Assessment of Climatic Change Related Hazards in Selected High Altitude Wetlands of Karakuram

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IN THE NAME OF ALLAH,

THE MOST BENEFICIENT,

THE MOST MERCIFUL

(Acceptance by the Viva Voce Committee)

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DECLARATION

I hereby declare that the work presented in the following thesis is my own effort, except where otherwise acknowledged and that the thesis is my own composition. No part of the thesis has been previously presented for any other degree.

Date 05-11-2012

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FORWARDING SHEET

The thesis entitled "**Assessment of Climatic Change Related Hazards in Selected High Altitude Wetlands of Karakuram"** submitted by **Shazia Sultan** in partial fulfillment of MS in Environmental Science has been completed under my guidance and supervision. I am satisfied with the quality of student's research work and allow her to submit this thesis, for further processes per IIU rules and regulations.

Dr. Maliha Asma

ABSTRACT

In Hindu Kush-Karakorum, there are many wetlands above 3,000 m known as High Altitude Wetlands (HAWs). These wetlands are remote and characterized by climatic adversity, thus they are highly vulnerable to predicted changes in climate. The present research has addressed the current climatic vulnerabilities of selected high altitude wetlands that are prone to climate related shocks and changes. It has focused on four selected high altitude wetlands in the Gilgit-Baltistan region of Pakistan that are suspected sites for climate related hazards with impacts on ecological, social and livelihood services. The proposed sites for the research study were Gojal with special emphasis on Passu Glacier, a site known for GLOF events. In comparison, to Shandur-Handrab wetland complex where two lakes Shandoor Lake and Handrab Lake are located and currently under review for declaration as Ramsar Wetlands Sites of high ecological importance. Two other important sites namely Yaseen and Qurumber with special emphasize on Qurumber Lake and Darkut Glacier were also studied. Since communities have long experience of adjusting and coping with a variable climate, local knowledge and perception were used in this research. The study was conducted through a questionnaire-based survey. Structured interviews and focused group discussions were conducted other than personal observation. The information collected were analysed to understand climate change patterns and its impacts on biodiversity, ecology and livelihood of associated local communities; moreover to produce an overview of the climatic changes from the local communities' perspective. It has been concluded that climate change is one of the major threat to these High Altitude Wetlands in terms of biodiversity and precipitation pattern along with the livelihood of people associated with these wetlands. Although many efforts have been made to reduce vulnerability, still most are vulnerable to climate change and there is need to take a proactive approach specially involving the local communities of the area.

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LIST OF ABBREVIATIONS

A.S.L	Above Sea Level
GCISC	Gilgit Conservation and Information Centre
GLOF	Glacial Lake Outburst Flood
HAWs	High Altitude Wetlands
HKH	Hindu Hush-Karakuram-Himalaya
HVRA	Hazard Vulnerability and Risk Assessment
IRS	Indus River System
IUCN	International Union for Conservation of Nature
M.A.F	Million Acres Feet
PWP	Pakistan Wetland Programme
UNDP	United Nation Developmental Programme
WAPDA	Water and Power development Authority

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INTRODUCTION

Climate change is a change in average weather conditions or the distribution of events around that average (e.g., more or fewer extreme weather events). The term sometimes is used to refer specifically to change caused by anthropogenic activity(human activity); for example, the United Nations Framework Convention on Climate Change (UNFCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable period of time".

Climatic variability (Global Warming) which results from an increase in concentration of Greenhouse Gases (GHGs) in the atmosphere due to the use of fossil fuels, industrialization, deforestation and other human/anthropogenic activities has become a major concern now a days. The instrumental records from past years have shown an increase in mean temperature all over the world (Folland *et al.* 2001), with global mean temperature increase at a rate of 0.07°C decade^{-1} over the last century (Jones and Moberg, 2003). Also, the 1990s was the warmest decade, and 1998 the warmest year since the start of the global mean temperature record in 1856 (Jones and Moberg, 2003). But, warming has not been uniform all around the world. The increase in temperature has particularly affected high mountainous areas of Gilgit-Baltistan, with records show that the late twentieth century has highest rate of increase of temperature (Mann and Jones 2003) and attributed to the anthropogenic forcing of climate (Thorne *et al.* 2003).It is particularly important for Pakistan because climate change is posing a direct threat to its water, food and energy regimes. The country's vulnerability to such adverse impacts is likely to increase considerably in the coming decades as the average global temperature, which increased by 0.6 °C over the past century, is projected to increase further by 1.1 to 6.4 °C by the end of the current century(TFCC, 2010).

Currently available climate models predict an increase of temperature because of high levels of green house gases (GHG) in the atmosphere (Barnett, *et al.*, 2010). Pakistan is low contributor of the pollution; however it is the most affected country in the global community. Pakistan's Green House Gas emissions are 0.8% of global emissions. It is located in warm region and therefore likely to experience higher temperature increase than global averages. Most of its land is semi-arid, arid or hyper-arid and only 60% land receives less than 250 mm of rainfall annually. Agriculture, food security, jobs and livelihoods are critically dependent on irrigation water

supplied by Karakuram Tibetan Glaciers (70%) and monsoons (20-30%) and both these sources are highly vulnerable to Climate Change (Dawn, 2008).The Gilgit-Baltistan of Pakistan is dotted with glaciers and mountains, which serve as water towers for the country. As an agricultural country, Pakistan is highly dependent on the Indus irrigation system, one 20 of the largest irrigation networks in the world (SIHP, 1990). Thus the threat of extreme monsoons could also occur in future. While in high altitude wetlands of Hindu Kush-Karakuram, increase in extreme weather events, melting of glaciers and rising temperatures are already have been observed

Gilgit-Baltistan with an area of 72,496 sq. kms is a federally administered territory and it shares border with China and Afghanistan (Khan et al., 2004). It has an estimated population approaching 1,000,000 The Gilgit-Baltistan has three highest mountain ranges (Karakoram, Himalaya and Hindu Kush) while it has geographical landscape with rocky and rugged mountains, glaciers, snow covered high mountain peaks including K2, and Nanga Parbat famous for international tourism and mountaineering. The climate of Gilgit-Baltistan varies from region to region; surrounding mountain ranges creates sharp variations in weather. The eastern part has the moist zone of the western Himalayas, but going toward Karakoram and Hindu Kush the climate dries considerably. While mixed dry temperate coniferous forests with pine, oak, juniper and scrub forests are present with rich high alpine flora, aromatic medicinal plants and biodiversity includes wild ungulate species like Markhor, Ibex, Snow leopard, Brown bear, Blue sheep and Marco-Polo sheep(Wani, 2011)

The definition of wetland as used by the Convention on Wetlands is "area of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tides does not exceed six meters". While high altitudes wetlands are regarded as "any wetland types that are found above the elevation of 3,000 m ASL, (Bhandari, 2005). Among 225 significant man-made and natural wetlands spread over approximately 10% of the country; nineteen are recognized as Ramsar sites, covering an area of 1,343,627 hectares (3,320,170 acres): wetlands of international importance (Dawn, 2010). There are more than 200 HAW in Gilgit-Baltistan and Khyber Pakhtoon khuwa (Khalid, 2006). Climate change has very pronounced impacts on mountain system in these areas while they are important because more than 60% population is related to these mountains, and it provides fresh water for human consumption and industrial use

as well as for agriculture purposes. These mountains are important source of genetic diversity and resources such as timber minerals etc. being an important source of livelihood for locals. (Husain et al., 2005). The high altitude wetlands in these mountainous systems are very important as they provide invariable services and benefits for human population including the regulation of climate. These are also crucial for fresh water reservoirs along with recharging of ground water aquifers during water rich periods ensuring water sources during drought: Provide alternative sources of food and water for people and biodiversity during drought periods as well as many important plant and animal species are related to the wetlands of Hindu Kush Karakuram (Ramsar, 2002).

These HAW's wetlands are remote and characterized by climatic adversity, thus they are highly vulnerable to predicted changes in climate particularly due to global warming. Available studies show that glaciers are retreating as study of Qurumber glacier shows that there is a strong correlation between increasing temperature and glacier retreat (Iqbal et al. 2009). Besides these glacial changes, HAWs and their catchments are suffering from many other factors such as glacial lake outburst floods (GLOF), pollution, habitat degradation, over-use of resources and human encroachment. These factors are both natural and induced by human activities. These mountainous areas are fragile and therefore their protection and conservation should be the main agenda, in order to maintain the livelihoods of the millions of people living downstream and depending on these systems (ICIMOD, 2009).

The climate has an important impact on physical, chemical, biological processes and species composition in mountainous ecosystem along with affecting their ecology, function and biodiversity. So the significant changes in climatic parameters will find out what would be the intensity of climate change in these high altitude wetland ecosystems. And it includes the direct variables like change in precipitation, temperature and droughts along with indirect variables like impact on pastures, cropping pattern, biodiversity and livelihoods. As wetland ecosystems in Hindu Kush-Karakuram are linked to hydrology, so that's why they are different from terrestrial or deep aquatic ecosystems. (Mitsch and Gosselink, 2000).This is the reason that makes them sensitive to climate change especially the change in its hydrology. Climatic variability is one of the major factor changing water regimes in these mountains (DSE, 2008). The climate change will have very pronounce impact on the precipitation cycle along with increase in rate of extreme

events in weather e.g. droughts, storms and flash floods (Bates *et al.*, 2008). As the HAW's of Hindu Kush Karakuram have a very important role in the hydrological cycle of whole catchment areas (Bullock and Acreman, 2003). So the climatic variability will not only change the regime of hydrology in these catchments, in fact the downstream areas as well, with which millions of people are related in terms of livelihood, power generation and agriculture.

The life of people in high mountainous areas of Gilgit-Baltistan, especially for those who are related to these HAWS, s will be harder further because it is anticipated that the climate change will further disrupt the environment of these wetlands (Husain *et al.*, 2005). As the mountainous ecosystems are more sensitive to variability in climate because they have a fragile nature, topography, steep gradients, and diversity of ecosystems like wetlands. For example the high altitudes of Hindu Kush-Karakuram will be affected because increasing temperatures will melt the glaciers and runoff will be increased which will result in accelerated soil erosion along with more chances of avalanches, rock falling and flash floods (Hussain *et al.*, 2005). Warming trends will increase the chances of catastrophes and these changes will force many important species of wetlands to move to higher altitudes while the local associated communities would also be forced to adapt to these changes. It is also foreseen that the poor communities of GB, in these wetlands will also be forced to migrate as the food and fuel sources will become scarce. Being agrarian region, many people in these wetlands depend upon agriculture for their livelihoods, but these extreme events will have adverse impact on farming because irrigation system will be affected in the context of floods and droughts. All these conditions could be the reason for making the livelihood options harder for subsistence farmers as well as those who grow cash crops both in these high altitude wetlands as well as people in lower catchments whose livelihood is associated with them.

The high altitude wetlands of Hindu Kush- Karakuram are fragile and vulnerable to climate change especially the temperature increase; therefore their protection and conservation is needed in order to maintain the livelihoods of the millions of people living downstream and depending on these high mountainous areas (Khan and Ali, 2010). Snow and grass (rangeland) are the two dominating features surrounding the wetlands. It has also been found out that these wetlands are undergoing major changes. For examples, during the 2001-2009 periods, the number of lakes has decreased from 2,323 to about 1,600. So climate change is threatening wetlands in number of

ways. Increased temperatures are adversely affecting temperature sensitive plant and animal species in HAW's (ICIMOD, 2009). Decrease precipitation in wetland areas are also resulting in shrinkage of wetlands that will release more carbon in to atmosphere.

During the period 1901-2000, the increase in mean annual temperature in the Gilgit-Baltistan was higher than that for the country as a whole (0.8 °C versus 0.6 °C) (Ali *et al,* 2009 and Chaudhry *et al.*, 2009). This increase in temperature and change in precipitation trends along with overall change in climate will affect these mountainous areas with diverse ecosystems which include lakes, rangelands, mountains and glaciers as they are sensitive to minor changes in general parameters of climate like, temperature, moisture, and precipitation. These areas are already suffering from pressures like population growth, lack of planning and management other than climate change threats. The IPCC assessments based on the projection of future global climate with the help of various Global Circulation Models (GCM), predict temperature increases, especially in these wetlands, because Pakistan is located at a position where there is high chances of climatic variability as compared to average global temperature increase (TFCC, 2010). Many researches proved that climate change is occurring rapidly as data of temperature from the last 100 years shows a visible increase in heat (Khan and Ali, 2010). It has been stated that Pakistan is among the top countries vulnerable to climate change. Particularly, during the last two decades, extreme weather events like heavy rains, heat and droughts have increased ((Dawn, 2011). This pattern of extreme weather could be noticed in Shandoor-Handrab wetland Complex, along with Yaseen where the dry-temperate climate coupled with glaciated landscape has posed significant threat to the local inhabitants due to extreme cold spells in winters along with increase rate of natural hazards like flash flood and land sliding. As a result of the extreme weather conditions, it triggers the mass migration of locals to comparatively plain areas downstream.

The Karakoram is considered to have the largest concentration of glaciers on mainland Asia apart from high latitudes, with eight glaciers over 50 km in length and more than 20 over 30 km and because of these enormous ice masses it is sometimes referred to as the third pole (Steinbauer and Zeidler, 2008).Pakistan's economy depend a lot on these high altitude glaciers of the Hindu Kush-Karakoram as about 50-80% of the 141 maf average river inflows in the IRS (Indus River System) is fed by snow and glacier melt in the Hindu Kush-Karakoram part of the

HKH mountain ranges (TFCC, 2010). The Hindu Kush-Karakoram Mountains receive most of their precipitation during winter under westerly winds and act as a reservoir, capturing snow and rains, holding the water and releasing it in summer into the IRS, which feeds the irrigation system of the country. It has also been found out that the Upper Indus Basin has more than 5,000 glaciers which cover a total glaciated area of about 15,000 sq. km. These glaciers correspond to about 2,700 cubic km of stored volume of ice (Roohi *et al.,* 2005), equivalent to about 14 years of average IRS inflows. Most of the glaciers in the Karakoram are going through a huge loss of ice mass and glacier recession was observed from the 1920s until the early 1990s, with exceptions for some short term advances in the 1970s and surges (Hewitt 2005 and 2007). Because of climate changes nearly all the glaciers in the world are retreating along that most of the Hindu Kush-Karakorum glaciers are retreating as well, which can result in the surges and outbursts having the potential of causing catastrophic flooding up to hundreds of kilometers downstream with serious damage to life, property, forests, farms, infrastructure and power industry. Although many incidents of outburst floods happened in past as in Shimshal glacier in 1884,1893 and 1905 causing major damages to downstream areas like Gojal and Hunza(UNDP, 2008). And it is anticipated that local communities living in the proximity of glaciers, glacial lakes and glacier fed rivers are particularly at more risk, as they live in remote and marginalized areas and depend on these high altitude wetlands for their livelihoods (Shekhar *et al.*, 2010).

