inter cooperation

The Livelihoods Programme Hindukush

Climate Change

Adaptation needs for Agriculture and Water resources in Khyber Pakhtunkhwa, Pakistan

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Credits

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List of acronyms

AUP	Agricultural University Peshawar
CC	Climate Change
DIK	Dera Ismail Khan district
EWS	Early Warning System
GCISC	Global Change Impact Studies Centre
HEC	Higher Education Commission
IC	Intercooperation
KP	Khyber Pakhtunkhwa
LPH	Livelihoods Programme Hindukush
NGOs	Non Governmental Organisations
PCRWR	Pakistan Council for Research on Water Resources
P&DD	Planning and Development Department
PDMA	Provincial Disaster Management Authority
PFI	Pakistan Forest Institute
PMD	Pakistan Meteorological Department
SRES	Special Report on Emissions Scenarios

Foreword

Climate change is fast becoming a reality and desperately needs timely adaptation measures. It holds a strong and sometimes threatening impact on our forests not to forget all other natural resources as well for which adaptation measures are extremely necessary. Sensitisation workshops, seminars, trainings and now this booklet are just first few steps in this regard. We would expect that the readers especially those serving at senior levels in the Government will deliberate and ponder on the issue and devise a way forward to climate change adaptation in the province.

The report contains a CD with detailed presentations by some of the participants of different workshops who have over the years shared their expertise on the subject. These include introduction to the global challenge of climate change, its linkages to hydro-meteorological disasters and the impact of climate change on agriculture, water and forest resources. Climate change scenarios for the country in general and KP in particular were also presented based on modeling based research.

For a safer and greener environment,

Herman Mulder

1. Introduction

Intercooperation through the Livelihoods Programme Hidukush (LPH) has periodically conducted various orientation workshops and training events to orient staff and partners on Climate Change since 1999. Partners and stakeholders from all provinces and Federal Capital Islamabad have participated in various events and have contributed their knowledge on the theme. A particular focus has been placed on officials from relevant government departments of the Government of KP who also collaborate with IC in different programmes. IC has been one of the forerunners in bringing the discussion on Climate Change scenario for selected places in KP, Pakistan for future well-being of communities.

This document is the result of an orientation workshop conducted with senior officers of Government of KP at the Agricultural University Peshawar. Many senior professionals from relevant backgrounds such as agriculture, livestock, fisheries, forest, water, management and irrigation provided inputs in the workshop and helped in sensitizing the participants. Some of the papers presented during this workshop have been integrated into the document. The workshop placed a major emphasis on agriculture (including livestock and fisheries), forestry and water resources sectors. The discussion on possible impacts, both risks and opportunities, of climate change and possible efforts to mainstream climate change adaptation in research and development were the core subjects of the workshop. Readers craving more detail will find a CD attached which includes the presentations made during the workshop.

2. Background

Pakistan being an agro-based economy is at threat due to the global climatic changes. The country ranks 12th among the Countries of the World that are expected to be severely affected by climate change. The country is sensitive to both increases in temperature and changes in precipitation. These could increase vulnerabilities for agriculture, forest and water resources upon which depend a large part of the economy and livelihoods. Increases in temperatures due to climate change could particularly alter bio-physical relationships for crops/livestock/fisheries/forests such as shortening of the growing periods, changing the species patterns, increasing thermal and moisture stresses, changing water requirements, altering soil characteristics, and increasing the risk of pests and diseases.

The effects of climate change on agriculture and other natural resources may vary across the diverse agro-ecological regions. In the dry western mountainous areas, the increase in temperatures could enhance the process of de-glaciations by affecting our water resources on which the country depends for agriculture and energy production. These mountainous areas are already under severe pressure due to various natural and anthropogenic (human) activities. Consequently, there is an ongoing process of environmental degradation in such areas. The major human induced factors causing environmental degradation in the mountainous areas are: mismanagement / overexploitation of natural resources, deforestation and unsustainable agricultural practices (cultivation on steep slopes and forest encroachment for agriculture land). Global climatic changes (i.e. increases in temperature and changes in precipitation) are expected to further enhance the on-going process of watershed degradation and would seriously endanger the sustainability both of mountainous areas as well as sub-mountain and downstream plain areas in Pakistan in general and Khyber Pakhtunkhwa (KP) in particular.

Some of the regions of the country over higher latitudes (including Chitral) that cover about 17 percent of the total area are short of heat and therefore may benefit from rising temperatures. Rise in temperature could well enhance crop growth and faster maturation that allow earlier planting and earlier harvesting of the winter crops. Crop yields are expected to increase in these areas as well as expansion of the crop area because of increase in temperature. Double cropping would also be possible utilising both winter and summer seasons. Forest species pattern may change. Fast growing species are expected to replace conifers. These higher latitude areas are however vulnerable to frequent flash floods causing heavy losses to land, agricultural properties and livelihoods assets. In the lower latitude areas, climate change will well reduce crop and livestock yields due to heat and water stresses especially the increases in temperature. The lower latitudes will also be affected by climatic hazards such as droughts and floods the frequency of which has already increased in these areas since the last two decades perhaps due to climate change.

Timely preparation and adaptation to climate change is needed not only to tap positive opportunities but also to reduce the adverse impacts of climate change in all sectors of the economy in general and agriculture, livestock, forest and water resources in particular. This would include among others for example the re-orientation of research and development to develop appropriate technologies, introduction of appropriate species/varieties and other management practices for crops, livestock and forestry etc. to tap the future potentials and opportunities arising from climate change. At the same time efforts would be needed to introduce measures (structural and non-structural including bio-engineering measures) to protect natural resources from climate related hazards that are expected to increase due to climate change and may well outpace the positive impacts of these climatic changes.

