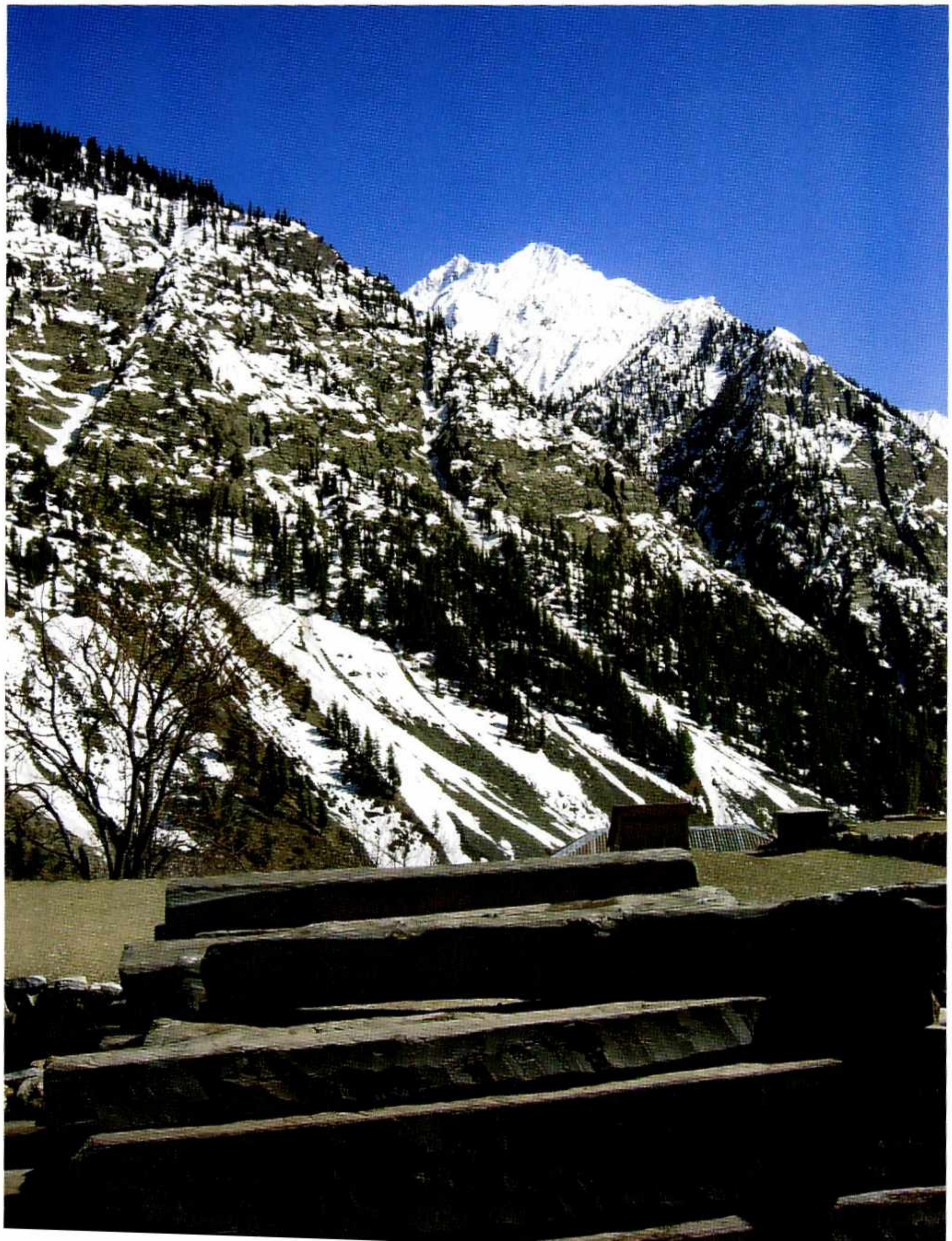


Source: Dr. Syed Sajidin Hussain

Table 3: Precipitation Trends in Chitral district

	Base	Observed	% change from base	Projected	% change from
Precipitation	**1971-2000**	**2001-2010**	**2001-2010**	**2001-2030**	**Base**
Annual rainfall	452.0	462.6	2.3	480.4	6.27
Winter rainfall	98.6	124.1	25.9	180.2	82.85
Spring rainfall	252.8	248.6	-1.7	230.2	-8.94
Summer rainfall	62.1	53.9	-13.1	35.5	-42.82
Fall rainfall	39.3	37.9	-3.6	34.5	-12.21
Snowfall	102.9	129.8	26.1	192.5	87.1