It has been observed that although the glaciers all over the world are found to be receding over the past century, but those in the Hindu Kush-Karakuram region are reported to be receding faster than in any other part of the world and fears have been shown that if the present rate of recession continues, the HKH glaciers might disappear by 2035 (Rees and Collins 2004, based on 1999 report of the International Commission on Snow and Ice; WWF 2005; IPCC 2007). While reporting its broad conclusions about the recession of Himalayan glaciers during the last century and the projected increase in their pace of recession during the 21st century, the IPCC has recently retracted its statement about the rate of recession and date for the disappearance of Himalayan glaciers (IPCC 2010).Meanwhile Meiners (2006) found a retreat of Kukuar and Baltar glaciers in north of Bar Valley since 1915 by eight km. His investigations were based on comparisons with Schomberg (1933), who also presented information obtained from local people, that Baltar and Kukuar glaciers had been retreating far back into their side valleys around

1833 and advanced between 1833 and 1915 by around ten km and 670 m in altitude. Schomberg (1933) also found out that there has been a strong retreat tendency of Bar glaciers and Daintar glaciers. He also stated that the Daintar glacier (Kerengi) retreated 2.5 km in length and 330 m in altitude within the last 67 years (Meiners 2006). According to reports of the local population the Toloibar glacier in the western end of the valley, as well as the small hanging glaciers along the valley are retreating as well (Meiners 2006).

IPCC's Fourth Assessment Report (Solomon *et al.,* 2007) concludes that there is more than a 90% chance that the observed warming since the 1950s is due to the emission of greenhouse gases from human activity (Ruosteenoja *et al.,* 2003) suggested that a temperature projection for the 21st Century shows a significant acceleration of warming (climate change) over that which was observed in the 20th Century. It has been observed through many researches that climate change is taking place in high mountainous areas of Gilgit-Baltistan. In the four important valley stations of Gilgit-Baltistan which are Gilgit, Bunji, Skardu and Gupis an increase in mean temperature was observed for the period 1980 to 2006, also maximum increase of 0.44 ^{0}C decade^{-1} was found in the winter month. Summer temperature however is declining at a rate of 0.26 ^{0}C decade^{-1}. Regarding precipitation trends in these four valley stations except of Gupis, no significant ($p < 0.05$) precipitation trends could be observed over the same period. Gupis had a dramatic increase in precipitation of 157mm decade^{-1}. This is a four-fold increase of mean precipitation between 1980 and 2006. Meteorological data for high altitude elevations are unfortunately neither available to the scientific community nor published (Steinbauer and Zeidler, 2008).

Because of climatic variability, changes in precipitation type (rain, snow) and its amount, intensity, and distribution will have a direct impact on total river flow in these wetlands (ICIMOD, 2009). As the trend of increasing precipitation has been observed along with increase rate of glacier retreating; it will increase water erosion, which will result in cutting arable land with standing crops; affecting the livelihood of local people. There will be an increase in evapotranspiration rates, because of increase in mean temperature in these high altitude wetlands (Steinbauer, Zeidler. 2008) and if protection measures are not taken than desertification may occur in these pastures (Li and Zhou, 2001; Qiu et al., 2001). Archer, (2001) stated in his study that climate change is impacting the high altitude wetlands of the Karakorum and Hindu-Kush on

very large scale, so most of the world's mountain glaciers have been shrinking for at least the last 30 years (WGMS, 2002), including the Greater Hindu Kush-Himalaya (Hasnain, 1999; Mastny, 2000; Shrestha and Shrestha, 2004). So these changes impact on grassland productivity, ecosystems, and the distribution and composition of plant communities (Wilkes, 2008).

Regarding precipitation at high altitude wetlands Winiger et al. (2005) illustrates large failures in common estimates of total precipitation, different authors have derived very different estimates for the higher Karakoram altitudes, ranging from only 130mm $year^{-1}$ to 1300mm $year^{-1}$ in the zone between 4000m and 5000m (Winiger et al. 2005). There were two short term studies from the Cultural Area Karakoram program were conducted in Yasin Valley (Jacobsen 1991) and the Bagrot Valley (Cramer 1991) with climate stations over a range of altitudes. Jacobsen (1991) and Cramer (1991) showed in their results that there has been an increase in precipitation with altitude up to the highest station at Alambar (4400m) with an annual total of 636 mm $year^{-1}$ and 720mm at station Diran (4120m), with the year of measurement being close to average in the valley stations, according to Archer (2001).According to the World Bank (2006) report: "Pakistan's Water Economy: Running Dry", the glaciers of Karakuram will retreat for next 50 years causing increase in Indus River flows. Then the glacier reservoirs will be empty, resulting in decreases of 30% to 40% in river flows in the Indus Basin. Similarly, a three-year modeling study by the Centre for Ecology and Hydrology, Wallingford, UK and Alpine Glacier Project, University of Salford, UK covering the 100-year time horizon starting from 1991 reports that in the Upper Indus the mean river flow will increase between 14% and 90% followed by flow decreasing to between 30% and 90% of baseline by the last decade of the 21st century (Rees and Collins 2004). A recent simulation modeling study by GCISC shows that if the average temperature in the Indus watershed were to rise by 3 °C and the Hindu Kush-Karakuram glaciers to shrink to half their present size, not only the overall annual flow would reduce by about 15%, the monthly flow pattern would also change considerably, with more water coming in spring and early summer and less water in the later part of summer (Sheikh *et al.,* 2009).

Climate change has impacted several important natural resources of these wetlands like pastures, range lands, and water resources in the form of glacier melt. One of the major impacts in Karakuram region in the form of impacting herder's life and livelihoods because most of their livelihood depends on the income they generate from these pastures in these high mountainous

areas (khan *et al.*, 2011). The subsistence farming and livestock totally depends on these high altitude pastures and climate variability is impacting them in the form of reduction in snow fall, increase in precipitation intensity causing soil erosion and long dry spells (Khan *et al.,* 2011). As Steinbauer and Zeidler (2008)stated that one of the renounce effects of climate change in these high altitude wetlands of Hindu-Kush and Karakorum is that more precipitation tends to fall as rain rather than as snow, which can lead to more intense precipitation even when the total annual precipitation is reduced slightly. So this warm climate therefore increases risks of drought in those areas where rainfall is not high and causes floods in high rainfall areas (Trenberth. et al. 2007).

As Beniston *et al.*, (1997) in his research provides an overview of climatic changes that have been observed during the past century at high mountainous areas of Gilgit-Baltistan stated that the average temperature change in this century is greater than the observed global change. It is likely, therefore that the impacts of future, accelerated climatic change will be proportionally more perceptible at high altitude wetlands; moreover there will be small shifts in precipitation patterns in high mountainous range, and it can lead to widespread disruption of fresh water supply for agricultural, industrial and domestic use in downstream areas of IRS. Meanwhile increasing temperatures globally because of climatic variability can result in a warming of water temperatures in lakes and rivers. But its greatest effect would be at high altitudes especially in the Hindu Kush-Karakuram which have many lakes e.g. Shandoor Lake and Handrab Lake and it is found out that the biological productivity would increase there. It has been observed that rare and endangered plant and animal species sensitive to small changes in temperature often have no alternative habitat, especially in isolated areas such as those in mountain and alpine wetlands (High altitude wetlands). The projected changes in climate are likely to affect wetlands, in their spatial extent, distribution, function and ecological aspect including flora/fauna composition and concentration (Patel *et al.,* 2005).

Withey and Kooten, (2010) employed linear regression analysis to determine the casual effect of climate change on wetlands with temperature, precipitation and the standardized precipitation index (SPI) used to predict the effect of potential climate change on wetlands. Results indicate that climate change could decrease wetlands by between 7 and 47%, and that the optimal number of wetlands to retain could decrease by as much as 38% from the baseline

climate. Irrigated lowland agriculture, found in all of the large basins receiving their runoff from the Hindu Kush-Karakuram system, is projected to suffer negatively from lack of dry season water. Considering that the reported or projected glacial melt water component amounts to, for example, 20 to 40% per capita in Western China (Tao *et al.,* 2005), 50% or more in the Indus (Tarar, 1982), and 30% in the major rivers in Nepal during pre-monsoon (Sharma 1993), the implications of dry season water stress are likely to be massive. In addition, an increase in agricultural water demand by 6 to 10% or more is projected for every 1 °C rise in temperature (IPCC, 2007a). As a result, the net cereal production in Pakistan projected to decline by at least between 4 to 10% by the end of this century, under the most conservative climate production projections (IPCC, 2007a).

Hussain *et al.,* (2005) analyzed climate variability in the mountain areas of Pakistan covering winter dominated high mountain region and monsoon dominated sub-mountain region and on the bases of these analyses, discusses implications for water and agriculture for the country. It has been shown in the study that relatively higher increase in maximum winter temperatures was observed, whereas minimum temperatures during winter showed a slight decline. These results suggest that days have become warmer whereas nights have become cooler during the winter season in the high mountain areas. It also has been observed that all these changes and seasonal variations have important implications for water resources and agriculture in the mountain areas in particular and for Pakistan in general. This research concluded that the increasing trends in temperature in the high mountain areas may have some positive impact on crop area and yields. However, these rising temperature trends may increase the melting of glaciers and snow, reduce snow accumulation during winter and enhance the overall de-glaciations process and therefore could well endanger the country's sustained sources of fresh water from glaciers and snow melting.

Over the last several decades there are many glacial lake outburst floods (GLOF) in Karakorum region of Gilgit Baltistan and it has a very devastating impact on socio-economic conditions, environment and natural resources of these areas. According to studies, these areas are more vulnerable to Outburst floods because climate has become hot and these glaciers are very sensitive to minor changes in temperature, mean while these glaciers are retreating at alarming rate. A case study by UNDP(2008) on Hunza river basin has stated that increase in temperature

has twofold impact on glaciers mass balance that increase temperature will speed up the glacier melting and second the precipitation especially the snowfall will occur in liquid state instead of solid state even at high altitudes. Water resources of Pakistan specially Gilgit-Baltistan, will be severely endangered if glacier melting continues with current speed, as a result, water will be available only seasonally or in rainy season (monsoon), meanwhile, temperature is already rising in Gilgit-Baltistan and also extreme events of precipitation with more damaging are also reported to be increasing in trend. Gilgit-Baltistan will suffer due to flash flood caused by rapid snow melting. The Hindu Kush-Karakuram region contains one of the most dynamic and complex mountain systems in the world. This mountain system is extremely vulnerable to global warming (Bandyopadhyay and Gyawali, 1994). So climate change is causing many threats to the fragile ecosystems and poor communities of these areas associated with these wetlands so adequate data are required for appropriate planning and decision making in HAWs.

1.1 Rationale

There is a lack of wetland related scientific and published data in Pakistan, especially in Gilgit-Baltistan, and that do exist is often scattered and not easily accessible. In addition, HAW climate change appear to be the least studied topics. This research work has assessed community perceptions and their response on changes in the climate, impacts on livelihood options as well as on social sector and crop production along with the ecology of wetlands.

1) There is lack of adequate information at national and local level covering high altitude wetlands, their functions and high altitude impacts as well because of lack of adequate research which results in failure of conservation and management of these mountainous areas.

2) There is lack of understanding of climate change impacts on high altitude wetlands particularly among communities and stake holders along with inequity in the ownership, management and flow of benefits from both use and conservation of biological resources. Therefore its resources are over exploited which results in habitat loss and fragmentation, misuse /mismanagement of pastures and loss of important biodiversity.

3) HAW's are also least appreciated in government policies and reforms/planning therefore there is no proper policy application regarding its conservation as well as community participation in conservation is not encouraged.

1.2 Aims and Objectives

The aims of this study are to fill the data gaps especially regarding the scientific research on high altitude wetlands of Hindu Kush-Karakuram with the context of climate change. An effort has been done to reduce these gaps and this study will help for policy makers and researchers to get basic data on impact of climate change in these high altitude wetlands. The specific objectives are as follow.

1) Exploring linkages between Climate Change and high altitude wetlands at Shandoor-Handrab Wetland complex, Qurumber, Yaseen and Gojal

2) To determine how changes in climatic parameters such as temperature and precipitation have affected the natural environment of the area and the lives and livelihoods of the local population and associated biodiversity/ecosystem

3) Analyzing and projecting high altitude wetland threats and vulnerability to climate change

CHAPTER 2

MATERIALS AND METHODS

2.1 Study Area

The universe of the study consists of four high altitude wetlands Shandoor-Handarap complex (Gulakhmuli and Handrab), Qurumber (Immit and Bilhanz), Yasin (Gartenz, Umal zat and Darkut) and Gojal (Gulkin, Hussani and Passu) valleys. The afore mentioned areas consists of further villages where a total population of 19117 is located in about 2287 Households.

2.1.1 Shandoor-Handrab Complex

There are approximately 8740 people living in shandoor-Handrab wetland complex (Khan *et al.*, 2009). The total number of households in Shandoor complex is 960 residing in 13 villages which are as follow; Barsat, Hilti, Teru, Karimabad, Teru Bala, Teru Paeen, Teru, Bahach, Gulaghtori, Handrab Bala, Handrap Paeen, Hrekuch, Bouyandeh, Khonandeh, Gulaghmuli, Bala, Gilghmuli Paen, Terch and Shahimal. The forest of the Shandoor-Handrab complex contains small patches of mixed juniper (Juniperus macropoda) and birch (Betulautilis) forests. Due to the shortage of the natural forests the community has planted willow (Salix tetra sperma) and popular species (Populus alba) to fulfill their basic needs of timber and firewood. The shrub cover is dominant with Pincle cedar (Juniperus communis), Sea buck thorn (hippo phaerhmnoides) and Barberry (Berberis lyceum) (Khan et al., 2009). The important wild life of Shandoor-Handrab Complex is ibex (Capra ibex sibrica sibirica), snow leopard (Unciauncia), wolf (Canis lupus), and fox (Vulpes vulpes Montana). There is more than 300 hectare of pastures available in the valleys, which are communal lands (Khan et al., 2009).

Shandoor Lake

Shandoor Lake is located in the upper region of Chitral near Shandoor Pass. Shandoor Lake is very beautiful and ecologically important lake. It has an elevation of about 3588 meter from Sea level. The lake is situated at North 36°04′58.2" Latitude and East 72°32′16.0" Longitude in Gilgit-Baltistan. Important natural resources of the area are; Local people graze their livestock during the months of June – October in the pastures of the Shandoor area. Shandoor Lake is a beautiful tourist spot and it provides activities like camping, bird watching and swimming activities for tourists.

Handrab Lake

Handrab Lake is one of the beautiful and ecologically important lakes in Ghizer district. It is situated in Handrabnullah, approximately 12 kms away from Handrab village, at an elevation of 10800 feet above sea level. The approximate size of the lake is 33.90 ha. The area has high mountain peaks and meadows towards east and west. This wetland provides a resting ground for winter migratory birds', visit the area during migration season. The lake provides angling and recreational facility to the domestic as well as foreign tourists. Handrab Lake, an Alpine Wetland is situated between 30°44'66" N Latitude and 72°44'35.5"E Longitude, in Ghizer district of Gilgit-Baltistan. Handrab valley is slight narrow and bounded by rugged mountains, having alpine and sub alpine vegetation. A beautiful perennial water body has formed by glacial water called Handrabnullah extends up to Swat valley of NWFP on one side and on the other side it coincides with the boundaries of Shandoor.