3. Climate Change – A Global Challenge

3.1 The Climate Change Phenomenon

Some gases like CO_2, Methane, N_2O, Chlorofluorocarbons (CFCs) exist naturally in the atmosphere. These are called Green House Gases (GHGs) that form a blanket surrounding the earth and keeps the earth warmer. Without these gases the earth's atmosphere could have been -15 °C and life on earth would have not been possible. This is called the Green House Effect.

The concentration of these GHGs is increasing mainly due to the unsustainable human activities (fossil fuel burning, depletion of sinks like forests etc.) and enhancing the Green House Effect causing rise in global temperatures of the earth. The phenomena of a rise in global temperatures of the earth and other associated climatic changes as caused by the enhanced Green House Effect is called "Global Warming" and in broader term "Climate Change".

According to the 3rd Assessment report of Inter-governmental Panel on Climate Change (IPCC 2001), the average global temperature has increased by 0.6 °C during the 20th Century. Future increases in global temperature are expected in the range of 1.4 – 5.8 °C and in South Asia, average annual temperatures could rise between 3.5 to 5.5 °C by the end of the 21st century. The IPCC 2007 report further concludes that the rise in global temperature of 2 – 4.5 °C is almost inevitable during the 21st century. The effects of climate change/global warning have been noticed throughout the world since 1990. The last two decades were found to be the warmest in instrumentally recorded period (1861-2010).

3.2 Linkages between Climate Change and Disasters

Climate Change is also bringing climatic variability/extreme climatic events, the frequency of which could be measured over a shorter period of time (2 – 5 years or less than a decade). The present climatic variability (extreme climatic events) has increased in recent years leading to hydro-meteorological disasters, which is a major concern world-wide. Storms, Floods, Droughts, and Cyclones have become frequent all over the world in recent years, resulting in loss of lives and livelihoods ~ exacerbating poverty.

The increasing frequency of climate variability/extreme events is also a major concern for Pakistan as it is the major cause of climatic disasters. The frequency of hydro-meteorological disasters has already increased since 1990s all over the world in general and in Pakistan in particular. The country is vulnerable to these climatic disasters because it has a high climatic and geographic diversity, a large part of our economy lies in the vulnerable sector (i.e. agriculture) and the majority of the rural population is poor and therefore less resilient to climatic hazards.

Given that one of the major threats posed by climate change is an increase in the climatic variability that increases the risks of extreme climatic events/ hydro-meteorological disasters, it necessitates to work towards both adaptation to climate change as well as Disaster Risk Reduction (DRR) especially to avoid the risks of disasters caused by extreme climatic events.

4. Impacts of Climate Change

There is now a consensus among the scientific community that Global Warming is occurring due to anthropogenic activities mainly the emission of Greenhouse Gases by burning of fossil fuel, deforestation and land use change. Global warming, or Climate Change, has both positive and negative effects but the negative impacts outweigh the positive impacts in Pakistan. It is a challenge for planners, policy makers, researchers and thinkers alike.

4.1 Impact on Agriculture

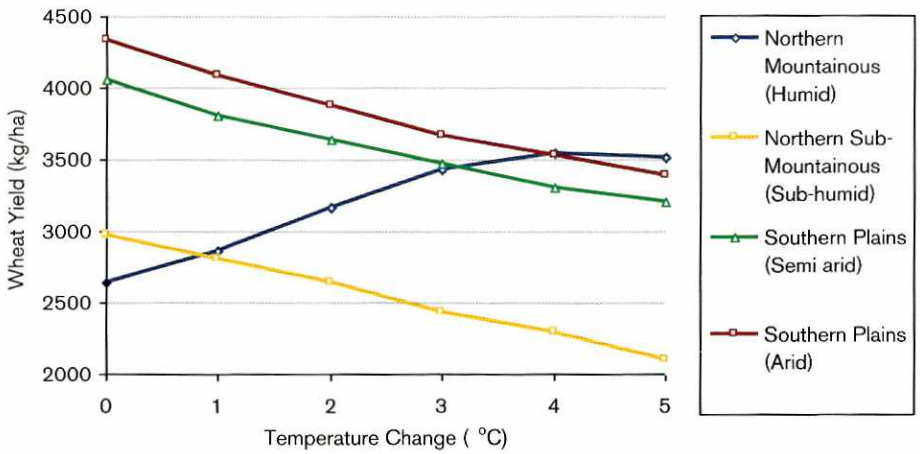
Climate change is likely to exert adverse impacts on productive resources and ultimately on agricultural productivity of the country. The major climatic stresses that will exert pressure on agriculture are: increasing temperatures in arable areas; changes in rainfall patterns (becoming irregular and severe); increased variability of Monsoon; changes in availability of irrigation water; severe water-stressed conditions in Arid and Semi-arid areas; extreme events, such as floods, droughts, heat waves, cold waves, cyclones, etc.

Communities most vulnerable to climate change in Pakistan are small land holders that form more than 80% of the total farming community. The farmers in arid and hyper-arid regions and those living in the mountainous and coastal areas are more exposed to the climate change and extreme events.

The impacts of climate change on agriculture include; the shortening of Growing Season Length (GSL), heat stress at critical reproductive stages and increased water requirements of crops. These factors cause a decrease in yield in arid and semi-arid regions by about 6 – 18%.

The following figure suggests that wheat yields in all the agro-climatic regions are showing a declining trend, except in the mountainous areas where wheat yields are showing an increasing trend mainly because the mountainous areas are still short of temperatures. Decline in yield (in between 12-18%) was also observed for basmati rice in semi-arid region of the country.