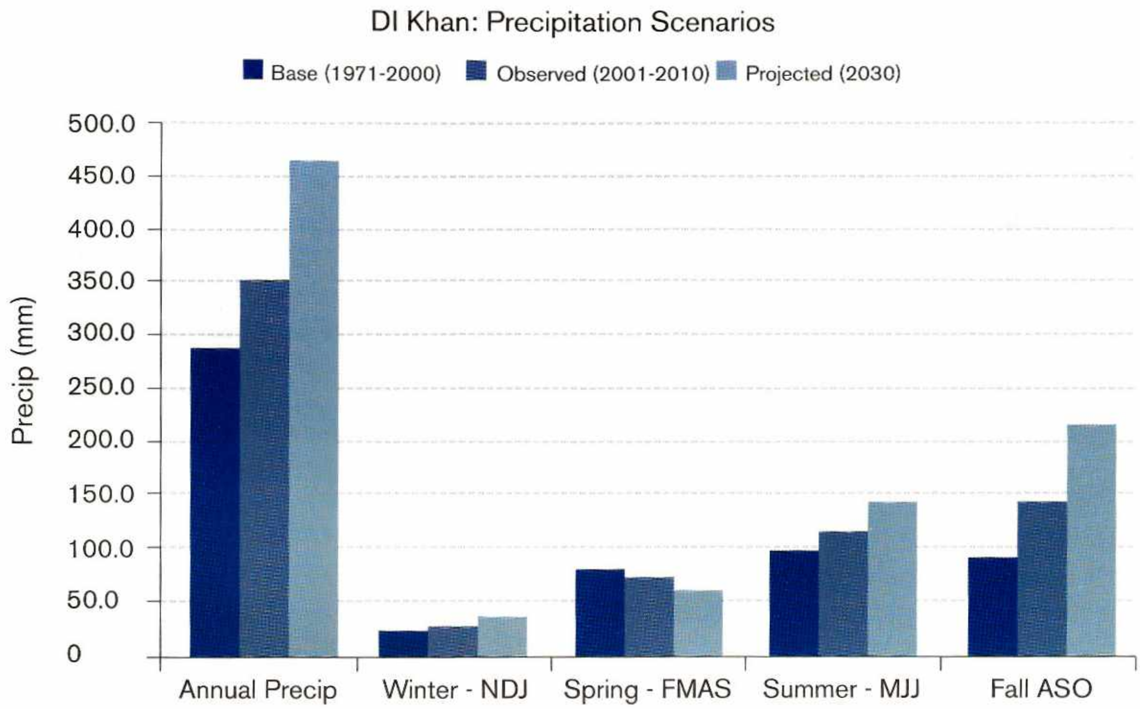
Source: Dr. Syed Sajidin Hussain



7. Precipitation Scenario for DI Khan

The changes in rainfall patterns for DI Khan District are given in Table 4 and Figure 13. The annual rainfall in DI Khan district has increased in the last decade (2001 – 2010) compared to the 30 year normal base (1971-2000). These are further expected to significantly increase by 2030. The spring season rainfall is showing a slightly decreasing trend. However, for all the other seasons rainfalls are expected to significantly increase, especially in the fall season that may be pointing towards the fact that monsoons are prolonging with monsoonal rains also occurring during the month of September.