2.1.2 Qurumber Valley

The Qurumber valley spread over an area of 640sq.km is located in the extreme north-west of Gilgit-Baltistan. Its spread heads its boundaries with Hindu Kush Mountain Range as it meets the Karakoram Mountain Range along the Bar valley catchments in the west. Stretching over 150 Km downstream, the valley begins at Bar jungle where Qurumber and Baru Rivers meet and goes up to Qurumber Pass along the boundary of Wakhan Corridor in the west. There are an estimated 7061 people living in different villages of Qurumber Valley. The population of study area is as follow.

Table 2.1: Population and household of research areas of Qurumber valley

S #	Villages	Total Households	Population	
			Male	Female
01	Immit	124	430	490
02	Bilhanz (Bala)	80	304	320
03	Bilhanz(Payeen)	35	104	112
	Total	**239**	**838**	**922**

The Qurumber Valley is rich in variety of natural resources i.e. wildlife, medicinal plants, pastures, minerals and water sources. A variety of wildlife includes the endangered snow leopard *(Unciauncia),* Himalayan ibex *(Capra ibex sibricia)* and wolf *(Canis lupus)* is found in the Valley. Birds found in the entire valley include snow cock (*Tatra galushamalyansis*), partridges (*Lerwalerwa*), house sparrow (*Paser domesticus*), wild pigeon, water fowls, white capped river chat, blue rock common thrush dove and Quail. Migratory birds are present in the area from December to March. The natural forest is limited to a few isolated patches of Juniper *(Juniperus excellsa)*, Blue pine *(pinus wallichiana)*, Birch *(Betula utilis)*, and Willow *(Salix spp.)*. The shrub cover is dominant *Artemisia* species, *Ephedra*, Wild rose and *Barbaris* species. There are over 20 pastures in the valley, which are owned and grazed by local communities. These pastures are depleting due to over grazing. The major glaciers of the valley are; Qurumbar, Bersat, Borth, Helber and Dewjerab. Qurumbar Lake is the highest high altitude wetland of Pakistan. The climate of the valley is almost dry; rainfall is mainly during the months July, August and Snow fall from Decembers to February. Maximum temperature goes up to 35 degree Celsius in summer and below freezing point in winter. Glaciers usually melt from June to August, being the major source of water for irrigation. Flood, earth quake, avalanche, lightening are the major hazards of the area.

2.1.3 Yaseen Valley

Yasin valley is situated at about 145 km from Gilgit towards northeast in HindukushMountains, bordering with Wakhan Corridor through the Broghil pass. Administratively it constitutes one of the four Tehsils of Ghizer District. TheYaseen bottom rises from 2160m in the south up to over 2700m near the village Darkut. Its sub-valleys include Taus, Sandhi, Barkolti, Nazbar, Qurqulti, Hundur, Thoi and Darkot. Population of the valley is about 35,000 inhabitants living in about 4000 households (census report 1998). Majority of the people are agro-pastoral, relying on subsistence agriculture, livestock herding and some employed in government sector, predominantly in the Pakistan's armed forces. Towards extreme north lies the last sub-valley namely Darkot, located amidst snow-capped peaks and glaciers. One of the glaciers has descended down the village. The famous Darkot pass is said to be the shortest distance between Oxus and Indus. The dry-temperate climate coupled with glaciated landscape has posed

significant threat to the local inhabitants due to extreme cold spells in winters. As a result of the extreme weather conditions a large number of local people have to migrate and reallocate in the comparatively plain areas downstream. As a result of a heavy snowfall in 2010 local people have to be evacuated to relatively safer places. Consequently the trend of out-migration has been high from the area over the last few years. Local communities are thus facing serious problems both in outmigration and competing with extreme weather events. The wildlife of the area is wild rabbits, wolf, markhoor, koyal, hawks, partridge, sparrows, and snow leopard. Crops being grown are wheat, potato, and maize.

2.1.4 Gojal valley (Ghulkin, Hussaini, Passu)

The Gojal valley with an area of about 8500km^2 is the largest Tehsil of the Gilgit-Baltistan. It lies in the upper Hunza and shares border with the China in the northeast and with the Afghanistan in the northwest. The three important villages of Gojal i.e,Ghulkin, Hussani and Passu (sites known for GLOF events) are located along KKH (Karakorum Highway) in Gojal tehsil. The Ghulkin valley is situated in the south and Hussaini in the northeast of Ghulkin. The Passu Village extends from the west to northeast of Passu glacier. It is important to notedown that Hussaini lies on a glacial landform e.g., lateral moraine, formed by Ghulkin glacier. Gojal has a population of about 8000 with different ethnic groups of Wakhi and Burushaski. The dwellers of the area have mostly moved from Pamir areas of China, Afghanistan, and Tajikistan and central part of Hunza.

Table 2.2: Demographic trends of Ghulkin, Hussaini and Passu

Villages	Household		Male		Female		Total	
	1998	2005	1998	2005	1998	2005	1998	2005
Ghulkin	124	138	477	589	438	544	915	1133
Hussaini	70	83	245	322	237	299	482	621
Passu	87	117	397	456	347	407	744	863

The source of livelihood in Tehsil Gojal is agriculture, government employment and non government employment and business. Three famous glaciers Passu glacier, Hussani glacier and Borit glacier are present there. The wildlife is snow leopard, chakoor; ram chakoor, ibex and pigeon. As Gojal valley falls in the Karakorum- Himalayan region which lies in an environment

that is glaciological complex with high altitude source areas (above 4500m) having permafrost and annual precipitation in excess of 2,000 mm while large glaciers snouts extending down to semi-arid valley floors (2700) receive annual precipitation of less than 100-200mm. the major hazards of the area are GLOF and flash floods along with heavy rainfall (land siding).

2.2 Methodology

The study was conducted through questionnaire-based survey. Following methodology was adapted for the study.

2.2.1 Sampling

Sample size and sampling design

As the population is heterogeneous in nature because there are four different climatic areas and each area holds different topographic, demographic, economic characteristics, and in such a situation stratified random sampling is the most suitable sampling design (Sekran; 2000). The sampled population comprised on people aged more than 40, while remaining are youngsters and students, whose point of view on climate change has been taken in questionnaire surveys, while in focused group discussion persons from every field regardless of gender and age have been included. Keeping in view the afore mentioned variability, time constraints and the endurable costs a sample of 210 individuals were selected as a sample of the study from total 4500 population of selected four areas.

2.2.2 Data Collection Methods

Following methods were used for data collection.

1) **Primary data collection**

To collect the primary data different methods were used which include questionnaire based survey, structured interviews, individual interview and focused group discussions

a) **Questionnaire survey**

Keeping in view the objectives of the study a thorough questionnaire was developed, through a consultative process. It was tried that the questionnaire should cover the maximum aspects of the objectives of the study. However, to avoid the chances of duplication, error as well as biasness,

the questionnaire was pre-tested in the field. The questionnaire was filled through the stratified random sampling, and all the efforts have been applied to cover the maximum information from total population while keeping in view the other attributes like available financial resources, allotted time and heterogeneity of the selected areas. The questionnaires were filled through structured interviews (Steinbauer and Zeidler, 2008).

b) Structured interviews

Structured interviews were conducted in all selected four areas to collect the detailed and comprehensive information. These interviews were conducted to gather useful information on the general perception on climate change of the area, climate change impact on ecological, social sector, as well as its impact on livelihood services along with agriculture sector. The area was divided in to different sectors according to their association with selected High Altitude Wetlands and desired person to be interviewed was selected randomly from the selected area (Khan and Ali, 2010).

i. Individual interviews

1. Individual interviews were done with the key stakeholders of the selected areas around three themes
   - Climate change impact on their socioeconomic conditions
   - Climate change impacts on livelihood and ecological services
   - Hazard vulnerability and its assessment
2. Individual Interviews with the officials regarding their perceptions and mitigation efforts on climate change.
3. Individual interviews with the students: their perception on climate change as well as taking their point of view regarding its mitigation and adaptation processes.

ii. Focused group discussions

Focused group discussions were held with elderly people of the village and key other informants. These discussions were very conductive especially from the elderly people as they know history well and they have very deep and long observation of climate change in the area. So very useful to get the general as well as historical information was gathered on the climate variability impacts on flora, fauna, avi- fauna and on general agriculture sector was obtained ((Khan *et al.*, 2010).

a) Personal observation and participation

Some of the data and real information was collected through personal observation and participation, especially the areas affected by climate change related hazards like flashflood/ landslide etc. To gather all the necessary and relevant information, personal observation and participation has been done, as sometimes respondents do not answer clearly about the question being asked. Therefore to obtain the broader information on the climate change related impacts specially the hazards in selected areas e.g. impact on glaciers or lake: field visit was done to obtain personal observation data.

2) Secondary data collection/review

As climate change is the long term process so literature survey and work done in the recent and distant past was studied and included in the literature cited. Important relevant reports were carefully and critically reviewed, and relevant data has been included in the study. The tools and protocols used to review the data were webliographies and data from WWF-Pakistan, PWP (Pakistan Wetlands Programme), IUCN-Pakistan, UNDP-Pakistan, Water and Power development Authority (WAPDA) Pakistan, Global Change Impact Study Centre (GCISC), and Aga Khan Rural Support Programme (AKRSP).

2.2.3 Data Analysis

The data was tabulated and analyzed in SPSS, with version 13 and different useful tests were applied to obtain the required results according to the objectives of the study. Descriptive statistics was applied to get the required graphs and the results were discussed with the help of those graphs.

Map of Study Area

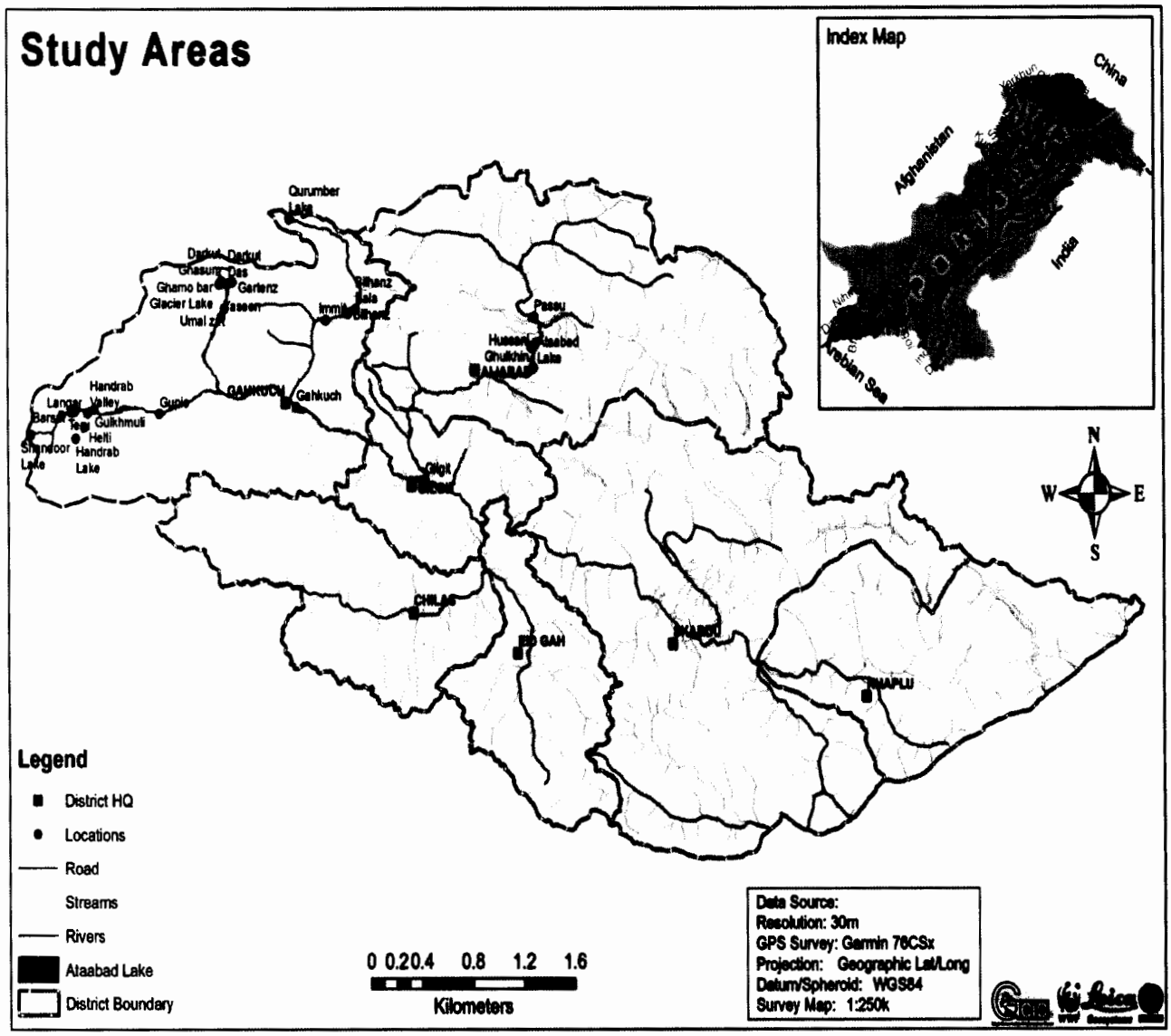

Figure 2.1: Map of study areas including Shandoor-Handrab Complex, Qurumbar, Yaseen and Gojal

CHAPTER 3

RESULTS AND DISCUSSIONS

3.1 Climate change of the area

The selected high altitude wetlands of Hindu Kush- Karakuram have number of lakes and wetlands which make them unique ecosystem that fulfills an important function in the overall ecology, livelihood and water cycle of the River Indus. These wetlands provide important ecosystem services such as provisioning, regulation, cultural and support services. Due to their unique characteristics in the Hindu Kush- Karakuram landscape, wetlands of this region are being categorized as a "special" category of wetland. The occupation of interviewee were found out in survey, which shows that more than 80% populations of these areas consist of farmers and they depend on the agriculture and livestock for their livelihood and 35% people are dependent on agriculture for their income other than the government employment including people who are dependent on daily wages. Being dependent on agriculture, local communities exploit the limited resources of wetlands and these wetlands are facing the population pressures other than the harsh impacts of climate change.

Figure 3.1 shows the general perception of local communities that climate change is occurred in last 25-30 years in these areas. Results shows that in last 25-30 years climate change related hydro-metrological hazards are increased in this areas.The most widely reported impact is the rapid reduction in glaciers, and snowfall, along with other climatic parameters like change in temperature, precipitation, and change in cropping patterns. Increase in frequency of natural hazards, degrading habitats of Shandoor Lake and pastures and Handrab Lake which results in migrating of species are becoming more prominent with time and almost same predictions were made by Khan and Ali, 2008.

