Research Article

Climate Change, Hydro-Meteorological Hazards and Adaptation for Sustainable Livelihood in Chitral Pakistan

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Abstract | This study contributes to the knowledge in the area pertaining to the Disaster Risk Reduction under overall domain of adaptation to climate change. Understanding occurrence and impacts of hydro-meteorological disasters on people's well-being and which livelihood assets are significant for identifying coping strategies to deal with disasters are important ingredients to increased resilience of communities living in disaster prone areas. This study relies on the data collected using the Community-based Risk Screening Tool – Adaptation and Livelihoods (Cristal) to map major risks and vulnerabilities along with coping strategies then ascertaining their relationship with community-based livelihoods assets. According to results, there are three frequent disaster risks in the study area which comprise avalanches, landslides and floods. These disasters inflict a heavy damage to the livelihood assets including crops, water, houses and other physical infrastructure. In order to overcome these losses, communities apply short-term coping strategies by spending limited means and hard-earned cash reserves. These unsustainable strategies further exacerbate vulnerabilities and give way to new ones. Taking empirical example of Chitral, the study recommends to formulate policies and encourage investment to substitute short term coping strategies with long term climate change adaptation measures in order to minimize impact of devastating disasters in future. There is a need for improved governance of irrigation water management, channel management and effective management techniques for on-farm water.

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Introduction

The recent increasing hydro-meteorological hazards including untimely torrential rains leading to floods, cyclones in several counties and droughts are associated with climate change (www.hindawi.com 2018 and UNFCCC, 2007; IPCC, 2014). These events have caused damages to properties, livelihoods as well as to lives around the world. Response to these events by the international community as well as the national governments has been to support the affected communities after the events have occurred. Post disaster response although very crucial for rehabilitation of the affected communities, we argue that only post disaster response is not enough and sustainable due to climate change indicators that suggest frequent events to continue in the future. Short-term response without building a common understanding of nature of disaster risks diverts attention from taking long term measures and increases longer-term vulnerability. Climate change adaptation (preparedness) and humanitarian

response (assistance in the aftermath of emergency) because of extreme climatic events have been treated largely in distinct research and policy spheres (Agarwal and Perrin, 2009). However, both scientists and practitioner communities increasingly relate these two emphasizing the need for preparedness to make response more effective and efficient (O'Brien et al., 2008; Red Cross, 2009; DFID, 2011; Nizami and Hussain, 2015). Relating these two fields will result in transforming vulnerability into longer-term resilience. Emergency response is usually short-term, focuses on search and rescue, temporary and rebuilt shelter, health, food aid etc. (Macrae, 1998; Macrae, 2002; Kiragu, 2009). Climate change adaptation on the other hand, has a comprehensive focus on long-term solutions comprising adjustments in systems and practices to potentially minimize negative consequences and maximize opportunities implying from actual or anticipated climate change (IPCC, 2007, 2012 and 2014).

Thus, the objective of this research is to generate study area specific knowledge to understand occurrence and impacts of hydro-meteorological disasters on people's livelihood and proposing coping strategies to deal with disasters to increase resilience of communities living in disaster prone areas.

Disaster Risk Reduction (DRR) is about mitigating impact of potential disasters and resilience building among communities by anticipating events and addressing risk factors that cause disasters. DRR sees things under the overall ambit of climate change adaptation. Our understanding of vulnerability, the nature of disasters, and adaptation to climate change has evolved and broadened during recent years (Adger, 2003; Nizami and Robledo, 2010; Ali et al., 2016). Literature shows that impact of disasters is directly proportionate with vulnerabilities, institutional, and social processes (Wisner et al., 2004; Agrawal, McSweeney and Perrin, 2008; Agrawal and Perrin, 2009). As a driver of vulnerability, poverty leads to increasing exposure to risks and multiplies the chances of risks turning into large hazards and disasters. In contrary, a more optimal combination of livelihoods assets deployed for preparedness and social wellbeing reduces the impact of disasters. The literature on climate change vulnerability understands vulnerability as driven by multiple stressors (Watts and Bohle, 1993; Polsky et al., 2003; Turner et al., 2009; UNFCCC, 2007; UNISDR, 2007). Vulnerability to climate change is exacerbated due to a range of environmental and social changes, and circumstances in which people live. Vulnerability can be exacerbated by non-climatic stresses, e.g., poverty, food security, conflicts, incidence of diseases, unequal access to resources, economic globalization etc. (UNFCCC 2007; UNISDR, 2007).