Figure 13: Trends in Annual and Seasonal Precipitation



Source: Dr. Syed Sajidin Hussain

Table 4: Precipitation Trends in DI Khan district

	Base	Observed	% change from base	Projected	% change from
Rainfall	**1971-2000**	**2001-2010**	**2001-2010**	**2001-2030**	**Base**
Annual	291.07	354.76	21.9	460.5	58.21
Winter	22.64	27.46	21.3	36.5	61.23
Spring	79.19	72.26	-8.8	60.5	-23.60
Summer	98.61	115.54	17.2	143.5	45.52
Fall	90.62	141.8	56.5	215.5	137.79

Source: Dr. Syed Sajidin Hussain

8. Implications of CC Scenarios for agriculture and water resources in Chitral and DI Khan

The above results suggest that Chitral temperatures are at an increasing trend and that the winter and spring temperatures are increasing at a faster rate. Rainfall shows an increasing trend but only because of increase in winter rainfall. For the other season rainfall is showing a decreasing trend while snowfall is showing a significant increase.

Summary of climate change scenarios and its implications for Chitral and DI Khan are given in Table 5. The table reveals that overall temperatures are increasing in both the districts. Both the districts will experience hotter springs implying that summers will become longer. The average and maximum temperatures will also increase in the other seasons in both the districts. However, in DI Khan the winter temperatures are showing negative trend implying that winters will become cooler in DI Khan. Specific implications regarding agriculture and water resources for the increasing temperature trends in the two districts are discussed below.

8.1 Chitral district

The increasing trend in temperature for winter and spring seasons has important implications for winter crop growth and yields. Especially the increases in temperature will increase growing degree days (GDD) for the crop and shorten the GSL (growing season length) leading to early maturity. This shortening of the GSL could be beneficial for the mountainous areas above 1500 m (e.g.,Chitral) but further down (e.g. Swat) it may have negative impacts. Chitral may therefore expect yield increases in the existing wheat varieties because warmer temperatures will make it more likely that the crop matures earlier.

A shift in cropping zone further north is likely to occur (GOP/UNEP, 1998), expanding wheat production to mountainous areas above 1500 m because temperatures are expected to rise in these areas (Hussain and Mudasser 2007 and Hussain et al., 2005b) and the corresponding shortening of the GSL would make it possible for the existing semi dwarf wheat varieties to reach early maturity. It may be noted that in general wheat grown above 1500 m in most years does not reach maturity and is prematurely harvested for fodder production (Heiseyet al., 1992). Warming temperatures would therefore make it possible to grow at least two crops per year in the mountains. It will also allow more time for land preparation of subsequent crops e.g.,maize, with beneficial effects on yield.

The increased productivity of the wheat–maize cropping system (both through yield increase as well as area expansion) in Chitral is expected to improve food security, increase farm income and reduce overall poverty of the farm households in the area. Warming temperatures may also be beneficial for diversifying the cropping systems into fruits and vegetable production due to decreased risk of winter damage. The process of diversification from wheat–maize cropping system into fruits and vegetable production has already started in the foothills (e.g. Swat). The production of vegetables and fruits in these areas has increased consistently since mid eighties (World Bank, 2005). The impact of this diversification on rural incomes appears to have been significant e.g. converting from traditional crops to horticulture can provide five times the income per hectare and up to five times as much labour input requirement, thereby providing increased income opportunities for both farm households as well as land-less labourers (World Bank, 2005).

Cross-sectional adaptive research may be conducted in the mountainous regions to assess the suitability of crops cultivars and cropping patterns under changing climatic conditions High Yielding Varieties (HYVs) of wheat of the semi-arid areas are likely to become more suitable hence these varieties may be immediately tested and disseminated in the mountainous areas.

Adaptation strategies may also be required for irrigation water management. Warming temperatures may accelerate crop evapo-transpiration and thereby increase crop water demand in the mountain areas. The early warming temperature in spring will also enhance the process of early snow melting and enhance de-glaciation that may endanger the sustainability of the source of irrigation water in the country, both in the mountains and in the plains (Rees and Collins, 2004). Detailed analysis is recommended to assess the impact of warming temperatures on demand and supply of irrigation water in the mountains as well as in the rest of the country.

8.2 DI Khan district

In the DI Khan district while winters are getting cooler, the rising spring temperatures are showing a trend of an early summer. This trend will increase vegetative growth of the winter crops but the early maturity due to warmer temperatures in spring will affect the grain formation of wheat crop with the resulting declining yields. Similar declines in wheat yields have already been reported in the semi-arid areas in the south of the country (GOP/UNEP, 1998; Hussain et al., 2005a; Malik et al., 2005). These areas have already crossed the thermal limits of the existing wheat varieties and the growing season lengths have reduced from optimal 160 days to about 140-135 days. No such short duration varieties are currently available for the wheat crop in the country. The increased temperatures may cause a shift in cotton zone towards north. With the current increasing trend in temperature, there is a high possibility that the cotton area and yields will increase in DI Khan. Fodder yields might also increase in the district.