Figure 1: Wheat production drops in sub humid, semi arid and arid areas and inclines in humid areas.



Source: Pakistan Meteorological Department

4.2 Impact on Forests

Climate change will also cause loss of biodiversity and shifting of forest areas northwards (to cooler places). Expected precipitation will have positive impact on the forests in the northern watersheds. Frequency of forest fires will increase due to increased heat and erratic rainfall causing damage to regeneration and plantation areas. Species composition may change with the changed ecology.

4.3 Impact on Pests and diseases

There will be enhanced risk of proliferation of pests and diseases under climate change. Some insect pests and diseases proliferate under high rainfall conditions (e.g. Bollworms of Cotton, Wheat Rust and Root Rot diseases), some thrive under warm and moist conditions (e.g. thrips and sucking pests) while others under dry conditions (e.g. locusts).

4.4 Impact on water resources

Climate Change will lead to irrigation water shortages due to changes in river flows as a result of glacial melt. Erratic and uncertain pattern of rainfall will affect arid and hyper-arid areas. Increased evapo-transpiration as a result of high temperatures will increase water demand of crops (by 10-30%).

Climate change will also affect glaciers. The Glaciers all over the world are receding fast due to global warming. Shrinking Glaciers have serious implications for sustainable water supply. Glacial melt in the Himalayas is projected to increase flooding within the next two to three decades. This will be followed by decreased river flows as the glaciers recede. The formation of Glacial Lakes and their outburst (GLOFs) has also been threatening the lives and livelihood of local population.

4.5 Impact on Livestock

Climate change will impact livestock productivity especially due to high temperatures. These include physiological stress on animals, productivity losses (milk and meat), stress on conception and reproduction; climate related disease epidemics, reduced productivity of fodder crops, decreased quality and palatability of forages and increased water requirements of animals and fodder crops.

4.6 Impact on fisheries

At higher elevations, fisheries are likely to be adversely affected by lower availability of oxygen due to a rise in surface air temperatures. In the plains, the timing and amount of precipitation could affect the migration of fish species from the river to the floodplains for spawning, dispersal, and growth. Future changes in ocean currents, sea level, sea water temperature, wind speed and direction, and predator response to climate change will substantially alter fish breeding habitats, food supply for fish and ultimately the abundance of fish populations. Areas under mangrove forests which are the breeding ground/hatching places for fish are decreasing rapidly due to climate change.

4.7 Impact on disasters

The increasing frequency of flash floods in hilly areas will cause river bank cuttings and landslides, damaging houses, agriculture lands, roads & properties. Thus, while the increased temperature will have a positive impact on crop yields in the mountainous areas, the negative impacts will be more pronounced in the mountains as well e.g. enhanced de-glaciations, overall increasing trend in rainfall leading to surface runoff, soil erosion, landslides, avalanches, biodiversity loss etc. The sedimentation loads from the mountainous regions are already causing silting of dams downstream and reducing the capacity of water reservoirs of the country.

5. Climate Change Scenarios for Pakistan

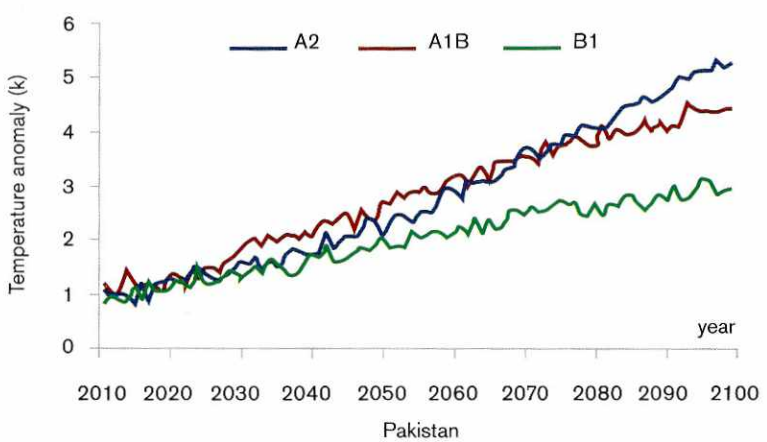
Analysis of the Pakistan Meteorological data (1960 to 2010) indicated that the area weighted temperature during 1960 to 2010 has increased. The last two decades were the warmest whereas the year 2010 was observed as the warmest year on record since 1880, even more than the years 1998 and 2005.

While temperatures have increased all over the country, the northern mountainous regions have experienced a higher rate of increase, especially in the past decade (2001 – 2010). Total accumulated increase in temperature was only 1.1 ^{0}C in 190 years, whereas the same amount of increase of 1.1 ^{0}C was seen only during the last ten years.

5.1 SRES Storylines

Future projections for temperatures show positive trends in the 21st century (2010 – 2100) in comparison to the base period (1960 - 1999) (see figure 2) under different SRES scenarios chosen for the climate change modelling e.g. A2 (heterogeneous world), A1B (A1 scenarios are of a more integrated world, and its subset of A1B is a balanced emphasis on all energy sources) and B1 (globally convergent world). Precipitations projections on the other hand show no significant change (Figure 3). The SRES storylines are described in Table 1.

