

**The Impacts of Climate-induced Changes and Related Disasters on
Socioeconomic Conditions and Livelihood Sources of the Mountain
Communities in Gilgit-Baltsitan, Pakistan**

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ABSTRACT

Mountain regions in Gilgit-Baltistan are among the most fragile environments in the face of climate threats although they are rich repositories and providers of ecosystem services and goods. Over the past years, the poor and marginalized communities living across mountain regions have been facing pressing challenges due to climate-induced changes and related disasters. To better understand how climate change impacts socioeconomic conditions of mountain communities and their livelihood sources in Gilgit-Baltistan, I conducted fieldwork in the summer of 2017 in one of the mountainous villages located in Gojal, known as Passu. I conducted 35 household surveys and 15 in-depth interviews among the residents of Passu village in order to collect their observations and past experiences about their own socioeconomic vulnerability led by climate-induced changes and related disasters. The interviews and household surveys responses' confirmed that climate-induced changes and their impacts have already been felt by the residents of Passu village. Their perspectives reflect that with time, residents of Passu village have reduced their reliance on climate-sensitive sectors such as agriculture in order to reduce their socioeconomic vulnerability and are now more engaged in different professions to earn income. Governmental and non-governmental organizations implemented different projects to assess and monitor multiple hazards that may associate with glacial lake outburst flood events. Although climate-induced changes and related disasters vary substantially across regions and agro-ecological zones in Gilgit-Baltistan, my research shows that vulnerability to the effects of climate change remains in those mountainous villages where the majority of the population is still dependent on agriculture and tend to have a poor adaptive capacity and weak institutional structures.

FOREWORD

This Major Paper is the final document to satisfy the requirements of my Plan of Study in the Master in Environmental Studies Program (MES) at York University. This research began with an interest in studying the impacts of climate-induced changes and related disasters on mountain communities and ecosystem services (i.e. glacial lake outburst floods (GLOF), snow avalanches, debris flow, flash floods, landslides, agricultural loss, and food insecurity) in northern areas of Pakistan, known as Gilgit-Baltistan. Growing up in a small mountainous valley known as Hunza located in the Hindu Kush Himalayan region of my country, Pakistan, I am fully aware that mountain ecosystem services and goods play a pivotal role in humans' well-being. Furthermore, mountains are hotspots and centers of biological diversity, key sources of raw materials, and important tourist destinations. However, mountains are highly vulnerable to the forces of global climate change, and they are true indicators of global climate change. I became aware that many studies have addressed the impacts of climate change on various components of the environment, yet relatively few studies have quantified the potential threats of climate-induced changes and related disasters on mountain communities across the world. This knowledge gap interested me to develop my Major Paper to address all the three components of my area of concentration: climate change impacts on mountain ecosystems, addressing the socio-economic vulnerability of mountain communities, and climate change adaptation and mitigation in mountains. My study aims to provide some insight into the complex relationships between climate change, poverty, and gender in the context of marginalized mountain communities in northern areas of Pakistan.

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LIST OF ACRONYMS

Acronyms	Name
AKRSP	Aga Khan Rural Support Program (Pakistan)
AKAH	Aga Khan Agency for Habitat
APAN	Asia Pacific Adaptation Network
CDKN	Climate Development Knowledge Network
DRR	Disaster Risk Reduction
FAO	Food and Agricultural Organization
GB	Gilgit-Baltistan
GCISC	Global Change Impact Study Centre (Pakistan)
GoP	Government of Pakistan
GLOF	Glacier Lake Outburst Floods
HVRA	Hazard Vulnerability Risk Assessment
IDRC	International Development Research Centre
IIED	International Institute for Environment and Development
IPCC	Intergovernmental Panel on Climate Change
ICIMOD	International Centre of Integrated Mountain Development
IUCN	International Union for Conservation of Union
NDMA	National Disaster Management Authority
PEPA	Pakistan Environmental Protection Agency
PMD	Pakistan Meteorological Department
UNDP	United Nations Development Program
UNISDR	United Nations International Strategy for Disaster Reduction

UNFCCC	United Nations Framework Convention on Climate Change
UNEP	United Nations Environmental Program
WWF	World Wildlife Fund for Nature

Glossary of Key Concepts

1. Adaptation:

Adaptation is defined as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploit beneficial opportunities (Ludena and Yoon, 2015).

2. Adaptive Capacity:

Adaptive capacity describes the ability of a system to cope with climatic extremes. However, the adaptive capacity to climate change depends on physical resources, access to technology and information, varieties of infrastructure, institutional capability, and the distribution of resources. Indicators for adaptive capacity compose economic capability, physical infrastructure, social capital, institutional capacity, and data availability (Ludena and Yoon, 2015).

3. Climate Change:

A change in climate that persists for decades or longer, arising from humans activities such as greenhouse gases emissions that alter the composition of the atmosphere (Oxfam GB, 2010).

4. Coping:

Refers to the use of existing resources to achieve various desired goals during and after unusual, abnormal, and adverse conditions of a hazardous event or process. The strengthening of coping capacities, together with preventive measures, is an important aspect of adaptation and usually builds resilience to withstand the effects of natural and other hazards (Oxfam GB, 2010).

5. Disaster Risk Reduction (DRR):

The concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced

exposure to hazards, lessened the vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events (Oxfam GB, 2010).

6. Livelihoods:

Comprise of capabilities, material and social assets necessary for a means of living. It includes the idea of coping with and recovery from external stresses and the sustainability of the resource base on which livelihoods depend (Oxfam GB, 2010).

7. Mitigation:

Measures to reduce greenhouse gas emissions (however, the term ‘mitigation’ is used differently by DRR practitioners, who use it as a mean to reduce or limit the adverse impact of hazards and related disasters) (Oxfam GB, 2010).

8. Resilience:

The amount of change a system can undergo and still retain the same functional structure while retaining options to develop in desired directions (Oxfam GB, 2010).

9. Vulnerability:

The characteristics and circumstances of a community, system, or asset that make it susceptible to the damaging effects of climate change and other hazards (Oxfam GB, 2010).

SECTION 1. INTRODUCTION

This chapter provides a brief overview of global climate change and its impacts particularly on mountain communities' livelihoods and their socioeconomic conditions. It ends with the problem statement and research questions for my study.

1.1.Global Climate Change

The phrase “climate change” raises eyebrows and interest now as never before because global climate change has already had observable effects on the planet. The Intergovernmental Panel on Climate Change (IPCC) (2011, p.1) defines climate change as, “climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity.” This definition differs from that in the United Nations Framework Convention on Climate Change (UNFCCC) (2011, p.1) which 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 time periods.”

Global climate change has become a stark reality that impacts everyone around the world in varying degrees. The globe has warmed by about 1 °C in recent years, but this warming has not been spatially uniform. The higher latitudes have warmed faster than the lower attitudes whereas continents have warmed faster than the oceans. For instance, in the Arctic, over the last 50 years, a higher rate of warming has been seen compared to the last 100 years of warming (Kohler et al., 2014). This indicates that the rates of temperature increase have rapidly changed over time. The computer-based models of the climate system estimate that by 21st century, the global average surface warming will increase by 1.1-6.4°C, the sea level will rise between 18 and 59 cms, the oceans will become more acidic, hot extremes and heat waves will be more frequent, more precipitation will be seen at higher altitudes, less precipitation will occur in most subtropical land areas, and more intense tropical cyclones

will likely occur (United Nations International Strategy for Disaster Reduction, 2008). The IPCC reports also illustrate that future temperature increases are expected to be stronger over land than over the ocean, stronger at high latitudes than in the tropics, and stronger at high altitudes than near the ground in the tropics. These predictions indicate that climate change impacts will inevitably affect entire humans' settlements due to their exposure and limited adaptive capacities to deal with the climate-related extremes (Pouliotte et al., 2009). Future projections of climate change are critically dependent on scenarios of future anthropogenic emissions of greenhouse gases and other climate forcing agents into the atmosphere such as CO₂, water vapors, and aerosols (Watson et al., 1998). The projections of future climate patterns are alarming and indicate that global climate change has and will continue to have adverse impacts on global ecosystem services and humans' well-being because the rapidly growing population and economic activities are also triggering the global emissions. There is a doubt that humans are the main drivers of this dire force and the alteration of the global climate. Their activities and practices have accelerated the increased emissions and concentration of greenhouse gasses into the atmosphere. Even though these emissions of greenhouse gases are starting to be controlled, there would still be some level of ongoing global warming because the planetary climate system is slow in responding to change (Betts et al., 2010).