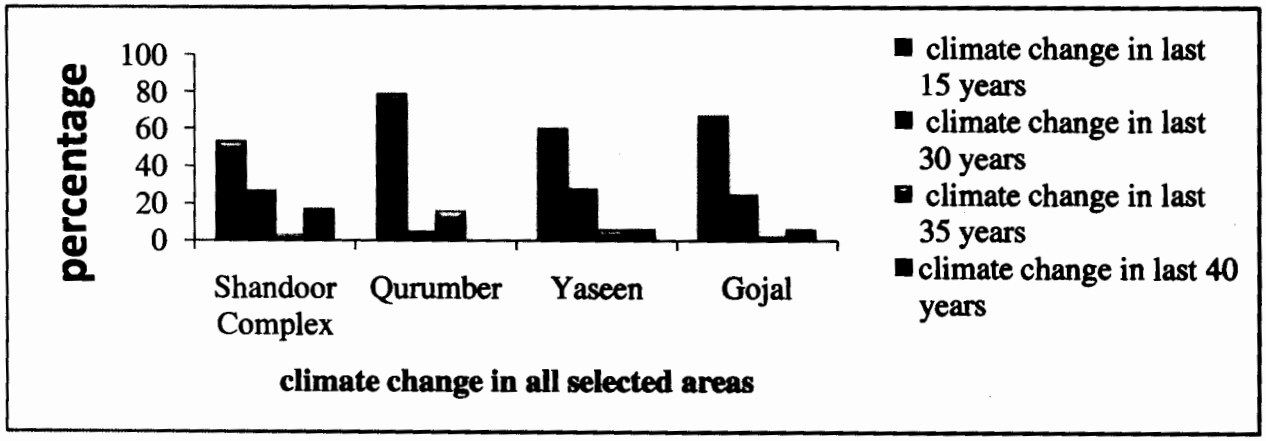

Figure 3.1 climate change of the area

3.2 Climate change being threat to ecological services

High altitude wetlands play a key role for investigations on the effect of climate change on ecosystems in general and on the patterns of plants and animal species in particular. Hydrological cycle change is one of the major indicator of climate change i.e., change in occurrence of precipitation, which directly impacts the crop productivity, it shows changing trend in overall climate. More than 90% local communities reported that climate change could be a major threat to species reduction, livelihoods and agriculture in most of the areas. Regarding the changed cropping pattern, 100% respondents perceived that climate change is one of the major threats to agriculture and livelihood in terms of extreme weather events like droughts and floods.

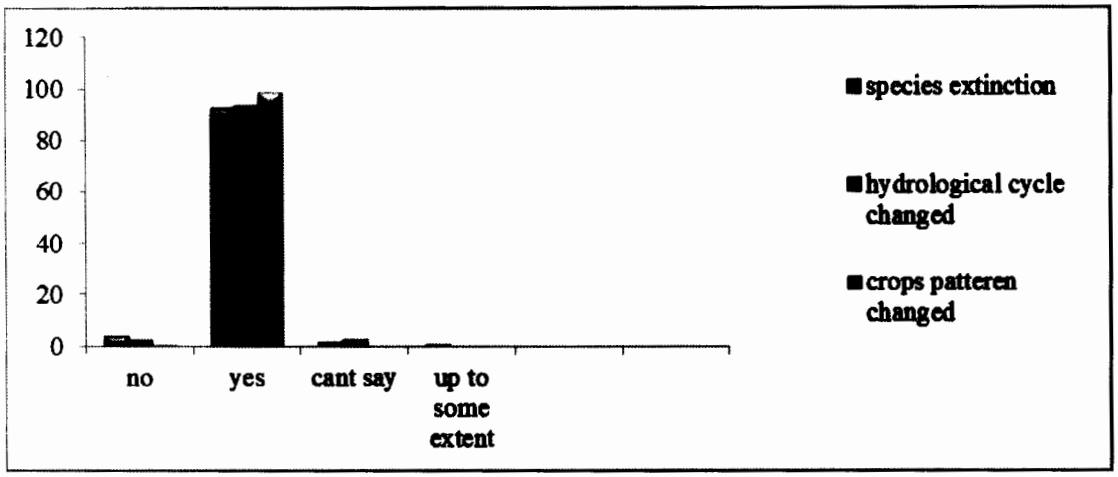

Figure 3.2 climate change being threat to ecological services

Figure 3.2 shows that changes are observed in Shandoor area, where snow fall is reduced and it melts early because of increase in temperature. Ducks are reduced, in fact almost locally extinct in these fragile ecosystems. Biodiversity is under serious threat in these wetlands due to excessive depletion of natural resources. Local people observed that species reduce since last 18 years. Livestock is one of major income source of local communities and it is reduced because there is a decrease in snowfall in pastures, results in less grass. The other main reason is the lack of interest in L/S rearing, because people are busy with jobs and education (Khan et al., 2010). In Handrab, Ibex, wolf, fox are endangered and pigeon are almost extinct.

Major changes which are observed in the all four study areas is the reduction in hail storm. Winters as well as summers are become warmer and dryer (Steinbauer, Zeidler, 2008). The

intensity of freezing in winter is decreased dramatically, due to climate change. Local communities reported that many years back they could cross the river over the ice in winter. Nowadays the river is not frozen at all. Grass reduced because of decrease in snowfall. Willow and poplar are largely reduce in number due to multiple reasons e.g. diseases, i.e. leaves become dry and after sometimes the whole tree becomes dry and pest attack is another reason. Markhoor, snow buck, chakoor, ram chakoor and ducks are reported to be endangered in Yaseen area. The reasons given by local communities are increase in temperature, decrease in snowfall, habitat destruction, overhunting, Misuse /mismanagement of pastures.

Figure shows another major impact of climate variability on hydrological cycle i.e. more torrential rainfall; therefore it causes more damage. Almost 5-10 years back the rainfall was with light showers and that occurred for 2-3 days with less erosivity and chances of floods specially the flash flood was less. But as the trend is changed with more torrential rains there are more floods in those areas causing more damages to infrastructure and livelihoods, details are enlisted in the table in annexure 2.

3.3 Impact of climate change on agro-pastoral life

High altitude wetlands have an important impact on agro-pastoral life of people who are associated with them. Figure 3.3 shows the impact of climate change on agro-pastoral life of local communities in context of cropping pattern, disturbing critical facilities, land fragmentation and grazing on pastures. Data shows that more than 90% respondents agreed that climate change has a prominent impact on these sectors, as shown in figure below.

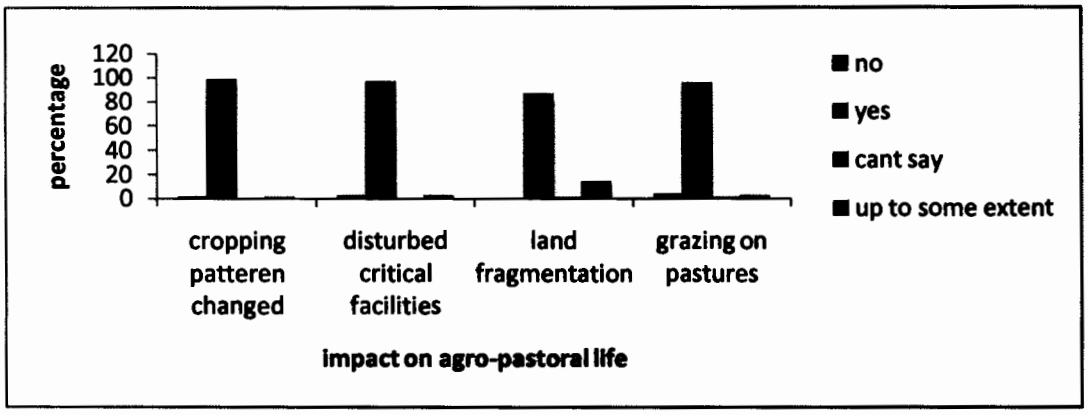

Figure 3.3 Climate change impact on agro-pastoral life

One of the impact of increase in temperature on cropping pattern is considered positive is that the crops are being grown in very remote parts of all selected areas, as well as they are harvest early while the fruits ripe quickly. Although Plantation time depends on snow melt from glaciers but crops are usually harvested early. There is a sowing time difference of 10-15 days than past (20-30 years) in Shandoor-Handrab Complex, Qurumber (Immit) and some parts of Yaseen, whereas crops are harvest 10-20 days before the usual time in all selected areas. Because of increase in temperature, now crops are being grown even at higher altitudes of these areas and wheat, potato and fruit production is increased.

Although increase in temperature has positive impact on cropping pattern as many new varieties of wheat from down areas are being grown on higher altitudes but there are many negative aspects. The torrential rainfall increased in 3 major areas which are shandoor Complex, Qurumber, and Yaseen. Because of these torrential rains there are more floods and especially the flash floods. According to 98% respondents; since last 10 years the natural hazards are increased, and critical facilities like roads are damaged and mobility to other areas is disturbed. Roads in Gulakhmuli and Handrab (Shandoor-Handrab Complex) and Darkut Ghasum and Darkut Das (Yaseen) are used to close during winters and it affects people's life in terms of transportation and general mobility.

Although climate change has some impacts on land fragmentation in terms of soil erosion and land sliding but the major reason is the increase in population as shown in the figure above. Land is being divided from generations to generations and now farmers have very small land holdings. Since last 25-30 years the grass in pastures is reduced due to reduction in snowfall because decrease in soil moisture and torrential rains erodes the upper fertile layer of soil. This is one of the major reasons for reduction of grass in Shandoor-Handrab pastures other than overgrazing and lack of management. Other reason for degradation of these wetlands specially the pastures is the inequity in the ownership, management.

3.4 Ecological impacts of climate change

Ecology is the relationship of an organism to its environment. Whenever there will be change in environment, it will have a very prominent impact on the organisms related to it. Wetlands

support many living organisms and many types of biodiversity are associated with it. It is observed that climate change is affecting these wetlands in terms of degradation due to the warmer and drier climate, increases in evaporation, reduction in snow cover, and fluctuations in precipitation (ICIMOD, 2009). Other impact that is foreseen as temperature rises; species shift their ranges to follow their principal habitats and optimal climatic conditions. Plant and animal species in these high altitude wetlands are projected to shift to higher altitudes, although some high altitude plant species and animal species with restricted habitat availability above the tree line are projected to experience severe fragmentation, habitat loss, or even extinction if they cannot move to higher elevations (Dirnbock et al., 2003).

3.4.1 Change in snowfall/rainfall pattern

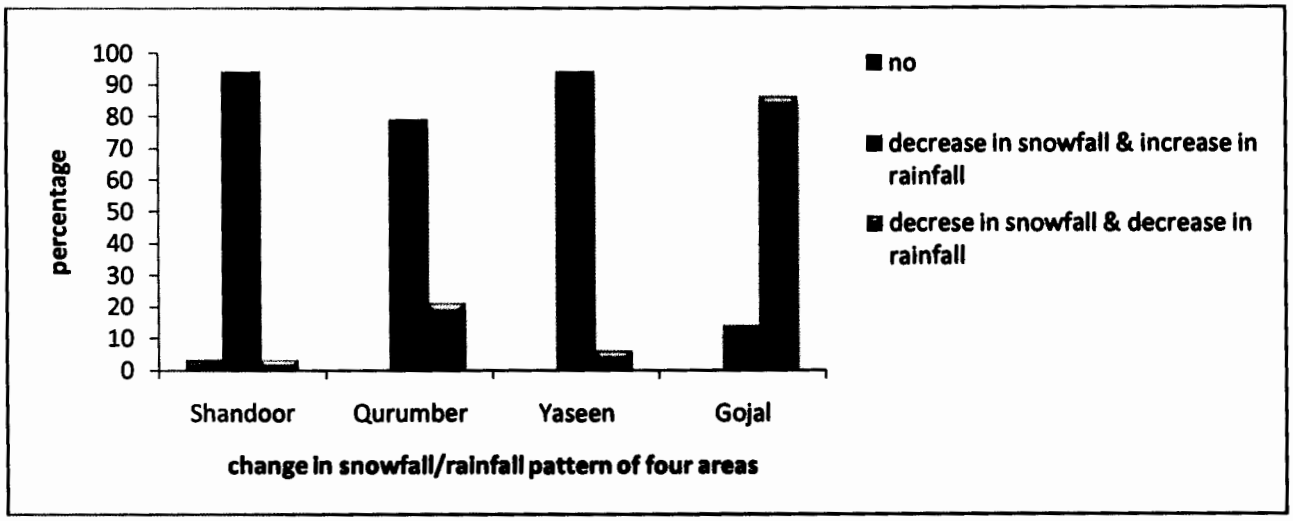

Figure 3.4 Snowfall / Rainfall pattern in all selected areas

Data shows in figure 3.4 that more than 90% local communities in Shandoor Complex, Qurumber and Yaseen have perceptive that the snowfall is reduced and rainfall is increased in past 25-30 years. The records form weather data shows a significant increase in summer rainfall in all four areas in last 30 years. The annual increase since last 10 years is significant especially in Shandoor and Yaseen area where the spring and winter precipitation shows the highest variations. Although there is an increase in rainfall but it shows a trend of torrential and it causes more destruction in the form of floods and flash floods. Figure shows that in Gojal more than 80% respondents have a perception of decrease in snowfall and rainfall. It is directly linked with reduction in glacier size, river and nullahs flow. According to the reports of local communities

20-30 years back there was 4 feet snowfall, but it is reduced to 2-2.5 feet and in Yaseen and Gojal to inches. Whereas in Gulakhmuli the snowfall is reduced from 5-6 feet to 1.5-2 feet only.

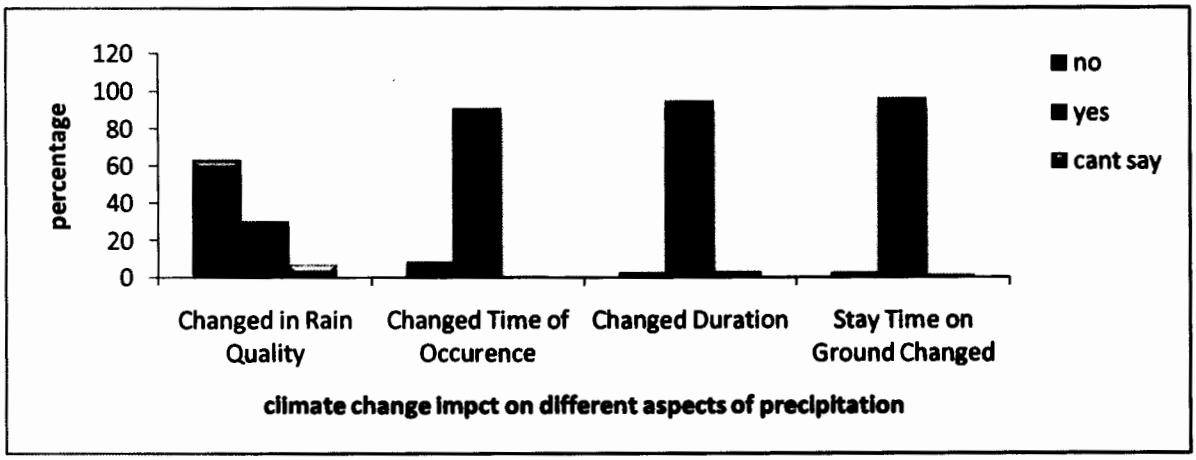

Figure 3.5 Impact of climate change on precipitation pattern

As the given figure shows that more than 95% respondents believed that rain falls randomly, the rainfall is decreased and the frequency of droughts is increased. Its pattern is changed from light showers for 2-3 days to torrential rains for few minutes to hours with more intensity and damaging power. Therefore, these torrential rains have caused more soil erosion in all areas which removes the top fertile soil as a consequence; soil fertility reduced. Data in figure 3.6 shows that 100% respondents stated that snowfall doesn't stay on ground for long time and therefore runoff is increased. It indicates that the temperature is increased in these areas. These are one of the reasons for the reduction of grass in high altitude pastures.