As depicted in the 5th Assessment Report of IPCC (IPCC, 2014), global surface temperature is to increase above 1.5°C. The temperature to continue rising afar 2100 in all scenarios with the exception of scenario having lowest CO2 emission. With the higher rates of emissions scenarios, by 2100 the likelihood of warming is to surpass 2°C. In certain parts of the world it could surpass even 4°C. The scenario arising from increasing temperature at global level is expected to pose new challenges particularly to the countries which are more vulnerable to effects of climate change. Climate Change Vulnerability Index puts Pakistan among the 32 most extreme risk countries when evaluated using the criteria; the physical exposure of the country to climate related risks, sensitivity of the population to climate risks, and the governmental capacity to adapt to climate change over the next 30 years (Maple Croft, 2015). Pakistan had experienced frequent hazards since the year 2010. The recovery cost of 2010 flood has been estimated to the tune of US$ 8,740 to 10,850 million (GoP, WB and ADB, 2010). In the year 2010 floods caused heavy damages to cultivated land with crops and inflicted loss of livelihood assets to rural population. In 2011 floods, Sindh province was affected the most where 5.2 million people badly suffered and an area of 2,280,000 acres covering crops was damaged as reported by UNOCHA (2011) and such floods continued in various districts every year till 2017.

The mounting alarms regarding climate change and increasing events of natural hazards resulted in coming up of a national Climate Change Policy (CCP) in the year 2012 as well as formation of a new ministry called Ministry of Climate Change aiming mainly at the adoption (GoP, 2012). One of the important objectives of the CCP is to lessen the risk(s) ascending out of anticipated increase in occurrence and intensity of extreme weather events including droughts, floods and tropical storms as referred by GoP (2012). A number of studies also argued that the climate of Pakistan is changing which include; Hussain and Hanif (2013), Hanif and Ali

(2014), Akmal et al. (2014). Presently, around 50 to 80 percent of the annual average water flows in the Indus system is generated from the glacier and snow melting in the Hindu Kush-Karakoram (HKK) part of the Greater Himalayas. The rest of the water flow in the system is added from the monsoon rains on the plains as argued by Yu et al. (2013). Unpredictability, both in the timing of snowfall and its distribution as well as variations in the glacier and snow melting might be augmented through climatic change having effects for the country in general and for the agriculture sector in particular. Agriculture contribution to GDP is 19.5% with labor employed to the extent of 43% (GoP, 2017; Pakistan Water Gateway, 2008; GoP, 2007). Studies argue some positive impact of climate change for higher altitude areas indicating prospects of increasing yield and area under wheat production to mountainous areas above 1500m where currently wheat is not grown because of shorter and colder growing season (Hussain and Mudassar, 2007).

It is important to know about ways for anticipating the risks and vulnerabilities triggered by climatic changes and involvement of other factor(s) in order to identify appropriate measures to enhance local resilience. Some of the researchers based their studies on household surveys and descriptions to understand the magnitude of recently occurred disasters or apparent risks of occurring natural hazards of various types. Mustafa et al. (2011) contended in their study that although descriptions and narratives have improved the understanding about multiple drivers causing vulnerability but such studies could put only little impact on hazard and climate adaptation policy. There are many ways of conducting risk and vulnerability assessment. South et al. (2013) referring the UN report on disaster risk reduction argued that risk measurement is a methodology to assess the extent and nature of risk(s) through examining possible hazards and evaluating existing conditions of vulnerability that together could potentially harm property, exposed people, services, environment and livelihoods of the communities. Beside technical characteristics of hazards such as location, frequency, intensity and probability, the risk assessment is based on the analysis of exposure and vulnerability including the social, physical, health, environmental and economic dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities in respect to likely risk scenarios. We founded our study on this definition on a premise that risk assessment and reduction strategies are embedded in adaptation planning which is also founded on these elements.