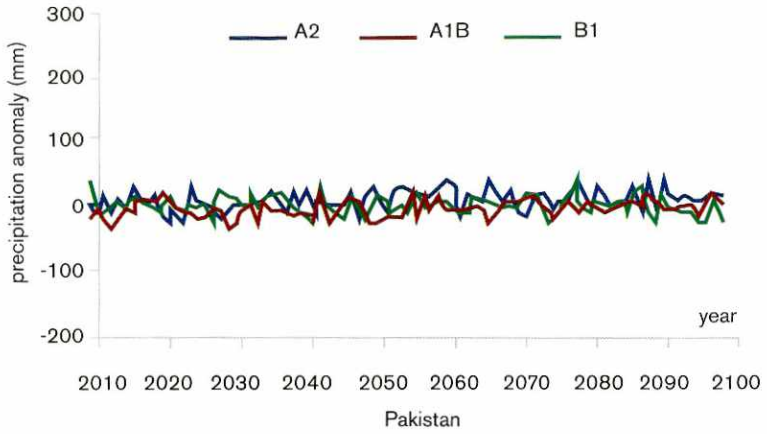
Figure 2: Future Temperature Projections (baseline 1960 - 1999)



Source: Dr. Ghulam Rasul, Pakistan Meteorological Department

No significant change in precipitation trends over the past century have been observed in Pakistan. For the northern mountainous region only 72 mm rise in precipitation has occurred over the period 1901 – 2009. However, significant decadal variation has been observed in the precipitation trend during the same period.

Figure 3: Precipitation change in future (baseline 1960 - 1999)



Source: Dr. Ghulam Rasul, Pakistan Meteorological Department

Table 1: Summer characteristics of four SRES storylines

A1	A2
World: market-oriented **Economy:** fastest per capita growth **Population:** 2050 peak, then decline **Governance:** strong regional interactions; income convergence **Technology:** three scenario groups: • A1FA: fossil-intensive • A1T: non-fossil energy sources • A1B: balanced across all sources	**World:** differentiated **Economy:** regionally oriented; lowest per capita growth **Population:** continuously increasing **Governance:** self-reliance with preservation of local identities **Technology:** slowest and most fragmented development
B1	**B1**
World: convergent **Economy:** service and information-based; lowest growth than A1 **Population:** same as A1 **Governance:** global solutions to economic, social and environmental sustainability **Technology:** clean and resource-efficient	**World:** local solutions **Economy:** intermediate growth **Population:** continuously increasing at lower rate than A2 **Governance:** local and regional solutions to environmental protection and social equity **Technology:** more rapid than A2; less rapid, more diverse from A1/B1

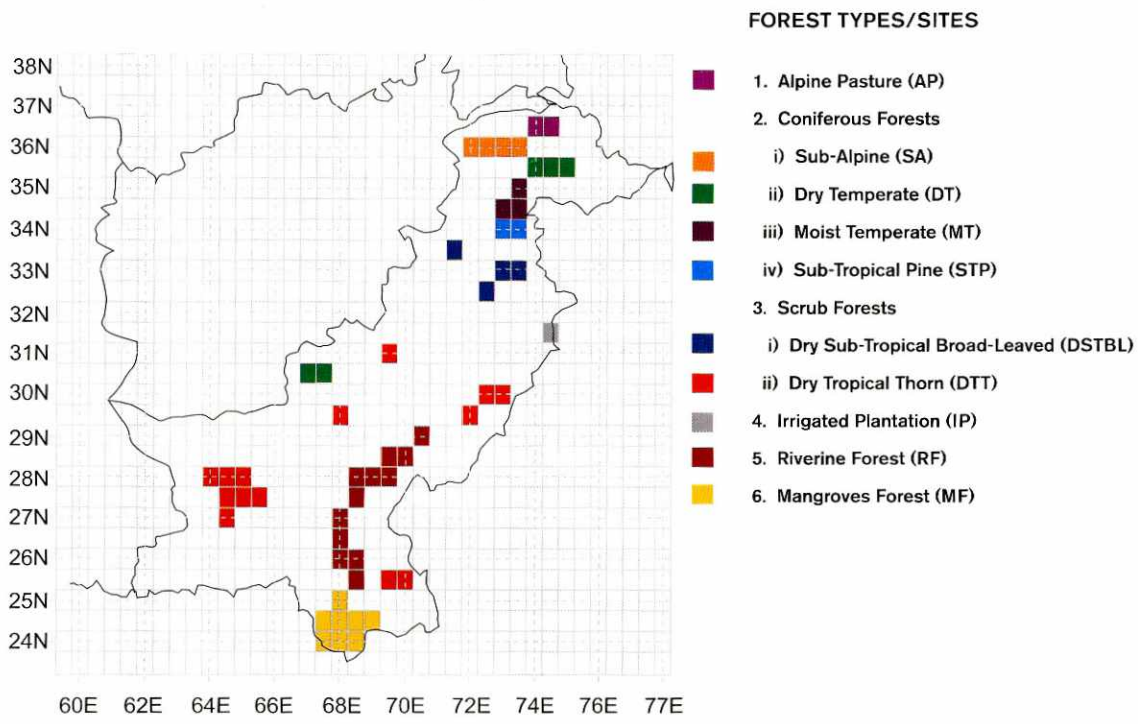
The increase in temperature under these scenarios is projected for all the regions of the country but rate of increase is expected to be higher for the northern mountainous region. Precipitation is showing no significant change for these regions except for the northern and coastal regions where

6. Case Study:

Climate Change Scenarios by forest types in Pakistan and vulnerability hotspots

Ten forest types were studied throughout Pakistan at a grid size of 50 x 50 kilometer scale covering alpine pastures (AP); Conifer forests (4 types); Scrub forests (2 types); Irrigated Plantations (IP); Riverine forest (RF); and Mangroves forest (see figure 4).