Today, with a changing global climate, fear is mounting in our civil society and among government and political representatives because this unprecedented change has led to serious complications across the globe such as the loss of sea ice, accelerated sea level rise, more intense heat waves and droughts, floods and cyclones, and shrinking glaciers (Watson et al., 1998). Over the past, the effects of global climate-induced threats and related disasters have already been observed across the globe. These catastrophic events have undermined progress in the alleviation of global poverty and food insecurity while impacting overall

development efforts (Karfakis et al., n.d). It is evident from the past and present global climate-related extremes that global climate change has also undermined development actions to increase agricultural production while affecting crop yields and productivity in various ways (Watson et al., 1998). For instance, the changes in parameters such as temperature, precipitation, length of growing season, and timing of extreme weather events have directly affected crop development (Watson et al., 1998). Middle to higher latitudes may experience an increase in agricultural productivity, depending on crop type, growing season, and changes in temperature and precipitation patterns (Karfakis et al., n.d). Evidence from global models indicates that farming populations residing in tropical regions are expected to experience deterioration in their agricultural yields and incomes (Karfakis et al., n.d). Reduced rainfall due to changes in temperature and precipitation patterns can adversely impact agricultural practices and livelihoods sources. As a result, poverty and food insecurity can increase across those regions (Karfakis et al., n.d). Furthermore, the economic sectors that largely depend on weather conditions can increasingly become subject to the impacts of climate-induced changes and related threats. For example, the depletion of natural resources as a result of increased environmental and demographic pressure tends to aggravate the severity of climate change impacts (Karfakis et al., n.d). However, critical methodological and evidence gaps exist with respect to the downscaled assessment of the impacts of climate change at the household level. As a result, these constraints limit our understanding of how climate-related changes and extreme events affect vulnerable households. This lack of understanding further reduces our ability to design and implement effective policy measures that should aim to assist households in order to prevent or mitigate negative impacts of future climate shocks and threats. Also, such policy measures should include and implement other risk management strategies such as adaptation and mitigation in order to enhance adaptive capacity and resilience in the face of future climate shocks (Karfakis et al., n.d). Any relevant framework

that intends to downscale and assess the impact of climate change and weather-related shocks at household level should recognize and define the nature of changes and extreme events that strike different types of livelihoods (Karfakis et al., n.d). Identification of such impacts enable experts, researchers, and policy-makers to analyze how welfare losses from gradual and extreme climate events are distributed among households (Karfakis et al., n.d). Climate-related changes and stressors do not directly affect all people within a given region in the same way at the moment of disaster. Therefore, policy-makers need to determine effective ways to reduce the loss and damage that arise with climate-related extreme events (Karfakis et al., n.d).

1.2.Impacts of Climate Change on Mountain Systems

Understanding the impacts of climate change on mountains has become vital because mountain regions are especially sensitive to the impacts of a changing climate while putting at risk many of the goods and services provided by mountains. The world's mountains are home to about 800 million people and provide crucial ecosystem services for the entire globe, including freshwater for half of the humankind (Kohler et al., 2014). Across the world, mountain regions display large climate gradients within small spatial scales and host a diversity of microclimates due to their altitudinal extent and topography (Kohler et al., 2014). Many scientists believe that the changes occurring in mountain ecosystems provide an early glimpse at the future of lowland environments. For instance, as the global temperature increases, mountain glaciers melt at rapid rates (Fort, 2015). At high elevations, a major indicator of climate change is permafrost. Any changes in permafrost conditions can lead to risks to the surrounding mountain population, infrastructures, and territories (Fort, 2015). It is evident that changes in climatic patterns can affect the world's mountain regions and may jeopardize the important services provided by mountains that include drinking water supplies, hydropower generation, agricultural production, and protection against the risks of natural

hazards (Kohler et al., 2014). Climate change is expected to alter climatic patterns in mountain areas. For instance, the extreme changes in temperature have enhanced severe losses in water supply due to changes in evaporation and precipitation patterns (Hussain et al., 2005). Moreover, there is substantial evidence that glaciers in most parts of the world across mountain regions are retreating due to increases in temperatures. For example, the famous snow-capped peak of Mount Kilimanjaro in Tanzania has already lost almost 82% of its permafrost since 1912 (Hussain et al., 2005). Similarly, rapid mountain glacier retreat in Greenland, Ecuador, Peru, Venezuela, New Guinea, and East Africa have also been documented by researchers (Hussain et al., 2005).

1.3.Livelihoods of Mountain Communities and their Socio-economic Vulnerabilities

Equally important is the fact that mountain people are generally among the world's poorest citizens, so they face even greater hardship due to climate-induced changes and related disasters. The isolation and displacement of mountain communities due to climate-induced disasters limit their opportunities to generate income (Kohler et al., 2014). Mountainous terrain, harsh climatic patterns, and existing extreme poverty impose critical conditions on mountain farmers and herders to live and work in a challenging atmosphere. The freshwater from mountains is fundamental in achieving global food security for many farmers in upstream and downstream areas. However, changes in the seasonal melting patterns of mountain glaciers due to an increased temperature variability can have an enormous impact on food production of many agricultural dependent mountain populations (Fort, 2015). According to the 2014 Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), rising temperatures and an increased frequency of extreme weather events have direct negative impacts on crops, livestock, forests, fisheries and aquaculture productivity in years to come (Kohler et al., 2014). This means that agriculture and farming-dependent mountain populations in upstream and downstream areas can

particularly be at risk due to their limited adaptive capacity and the lack of modern technology to sustain and enhance their agricultural yield (Kohler et al., 2014). Moreover, climate-induced hazards such as storms, landslides, glacial lake outburst floods, and avalanches can affect mountain communities by disrupting access to basic infrastructures such as health services, schools, extension services, roads and markets (Kohler et al., 2014). The sensitivity of mountain ecosystems to climate change is particularly high because of their fragile environment, topography, steep gradients, and diversity of ecosystems (Kohler et al., 2014). The mountains can become even more sensitive as rising temperatures enhance melted permafrost and glacial run-off that accelerates soil erosion and the likelihood of landslides, floods, and avalanches (Kohler et al., 2014). Besides this increased instability of glaciers and threat to infrastructures, changes in the volume of mountain glaciers and in their seasonal melting patterns can significantly impact the residing mountain populations due to their reliance on climate-sensitive sectors (Kohler et al., 2014).

1.4.Problem Statement

Gilgit-Baltistan, formerly known as Northern Areas of Pakistan, has become one of the vulnerable mountain regions to the effects of climate-induced changes and related disasters due to existing poverty, the lack of technical management and planning, and destabilized infrastructure and communication links. In Gilgit-Baltistan, climate-induced changes and related disasters such as floods, landslides, debris flow, and glacial lake outburst floods have deeply transformed mountain communities' livelihoods and their primary sources of income such as agricultural farming and livestock. The escalation of poverty and hazard vulnerability have mutually required local people to exploit natural resources for survival, which has hampered environmental sustainability and poverty reduction initiatives across the region. However, such socio-ecological and environmental transformations can intensify socioeconomic marginalization of poor mountain communities and their livelihood sources,

which may encourage migration to urban areas on a larger scale. Therefore, it has become crucial to safeguard against likely climate change impacts to ensure the safety and security of mountain communities' livelihoods and ecosystem services.

1.5.Objectives and Study Research Questions

The purpose of my research is to explore local peoples' observations and past experiences about the key challenges of climate-induced changes and related disasters faced by mountain dwellers in Gilgit-Baltistan. The research highlights how changes in climatic patterns are affecting the lives and livelihood sources of the local people. The study also focuses on how changes in the climatic parameters are perceived by local people with particular focus on the role of organizations, gender, and awareness education in coping with challenges associated with climate-induced changes and related disasters. The research also provides a roadmap on how to reduce the climate change vulnerability of mountain communities and their livelihood sources.

To meet these objectives, my overarching research question is *How do climate-induced changes and related disasters impact mountain communities in Gilgit-Baltistan, Pakistan, and how are local people responding to these changes?*

The sub-research questions are:

1. How are the residents of Passu village affected by climate-induced changes and related disasters?
2. How are the impacts of climate-induced changes affecting local livelihoods?
3. How are these residents adapting new strategies to sustain their livelihoods?

SECTION 2. LITERATURE REVIEW

This chapter begins to answer these research questions through a literature review of published sources. The chapter describes an overarching analytical framework of this study and highlights some of the complexities of climate change impacts on Pakistan. In particular,

it addresses the growing threat climate change poses to the livelihoods of vulnerable populations living in underprivileged areas in Gilgit-Baltistan. It also highlights how climate-induced changes and related disasters can exacerbate the poverty and food insecurities among marginalized mountain communities in Gilgit-Baltistan.

2.1. Climate Change Impacts on Pakistan

Climate change is impacting communities and countries around the world and further impacts are projected. Climate change as a threat multiplier represents an additional stress over an already resource-stressed country. The Brookings Institute's *Asia Third Assessment Report* illustrates that the intensity and frequency of extreme weather events in the region have increased over the past 20 years (Daniel and Ahmed, 2015). However, Pakistan is among the countries, which are hit hardest by climate change even though it contributes very little to global warming. These impacts are compounded by rapid population growth, unregulated development, terrorism, and over-exploitation of ecosystem services. Pakistan is significantly exposed to climate-induced disasters and related threats and has experienced a wide range of disasters over the past 40 years, including floods, earthquakes, droughts, cyclones, and tsunamis (Chaudhry, 2017). These hazards are striking in the country due to its geographical location on a seismically active geological plate. The active floodplain fed by snow and glacial melt from three mountain ranges (the Himalayas, the Karakoram, and the Hindu Kush) is triggering the intensity of extreme weather events whereas the coastlines and semi-arid lands are frequently hit by heat waves, droughts, and cyclones (Chaudhry, 2017). The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) for the Asia region notes that sensitivity to climate change threats in agriculture-dependent economies such as Pakistan, arises from their distinct geography, demographic trends, socioeconomic factors, and the lack of adaptive capacity, which determine the vulnerability profile of a country (Chaudhry, 2017). The fifth assessment report on climate change

projections for South Asia as a whole shows that warming is likely to be above the global mean. As a result, climate change will intensify the melting rate of glaciers and precipitation patterns as well as affecting the timing and strength of monsoon rainfall (Chaudhry, 2017). This will significantly impact the productivity and efficiency of water-dependent sectors such as agriculture and energy. It is evident that the rise in temperatures and variation in precipitation patterns will adversely impact the agricultural productivity as agriculture is the mainstay of Pakistan (Malik, et al., 2012). Projected climate-induced changes in Pakistan include strengthening of monsoon circulation, increase in surface temperature, and increases in the magnitude and frequency of extreme rainfall events. As a result of these changes and climate-induced disasters, major impacts can result on the country's biodiversity, ecosystem services, mountains and coastal lands, and human settlements and public health (Hussain et al., 2005).