Therefore, the current study provides an insight into the significance of formulating specific policies and make informed investment to reduce vulnerabilities and risks and adapting strategies to safeguard communities' wellbeing and scarce livelihood assets from disasters.

Materials and Methods

The methods and material used in this study are explained as following.

The study area

This case study was conducted in the Garam Chashma Valley district Chitral of Khyber Pakhtunkhwa province. Two sub-valleys of Garam Chashma Valley namely Gobor and Karimabad were selected for this study. The eight clusters of villages included in the study were Murdan, Gobor, Begusht and Doaba in Gobor; and Karimabad, Shogor, Parsan, Hearth and Susume in Karimabad. The selection of areas was purposeful due to access and availability of men and women clusters. Chitral is the northern most and the largest district at an altitude of 4,921 feet above sea level with a latitude and longitude of 35_ 51^{0}N and 71_ 50^{0}E, respectively. Chitral is a mountainous area and is disposed to natural disasters such as snow avalanches and flash floods from steep valleys. The mean annual temperature in Chitral district is 16^{0}C (minimum 8^{0}C and maximum 24^{0}C). Temperatures in winter usually drops around minus (-)5. The district receives an annual total rainfall of 451mm with heavy snowfall during winter, especially in the high mountains. Subsistence agriculture and natural resources serve the main source of livelihood for local communities.

Garam Chashma in local language means hot spring. The valley is located at approximately 45 kilometers (2 hours' drive) northwest of Chitral town through steep mountainous road, lies between latitude of 35°59'42"N and a longitude of 71°33'32"E with an average elevation of 6099 feet above the sea (Khan et al., 2013). The weather of Garam Chashma Valley is usually cold with heavy snowfall received during winters that makes the valley inaccessible by road.

Summers (June to September) are mild and pleasant. The estimated population of the valley is 25,835 living in 2923 households spread over 47 revenue villages. Beside seasonal labour and government jobs, the main income sources for local people include crops, livestock, horticulture and poultry rearing. Major crops grown in the area include maize, wheat and potato. The presence of hot springs in the valley attract tourists' attention. Patients with ailing skins from other parts of Chitral and the rest of the country also frequently visit Garam Chashma. These limited livelihood resources are crucial for communities in a steep mountainous context and the physically challenging distance at which people of Garam Chashma are located from Chitral and the rest of the country.

Information gathering

This study is an effort to document hazards and coping strategies based on livelihoods assets with the help of primary data from district Chitral of Khyber Pakhtunkhwa (KP). This study makes use of Community-based Risk Screening Tool, Adaptation and Livelihoods (CRiSTAL) tool for mapping key risks and vulnerabilities as well as livelihood assets and their relationship with coping strategies applied at the community level. This methodology is in line with the UN Office for Safety and Security (UNDSS, 2013) guidelines for steering risk and vulnerability estimation. The data for this research study come from seven contiguously situated groups of villages. The study elaborates the importance of livelihood assets for implementing long term coping strategies in the study area and how livelihood sources are impacted by natural hazards.

CRiSTAL capitalizes on two key sets of information. One, based on secondary data on ecological, livelihoods and climate contexts within which CRiSTAL discussions and analysis are being undertaken. Two, based on primary data collection through holding discussion with a defined group at local level using participatory methods. This is a major part of CRiSTAL exercise which helps users to fully understand and analyze local vulnerability context of the population. The discussion takes an account of current and potential climate hazards which may influence communities' livelihoods and assets that are most affected by climate induced hazards; and at the same time are important for planning response strategies. CRiSTAL exercise essentially counts on good probing and listening abilities of the facilitators. The representatives, women and men, from different villages and clusters gathered at a common place for full day exercise to analyze hazards and vulnerability context of each cluster. Women and men from the clusters included village and cluster activists, staff of local NGOs, teachers and opinion makers.