Figure 4: Observation Points



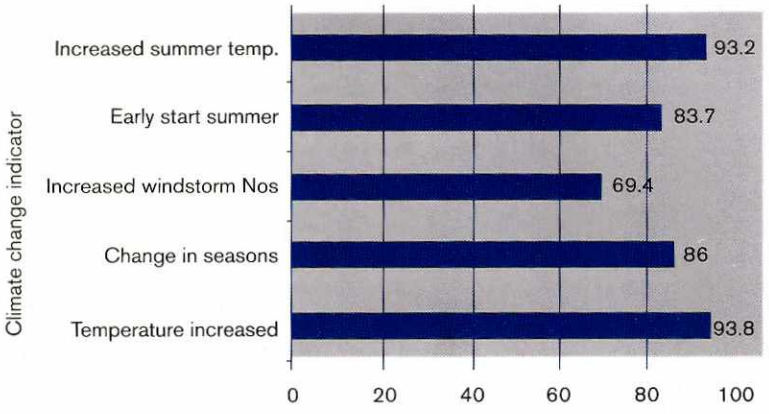
Source: Dr. Ghulam Ali Bajwa

These forest types were studied under two global scenarios: A2 scenario (extreme conditions of heterogeneous world) and B2 scenario (moderate conditions with emphasis on local sustainable solutions). The time scale used was 2020, 2050 and 2080. The results indicate that mean temperatures will increase both under A2 and B2 scenario throughout forest types in the country. By 2080, highest temperature increases (4.65 - 6 ^{0}C) may occur in the areas under alpine, sub-alpine forest types (e.g., in the mountain and sub-mountainous areas) and lowest increases (3 - 4 ^{0}C) in the irrigated areas. The increases in temperatures will be mainly during the winter and spring seasons.

The rainfall trends indicate that spring rains will increase in almost all the regions. Summer rains will however decrease in the alpine and conifer forest types lying in the mountainous areas but in all other regions, the summer rains will also increase. Overall rains under the mangroves forest area are expected to decrease by 60% by 2080.

The study also obtained perception of the public about climate change in the mentioned areas and their response is summarised in Figure 5 below. Almost all the respondents have noticed that overall temperatures have increased in Pakistan. They have noticed an early start of summers and overall changes in the seasonal patterns.

Figure 5: Public Perception Response towards Climate Change



Source: Dr. Ghulam Ali Bajwa

Implications for forestry

Under the above climate change scenario, the case study concludes that climate change will shift the tree line up by about 602.86 - 874.29 meters. Species composition may change caused by migration of biome @ 8.8 to 14.7 m/year. The area under Conifers will decrease by 7.5 to 9.96% and the area under Scrubs will increase by 37.26 to 45.7%. This will have major implications for the valuable timber forest of the country.

Major vulnerability hotspots identified by the study are listed below:

Because of rising temperatures:

- Alpine pasture will be extremely vulnerable.
- Sub-alpine, dry tropical scrubs in South Punjab, Lower Sindh & Baluchistan will be severely vulnerable
- Dry temperate. (Quetta) and Sub-tropical pine will be highly vulnerable
- Sub-tropical broad-leaved in Northern foothills and irrigated plantations will be mildly vulnerable.

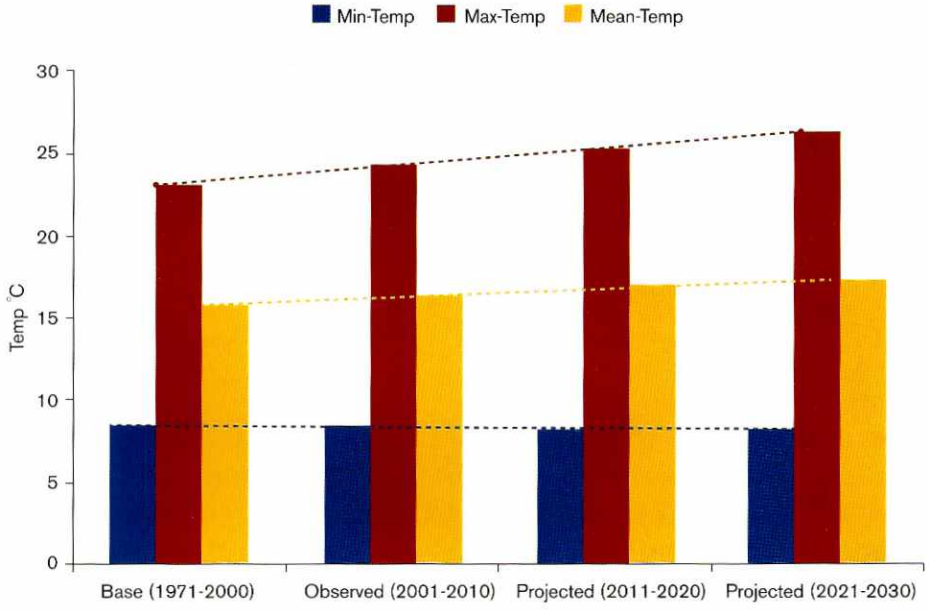
Because of changes in precipitation patterns:

- Mangrove forests are extremely vulnerable because precipitation will decrease in those areas by more than 60%.
- Alpine pasture, Sub alpine and Dry tropical thorns will be severely to extremely vulnerable.

7. Climate Change Scenarios examples from Khyber Pakhtunkhwa (Chitral and DI Khan)

Two extreme environments were selected in KP for the study : Chitral with temperate and cooler weather and DI Khan with arid and hotter weather. Coupled Global Climate Model (CGCM3) was used and 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) were analysed. Detailed methodology may be seen in the IC report for climate change scenarios of DIK and Chitral, 2012).