Climate change is not the only issue in Pakistan that impacts the lives and livelihood sources of the millions of people. The vulnerability to the effects of climate-induced changes and related disasters is also exacerbated by existing poverty, geopolitical issues, trans-boundary conflicts, and terrorism. The vulnerability has become an important concept in hazard and risk assessment. It refers to the susceptibility of people, communities, and regions to natural, human-made, and technological hazards (Khan and Salman, 2012). The vulnerability is a function of the character, magnitude, rate of climate change, and the variations to which a community is exposed (Lal et al., 2011). The IPCC defines vulnerability as a function of exposure, the sensitivity, and the adaptive capacity of a system as shown in Figure 1. These three components are the key factors in determining a system's vulnerability to climate change and provide useful information for assessing and reducing climatic threats (Ludena and Yoon, 2015). However, from the socio-economic perspective, it is a result of how sensitive a system is to environmental hazards, and how effectively the affected people

can respond to reduce the effects of climate change (Ludena and Yoon, 2015). According to Schneider et al (2007), the concept of vulnerability is central to understanding how ecosystems, communities, institutions, and social relationships such as gender are affected by climate change. Although there is a considerable debate about the conceptualization and definition of vulnerability in the academic community, climate change vulnerability is a function of a society's exposure to stresses to which it is sensitive, and its capacity to adapt and respond to changes (Pouliotte et al., 2009).

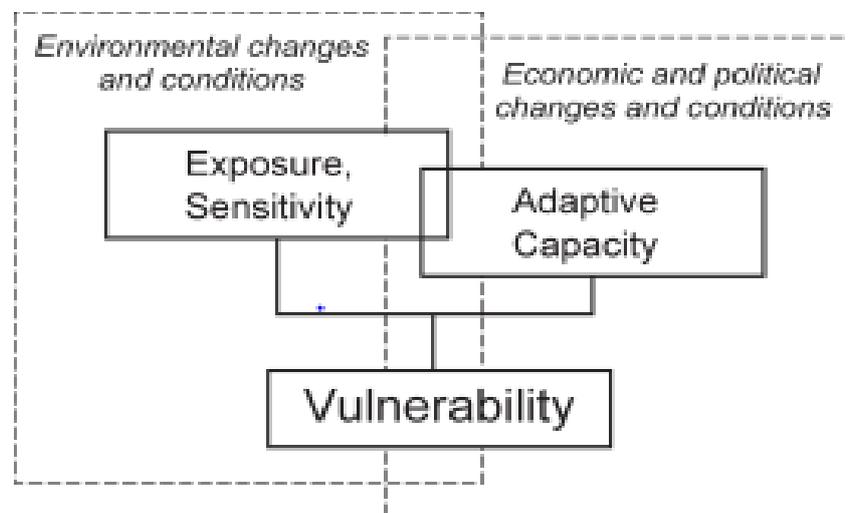


Figure 1. The vulnerability framework in the given chart describes vulnerability as a function of exposure to the impacts of climate change, the sensitivity of a system, and adaptive capacity (Pouliotte et al., 2009).

The conceptualization of vulnerability illustrates that climate change vulnerability differs considerably across different socio-economic groups (Schneider et al., 2007). For instance, in the context of key vulnerabilities, the impacts focus on aggregated impacts such as those impacts faced by island nations due to sea-level rise and the impacts faced by developing and the least developed countries in semi-arid regions due to a marginal agricultural base (Schneider et al., 2007). However, within developed countries, research on

vulnerability often focuses on those socially vulnerable groups of people who are living in coastal and flood-prone regions (Schneider et al., 2007). The concept of vulnerability is difficult to define, but the overall idea refers to the capacity of a person, group, or natural and human system to anticipate, adapt, resist and recover from the impact of natural hazards (Ullah and Takaaki, 2016). These definitions summarize that how vulnerable a country or society is to the effects of climate change depends not only on the magnitude of climate stimuli or their effects but also on the adaptive capacity of the affected system to cope with or adapt to such stress.

The application of vulnerability assessments to identify the main activities for adaptation has been well documented, and vulnerability assessment can take many forms such as climate change adaptation, disaster risk management, and poverty and development (Weis et al., 2016). Adaptation to climate change is defined as “adjustments in natural and human systems in response to actual or expected stimuli or their effects, which moderates harm or exploits beneficial opportunities” (Daniel and Ahmed, 2015, p. 308). Adaptation consists of measures and strategies to deal with the negative impacts of natural hazards and to address future consequences of climate change (Daniel and Ahmed, 2015). Climate change adaptation assessments aim to focus on social structures, such as human activities, in order to develop policies that will reduce risks associated with climate change (Weis et al., 2016). However, developing and implementing effective adaptation measures require access to economic, natural, and human resources. At a national level, vulnerability and adaptive capacity are measured based on economic development, availability of resources, education levels or indicators of human health (UNIQUE Forestry and Land Use GmbH, 2013). However, within a country, different regions and social groups have different adaptive capacities. Therefore, vulnerability to the effects of climate change also varies considerably among different regions and socio-economic groups within a country (Schneider et al., 2007).

In the context of Pakistan, effective and efficient climate change adaptation is a major governance issue due to conflict risk and the lack of national political will (Daniel and Ahmed, 2015, p. 308). Therefore, the World Risk Index report identifies Pakistan and Afghanistan as two of the most vulnerable countries in Asia with poor adaptive capacity (Daniel and Ahmed, 2015). Adaptive capacity is the ability to adapt and cope with climatic stress which relies on various factors, such as wealth, technology, education, and access to resources. However, in Pakistan, the combination of extreme droughts and conflict risk with low adaptive capacity make it challenging to implement a climate change adaptation agenda because adaptation is a long-term process that includes structural changes (Daniel and Ahmed, 2015). It is commonly understood that the poor are likely to be hit hardest by climate change because the capacity to respond to climate change is lower among the poorest residing in risk zones. To understand vulnerabilities of poorest to different hazards, it is important to identify who is poor because people who are most exposed and have least potential to recover and adapt to climate change are considered as most vulnerable (Ullah and Takaaki, 2016).

2.2.Climate Change Impacts on Gilgit-Baltistan

Gilgit-Baltistan (GB) of Pakistan plays a unique and vital role in the sustainable development of Pakistan. It has an area of 72,971 km², located in the extreme north of Pakistan, with an estimated population of 2,000,000 (Khan, 2014). It borders Afghanistan's Wakhan Corridor to the north, China to the east, Khyber Pakhtunkhwa (KPK) province to the west and India to the south-east as shown in Figure 2 (Khan, 2014). Gilgit-Baltistan is rich in biological diversity and hosts many endangered species such as snow leopard and brown bear (Khan, 2014). Nature has gifted this area with high mountainous ranges, massive glaciers, rivers, and splendid valleys. It serves as a major water catchment for the Indus River Basin (IRB), and the majority part of Pakistan heavily depends on it for hydropower and irrigation purposes (Khan, 2014). The mountain valleys of Gilgit-Baltistan are generally narrow, deep,

and steep in appearance. Natural beauty, snow-covered mountains, unique biodiversity, topographic differences, and a diversity of cultures and languages have attracted many scientists to conduct research in Gilgit Baltistan (Khan, 2014).



Figure 2. Given image is the map of Gilgit-Baltistan (GB). The red mark indicates Passu village, which falls under Hunza district.

However, the socio-economic conditions of mountain communities' depend heavily on the local resource base at all elevations although the specific agro-ecological and livelihood potentials vary considerably (Rasul and Hussain, 2015). The framework in Figure 3 also shows that agriculture, livestock, and horticulture are the main sources of livelihood at higher elevations across all mountainous villages in Gilgit-Baltistan. In addition, remittances, small business, wage labor, tourism, and collection of medicinal plants and other herbs also contribute to livelihoods and food security of mountain people (Rasul et al., 2014). However, over the recent years, various biophysical and socioeconomic factors have led to depletion of natural resources across the Hindu Kush Himalayan (HKH) region. This has resulted in a significant loss of ecosystem services, particularly in terms of soil nutrients, water, biomass, and food productivity (Rasul et al., 2014). The reduced productivity has led to a poor economic growth and intensified the vulnerability of mountain people (Rasul et al., 2014). Across all the vulnerable mountain villages, climate-induced disasters have threatened lives and livelihood sources of poor people. For instance, the receding glaciers and glacial lake outburst floods have led to the displacement of settlements, loss of property, land, and livestock. It has been recorded that the glaciers in northern areas of Pakistan are receding at a rate of almost 40 to 60 meters per decade, resulting in the formation of new glacial lakes (Gohar, 2013). In the past, 35 destructive glacier lake outburst floods were recorded in the Karakorum region which had led to huge amounts of destruction. To assess risks and vulnerabilities, a glacier lake outburst floods pilot project was launched in 2011 covering two sites in Northern Pakistan (Khan, 2014). Although the focus of glacier lake outburst flood project was to establish community-based disaster risk management, the project document did not mention incorporation of local adaptations on risk management, which could help the development of appropriate policies and to design sustainable interventions (Khan, 2014).