Warming temperature trends may also increase crop/livestock requirements due to increased evapo-transpiration. The nutritional needs for livestock may also increase.

Genetic research has to focus on developing short duration varieties for the plain areas including DI Khan. Simultaneously, operational research has to focus on testing and developing cultural practices to mitigate the warming effects on crops e.g. adjusting sowing windows – maybe an early planting of the existing varieties; zero tillage technologies to reduce soil water evaporation, adjusting number of irrigations etc.

Given that rainfall is showing an increasing trend in DI Khan district that may therefore benefit rainfed areas. Necessary measures would also be needed to introduce water conservation practices e.g. mulching, rain water harvesting and water storage techniques. Adaptation measures may also look at the possibility of re-introducing/ improving seeds of traditional crops such as pulses, millets, peanuts and gram - all that are heat and water resistant under the changing climate.

9. Associated Hazards under the CC scenarios

Increasing trends in rainfall and if accompanied with high intensity rains may further increase the possibility of flash floods in both Chitral and DI Khan districts as well as throughout the KP/ country. Climate change may also enhance droughts in DI Khan. On the other hand increasing temperature trends may cause increasing incidence of snow avalanches and GLOFs in Chitral district. Necessary adaption measures would be needed to prepare the local communities and increase their resilience to timely cope with these disasters.

Table 5: Summary of climate change scenarios for Chitral and DI Khan and its implications

Season	Chitral			DIK		
	Av	Max	Min	Av	Max	Min
Annual	+	+	-	+	+	+
Winter	+	+	-	-	-	-
Spring	+	+	+	+	+	+
Sum	+	+	-	+	+	-
Fall	+	+	-	+	+	+
IMPLICATIONS	• Overall temeratures are increasing • Days are getting hotter and nights are getting cooler • Hotter springs bring early snow melting and early summers. • Shorter winters and springs/ longer summers			• Overall temeratures are increasing • Cooler winters • Hotter springs, summers and fall • Summer days are getting hotter and summer nights are getting cooler		
IMPACTS ON AGRICULTURE &WATER	• Increase in crops and fodder yeilds • Shift in cropping zone further north with a possibility of double cropping and area expansion at higher altitudes. • Warming temperatures provide suitable conditions for diversifying cropping patterns to fruits and vegetables. • More water will be available because of early snow melting. The less snow accumulation will imply lesser water in summers and the increase in melting glaciers, will compensate. • Increased snow and glaciers melting may increase snow avalanches and GLOFs			• Decline in winter crop yield due to heat and mointure stress • Cotton yields might increase • Higher evapo-tranpiration • Increased water requirements for crops and livestock • Increased nutritional needs for livestock. • Decline in livestock productivity. • Increased incidence of diseases (human, crops, livestock and poultry).		
ADAPTATION NEEDS	1. Varieties of the sub-mountain areas (e.g. Swat) may be tested in the high altitude mountain areas. 2. Methods for conserving water from early/ increased snow/glaciers melting 3. Mulching techniques to reduce the impacts of cooler nights on crops			4. Genetic research to develop stress resistant varieties 5. Changing the sowing windows (early planting) 6. Changing irrigation scheduling 7. Changing crop scheduling/ patterns 8. Re-introduction of traditional crops under rainfed agriculture 9. Livestock fodder and nutritional requirements		

Source: Dr. Syed Sajidin Hussain

The data from Chitral and DI Khan on future scenarions suggest that temperatures and precipitatio will change over the years, which is a significant change for people's livelihoods. Climate change i a reality in these areas and timely adaptation to these changes is the only and urgent choice. W recommend conducting similar studies for other districts in Pakistan. particularly where agricultur serves a primary source of livelihoods, since only localized projections can lead to suggesting a effective adaptation path for famers' livelihoods.

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