Climate trends in Chitral

This study has also benefited from climate assessment (Hanif et al., 2016) that reported that climate of Chitral is changing rapidly since base years selected for the study (1971-2010). Climate scenarios of Chitral were developed separately for North and South Chitral and are documented as a separate study.

In case of North, increasing trend of annual rain up to 2030 has been noted, then indicating a declining trend (Figure 1). The Winter rain gradually increasing in coming decades, small increase in the spring rain till 2020, then gradually decreasing, minor increase in summer rain for the next 5 years the then continues decline while the fall rain is showing continuous minor increasing trend.

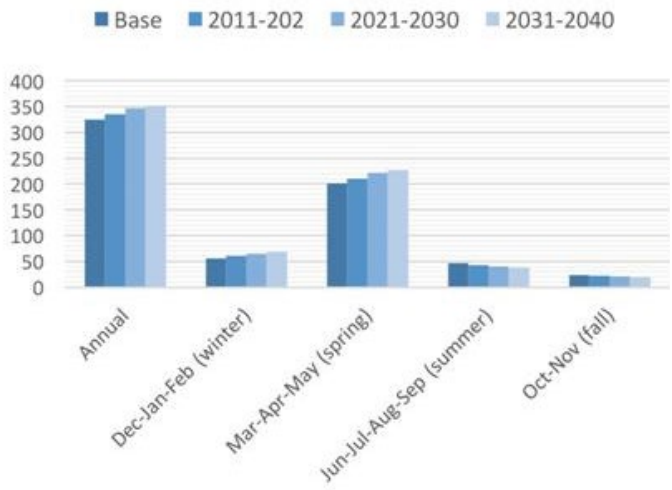

Figure 1: *Rainfall Scenario of North Chitral (mm).*

Temperature data (North)

(Figures 2 and 3) indicate that both maximum and minimum mean annual temperatures are increasing. Maximum temperature is increasing with a higher rate. Whereas the minimum has a slower increase in comparison to the base years (1981-2010). This means days are getting hotter than the nights. An overall average decadal rise in mean annual temperature noted.

Temperature increase is about 0.6 ^{0}C. This pattern

of temperature increase has been observed for all the seasons. Mean annual temperatures, both maximum and minimum, are increasing. In every individual season, temperatures show an increasing trend in days and nights. Increase in days is higher than in the nights therefore the degree with which days are becoming warmer is higher than the warming of nights. It is important to note that the increase of day temperatures in winter is higher than other seasons.