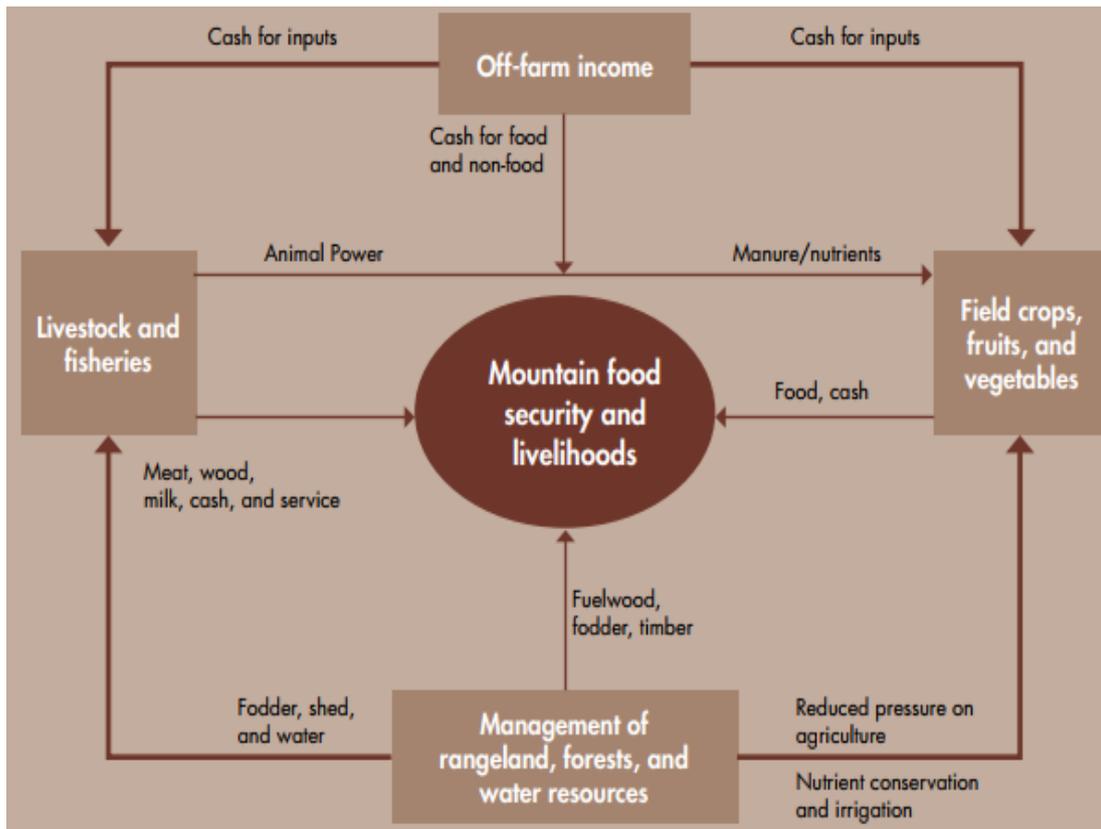


Figure 3. The chart shows main sources of food and livelihood security across the mountain regions in northern areas of Pakistan (Rasul et al., 2014).

Moreover, United Nations Environment Program scientists, working with experts from the International Centre for Integrated Mountain Development (ICIMOD) have used satellites and on-the-ground studies to pinpoint 44 glacial lakes formed in the Himalayan region of Pakistan (Gohar, 2013). It is evident that changes in the depth of mountain glaciers and in their seasonal melting patterns can have an enormous impact on water resources in Pakistan because the country's 70% of freshwater resources are coming from these glaciers and snowmelt in the high mountain areas of Himalaya and Hindu Kush (Hussain et al., 2005).

As the ecological and geological conditions of high altitude mountain ranges of Himalaya, Karakorum, and Hindukush are sensitive to climate change, such challenges can be reduced through research, systematic adaptation mechanism, improved mitigation, and by establishing early warning systems. Also, the incorporation of local knowledge on climate

change adaptation can strengthen the policies and practices on climate change (Khan, 2014). Mountains are considered to be sensitive indicators of global warming, a slight variation in temperature can lead to significant shifts in the local climate, which can in turn drastically affect the natural environment and local people's lives and livelihoods (Gohar, 2013). The decline in availability and quality of natural resources due to natural hazards can reduce the viability and security of their livelihoods because limited capacities and resources for responding to stresses constrain vulnerable communities' ability to meet basic needs and move out of poverty (John et al., 2014). Although climatic variability across all mountain regions is alarming, the urgent need to deal with the challenges of climate change also offers an opportunity for mountain dwellers to transform their livelihood strategies and promote new ways of reducing poverty, hunger, and food insecurities. One of the essential steps toward improving the quality of mountain communities' livelihoods and their socioeconomic conditions is the local community empowerment and engagement in nature-based adaptation solutions.

SECTION 3. FIELDWORK AND METHODOLOGY

3.1. Study Area and Climate-related Challenges

The nature of this research is exploratory to grasp a thorough understanding of climate change impacts and related disasters on socioeconomic conditions of mountain communities and their livelihoods. To investigate climate-related issues and challenges faced by mountain communities in Gilgit-Baltistan, I decided to conduct fieldwork in Passu village for several additional reasons. Firstly, Passu village is sandwiched between two massive glaciers, Batura and Passu glaciers, as shown in Figure 5. Thus, the rapid glacial melt can intensify local people's risk to the effects of flash flooding. In fact, the village had been geographically vulnerable to climate-related disasters such glacial lake outburst floods, river erosion, and sliding of snow avalanches. In the year 1884, a disastrous GLOF event occurred

in Shimshal valley, which originated from the advancement of Khurdopin glacier and led to huge destructions in the downstream areas including Gojal valley (Amin, 2018). Shimshal valley is located in the Central Karakorum Range of Pakistan, which is known for its massive north-faced tributary glaciers such as Khordopin/Yukshin Gardan, Yazghil, Malungutti, and Virzrav (Amin, 2018). In addition, strong rainfall events were recorded in 1992, which had led to the death of ten people in Passu (Steinbauer and Zeidler, 2008). Moreover, FOCUS Humanitarians Assistance Pakistan Gilgit had reported a glacier lake outburst flood event on 6th January in 2008 at Passu Glacier. In the same year, another GLOF event occurred in April at Ghulkin glacier (Din et al., 2014).