3.4.2 Impact on river and nullahs flow

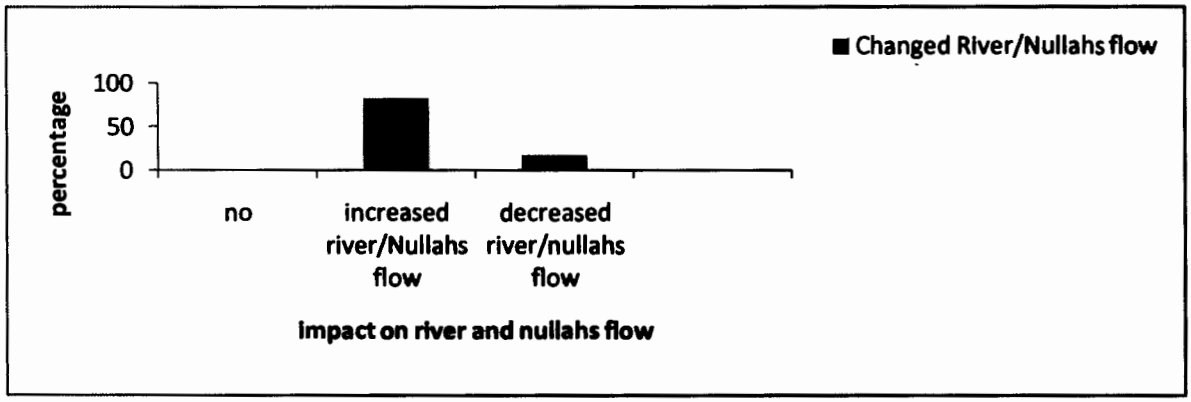

Figure 3.6 climate change impact on river and nullahs flow

High altitude catchments like Gojal and Hunza have 60% of annual runoff in July and August (Steinbauer and Zeidler, 2008). Climate variability has very pronounced impact on rivers and nullahs flow because river and nullahs flow in these areas depends on the glacier and spring water. According to more than 80% respondents there is a very positive trend of increase in temperature, therefore more glacier melt results in the form of water level/flow in river and nullahs increased. Data analysis as shown in figure 3.6 revealed that land cutting is enhanced especially the arable land in Shandoor-Handrab Complex, Yaseen and in Bilhans (Qurumber). In Gojal 18 % respondents have observed decreasing trend in rivers and nullahs flow, but in Passu the flow is increased and river water has damaged many acres of land as shown in annexure 2. In Hussani and Ghulqin; the reason for decreasing water flow is the decrease in snowfall/rainfall and due to high glacier melting.

River/Nullah basin widen

One of the major hazards related to climate change is the widening of rivers and nullahs basin. As shown by the graph 3.7, that more than 95% respondents believe that increase in natural hazards, especially increased glacier melting and heavy rains, water flow is increased. Therefore erosion is increased and river and nullahs basin widen. Many acres of cultivated land is eroded by the river and affected the livelihoods of local communities.

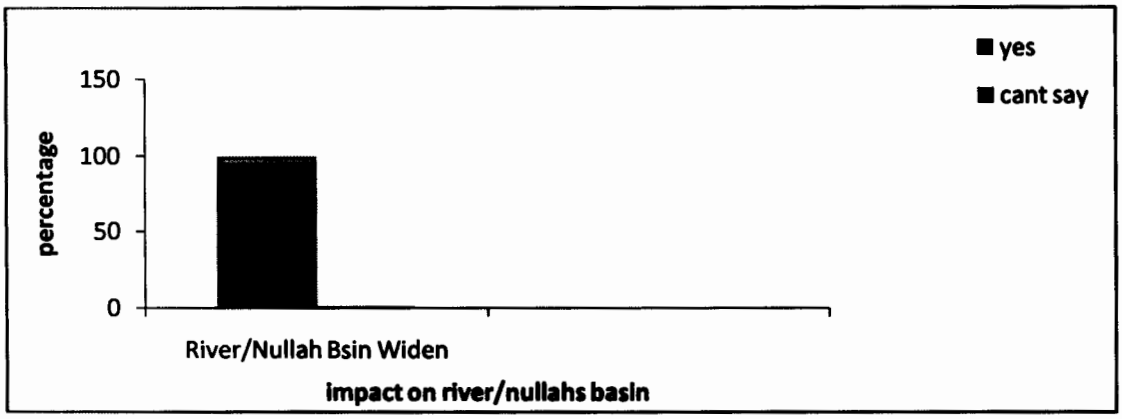

Figure 3.7 climate change impact on river/nullahs basin

In Immit, Bilhans Bala ,Bilhans Payeen (Qurumber), and Passu (Gojal) more than 130 acres (52 hectares) cultivated land with standing crops like wheat and potato, with cattle farms and houses

have been damaged and cut down by the widening of river basin. In Umalsat, Darkut Das (Yaseen) several kilometer road is washed away and sunken under the river.

3.5 Climate change impact on glaciers

The Karakoram is one of the most heavily glaciated regions outside of the Polar Regions with valley glaciers reaching up to 72 km in length (Iturrizaga, 2007). Glaciers are among most vulnerable landscape, of globe, due to climate change. In Gilgit-Baltistan about 5000 small and large glaciers feed the main Indus basin. Second and third longest glacier (Siachen 74 km and Batura 64 km) outside poles are in the Karakorum Range of Pakistan. Global warming has very negative effects on these glaciers. Most of the glaciers of Hindu Kush-Karakorum are retreating and it is fear that if these glaciers retreat at this pace than Pakistan will face water shortage problems very soon (TFCC, 2010).

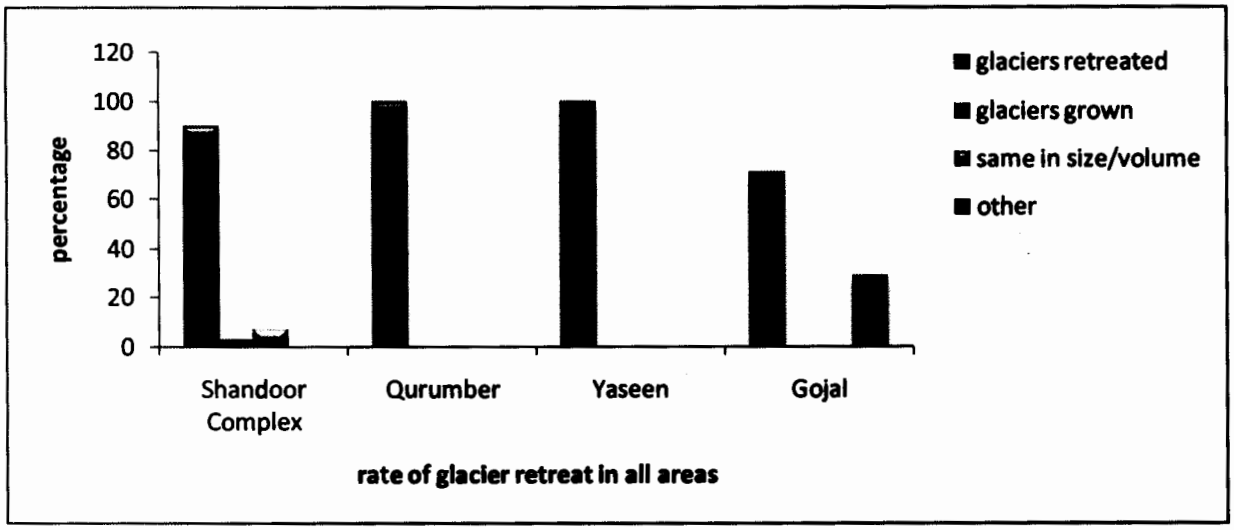

Figure 3.8 Impact of climate change on the glaciers of the area

Figure 3.8 shows more than 90% respondents in all four areas have a general perception that glaciers are melting and they feared of water shortages near future. According to reports of the local population in Yaseen area the glacier is melted almost 1000 meters. In 1989 there was no lake in Darkut (Yaseen), but in 2011 20-30 kanal of glacial lake made due to glacier melt in Ghamu Ber place. There are more chances of GLOF hazard because these glacial lakes have capacity to cause the catastrophic discharge of water which can results in a swear damages. Data

analysis shows that although glacier melt is increased, but overall water flow is reduced because glacier size is decreased. In Hussani (Gojal), Hussani glacier is reduced almost 70-80 feet

In Gojal although more than 70% people perceptive that all the glaciers are melting like Hussani glacier, Passu glacier, Batura glacier, and reported about the major surge of Hussani glacier. According to local communities people the Hussani glacier moves forward and backward after every seven years and it is melting increasingly. Because of major surge of Hussani glacier many acres of cultivated land and cattle houses are damaged. Passu glacier melting dring summer months is inch per day and since 1960 the glacier has melted back 4km (PMD, 2010).

Over the last several decades many glacial lake outburst floods (GLOF) are occurred in Hindu Kush-Karakorum region of Gilgit-Baltistan and it has a very devastating impact on socio-economic conditions, environment and natural resources of these areas.1n 1920-30s, there were major glacier dams and dams bursts in Indus system (Khan, 1994). These risks are still existed especially in the Gojal region with 3 major glaciers Hussani, Batura and Passu glacier and more are anticipated in future. A GLOF is created when water dammed by glacier or moraine is released (UNDP, 2008). It is catastrophic discharge of water from glacial lake. According to local communities they feel more vulnerable to outburst floods. Because global warming is impacting these massive ice reserves and they are sensitive to minor changes in temperature, meanwhile these glaciers are retreating at alarming rate (Campbell, 2004). Past events of GLOF in these areas are detailed in the table in annexure 2.

3.6 Climate change impact on wetland biodiversity

Wetlands are mostly biodiversity hotspots. Shandoor Complex, Qurumber, Yaseen and Gojal are having nationally important and globally significant wildlife species. These high altitude wetlands also provide habitat to diverse aqui-fauna and avifauna. All these areas are famous for its variety and abundance of unique wildlife species i.e. Brown bear Snow partridge, Tufted duck, Grey heron, Eurasian sparrow hawk. These wetlands with fresh water bodies like streams, rivers and lakes are abundant with the aquatic life i.e. crap, cat fish and trout. Medicinal plants are also abundant in these wetlands e.g. thorn apple, sea buckthorn, horsemint, barberry and wild rue.

Climate change has very renounce impact on wetland biodiversity, because relatively small increases in precipitation variability and temperature can significantly affect wetland plants and animals at different stages of their life cycle. With the alternation in climate, these changes impact the biodiversity in multiple ways. Temperature change, habitat destruction, unavailability of food, change in physical environment i.e. pH, temperature, humidity are an important parameters, therefore slight change in these parameters can alter the biodiversity in a very negative way.

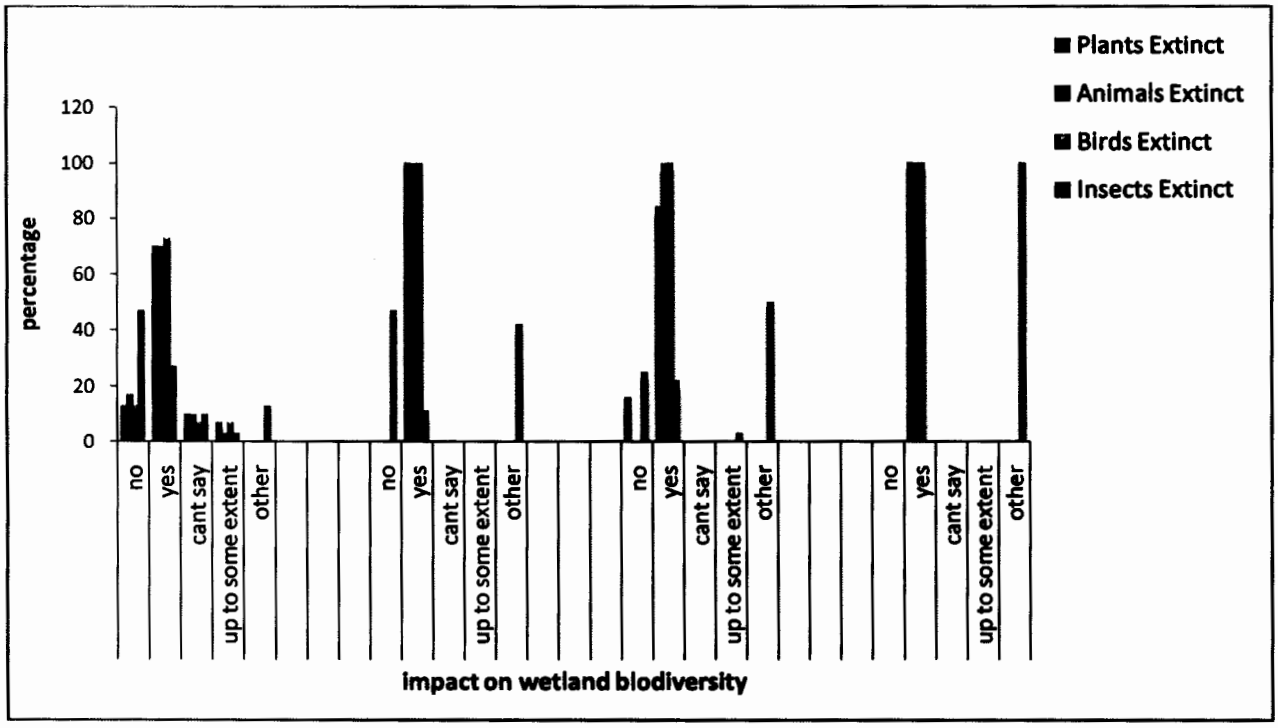

Figure 3.9 climate change impact on wetland biodiversity

Figure 3.9 shows that questionnaire survey, interviews and personal observation revealed that vegetation cover/forest cover has undergone immense changes in these areas. More than 80% respondents in Qurumber, Yaseen and Gojal Shandoor-Handrab complex relate these changes with climate change. These changes are anthropogenic as well as natural. In Shandoor-Handrab Complex (Gulakhmuli, Handrab) Poplar and willow are reduced to a larger extent, which is one of the important sources of fuel and construction purposes. Data analysis revealed a 70 % reduction in forest cover in these areas (Forest Department Gilgit- Baltistan, 2010). Another reason for reduction in tree species is the increase in pests and diseases. Poplar and Willow have more diseases now, specially infested by worm. Local people in Yaseen stated that they observed

more worms in wild plants and trees like sea buckthorn and Juniper. Many acres of forests in Darkut, Yaseen are disappeared since 1970 because of deforestation and destroyed by floods, specially flash floods and avalanches. In Gulkhmuli (Shandoor-Handrab Complex), Qurumber, Yaseen and Gojal areas more than 90% respondents perceptive that climate change is reason for the local reduction of plant species like willow and poplar in terms of natural hazards i.,e flash floods, avalanches and land sliding. Favorable conditions for pests prevail which results in the form of diseases on plants, the consequence of which is the reduction of forests. Another reason which was stated that plants require micro environment and macro environment for their growth, climate change might have altered these climatic conditions which result in reduction of plant species.