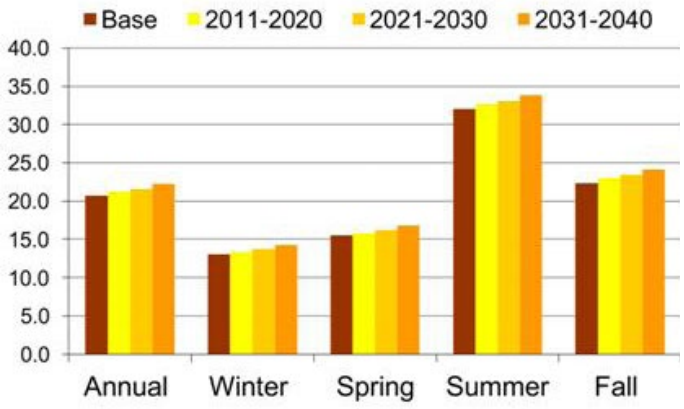

Figure 2: *Mean Maximum Temperature in North Chitral (⁰C).*

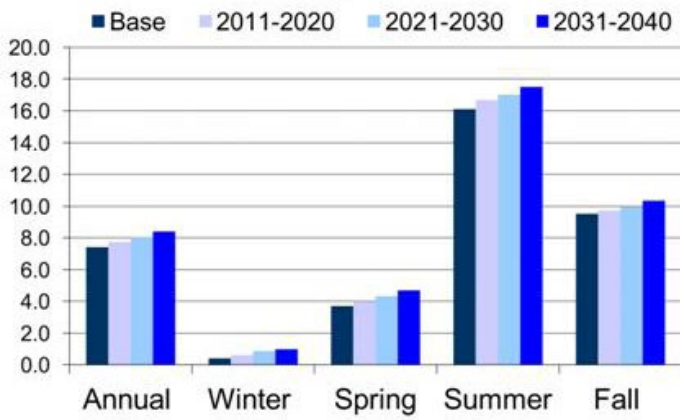

Figure 3: *Mean Minimum temperature in North Chitral (⁰C).*

In case of South, annual rain shows increasing trend up to 2030 then indicating a declining trend (Figure 4). The winter rain is declining till 2020 then increasing, Spring rain increasing till 2020, stable during next decade then showing a sharp decrease, the summer rain is increasing in next 5 years and then gradually decreasing, while the Fall rain indicating minor decline in the next 5 years and then gradually increasing.

Temperatures data (South)

Figures 5, 6 and 7 show that both the annual maximum and minimum temperatures are increasing. Like in case of North, maximum temperature is increasing with a higher rate than increased noted in minimum temperatures in comparison to base period (1981-2010).

This implies that the days are getting warmer than the nights. An average increase in mean annual temperatures is about 0.6 ⁰C per decade. This pattern of increasing trend for maximum and minimum temperatures has been observed for all the seasons. In every individual season, temperatures show an increasing trend in days and nights except in case of winter nights when the current decade shows a trend of cooler nights and then temperatures increase rather sharply. In several instances, temperature increase in nights is higher than in the days therefore the degree with which nights are becoming warmer is higher than the warming of days.

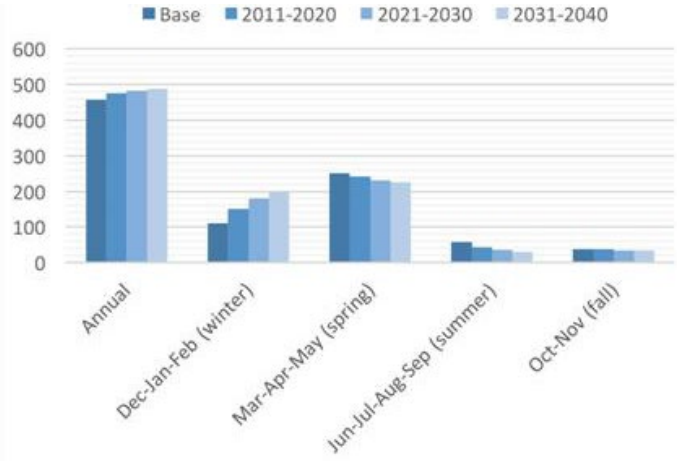

Figure 4: *Rainfall Scenario of North Chitral (mm).*

Results and Discussion

Important livelihood resources

As a first step to the exercise, the communities listed important livelihood resources that are most important to them in the order of priority. These assets fall in five types of livelihood assets namely social, financial, physical, natural, and human. The respondents enlisted resources in the order of significance for their livelihoods (scale 1-3). The graph (Figure 8) presents livelihoods assets indicated rather frequently by the groups. The graph shows that the groups had a higher inclination towards social and natural assets whereas financial and physical assets were placed as the second most prioritized resources. Water was indicated as the most important natural resource which is crucial for local livelihoods. Interestingly, water channels were not ranked high among physical assets. These