Figure 6: Chitral Decadal Temperature Scenarios (Annual)

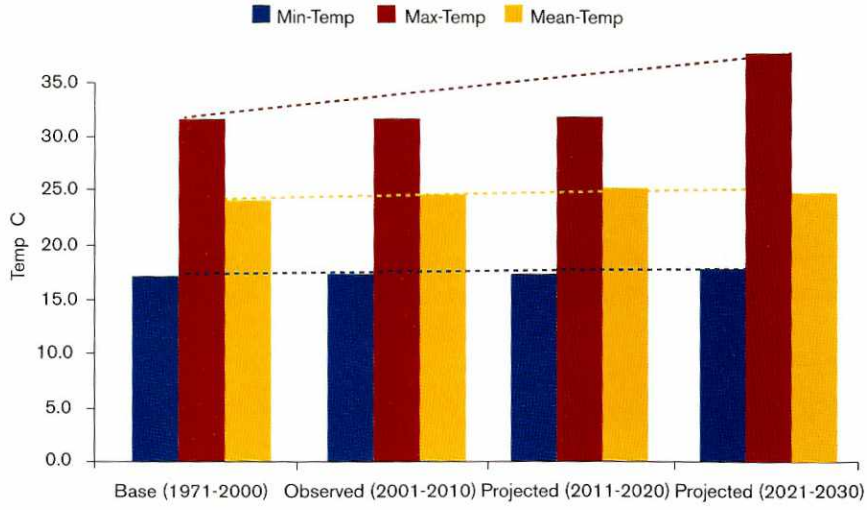


Source: Dr. Syed Sajidin Hussain

Decadal temperature scenarios for Chitral district revealed 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 6). This implies that days are getting hotter and nights are getting cooler. On average the increase in annual mean temperatures is about 0.6 ^{0}C per decade.

Similar trends in the annual mean temperature (on average increase of 0.4°C per decade) may also be seen for DI Khan (Figure 7) 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).

Figure 7: DI Khan Decadal Temperature Scenarios (Annual)



Source: Dr. Syed Sajidin Hussain

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 district (Table 2). The rate of change in temperatures is higher in the winter and spring seasons compared to the summer and fall seasons. Winter mean temperature is increasing with 0.45°C per decade whereas the spring mean temperature is increasing with 0.7°C per decade.

On the other hand, the seasonal patterns for temperature change in DI Khan indicate that winter will become cooler falling by about 0.3 °C on average per decade. Spring season will become hotter by about 0.7 ° C per decade that may also imply early summers.

Table 2: Summary of the Temperature Change in Chitral and DI Khan (Annual)

Season	Chitral			DI Khan		
	Av	Max	Min	Av	Max	Min
Annual	+	+	–	+	+	+
Winter	+	+	–	–	–	–
Spring	+	+	+	+	+	+
Sum	+	+	–	+	+	–
Fall	+	+	–	+	+	+

Source: Dr. Syed Sajidin Hussain

Decadal changes in precipitation (rainfall and snowfall) for Chitral and DI Khan Districts were also analysed. The results showed that annual rainfall in Chitral 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 only. For the other seasons, rainfall is showing a declining trend. Chitral also receives snowfall during the winter season which is showing a significant increasing trend.

For DI Khan the annual rainfall is showing an increasing trend during 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 the monsoon season is prolonging (with monsoon rains also occurring during the month of September).

7.1 Implications for agriculture and water resources:

Table 2 reveals that overall temperatures are increasing in both the districts but the rate of increase is higher in Chitral district. Both the districts will experience hotter springs implying that summers will become longer. Chitral district crop yields will increase due to increasing temperatures. On the other hand in DI Khan, the vegetative growth of the winter crops will be enhanced by hotter springs but it will negatively impact the winter crop yields. Cotton yields might increase in DI Khan. Crop water requirement and water and nutritional needs for livestock will increase in DI Khan district.

Adaptation strategy will be necessary to introduce short duration varieties in both the districts. For Chitral the available varieties of the sub-mountainous region (e.g. Swat) shall be tested and introduced. For DI Khan genetic research has to concentrate on developing new short duration varieties for wheat crop. Alternatively adjustments in cropping and sowing patterns are recommended in DI Khan. Adaptation strategies may also be required for irrigation water management. Warming temperatures may accelerate crop evapo-transpiration and thereby increase crop water demand. In Chitral, 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.