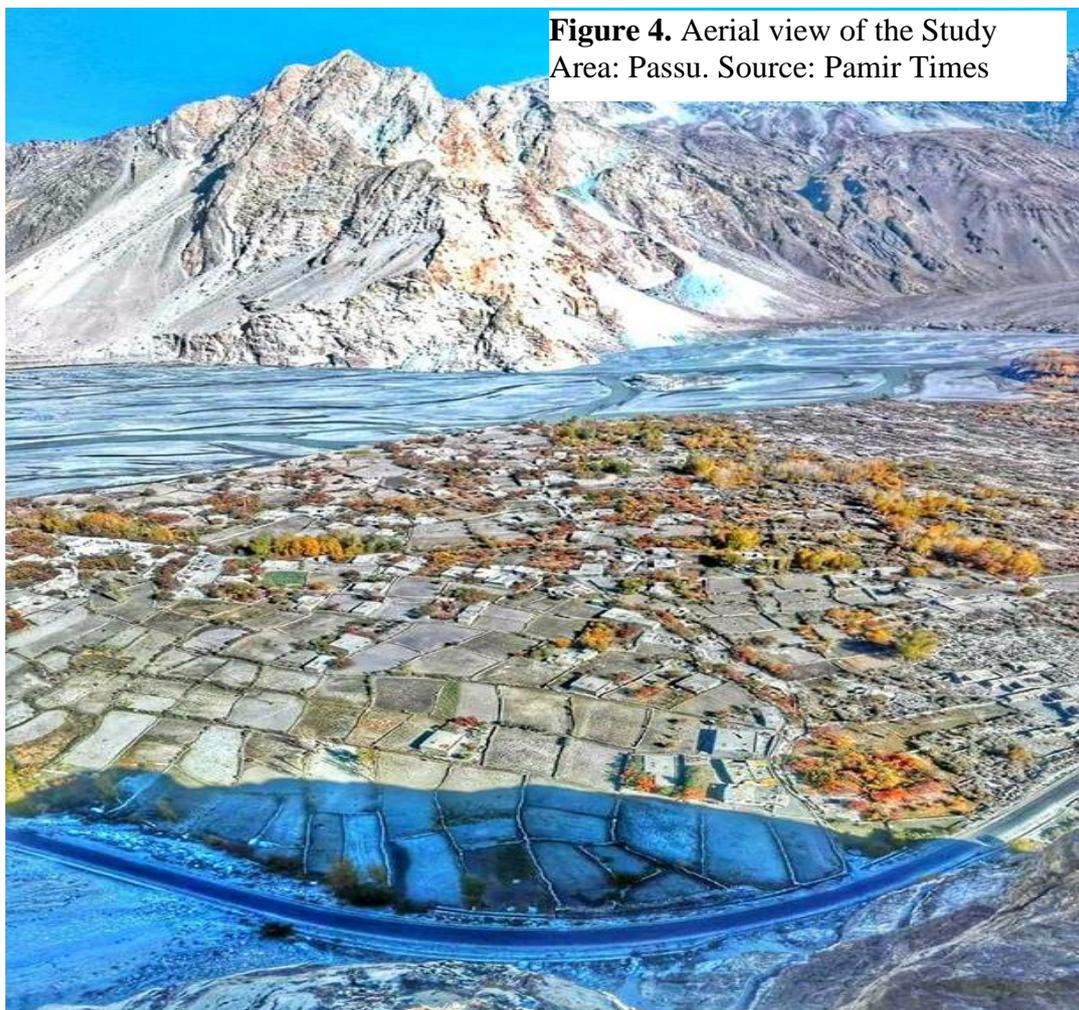


Figure 4. Aerial view of the Study Area: Passu. Source: Pamir Times

Secondly, a majority of the mountain villages in Gilgit-Baltistan are reliant on climate-sensitive sectors for food and income generation such as agriculture. However, frequent changes in climate and weather patterns can disrupt their annual agricultural yield while affecting the overall food production system. Passu, thus shares similar characteristics with many other mountain villages in Gilgit-Baltistan. In addition, water from glaciers and snowmelt is the main source of fresh water in Passu village and indeed in the entire country. However, the rapid melting of glaciers and snow with increased temperature can place significant pressure on resource-dependent communities both in rural and urban areas in Pakistan. Also, it is clear from the history of GLOF events occurred in Passu that vulnerability impacts of climate change on water availability and quality may likely to threaten the livelihood sources of the local people.

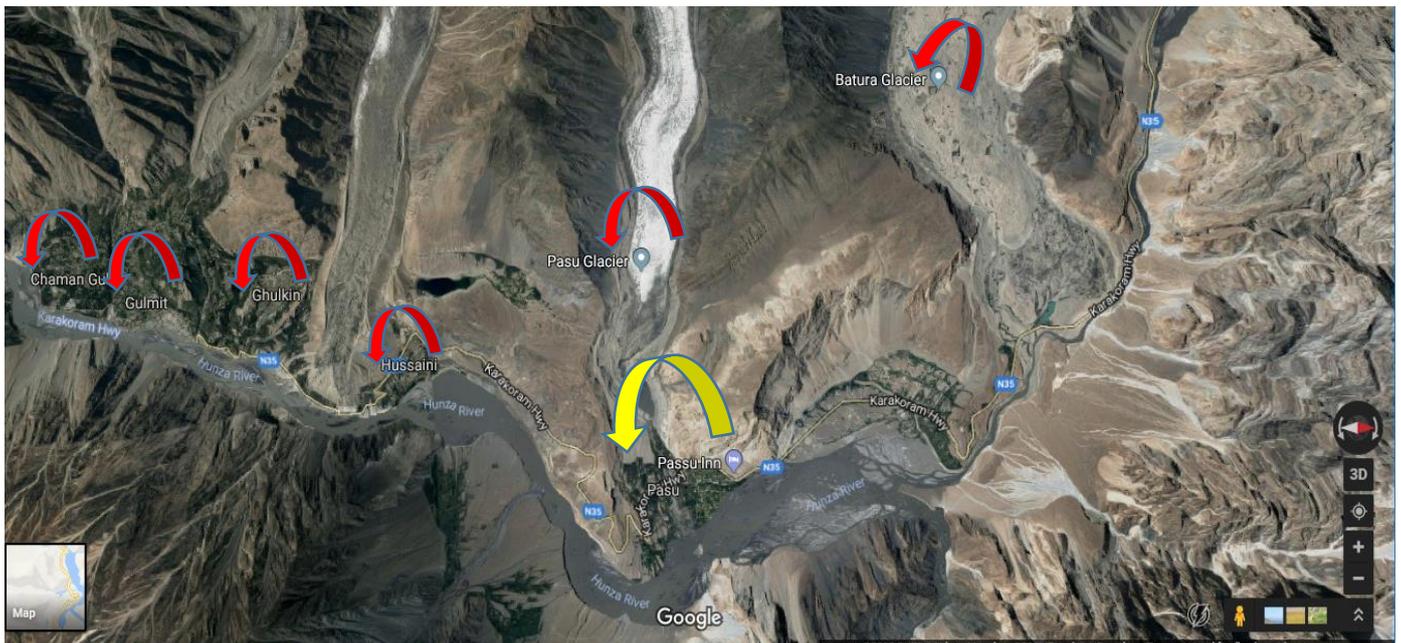


Figure 5. Given picture is a satellite image of Gojal. The yellow arrow shows study area, Passu, which is sandwiched between two massive glaciers (Batura Glacier and Passu Glacier). Source: Google Map

Last but not least, the lack of adaptive capacity and sustainable methods for managing climate-induced changes and related disasters restrain local people's ability to respond to a disaster in an effective manner. Therefore, documenting local people's perspectives about the impacts of climate change on socioeconomic conditions and livelihood sources of mountain communities is the main focus of this research. Given these reasons, I hypothesized that the residents of Passu village will be more vulnerable to the effects of climate-induced changes and related disasters. Although there are many other mountain villages in Gilgit-Baltistan, which are highly vulnerable to the effects of climate change, I decided to conduct fieldwork in Passu village for safety and security concerns. Moreover, Passu village is similar to other mountain villages as shown in Figure 5. However, it falls under the jurisdiction of my hometown, known as Hunza. Hence, to conduct fieldwork in a timely and effective manner, I decided to choose Passu village in order to investigate local people's perspectives about the impacts of climate change on their livelihood sources and socioeconomic conditions.

3.2.Data Collection

In the summer of 2017, I conducted household surveys and in-depth interviews with the local residents in Passu village to understand their perspectives about the changes they have observed in climatic patterns and their impacts on local people's livelihood sources. I was particularly interested in whether local people in Passu village had the same understating about the impacts of climate change on mountain people as the literature review conveys about the impacts of climate change on mountain ecosystem services and human settlements. I was also curious to know about the local people's action in response to a changing climate. Thus, to generate more information about general perceptions, observations, and experiences, I conducted 15 semi-structured interviews. By using the snow-ball sampling method, I selected interviewees while reaching out to the local residents who were older than 40 years. I was interested to speak with older people because of their past experiences and observations

about climate-induced changes over the past 30 years. Thus, I interviewed nine men and six women, who were above 40 years old. The interviewees were asked open-ended questions related to climate-induced changes, related disasters, and their impacts on the socioeconomic conditions of the residents of Passu village. The interviewees were also asked questions related to the differential impacts of climate change on gender and how institutional structures and community-based organizations have been playing roles in mainstreaming climate change adaptation in the context of this particular village. To understand the impacts of climate change from mountain people's perspectives, I asked following key interview questions about the impacts of climate change on socioeconomic conditions and livelihood sources of the residents of Passu village.

1. Have you ever observed any change in weather and climatic patterns living over the last 30 years? Can you explain with some examples how the climate change has occurred in your area?
2. Do you think the climatic patterns such as rain, precipitation, and snowfall have changed over the past 30 years? Can you share your experience about changes you observed in climatic patterns in your surroundings?
3. How climate change has affected your agriculture system? Can you share your experience and explain with some examples? What are the alternative means of your subsistence other than agriculture?
4. How climate change has affected your living standards, health, food, and shelter? Can you share your experience and explain with some examples?
5. Have you ever anticipated any climate-related disasters such as snow avalanche and glacial lake outburst flood?

6. Is there any agency in your local area/village/town or city, which conducts the awareness session/training/workshop on the impacts of climate change? Can you mention the name of agencies and explain briefly?
7. Have you ever attend any climate change related workshop/program/seminar/session/ training?
8. Can you share your experience and explain with some of the adaptation and mitigation strategies you practice? Can you share your traditional knowledge on adapting and mitigating climate change?
9. To what extent, the government agencies and other NGOs are helping you out to cope with the climate-induced changes?

In addition to these “key informant” interviews, I conducted 35 household surveys to better understand how climate-induced changes and related disasters have affected the socioeconomic conditions and livelihood sources of the residents of Passu village. By using the snow-ball sampling method, I selected each survey participant. It was my first visit to this village so I randomly selected the first survey respondent. However, I asked my first survey respondent to help me in finding the next household. In this way, I approached 35 survey participants, who were older than 25 years old. Out of 35 survey participants, 16 participants were male and 19 participants were female. To generate local people’s perspectives on climate change, I gave them close-ended questions to indicate the impacts of climate-induced changes and related disaster they have encountered over the past 30 years. Out of 35 survey participants, 14 participants filled out the survey questionnaires by themselves. However, I filled the remaining 21 survey questionnaires based on the participants’ responses. Given below is the household survey questionnaire.