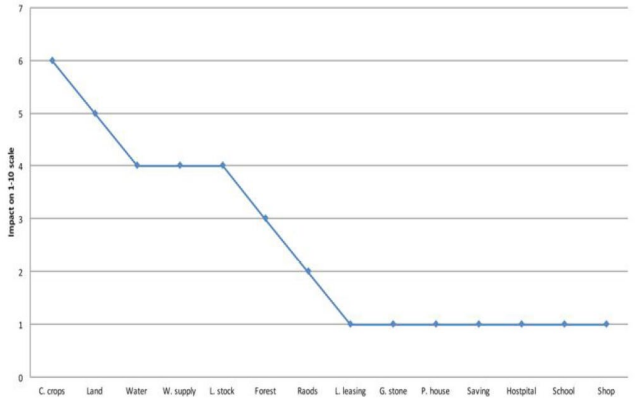

Figure 5: *Impact of hazards on livelihood resources.*

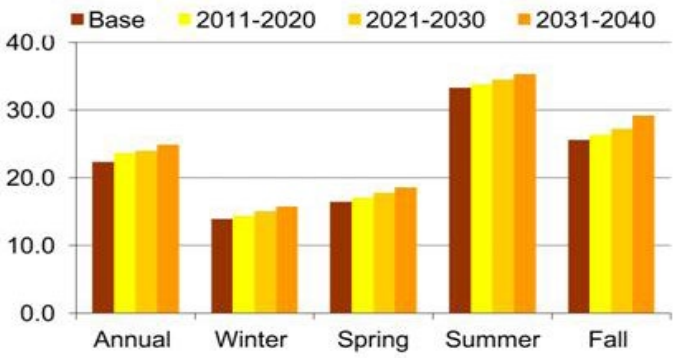

Figure 6: *Mean Maximum temperature in South Chitral (°C).*

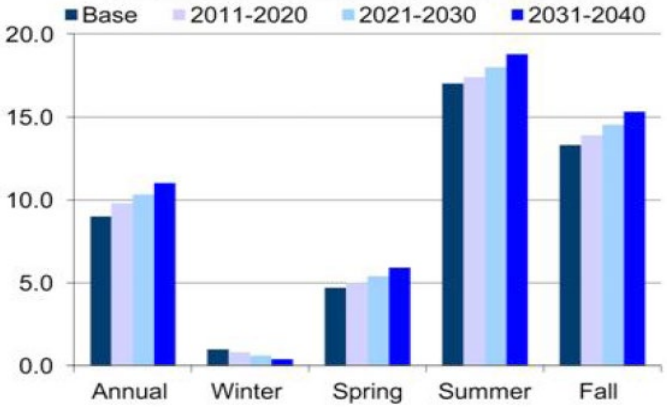

Figure 7: *Mean Minimum temperature in South Chitral (°C).*

channels were built by NGOs in the 80s or even earlier during princely rules.

Other physical assets namely health centers, schools, and micro-hydel units were ranked high because they are associated with local employment opportunities. Under each group of livelihoods assets, one or two resources were identified as very important for people's livelihoods. These include minerals and water, health center and school buildings, cash crops, livestock and savings, fabric *patti* making, social organizations and volunteers.

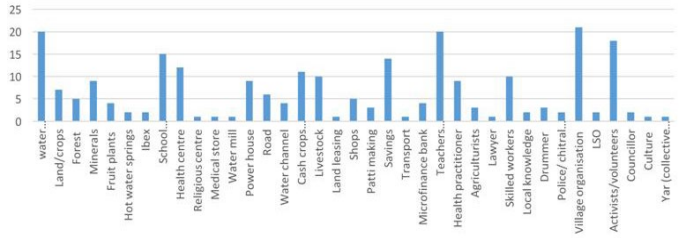

Figure 8: *Most important livelihood assets.*

Main Hazards in the Area

The respondents from each cluster were asked to select three top most hazards from the list of hazards identified in Chitral. The cluster selected 6 hazards. Some hazards are common in most villages whereas others are cluster specific. For example, avalanches are the most frequent hazard in the study area. People choose safer locations for building settlements to prevent disasters. However, flash floods are perceived to cause greater damage than other hazards. The ranking of hazards by perceived severity is given in Figure 9.