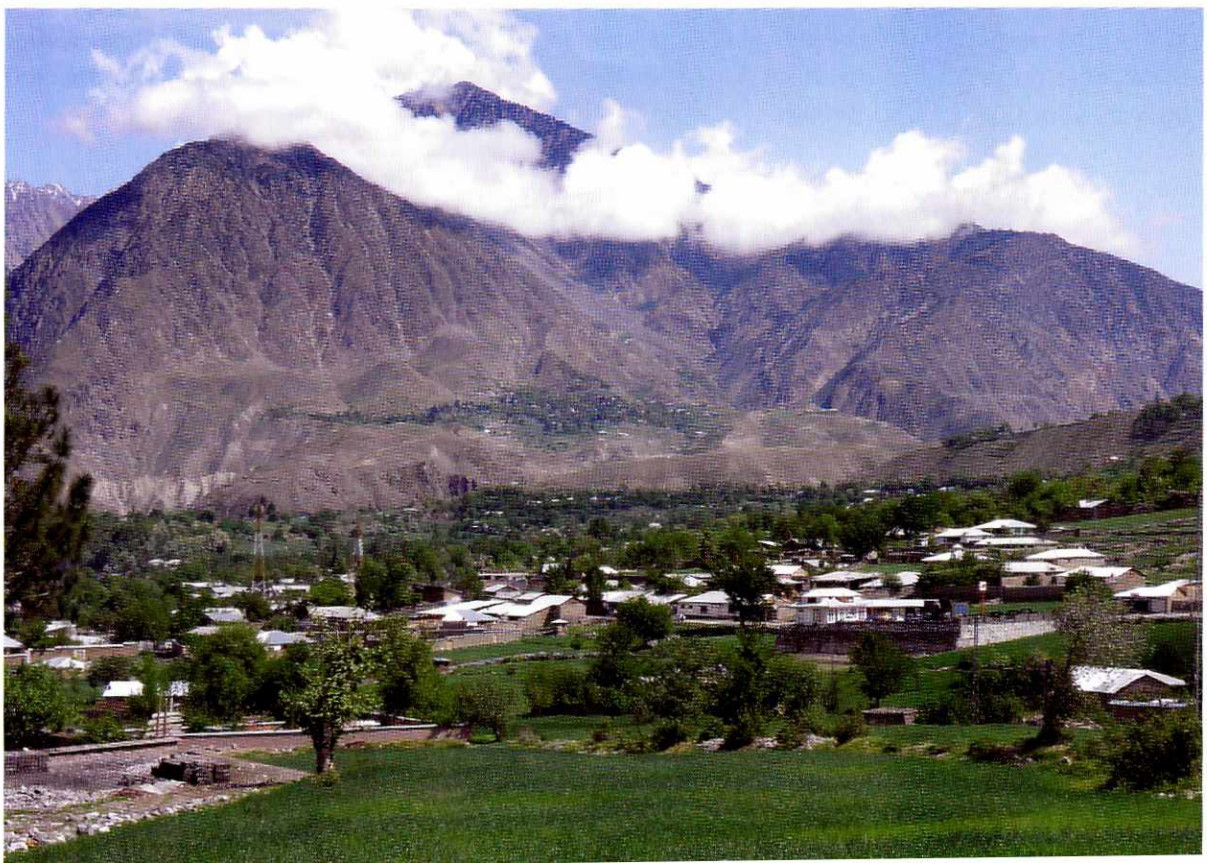


Table 3: Implications of temperature changes in Chitral and DI Khan and implications for agriculture and water resources.

	Chitral	DI Khan
IMPLICATIONS	1. Overall temperatures are increasing 2. Days are getting hotter and nights are getting cooler 3. Hotter spring seasons bring early summers 4. Shorter winters and springs/ longer summers	1. Overall temperatures are increasing 2. Cooler winters 3. Hotter springs, summers and fall 4. Summer days are getting hotter and summer nights are getting cooler
IMPACTS ON AGRI &WATER	1. Increase in crops and fodder yields 2. Possibility of double cropping and area expansion at higher altitudes 3. Early snow melting, less snow accumulation 4. Increased glacial melting/ avalanches/GLOFs	1. Decline in winter crop yield due to heat and moisture stress 2. Cotton yields might increase 3. Higher evapo- transpiration 4. Increased water requirements for crops and livestock 5. Increased nutritional needs for livestock
ADAPTATION NEEDS	1. Varieties of the sub-mountainous areas (e.g. Swat) may be tested in the high altitude mountains. 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

8. Adaptation to Climate Change

Climate change holds both negative and positive impacts on various sectors of the economy. For the adaptation to climate change positive impacts should be exploited and negative impacts avoided. Following sector specific adaptations are proposed.

8.1 Adaptation for crops

In the crop sector climate change will induce reduction in yield, shortening of growing cycle of corps, increased evapo-transpiration, surge in insects, pests and diseases. The following adaptations are recommended.

- Genetic research for the development of new varieties of crops/breeds of livestock tolerant to high temperatures.
- Alteration in sowing dates to escape high temperature during the sensitive growth stages
- Changes in cropping pattern
- Increasing water use efficiency by crops
- Fertilizer management for increased production while protecting environment (reduction of N_2O and CH_4 emissions, Nitrate leaching)
- Adoption of Resource Conservation technologies e.g. soil and water conservation technologies, biodiversity conservation etc.

The GCISC studied nine sowing days for wheat crop, starting from 1st week of Oct. to last week of Dec. at 10-day interval in the Northern mountainous and sub-mountainous regions. The results indicated that the Growing Season Length (GSL) decreased on the average by 6 days per 10-day delay in sowing. In the mountainous area, shift towards earlier planting improved wheat yield while in sub-mountainous areas, it decreased the yield .

8.2 Adaptation for livestock

Livestock feeds and water requirements will increase with climate change.. Following adaptation practices may help.

- Use of multi-nutrient feed blocks, e.g Urea-Molasses feed blocks
- Feed conservation e.g by hay making, storing in silos, especially for the winter season
- Planned grazing - alteration in timing, location and duration of grazing animals

8.3 Adaptation for water resources

Acute future water shortage is expected during the next 30 years in Pakistan. Water modelling research suggests that the irrigation system cannot meet the demand. The adaptation strategies propose that there is an urgent need of storage of 5-7 million acre ft in the future. Conservation of water, small dams, and village ponds with sizes of 10-15 acre ft can help in addressing water scarcity. Reduction in evaporation would be possible by using different evapo-retardants. Some scenarios of climate change also indicate no outflow to sea and would need management through system operation and optimisation to ensure fresh water to the sea so that sea life could be sustained.

A major measure for adaptation to climate change would be improving the irrigation efficiency for crops. This includes:

- Adaptation of high efficiency irrigation practices, such as drip, sprinkler and pitcher irrigation
- Making sub-surface irrigation channels in hot areas like Karez in Balochistan, to evade evaporation

- Integrating irrigation with water-sensitive growth stages of crops
- Spreading the same quantity of water into greater number of irrigations, withholding irrigation or applying lesser amounts of water at less-sensitive growth stages of the crop
- Planned use of groundwater for irrigation, to avoid soil degradation due to bad quality of groundwater, and to avoid depletion of natural aquifer

GCISC studied irrigation scheduling at critical growth stages of wheat and by increasing the number of irrigation to 5 a positive impact was noticed on wheat yields. In another study, it was observed that lowering quantity of irrigation water (150 mm) would not sustain baseline yield at any temperature whereas 300 mm water will sustain yield up to 1°C at 360 ppm CO_2 and up to 3 °C at 550 ppm.