Survey Questions

In addition to asking their name/pseudonym, age, gender, education, number of people at home, and recording the date and location, I asked:

1. Do you know what climate change is?
 - a. Yes
 - b. No
2. If yes, how did you hear about climate change?
 - a. TV
 - b. Newspaper
 - c. Governmental Organization
 - d. Private NGOs
 - e. Other
3. Have you observed any change in the local climate over the last 30 years such as wild summers, cold winters, and warm winters?
 - a. Yes
 - b. No
 - c. I don't know
4. If yes, have you observed any change in the volume of glaciers?
 - a. Yes
 - b. No
 - c. I do not know
5. Is climate change is threatening your livelihoods?
 - a. Strongly agree
 - b. Agree
 - c. Strongly disagree

- d. Disagree
 - e. Not at all
6. Is climate change impacting your agricultural practices and land use patterns?
- a. Strongly agree
 - b. Agree
 - c. Strongly disagree
 - d. Disagree
 - e. Not at all
7. Is climate change is affecting your water sources such as glaciers, snow, and ice?
- a. Strongly agree
 - b. Agree
 - c. Strongly disagree
 - d. Disagree
 - e. Not at all
8. Is climate change also influencing your livestock?
- a. Strongly agree
 - b. Agree
 - c. Strongly disagree
 - d. Disagree
 - e. Not at all
9. Have you observed any kind of change in rainfall patterns over the past 30 years?
- a. Yes
 - b. No
 - c. Not at all
10. If yes, how often does rainfall occur during monsoon period (May-September)?

- a. Two weeks
 - b. One month
 - c. Two months
 - d. Three months
 - e. Other
11. Have you observed any kind of change in snowfall patterns over the past 30 years?
- a. Yes
 - b. No
12. If yes, how often does snowfall occur in winter season?
- a. Once a month
 - b. Twice a month
 - c. Thrice a month
 - d. Other
13. Is climate change affecting particular groups such as women, children, and elderly?
- a. Strongly Agree
 - b. Agree
 - c. Strongly Disagree
 - d. Disagree
 - e. Don't know
14. Do you see any positive impacts of climate change?
- a. Strongly Agree
 - b. Agree
 - c. Strongly Disagree
 - d. Disagree
 - e. Don't know

SECTION 4. FINDINGS

This chapter offers an analysis of the impacts of climate-induced changes and related disasters on socioeconomic conditions of the residents of Passu village. It provides a detailed information about the changes in climatic patterns observed by the residents of Passu village over the past 30 years. The result section addresses my first two sub-research questions. The discussion part addresses the third sub-research question and main research question and the overall objective of this study. The results are analyzed based on the participant's responses about the observed changes and their past experiences related to the impacts of climate change on their socioeconomic conditions and livelihoods sources. My key research findings are compared with the literature of local, national, and international sources and studies on climate change impacts on mountain communities.

4.1. Respondents perceptions about observed changes in temperature, precipitation, snowfall, and seasonal monsoonal cycle in Passu village

Climate-induced changes and related disasters are impacting the socioeconomic conditions and livelihood sources of the residents of Passu village both direct and indirect pathways. The responses of the respondents to the questions related to climate change and its impacts on their livelihood sources clearly show that the residents of this particular mountain village are aware of the changes in the climatic patterns such as increased temperatures, increased rates of glacier retreat, decreased snowfall, and changes in rainfall patterns. This conclusion is confirmed based on the response rate of an interview question that I asked interviewees: "Have you ever observed any change in climate patterns over the last 30 years? Can you explain with some examples how the climate change has occurred in your area?" Each of the interviewees mentioned that climate has entirely changed in their local area over the past 30 years. For instance, in the past, the residents of Passu village used to get a lot of rainfall in summers and during the monsoon period. However, over the past 30 years, these

cycles have changed. The winters and summers tended to be longer, but these periods have altered over the past ten years. According to the Head Master of the Aga Khan Diamond Jubilee Middle School Passu, “the summers are getting hotter and starting early in the spring. In this particular area, the temperature has also increased over the past ten years. The snowfall and precipitation patterns have also changed within five to ten years. We used to get heavy snowfall when we were in schools, but now the weather patterns have been altered. As a result, we cannot harvest crops on time due to these shifts”. According to 11 interviewees’ personal observation, during monsoon period (June-August), they were getting heavy rainfall along with flash floods in the past. However, within 30 years of the period, the monsoon cycle has shifted, which starts earlier in May, and sometimes in April. As a result, rainfall patterns vary throughout a year, which entirely disrupts their annual agricultural yield.

Climate change has not only shifted the monsoon cycle in this area, it has also affected the water resources of the local people of Passu village. As upstream and downstream mountain populations are highly dependent on water resources from snow and glacier melt, the increase in global temperature can trigger melt of glaciers and snow. For instance, in the context of this mountainous village, the residents have observed that the volume of snowfall has reduced over the last 30 years. According to one of the interviewees (farmer-80 years old), “we used to get heavy rainfall and snowfall in winters. We were not even able to go outside or work in our fields due to extremely cold weather in winters, so we used to stay at home for the rest of the day. Every time, we go out, we never dressed up properly because we did not have access to such clothes as you are having now. Instead, we would wear an ancient long jacket made of wool (so-called “Choga”, woolen robe in the Burushaski language). While hunting in winters, we never had put on shoes because we did not have proper shoes. Instead, we had leather footwear (so-called “tawchin” in the Burushaski language). With the passage of time, everything got change including our living

style and weather patterns. ” Other interviewees also mentioned that they used to get heavy snowfall during winters followed by wetter summers, which would prevent them from grazing their cattle in near pasture lands. However, the local people have observed that the snow-covered mountains surrounding their village have completely lost snow and have become more prominent. According to one of the interviewees (a news reporter from the Passu Times), “the temperatures have increased over the past years. We can see that winters are warmer now as compared to past decade. We have also seen that the snow is melting rapidly due to increased temperature. The reduction in snowfall can lead to a crisis in water resources in the next decade because glaciers in our area are also retreating. We are not sure whether we will have access to fresh water for drinking and for harvesting our crops if all the glaciers and snow, melt at unprecedented rates. Unfortunately, we do not have access to advance technology to restore rainwater or water from snowmelt and glacial melt. Therefore, we need to understand the possible consequences of climate change on our livelihood sources in the next decade”.

4.2. Local perception of the impacts of climate-induced changes and related disasters on their socioeconomic conditions

Based on my interviews with local people, the residents of Passu village are aware how climate-induced changes and related disasters are impacting their socioeconomic conditions and livelihood sources. To find the local people’s perceptions on how the impacts of climate change lead to their own socioeconomic vulnerability, I asked the question: “How climate-induced changes and related disasters have affected your agriculture and livelihoods sources?” Each of the interviewees mentioned that climatic variability and climate-induced disasters have affected their lives and livelihood sources over the past decade. According to one of the female interviewees (she is a nurse at the Aga Khan Health Center in Gojal), “I have personally experienced that the temperature has drastically changed over the years. The

summers are becoming milder. In the past, we used to work in our agricultural fields in the afternoons after coming from our schools. We could visit our pasture three to four times in a day. But now, it is even harder to sit outside for a while. I have also observed that the rainfall is not constant throughout the year. Sometimes, there would be heavy rainfall that would wash away all our agricultural fields. As our lands and homes are situated along the Hunza River, our lands are always eroded due to a rise in the level of the Hunza River during summers”. Similarly, other interviewees mentioned that the variations in the climatic patterns have affected their annual agricultural yield due to variation in the monsoon cycle. In the past, they could maximize their annual yield because crops and fruits would ripe on time. However, with increased temperatures, now they do not harvest their crops on time due to heavy rainfall earlier in spring, which destroys the flowering of fruit trees while reducing the annual agriculture yield.

Passu village is sandwiched between two glaciers, named Batura and Passu glacier, as shown in figure 4. Aman Ullah is a Community Emergency Response Team (CERT) captain, who is also responsible to monitor these two glaciers. According to his personal experience, these two glaciers have reduced their volume over the past few years. It was easier for him to graze his pasture when these glaciers were covered with mud. According to Aman Ullah, “I remember, these two massive glaciers used to be covered with mud over the past 50 years. It was easier for me to graze animal because there was a clear path on these glaciers. But now, there is no any path neither we graze anymore because the volume of these glaciers has been reduced over the years. Now, we can clearly see glaciers”. Other interview respondents also mentioned that these two glaciers have lost their volumes over the past 30 years. According to the personal experiences of the respondents, the glacier retreat had also led to flash flooding and destroyed their land over the past years. According to Aman Ullah, there was a disastrous flooding in summer of 2004 due to runoff from Passu glacier, which devastated the

surrounding area. Another interview respondent also mentioned that there was a flash flood earlier in summer of 2010 due to heavy rainfall and runoff from Passu and Batura glaciers. As a result, their means of communication and infrastructure were completely damaged.

In addition to these “key informant” interview responses, the survey participants also indicated the changes that have occurred in this particular village over the past 30 years. When I asked the question, “Have you observed any change in the local climate over the last 30 years?” Each of the survey participants answered “Yes”. Their responses show that climate change has already been observed by the residents of Passu village. Each of the survey participants indicated that the volume of glaciers has been receding over the past 30 years. In additions, they indicated reduced snowfall in winters, heavy rainfall in summers, warmer winters, hotter summers, and early spring. Moreover, when I asked the question about the impacts of climate-induced changes and related disasters on their agriculture system, livestock, water availability, and food security, 30 survey participants chose “Strongly Agree”. Their strong responses show that climate-induced changes and their effects have already been felt by the local people in Passu village. The following Table 1 summarizes the responses of the survey participants about the changes they have observed over the past 30 years such as receding glaciers, variations in snowfall and rainfall patterns, and a shift in the monsoon cycle. It summarizes that the selected survey participants have already encountered the impacts of climate-induced changes and related disasters over the past 30 years. It also shows that the selected survey participants have become aware of the possible consequences of climate change on their water resources, agriculture, food security, and health.