Generally, when climate becomes warm, it is expected to start a drying trend in wetland ecosystems, so that results in habitat loss of many wild life species. These high altitude wetlands of four selected areas are extremely fragile ecosystems and have great importance as breeding grounds of rare and unique avifauna. Due to the combined effects of temperature and water stress, the extinction of some amphibians and other aquatic species is projected in Shandoor Lake and Handrab Lake. Drying of these wetlands will affect the migration process of birds that uses these high wetlands as stopovers in their migration during winter.

In Gulakhmulli and Handrab (Shandoor complex) 70% respondents stated that ducks, pigeon, wolf, ibex, Wild rabbits, wolf, Markhoor, koyal, hawks, partridge (local name; gawu), magpie(local name; ghashep), sparrow and crows are endangered. These species are endangered since last 18 years, because change in climate in terms of decrease in snowfall and increase in temperature and fish due to overhunting. In Qurumber 100% people relate the animal extinction with climate change and detailed the list that Ibex, wolf, brown bear, fox, chakoor, ram chakor, eagle and markhoor are endangered due to overhunting and they migrated to other areas.

Temperature change with increase in moisture and humidity in the atmosphere has increased the population of insects in all four areas. As shown in figure above that 100% local people believe that insects are increased, especially on crops. Almost 10 years back they hardly found any insect or worm on the plants, but now every crop plant specially potatoes and in fruits like apple, peach and apricots are attacked by different pests. Infestation of pests is occurred by two reasons. First is the growing of seeds which are brought from down areas. Adulteration and vast transport of

seeds to different areas has introduced pests in the crops as some pests remain in seeds in dormant conditions and grow when favorable conditions are available. 2nd reason is the enhanced conditions for growth of pests. Rainfall is increased results in increases in humidity in the atmosphere and increase in temperature; these conditions are very conducive for the growth of pests/insects and different plant disease like rust and smut. This condition is most prominent in Gojal area where local people added that after the formation of Atta Abad Lake, moisture content in the atmosphere is increased and temperature is becoming more moderate due to reduction in cold waves because of the lake. So there is more pest attack on apricots, peach, apple and potato than former times.

3.7 Climate change impact on agriculture

Agriculture is the backbone of economy of Gilgit-Baltistan. Most of the area is used for subsistence farming and rest is being used as a range land (pastures). Although farming (agriculture), is the major use of land; but it is still not much productive. Farming is not mechanized and modern, new and improved seeds with highly productive yields are not commonly used. Main crops are Wheat, maize, fruits and vegetables specially potatoes. In all selected areas barley, black and green peas have lost their significance, wheat and especially potatoes are now grown as cash crops.

3.7.1 Change in sowing & harvesting time

In All four study areas, agriculture depends on the glacier and spring water. Crops are sown when the glacier water melts and it starts usually in February-March. As illustrated in figure 3.10 that more than 90% people in Shandoor Complex, Qurumber and Yaseen stated that because of increase in temperature the glaciers melt quickly and water in the channels come early so crops are sown early. Local farmers reported that the harvesting time is changed, and crops are being harvested 10-20 days and fruits ripe 20-30 days before the regular time. In areas which are Bilhans Bala (Qurumber) and Yaseen (Darkut Ghasum) wheat and fruits did not grow before 10-20 years, but with the increase in temperature fruits started ripening and wheat grows.

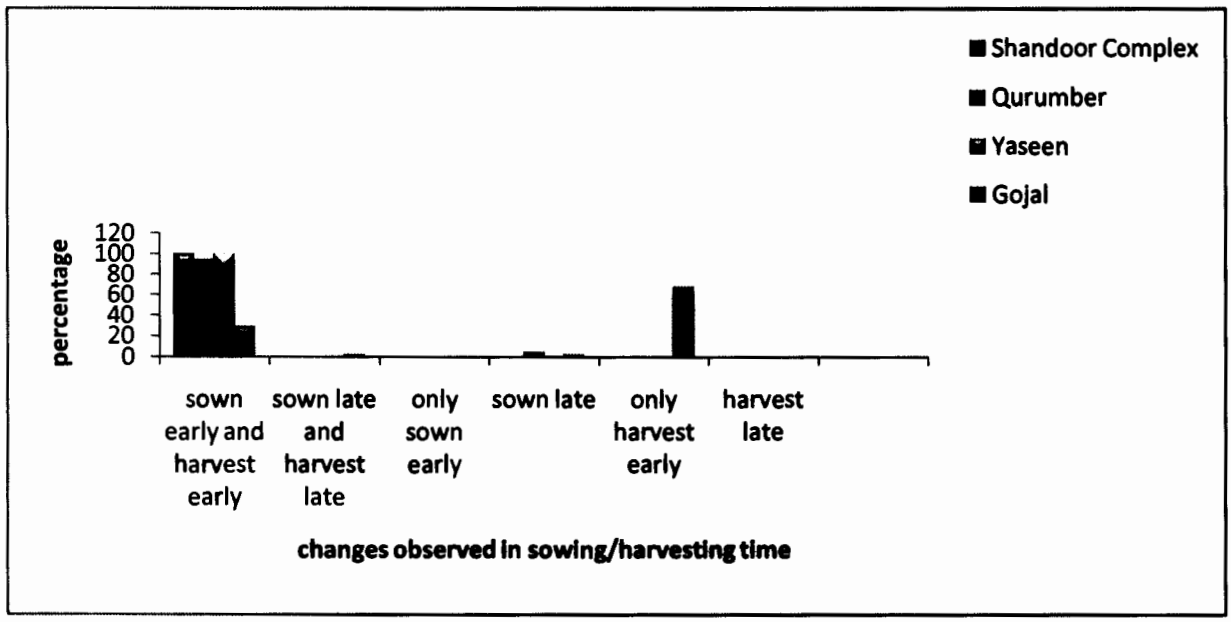

Figure 3.10 Impact of climate change on the sowing and harvesting time

3.7.2 Months for growing crops and number of crops

Figure 3.11 shows the months for growing and harvesting of crops and all four study areas are single cropping with 4-6 months for growing crops. More than 50% farmers in Yaseen and Gojal reported that cropping pattern is converting to marginal cropping, therefore they get the second crop, though not fully ripen and it is as a fodder for livestock.

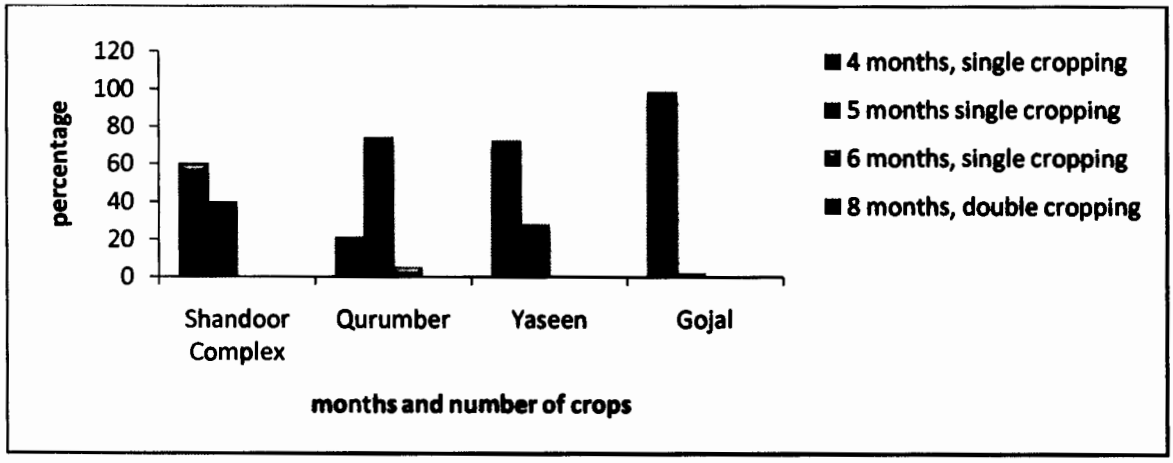

Figure 3.11 Shows month for growing/harvesting crops in different areas

3.7.3 Impact on overall crop production

More than 90% local communities in all studies areas agreed that there is a decrease in crop production. Although new improved varieties and cash crops, which are genetically improved for more production, are grown, still the overall production is less. Though at high altitudes, crop yields increased because of reductions in frost and cold damage but general decrease in crop production is observed. After 1990 AKRSP introduced new varieties of wheat, so these verities are being grown now and its production rate is high. Because of increase in temperature these verities from down areas are growing at higher altitudes. The cropping pattern for the following crops has changed.

S.NO	New trend of crops	Crop name	
	New improved varieties and cash crops		
1.		Potato, wheat, maize	84%
2.		Potato, wheat, fruits	8%
3.		Wheat, maize, fodder	5%
4.		Wheat, fruits, vegetables	3%

Table 3.1: showing new trends of crops being grown now

The crops which are not grown now days are as follow.

Serial No	Crops Name
1.	Old varieties of wheat
2.	Lentils
3.	Barley
4.	Peas

Table 3.2: showing crops not grown now

Over the past few years, the agriculture sector especially the crop production is more inclined towards a downward trend. More than 95% local people stated that there is a general reduction in crop production. In Gojal there was an increase of crop production, but after the formation of Atta Abad Lake, other than the transportation problems, there is a decline in crop production .because decrease in rainfall and increase in humidity/moisture in the atmosphere (because of lake), results in more pest attack on fruit and potato as well as rust and smut on wheat.

There are multiple reasons for reduction of crop production, although all of which are not climate change induced ones.

- Diseases on crops are increased, especially the rust and smuts on wheat crops, and pest attack on fruits specially apricots, apple and peach. More than 95% local communities as shown in figure 3.12 stated that pest attack and diseases on crops is one of the main reasons for reduction in crop production.

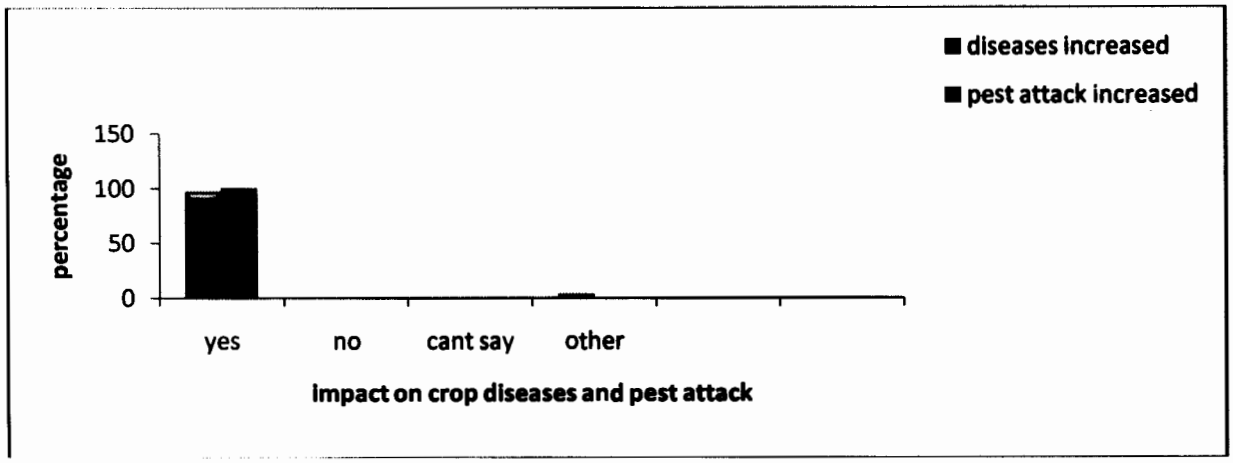

Figure 3.12 showing impact of climate change on the crop diseases and pest attack

- No access to the main market. The main agriculture inputs like fertilizers, seeds and pesticides are not easily accessible, and high prices are another reason.
- Land fragmentation is also one of an important reason; the land is divided and subdivided. Landholding is small with low production.
- Lack of interest and switching to other jobs.

3.8 Climate change impact on overall livelihood of local communities

Climate change has very renounced impact on the livelihood of local communities. The survey results as in figure 3.13 shows that local communities are dependent on natural resources related to these high altitude wetlands (forest, wildlife, agriculture, livestock, wetlands and pastures). The conditions of these HAWs are optimal and declining. In last 5-10 years, the climate change related hazards are increased. There were very high intensity floods in 2010, which destroyed many areas and damaged many infrastructural facilities. Many human lives were lost along with

cattle, yaks and many acres of cropping land become barren and crops damaged while many forest trees and fruit trees were uprooted (Qasim et al., 2010). The losses were in million, the details are in annexure 2.