Other water conservation measures may include regulating reservoir capacity of Indus River System (IRS) by developing new water resources and increasing capacity of existing resources to conserve and tap flood water during flood years and ensure minimum environmental flows, below Kotri during dry years, promoting local rain harvesting and introducing technologies for reusing marginal quality irrigation effluent.

Soil conservation practices may also be adopted e.g. soil mulching techniques to suppress evaporation and to lower soil temperature; and incorporation of crop residue into soil to increase organic matter content and to conserve soil moisture.

8.4 Adaptation for Forest, Watershed and Disaster Risk Reduction

Because of expected increasing precipitation in the mountainous areas, reforestation programmes can be successful in future in normal years. As droughts do not affect tree growth, being deep rooted but these may affect adversely the reforestation programme because the young plants would need moisture for establishment.

Following adaptation measures are proposed for watershed and DRR

- Construction of reservoirs to store maximum runoff water in the watershed.
- Large scale reforestation programme for reducing soil erosion and floods
- Large scale Integrated Watershed Management programme to minimise flood intensities and livelihoods
- Mini-dams and ponds for water resource development can be beneficial for reducing the floods intensity and river bank erosion problems
- Adopt landslides and river bank erosion control measures in the mountainous areas
- Gabion spurs and gabion check dams in small tributary streams are needed for bank erosion control during the future flood events
- Increasing tree component on agricultural land in the shape of agro-forestry and fruit orchards can enhance the income and reduce soil erosion in watershed
- Management of all land uses including rangelands
- Adoption of soil-bioengineering technology for landslides control and soil conservation is also direly needed.

The following pictures demonstrate an example for water shed treatment in Azad Jammu Kashm

Combination of concrete, vegetated soft gabion and live brushwood R. Walls

Same site in August 2010

9. Conclusions and Recommendations

The main recommendations are given in the following bullets. These include policy recommendations to devise a road map for climate change adaptation, strengthening institutional set-up for climate change work, capacity building and awareness raising at all levels. Specific recommendations for research and extension of the various relevant departments have also been proposed including forestry, agriculture, water, livestock and fisheries. These included studies for more understanding of the climate change impacts by sector, conservation of gene-banks, development of heat/ moisture stress species/varieties, irrigation management, early warning systems, and community level adaptation of methods/practices to adapt to negative/positive impacts of climate change.

- Climate change is a global phenomenon but its impacts are localised and vary from area to area in Pakistan.
- Climate change is happening and the change in Pakistan is higher than global average as the major part of the country falls in arid and semi-arid region which is already heat surplus zone.
- Livelihoods are predominantly climate sensitive in KP as well as in Pakistan e.g. adverse impacts are very likely on agriculture, soil, water, forestry, livestock and fisheries etc.
- The temperatures in the mountainous areas are increasing faster than plains that have implications for water resources – glaciers and early melting.
- Seasonal shifts are being experienced – winters are getting shorter and summers longer. The early and hotter spring seasons have implications for crop production and water availability.
- Rainfall in north and coastal areas is expected to increase but will become erratic and intensive causing floods and droughts.
- CC will have impact on biodiversity and shifts of species composition towards the north.
- Plain area yields are expected to be negatively affected necessitating revisiting suitable varieties and species in the plain areas and sub-mountainous region.
- Agriculture in the high mountainous areas is expected to benefit from increasing temperatures such as increase in yields, double cropping and area expansion at higher altitudes.
- We need to prepare ourselves to find ways and means for timely adaptation to climate change (both positive and negative). Through concerted and collaborative efforts even some of the negative impacts can be converted into opportunities.
- Because of climate change, the present climatic variability (extreme climatic events) has increased in recent years. This is a cause for major concern due to the related increase in events such as hydro-meteorological disasters. We are already experiencing heavy and unprecedented intensity in rainfalls, storms, floods, droughts, and cyclones. These disasters have become frequent in recent years, resulting in loss of lives and livelihoods ~ exacerbating poverty.
- The above findings therefore reveal that we need to find ways and means to timely adapt so as to tap opportunities and reduce negative impacts in climate sensitive sectors for human security and economy.

Table 4: Generic recommendations

1.	A need to devise climate change adaptation policy and road map (Baseline data & regular monitoring) for all concerned departments with coordination/collaboration mechanisms at provincial level. It is recommended that a committee be formed to devise such a road map.
2.	Establishment of Centre of Excellence for thematic guidance. This Centre may be established at AUP but in close coordination with allied sectors with linkages at regional and local centres/institutions (including farmers).
3.	Capacity improvement with regard to CC, adaptation and mitigation in all sectors
4.	Timely dissemination of Climate Scenarios and weather forecast information to farmers.
5.	Biodiversity conservation through genetic engineering research and gene banks for agriculture, forestry, livestock and fisheries.
6.	Detailed research to assess the impacts of climate change on natural resource and adaptation by region covering water, agriculture, forestry, livestock, fisheries and rangelands.
7.	Development of integrated water management strategy to combat CC in fragile watersheds and study the CC effects on crop water requirements and propose adaptation measures.
8.	Awareness campaigns to further plan adaptation with communities should be initiated in all sectors (Forestry, agriculture, Livestock and Fisheries).