Table 1. The table summarizes the responses of the survey participants about climate-induced changes and related disasters they have and their impacts on local people’s livelihood and socioeconomic conditions

<i>Impacts of climate change and observed changes over the past 30 years</i>	<i>Percentage of response rate=$n/N*100$</i>
<ul style="list-style-type: none"> • Observed change in local climate over last 30 years • Receding glaciers • Less snowfall, heavy rainfall, wild summers, and a shift in the monsoon cycle 	<p>Yes 35; No 0, 100% of response rate</p>
<ul style="list-style-type: none"> • Impacts of climate-induced changes and related disaster on agriculture, water resources, food security, health 	<p>Strongly agree 30; 85% of response rate Agree 5 15 % of response rate</p>

SECTION 5. DISCUSSION

As Passu village had periodically become vulnerable to GLOF events and natural disasters in the past, I hypothesized that climate change vulnerability of the residents of Passu village would be higher now due to climate-induced changes and related disasters. However, the personal experiences, observations, and perspectives of interviewees show that the climate change vulnerability of the residents of Passu village is lower due to strong institutional contribution in building adaptive capacity and resilience among local people. Over the past decade, the climate-induced changes and related disasters had affected the residents of Passu village due to the lack of awareness among local people, poor adaptive capacity, and weak institutional structures. However, with the passage of time, various

institutions have played a fundamental role in raising awareness and educating local people about climate-induced change and related disasters. By organizing community-based resilience activities and practical simulations, governmental and non-governmental organizations have built adaptive capacity and resilience among local people. This is confirmed by the results of questions that asked interviewees to share their technical knowledge and experiences on how to respond to a disaster. The questions asked: “Is there any agency in your local area/village/town or city, which conducts the awareness session/training/workshop on the impacts of climate change? Can you explain briefly to what extent the government agencies and other NGOs are playing their roles to build community-based resilience against climate-related disasters in the context of your village?” Each of the interviewees indicated that they have attended at least one session and training and simulations related to pre and post-disaster response. According to one of the interviewees, WWF-Pakistan and International Center for Integrated Mountain Development (ICIMOD) have been also organizing workshops and awareness session for relevant stakeholders at district, provincial, and national levels including local communities, journalists, media, and representatives from public and private sector organizations and institutions.

In addition, in each of the interviews, the participants clearly mentioned that governmental and non-governmental organizations are playing a fundamental role in this particular village to raise awareness among local people in order to reduce the possible consequences of climate-related disasters and threats in their local area. They mentioned that both men and women have been actively engaged in different capacity building activities so that they can respond effectively when a disaster strikes. According to one of the interviewees (retired school teacher), “Our lives would have been different if NGOs were not established. We were not familiar with natural hazards, and we did not know how to respond to a disaster. However, we thank Aga Khan Development Network (AKDN) for playing a

fundamental role in protecting our lives and livelihood sources in our area. In particular, we thank FOCUS Humanitarian Assistance Team for engaging us in developing community-based disaster management plans (CBDRM) and village-based disaster management plans (VBDRM). Now, we have CERT and VERT teams, which play an active role in assessing and disseminating risks related to natural hazards. Now, we have become familiar with evacuation and shake-out drill, and we are confident to react when a disaster strikes.”

According to one of the interviewees’ responses (an archeologist), “We thank all those NGOs which are working in our region in order to educate us and raise awareness among our local people. By educating us through capacity building training and sessions, we have now understood that a well-educated population with reasonable and diversified income sources and developed institutional structures is better at managing and preventing climate-related risks and damage”. Most of the interviewees mentioned that Aga Khan Rural Support Program (AKRSP), International Center for Integrated Mountain Development, Aga Khan Agency for Habitat (AKAH), FOCUS Humanitarian Assistance Pakistan, and Pakistan Ministry of Environment have been actively working in their local area on different projects related to mitigation, Hazard Vulnerability Risk Assessment (HVRA), glacial lake outburst floods, and monitoring GLOF risk.

The local people’s response, personal experiences, and observations reflect that institutions play a fundamental role in reducing the vulnerability of households and communities. According to one of the interviewee’s responses, “A massive glacial lake outburst floods event occurred in Shimshal at Virzrav glacier back in 1981, which had completely devastated our land and the entire Passu village. We were in a terrible condition because we lost all our agricultural lands. However, we really pay our sincere gratitude to the Aga Khan Rural Support Program (AKRSP), for supporting us at the time of a disaster. AKRSP bought us another patch of land, where some of the Passu villagers live there. The

AKRSP has also done plantation for us in that piece of land as well in other parts of Passu in order to reduce possible damage and cost that may arise with flooding, debris flow, and landslide.” This positive feedback of the interviewees shows that institutional engagement within a community plays a key role in strengthening the adaptive capacity of households, communities, and societies to adapt to changes effectively. It indicates that such institutions as the information provider, play an important role in raising awareness among local people about climate risk. The capacities of institutions and their networks are essential structures in effective implementation of climate change adaptation (UNIQUE Forestry and Land Use GmbH, 2013). Many in-depth studies show that organizations, networks, and social relations between families, friend, and neighbors play a positive role in enabling households and communities to cope with natural disasters (UNIQUE Forestry and Land Use GmbH, 2013). For instance, community organizations can have positive roles in enabling households and individuals to access natural resources or better manage their crops. The positive response of the interviewees indicates that higher level organizations and community-based forums are enabling households to prepare for and cope with climate risks. By providing resources, knowledge, and technical support, these institutions strengthen community-based resilience against natural hazards. Hence, this case study shows that higher level organizations play key roles in proactive planning and policy-making to address climate variability and longer-term climate change. Conversely, certain laws and policies implemented by higher level organizations can increase the vulnerability of communities to climate change (UNIQUE Forestry and Land Use GmbH, 2013). For instance, restricting community access to natural resources such as restricting pastoralists in moving their herds in times of droughts or policies that cause degradation of mangrove forests to enable shrimp farming (UNIQUE Forestry and Land Use GmbH, 2013). The lack of coordination across administrative boundaries may constrain adaptation options, such as herder movements to new pastures. At the same time,

communities may face stresses not only from climate risks but also from governmental bodies and organization which operate at large scales (UNIQUE Forestry and Land Use GmbH, 2013).

In addition, the residents of Passu village have adopted new strategies to reduce their socioeconomic vulnerability to the effects of climate-induced changes and related disasters. For instance, the Passu residents have minimized their reliance on climate-sensitive sectors such as agriculture and subsistence farming. Barley, black and green peas were formerly grown, but now wheat and potatoes are mostly grown as cash crops in Passu village (Steinbauer and Zeidler, 2008). Agriculture is given less importance by local people in Passu village because agricultural yield has been reduced over the past ten years due to shifts in monsoon cycle. Although they harvest some of the cash crops, they are less engaged in agricultural practices. The reason given is an overall change in lifestyle an adaptation strategy for them to reduce their vulnerabilities and food insecurities. They are more engaged in other sectors such as tourism. The literature also shows that dependency on agriculture for income generation due to a narrow range of limited resources often leads to social and economic stresses. Therefore, diversity of income, social stability and resilience of the community can minimize the vulnerability to the effects of climate change (UNIQUE Forestry and Land Use GmbH, 2013). From my personal experience, I have also observed that Passu is one of the best tourist destinations in the world. The snow-covered mountains, natural beauty, massive Atta Abad Lake, Karakorum Highway, and glaciers can attract tourists from all over the world. In fact, they have started building hotels in various locations in Passu, which can strengthen their socioeconomic conditions and promote more equitable approaches toward sustainable development.

Moreover, the local people have changed their house construction in order to reduce the possible damage that may be associated with natural hazards. As elsewhere in the world,

the residents of Passu village are also using new materials for constructing their houses. This is confirmed by the interview question that asked: “How has climate change affected your living standards, health, food, and shelter? Can you share your experience and explain with some examples?” According to one of the interviewees, “due to poor facilities, we were constructing our houses with simple materials that were available in the market. Whenever it rained heavily, it often destroyed our roofs. The rainwater seepage from roofs also rotted wood and other materials. As a result, some of the local people had even lost their houses due to heavy snowfall and rainfall.” The responses of local people show that new materials and traditional designs are more suitable to local conditions in this particular village. Their perceptions about the house construction is a basic example how they have adapted in relation to their local climatic conditions. Since adaptation is a process of change, it is often deliberate and under the influence of a number of factors that affect lives (Khan, 2014).