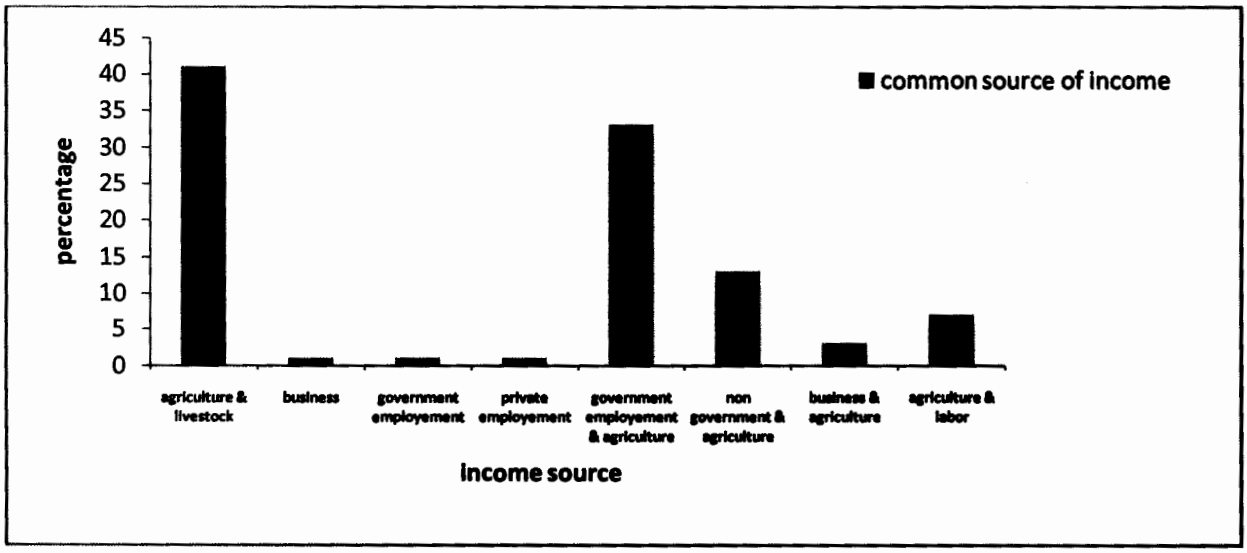

Figure 3.13 Common source income of the local communities of the area

The associated communities with these HAWs reported that since 2000, climate change related hazards are increased, and they feel more vulnerable to these hazards. Survey of selected four areas shows that agriculture and livestock is the major source of domestic economy and livelihood. Local people depend on agriculture to fulfill their basic needs of life. But due to natural hazards, many acres of land is become barren (land sliding, flash floods, avalanches) and water shortage is also another problem. More than 80% respondent's opinions that production decrease because of absence of high yielding seeds, high production costs, absence of agriculture supplements and accessibility to main market. Farmers have lost interest in the agriculture and searching other sectors to switch over as in Shandoor Complex, Qurumber and Yaseen which results in decrease in income from agriculture.

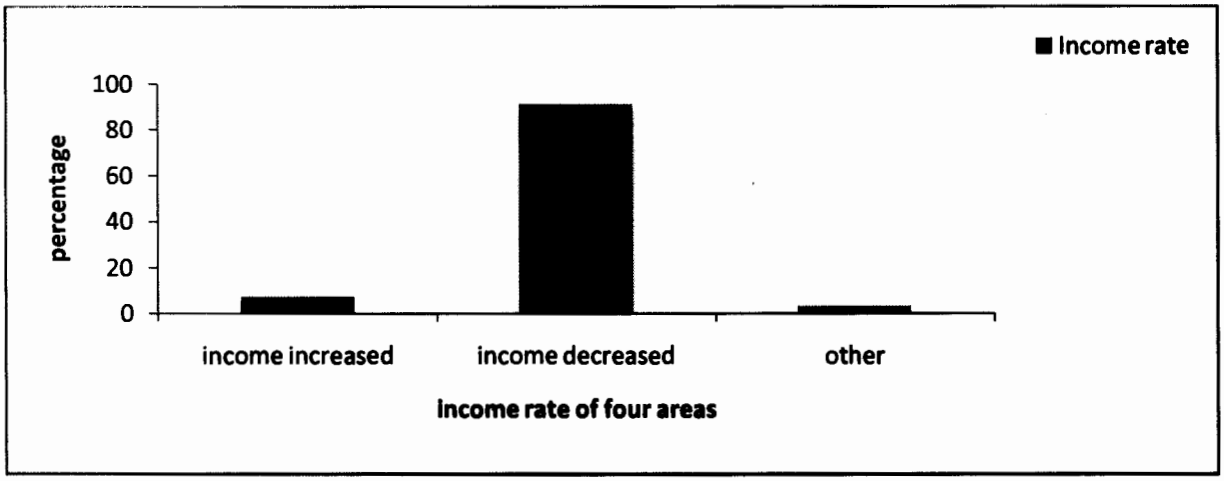

Figure 3.14 Climate change and income rate of the area

In Ghulqin, Hussani and Passu (Gojal) 95% respondent stated that Atta Abad Lake is the main reason for reduction of income especially from agriculture, because of Atta Abad Lake farmers cannot access market easily (Melyabeen, et al., 2011). Potato and fruits are the main agricultural items, but their transportation through lake become costly and farmers cannot afford. Therefore farmers are switched to the old crops like lentils, maize and wheat, which are not cash crops results in low income.

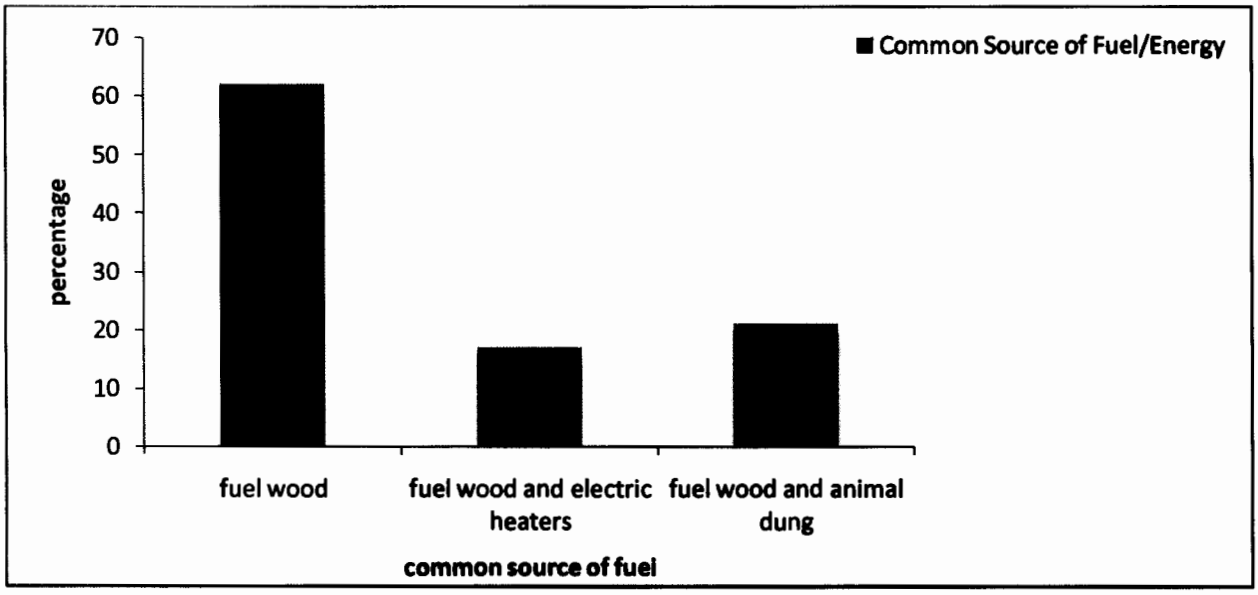

Figure 3.15 Common source of energy

More than 80% local people in all four areas use fuel wood for energy. In Shandoor Complex animal dung is being used along with fuel wood, whereas in Yaseen and Qurumber more than

90% people are totally dependent on fuel wood from forests. There is no alternate source of energy therefore local people cut the trees as a source of fuel and timber. In Yaseen and Gulakmuli, 80% of the forests are cleared for domestic purposes result in land erosion, land sliding and flash floods.

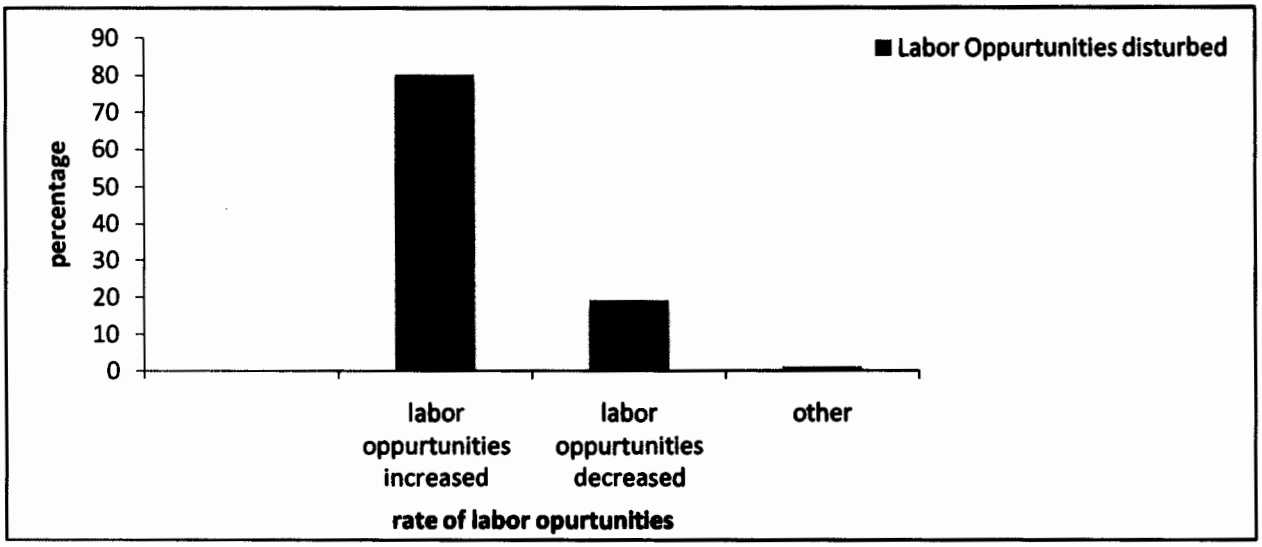

Figure 3.16 Climate change impact on labor opportunities

Although labor opportunities are increased in all areas especially in Gojal and Yaseen, yet the overall income is decreased. In Darkut Das (Yaseen), where more than 80% are farmers and most of them also depend on daily wages from labor opportunities reported that although labor opportunities have been increased, yet the overall income decreased. Because the major flood of 2010 damaged more than 100 acres land, details are in annexure 2.

CHAPTER: 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusion

High Altitude Wetlands are distributed globally. Some 14 sites are found in the HKH. Among the wetlands studied all over the world, HAWs are the least studied systems. HAWs have significant cultural, spiritual, religious, economic and hydrological significance. These wetlands are also important buffer zones for flood hazards. Within the context of Pakistan, it is particularly vulnerable to climate change because it has generally a warm climate; as Pakistan lies in a region where the temperature increase is expected to be higher than the global averages; while its land area is mostly arid and semi-arid (about 60 per cent of the area receives less than 250 mm of rainfall per year and 24 per cent receives between 250-500 mm); its rivers are predominantly fed by the Hindu Kush-Karakoram-Himalayan glaciers, as this study shows that they are retreating which are due to climate change. The economy of Pakistan especially of Gilgit-Baltistan is largely agrarian and hence highly climate sensitive along with all four selected areas (Shandoor complex, Qurumber, Yaseen and Gojal) that face increasingly larger risks of variability in monsoon rains large floods and extended droughts. Under the influence of all these factors the Water Security, the Food Security and the Energy Security of the country as well as these areas are under serious threat.

All selected four areas have unique topographic, environmental and cultural settings, however with a variety of specific problems and future challenges. Climate change has been observed in all selected areas, it has impacted people lives, economically, socially and livelihood sector. Climate variability has also highly impacted the ecology of these mountainous areas, particularly high altitude wetlands. Many important species, which are internationally significant as well as an important part of mountain ecosystem have declined in numbers. Cropping pattern has changed in all areas. Agriculture changed from wheat, peas, barley and maize to potato as the main planted crop. Also yields have decreased as less manure is available for fertilization due to a decline in livestock. A great change in the growing season has been observed in all four areas. Due to an increase in temperature, crops are harvested 10-20 days before the normal time. Winters as well as summers have become warmer and dryer. The major change is in the form of reduction in snowfall as in the last 10 to 15 years have had extremely little snow in winter. Melting definitely starts earlier as at least the last five to six years have been very warm.

Although increase in temperature may have some positive implications for agriculture in these high altitude wetlands (HAW's) in a way that temperature increase has made crops/fruits to mature/ripe early, along with making it possible for growing of wheat and fruits at higher altitudes of the villages, where they did not grow there once. But according to respondent's point of view, general group discussions and personal observation showed that, the climate change has some positive impacts for the time being. But in the long run it has very negative consequences. The temperature increase could affect the country's sustained fresh water resources in the long run through accelerated melting of glaciers and snow in these high altitude wetlands. Glaciers are melting day by day, and if this rate remains continue, there will be water shortage in the long run. Reductions in snowfall along with increase in torrential rain falls have brought more floods, specially the flash floods, landslides and avalanches. These major natural hazards which have done lot of losses in terms of damaging livestock, land, crops and taking precious life. Temperature change has also made another major hazard in the form of GLOF especially in the Gojal area. These areas have become more vulnerable to major GLOF events along with the glacier surges, posing serious threat to people's lives and livelihoods. Also there are more chances of increase in, flash floods in these areas due to increase in precipitation especially in monsoon season, which will cause land sliding and destruction of resources and lives. Furthermore, there are also chances of more soil erosion, which will wash away the top fertile soil resulting in to decrease in crop yields.

Although many efforts are made to reduce vulnerability, and enhance the resistance and adaptive capacity of people, most vulnerable to climate change because near to all natural ecosystems in these areas are susceptible to climate change, but still there is need to take a proactive approach specially involving the local communities of the area, that addresses the social processes leading to vulnerability and the structural inequalities that are often at the root of social-environmental vulnerability. The poor and prone communities of the Gilgit-Baltistan are unable to response to the climate change and their impacts on life, livelihood and fragile ecosystems due to lack of awareness, capacity building, , knowledge networking, resources, natural resource management and modern climate change adaptation knowledge. So assessing the combined effect of social and climate changes is a major task for the future.

4.2 Recommendations

Following are some recommendations to reduce the risk of climate change on these high altitude wetlands and reducing people vulnerability to climate change.

1. Adequate data are required for appropriate planning and decision making in HAWs, so there is need to promote research to support conservation and management of HAWs;
2. Community participation in conservation process should be make sure, while environmental impact assessments of every developmental project should be done to support decision making which have the likelihood of impacting HAWs and their ecosystem services and associated communities.
3. There are no proper research facilities in these areas, so research facilities should be provided and quality research should be encourage, gaps in knowledge and its application should be filled.
4. Awareness raising programmes regarding climate change should be started, along with encourage, document and disseminate traditional techniques, best practices, lessons learnt and successful examples concerning the wise use of HAWs in all areas.
5. strategic partners, academia, NGO and research institutions should be encouraged to help the government regarding development and implementation of management plans for HAWs;
6. Efficient water management technologies need to be introduced and through agricultural research crop varieties should be introduced which are suitable for the mountain areas under the changing climatic variations.
7. Plantation activities in barren areas, river banks and Nullahs will help to combat climate change and their negative impacts especially in Darkut area of Yaseen. Meanwhile alternate source of energy especially in upstream areas is very important to reduce the deforestation
8. Solid waste management especially in tourist hot spot areas like Shandoor Lake
9. Management of pastures and controlled grazing to reduce the desertification process especially in pastures of Shandoor area.

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ANNEXURES

ANNEXURE: 1

TABLES

Table 1: Shandoor and Handrab lake Problems

S. No	Problem	
1.	Uncontrolled construction , specially permanent construction/structures	destroying natural habitat, natural environment, disturbing food cycle
2.	Lot of garbage, specially plastics, cans, bottles, paper etc.	littering may spread diseases to animals specially the wild animals
3.	Lack of proper waste disposal and sanitation facilities	water and soil contamination, increase of bacterial diseases
4.	Over/uncontrolled grazing	Grass reduced, desertification rate increased
5.	human impact and poor management of lake and pastures	Degradation of an important wetland, deprive of natural resource and habitat destruction of important wildlife species
6.	Over hunting of wild species and fish	Many important species of fish especially trout fish are much reduced in number. Extinction of nationally important wild species i.e. markhoor, ducks, wolf and ibex

ANNEXURE: 2

PROBABILITY OF DISASTER RISKS AND HISTORY OF DISASTERS

Table 2: Probability of Disaster Risks in Shandoor–Handrab Complex

Hazard	Probability	Time line	Duration	Intensity	Severity
GLOFs	High	July-August	1-10 days	High	High
Floods	High	July - August	1 day	High	High
Avalanche	Medium	March- April	1-10 days	Medium to high	High
Land Slide	Medium	June-September	3-4 days	Medium to high	High
Thunder Lightening	High	July- August	3-6 days	High	High
Heavy Rainfall	High	July-August	3-6 days	High	high
Flash Floods	High	July-August	Seconds	Low	Low
Earthquake	low	Several	seconds	Low	Low

Table 3: Probability of Disaster Risks in Qurumber (Immit)

Hazard	Probability	Time line	Duration	Intensity	Severity
GLOFs	High	January-February	3-4 days	High	High
Floods	High	July-August	1-2 hours	High	High
Avalanche	High	March	10-15 minutes	High	High
Thunder Lightening	High	July-August	Few seconds	High	High
Heavy Rainfall	High	July-August	10-15 minutes	High	High
Wind storm	High	February-March and July-August	1-2 hours	High	High

Table 4: Probability of Disaster Risks in Qurumbar (Bilhans)

Hazard	Probability	Timeline	Duration	Impact	Severity
GLOFs	High	July to August	1-4 hours	High	High
Flash Floods	High	July - August	1-2 hours	High	High
Avalanche	High	March-April	2-3 minutes	High	High
Heavy Rainfall	High	July-August	1-2 hours	High	High
Strong winds	High	February-March July-August	1-2 hours	High	High

Table 5: Probability of Disaster Risks in Yaseen

Hazard	Probability	Timeline	Duration	Impact	Severity
Flash Floods	High	May-August	1-2 hours	High	High
Avalanche with rocks	High	February-April	5-10 minutes	High	High
Thunder Lightening	High	July-August	Few minutes	High	High
Heavy Rainfall	High	July-August	30 minutes-1 hour	High	High
Wind storms	High	May-August	30 minutes-1 hour	High	High

Table 6: Probability of Disaster Risks in Gojal

Hazard	Probability	Timeline	Duration	Impact	Severity
GLOFs	High	May to August	1-15 days	High	High
Floods	High	July-September	1-5 days	High	High
Avalanche	High	February- May	Seconds	High	High
Land Slide	High	May to August	10-30 minutes	High	High
Thunder Lightening	High	May- September	Few seconds	Medium	Medium
Heavy Rainfall	High	May-September	Few minutes-hours	High	High
Flash floods	High	May-August	Seconds	High	High
Cold winds	High	November-February	30 minutes-1 hour	High	High

History of Disasters

Table 7: History of Natural Disasters in Shandoor-Handrab Complex (Gulakhmuli)

S #	Disaster Type	Year	Magnitude	Area affected	Human Loss	Livestock	Property
1.	Avalanches	1988	High	Gulakhmuli	Nil	22 yaks	Nil
		2009	High	Helti	2	Nil	7 houses
2.	Flood	1950	High	Terch	Nil	Nil	2.5-3 acres land, 10 homes, many acres forest sp. Eucalyptus trees.
		2011	High	Akhtubring, Gulakhmuli	Nil	Nil	Break water channels, many tress, and 2-2.5 acres land.
3.	Land Sliding	Number of times	High	Gulkhmuli, specially the roads	Nil	Nil	No transport, effects mobility.
4.	Lightening	Every year sp. In 2007	High	Helti	Nil	Nil	Crops are badly affected.

Table 8: History of Natural Disasters in Shandoor-Handrab Complex (Handab)

S #	Disaster Type	Year	Magnitude	Area affected	Human Loss	Livestock	Property
1.	Avalanches	1942	High	ShunjeNullah	1	Nil	Forest area
		1999	High	ShunjeNullah	1	Nil	Road, 40-50 houses, 0.5 acre land.
		2005	High	Handrab	1	Nil	land with standing crops
2.	Land sliding	2009	High	Handrab	Nil	40 yaks and cattle	Nil
3.	Flood	2005	High	River bank Handrab	Nil	Nil	18 houses, 2 acres land with standing crops
		2009	High	Khulter (shunjenullah)	Nil	Nil	2-2.5 acres of forest land
		2010	High	Burumzha	Nil	Nil	0.5 acres land with standing crops, 5-7 acres forest area
4.	GLOF	2009	high	Sharan Bar	Nil	Nil	1000,s of wild trees

Table 9: History of Natural Disasters in Qurumber (Immit)

S #	Disaster Type	Year	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1.	Avalanches	2005	High	Chandi	0	13 goats	1 house, standing crops and many trees
		2008	High	Adrakh		16 cattle	Grass and tress
2.	Land sliding	2006	High	Gish gish	2	0	1 vehicle
		2010	High	Chandi	0	0	Standing crops 3-4 kanal land
3.	Flood	2010	High	Immit	0	0	7 acres land.
				Shamsabad	0	0	20-30 acres land
4.	GLOF	1905	High	Immit	0		Lot of Animals, crops, land, tress
5.	Lightening	2006	High	Mujaaver	0	0	9-10 kanals

Table 10: History of Natural Disaster in Qurumber (Bilhans)

S #	Disaster Type	Year	Magnitude	[illegible]	[illegible]	[illegible]	[illegible]
1.	Flood	2010	High	Bilhans	Nil	Nil	4 houses, 50 acres land, tress and standing crops
2.	Avalanches	2005	Medium	BilhansPaady	Nil	Nil	2 cattle houses, 10-12 poplar trees, many fruit trees
3.	Land Sliding	2010	High	Central Bilhans	Nil	Many donkeys	Nil
4.	GLOF	2006	High	BarsatNullah	Nil	Nil	15 acres land destroyed with forest and standing crops

Table 11: History of Natural Disasters in Yaseen

S #	Disaster Type	Year	Magnitude	Area affected	Human Deaths	Livestock	Property
1.	Flood	1977-1980	High	Darkut Das	4	300 cattle	150 houses, 15 acre land, 2 religious Centres
		2010	High	Darkut Das	Nil	Nil	55 houses, 15 acres land with standing crops and fruit trees, forest with more than 50000 tress, 2 religious Centres
				KhatGiram	Nil	Nil	10 houses
							1.5 acres land with standing crops and fruit trees
							6 houses, 10 acres land with crops and fruit trees
	Flood	2010	High	Minher	1	Nil	
		2010	High	Supatindas	Nil	Nil	
		2010	High	Burum Bun	Nil	8 cattle	
3.	avalanche	2010	High	Darkut Das	2	20 cattle	1 house, 100 fruit trees and standing crops

Table 12: History of Natural Disasters in Gojal

S #	Disaster Type	Year	Magnitude	Area affected	Human Deaths	Livestock	Property
1.	GLOF	1977	High	Shishket, Passu	Nil	Nil	Bridge, many kilometer road, several houses
		2009	High	Passu	Nil	Nil	2-3 shops, 0.5-1 acre land, 60-70 trees
2.	Heavy rain fall and flood	1992	High	Passu	12	Nil	Roads, several houses, fruit trees and standing crops.
3.	Land sliding	2011	High	Ghulqin	Nil	Nil	Destroyed many trees and forest area.
4.	Glacier Surge	2011	High	Ghulqin and Hussani(Shabad)	Nil	Nil	Destroyed arable land,

ANNEXURE 3

QUESTIONNAIRE

Investigating climate change related hazards in selected high altitude wetlands of the Karakoram

Village Name: _____ **Name of interviewer:** _____

Occupation _____ **Age:** _____

Surveyor(s): _____ **Coordinates** _____

General opinions

1) **Do you believe that there has been change in overall climate of the area?**

- o No
- o If yes

a) Last 15 years b) last 30 years c) last 35 years d) last 40 years e) other

2) **Do you believe climate variability is threat to ecological services?**

- o No
- o If yes

a) Species extinction b) hydro-cycle changed c) crops pattern changed
d) Ecological services disturbed e) others

3) **Do you think climate change effects agro-pastoral life?**

- o No
- o yes
- o If yes

a) Cropping pattern changed b) disturbed critical facilities c) macro and micro economic options
d) Land fragmentation e) grazing on pastures f) other

ECOLOGICAL IMPACTS OF CLIMATE CHANGE

4) **Do you think rain fall/ snow fall pattern has changed over the past 15 – 35 years?**

- o No
- o If yes

a) Changed in rain quality stay time changed b) changed time occurrence c) changed duration d) snow ground e) other

5) **Do you believe climate change impacts on river and nullahs?**

a) Increased river/nullahs flow b) Decreased river/nullahs flow c) River/nullah basin widen

d) Rate of erosion increased/decreased e) Debris load increased/decreased

6) **Is there any impact of climate variability on glaciers?**

- o No
- o If yes

a) Glaciers retreated b) Glaciers grown c) same in size/volume d) others

7) **Is there any impact of climate change on wetlands biodiversity?**

- o No
- o If yes

a) Plants extinct b) animals extinct c) birds extinct d) Insects extinct e) others

Enlist please

_____

_____

_____

SOCIAL IMPACTS OF CLIMATE CHANGE

Social sector

8) Is there any impact of climate change on social sector?

- o No
- o If yes

a) Disturbed critical facilities b) disturbed capacity (skill and resources) c) disturbed life support items d) disturbed agriculture crops e) water courses / sources f) Livestock g) others

9) Is there any impact of climate change on health and health facilities?

- o No
- o If yes

a) Diseases increased b) diseases as us usual c) health facilities disturbed d) others

LIVELIHOOD SERVICES

10) Is there any impact of climate change on livelihoods options?

- o No
- o If yes

a) Micro business disturbed b) macro business disturbed c) labor opportunities disturbed d) other

11) Is there any impact on agro-pastoral life?

- o No
- o If yes

a) Income increased b) income decreased c) same as in past d) other

12) Is there any impact of climate change on crops?

- o No
- o If Yes

a) Dieses increased b) dieses decreased c) same as in past d) other

13) Does the pest attack/diseases on plants increased or decreased?

- o No
- o If yes

a) Pest attacked increased b) pest attacked decreased c) same as in past d) other

HAZARD VULNERABILITY DUE TO CLIMATE CHANGE AND ITS RISK ASSESSMENT

14) What are major types of hazards?

What are the major hazards in village and detail list?

Where is location of hazards?

15) What is the nature of hazards?

16) What is frequency of hazards?

17) Which area is impacted high?

18) What is magnitude of hazards?

19) Time of hazards?

20) Past history of disasters in village?

21) What are critical facilities affected by the disasters?

22) Responses adopted by the community (in such situations)?

23) Suggestions, if any to enhance community resilience against hazard risks / disasters

19) Time of hazards?

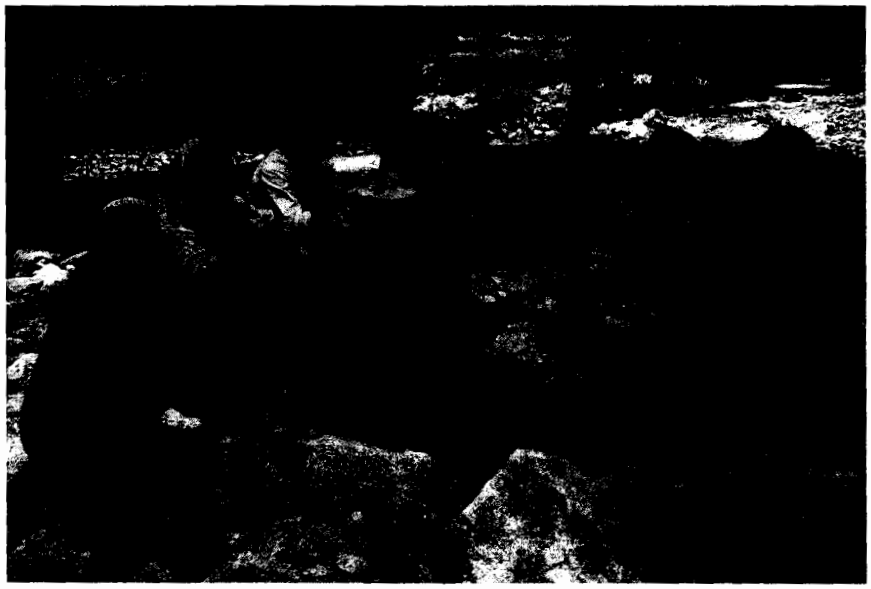
20) Past history of disasters in village?

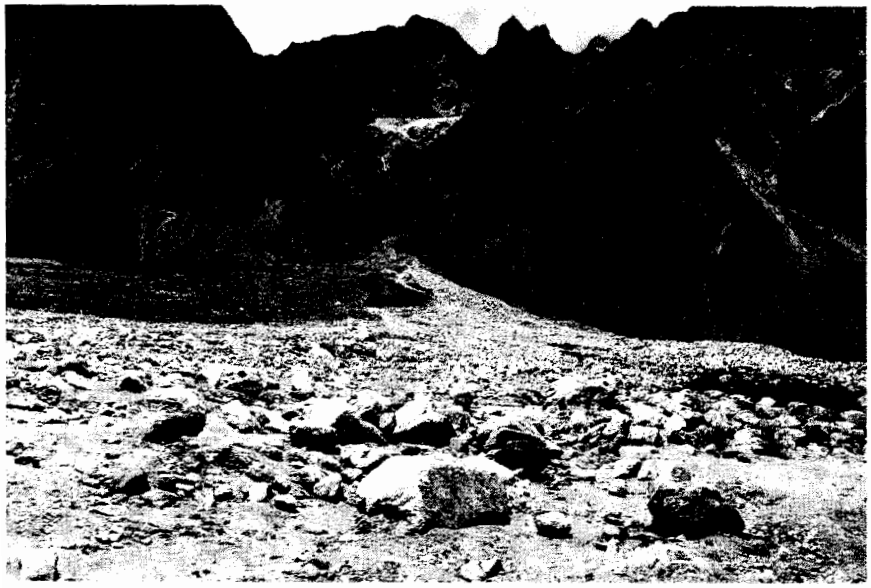
21) What are critical facilities affected by the disasters?

22) Responses adopted by the community (in such situations)?

23) Suggestions, if any to enhance community resilience against hazard risks / disasters

Study Area and Snap Shots of some of the Disaster Areas





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