Moreover, the residents of Passu village have adopted migration as an alternate option to reduce their socioeconomic vulnerabilities. Most of the residents of this village have started migrating to urban areas as well as to other countries such as Canada and United States. According to one of the interviewees, “My son also lives in Canada with his family”. Another interview participants mentioned, “Me and my wife live here to look after our house and lands. However, my sons and daughters live in America with their families”. Two of the interview participants also mentioned that their relatives have recently moved to the US with their families. Moreover, in each of the interview, participants have clearly mentioned that at least more than two family members from their households are living in urban areas for the sake of jobs and higher education. According to the interviewees’ responses, migration is one of the adaptation mechanisms that has been adopted by the residents of Passu village over the past decade to improve their quality of life and to reduce their reliance on climate-sensitive sectors. According to Macchi et al, outmigration of young household members has become a

vital livelihood strategy that reduces the dependence of mountain communities on natural resources (2010). In the context of Gilgit-Baltistan, past studies have shown that migration from rural to urban areas is predominantly seasonal. The financial remittances from migration contribute about 25% of GDP, which is a significant source of cash income for mountain communities in Gilgit-Baltistan (Khan, 2014). To generate evidence-based reliable knowledge about the role of migration and remittances in upper Indus Basin, World Wildlife Fund for Nature Pakistan (WWF-Pakistan) and International Center for Integrated Mountain Development (ICIMOD) have implemented a pilot project in Hunza and Nagar districts of GB through an action research titled “HIMALICA: Rural livelihoods and climate change adaptation in the Himalayas” (Khan, 2014). This HIMALICA project aims to build adaptive capacity among local communities through technical training related to the flood preparedness and flood resilient value chains. A baseline survey conducted in villages of Hunza and Nagar districts for HIMALICA project shows that 60% of the sampled households heads travel on a daily basis to different areas for jobs and to earn income (Khan, 2014). Although migration may equip mountain communities with financial and social remittances, it can place a significant burden on rural-urban linkages (Macchi et al., 2010). In the context of Gilgit-Baltistan, the number of migrants from upstream areas to downstream areas can increase with an increase in environmental shocks. On the other hand, outmigration will not necessarily reduce climate change vulnerability of marginalized mountain communities because migrants may experience other forms of social and economic vulnerabilities in urban areas. Therefore, according to my views, to reduce the climate change vulnerability of mountain communities and the repercussions of outmigration, more economic opportunities need to be created across all mountain villages in Gilgit-Baltistan for sustainable development of mountain communities.

The experiences and perceptions of the residents of Passu village show an awareness of the impacts of climate change on their socioeconomic conditions and livelihood sources. However, their responses predict that increased temperatures will accelerate glaciers and snowmelt, resulting in rapid and earlier spring runoff in their local area. In fact, if the freshwater runoff is reduced in the summer months due to earlier snow and glacier melting, soils and vegetation will become drier, which may increase the risk and intensity of wildfires (Hussain et al., 2005). Mountainous villages like Passu will experience more intense heavy rains in the summer due to shift in the monsoon cycle. As a consequence, the runoff will wash away more sedimentation and soil nutrients. It will also affect vegetation cover, disrupt agriculture, and may threaten overall biodiversity (Hussain et al., 2005). In general, if water quality and availability become increasingly scarce with increased temperatures, the ability to absorb these stresses and cope with new changes will become more critical for natural resource-dependent communities (Füssel, 2009). Therefore, in the context of Gilgit-Baltistan, it is important to build resilient infrastructures to manage and restore water resources in order to reduce vulnerabilities and food insecurities among mountain communities.

On the other hand, it is possible that increasing temperatures may have a positive impact on agriculture in the mountain areas. In the high mountain areas, the practice of only one crop per year is prevalent on almost half of the arable land due to low temperatures (Hussain et al., 2005). The future increases in temperature will make it possible to grow two or more crops per year due to the shortening of the growing season length for winter crops. The shortening of the growing season length due to rise in temperature will help the winter crops to mature in the optimal period of time, with beneficial effects on crop area and yields (Hussain et al., 2005). Past temperature trends in the high mountain areas such as in Chitral district have already led to the shortening of the growing season length which certainly has helped in increasing wheat yield as well as crop area in these high mountain areas (Hussain et

al., 2005). Nevertheless, like Passu village, all mountain villages in Gilgit-Baltistan need to have proper awareness and education about climate-induced changes and related disasters. To reduce climate change vulnerabilities in all mountain villages in Gilgit-Baltistan, I think that adaptation measures should be effectively implemented at all levels in order to enhance local people's resilience and adaptive capacity against anticipated changes. To reduce climate risks and damage, integrated disaster risk reduction and climate change adaptation measures need to be implemented at all levels so that local people can respond effectively. For some of the poor mountain dwellers, reducing their reliance on climate-sensitive sectors may not be easy. It may ultimately trigger their poor socioeconomic conditions. Also, migration is not the alternate option for poor mountain dwellers. It is possible that migrating to the urban areas may lead to other forms of vulnerability. Therefore, to reduce climate change vulnerability amongst marginalized mountain dwellers in Gilgit-Baltistan, local people need to be equipped with skills and practical adaptation and conservation solutions so that they can sustain their livelihood sources. For the poorest and the most vulnerable communities living in fragile environments and degraded lands in Gilgit-Baltistan, these response measures should also address the deteriorating environmental conditions that undermine their livelihoods and capacity to cope with disasters.

Research Limitations

Although I successfully conducted my fieldwork in Passu village, there may be some key limitations in my research. After analyzing my surveys and interviews' responses, I found that "key informant" interviews have generated more information about local people's observations and experiences than household surveys. Through open-ended discussion and conversation with interview participants, I learned more about the impacts of climate-induced changes and related disasters on socioeconomic conditions and livelihood sources of the residents of Passu village. Each of the interviews equipped me with an insightful knowledge

and information about the adaptation strategies that have been adopted by the local people in Passu village over the past decade in order to reduce their vulnerability and reliance on climate-sensitive sectors.

Indeed, each household survey was conducted in an effective manner. However, the 21 survey participants' responses were not explanatory. When I asked survey questions, each of their responses was simple, which did not allow me to grasp a thorough understanding of the impacts of climate change on their livelihood sources and socioeconomic conditions. This can be one of the limitations of my research. However, I learned from my own fieldwork experience that to better understand local people's perspectives and personal experiences about climate change impacts on their livelihoods, in-depth interviews are more effective in knowledge production than household surveys. I could have conducted more in-depth interviews than household surveys. However, it is not easy to conduct fieldwork in remote areas during summers, where a majority of the rural poor spend their time in agricultural practices. Similarly, I conducted my fieldwork in summer, so it was a bit challenging to convince both survey and interview participants due to their busy schedules.

In addition, I learned that poor understanding of the local language of a study area becomes an obstacle in conducting fieldwork with the local people. As I do not share the same language with the local people of Passu village, so I conducted all my surveys and interviews in Urdu. However, when I was conducting "key informant" interviews, there were three participants, who could not even understand Urdu. Every time I asked questions, one person from each house was translating their responses from their local language "Wakhi" into Urdu. I think that this could be another limitation of my research because it is possible that I might not have understood their exact responses. I was not expecting that I might need an enumerator because I assumed that my respondents would be able to understand Urdu.

However, from my own field-experience, I learned that it is important to understand the local people's culture of the study area before we depart on to conduct our fieldwork.

SECTION 6. CONCLUSION

This study addresses sub-research questions and a major research question, "*How do climate-induced changes and related disasters impact mountain communities in Gilgit-Baltistan, Pakistan, and how are local people responding to these changes?*" The key findings of my fieldwork conducted in Passu village show that the local people have clearly observed changes occurred in the climatic patterns such as increased temperature, reduced snowfall, variations in rainfall patterns, shifts in monsoon cycle, early summers, and warm winters. The sub-research question about the impacts of climate-induced changes on local livelihoods reflects that climate-induced changes and related disasters have significantly impacted the socioeconomic conditions and livelihood sources of the residents of Passu village over the past decade in the form of glacial lake outburst floods, river erosion, and runoff. The local people have lost their lands due to flash flooding and river erosions. The annual agricultural yield has also fallen over the past 30 years due to the shifts in the monsoon cycle. As a consequence, local residents have reduced their reliance on agricultural practices.

However, in recent years and at present, the residents of Passu village have not encountered any climate risk or threat because they have adopted different adaptation strategies to cope with the possible challenges that may be associated with climate change in the future. The local people's perceptions and personal experiences illustrate that some of the local people have adopted migration as a coping strategy to reduce their vulnerability. However, others who currently live in Passu village have changed their lifestyle by reducing their reliance on agriculture in order to minimize possible vulnerabilities and food insecurities. They have adopted different professions and engaged themselves in other

activities for income generation. They have also strengthened their adaptive capacity by engaging and educating themselves in different sessions and training related to disaster preparedness, risk reductions, pre-and post-disaster response, and monitoring glaciers.

In short, this case study concludes that climate-induced changes and related disasters impact socioeconomic conditions and livelihood sources of mountain communities in different ways. Local people's perceptions and experiences reflect that vulnerability to climate change impacts tends to be greater in those mountainous villages where the majority of the population is dependent on agriculture and livestock, and tend to have a poor adaptive capacity and weak institutional structures. However, significant contributions from higher level institutions can play a pivotal role in reducing climate change vulnerability of mountain communities in Gilgit-Baltistan. The efforts and support from these institutions can minimize the exposure of resource-dependent mountain communities to the impacts of climate change. This can be approached by conducting awareness sessions and campaigns, and engaging communities in capacity and resilience building activities to enable them to cope and adapt to a changing climate. More research is needed across all mountain villages in Gilgit-Baltistan, to address possible consequences of climate change on all aspect of life. Such research should also focus on designing integrated mitigation and adaptation measures for precise assessment of the impacts of climate change. Last but not least, there is a great need to establish long-term observatories and monitoring mechanisms across Gilgit-Baltistan that will allow researchers and local experts to build reliable and long-term data on mountain climates and predictions of climate change and its impacts on mountain dwellers.

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