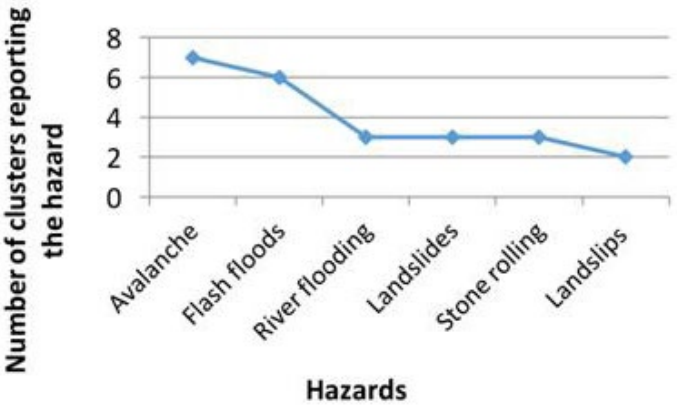

Figure 9: *Frequency of hazards by type.*

Floods, due to unpredictable and intense rains, have caused damages to crops, land and property frequently during the last 30 years. Chitral is generally not a monsoon area. However, in recent years unprecedented intense short duration rain showers have increased as reported by the clusters, triggering landslides and flash floods. There is no significant increase in rains in terms of quantity on an average. However, there is an increased intensity in rainfall recived which causes problems. Severity of hazards varies among clusters. Communities have ranked landslides as the third most severe hazard. However, it is reported by three clusters only. Another form of landslide was identified as a hazard called landslips by Murdan and Parsan clusters. Landslips are slower form of landslides. Severity of both phenomena was reportedly high (3 on a scale 1-3). Three clusters situated close to the rivers

report river over-flooding and heavy glacial melting. This phenomenon increases with temperature rise and accelerated glacial melting. River overflows have severely damaged several villages situated along the river. Three clusters also reported stone rolling, however the severity of this hazard is not high. According to respondents, landslip is relatively newly noted and very serious hazard for the two clusters (3 on a 1-3 scale). The landslips phenomenon has been analyzed by another study (Ali and Nizami, 2017) suggesting water seepage from mismanaged irrigation causes this issue at higher altitudes of Chitral.

The severity of impact of hazards on livelihood assets was ranked on scale 1-5 (1 being minimum and 5 being maximum). Figure 10 illustrates that cash crops are most severely affected by hazards followed by land, water and livestock as reported by most of the respondents. Damages to cash crops were recorded by 6 clusters on a scale of 5. Five clusters reported damages to cultivable land. Damages to livestock and water were recorded on a scale of 4.

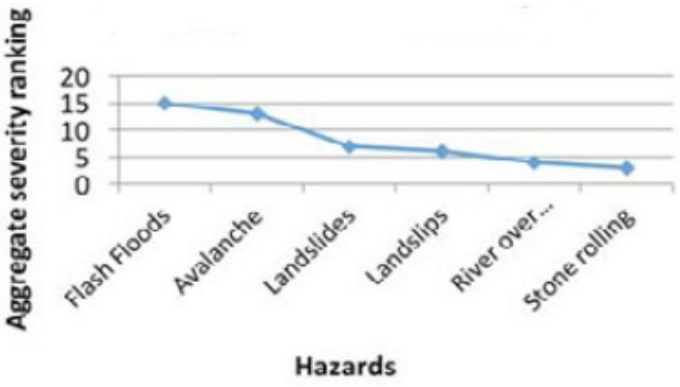

Figure 10: Severity of hazards by type.

One reason for reporting cash crops being so high on damages is because potato is cultivated on large scale and which fetches crucial cash income for the farmers' livelihoods. Other resources including roads and forest trees also receive severe damaged. Another important cash resource is gemstone excavation, collection and marketing. These activities are impacted in various ways. Collectors are exposed to stone rolling during collection whereas gemstone collection sites are vulnerable to landslides. Floods and landslides result in roadblock which impact transportation and marketing of agriculture produce and gemstones. This analysis leads to the fact that hazards directly affect cash resources of the people living in these clusters. The people affected by disasters also drastically lose their savings in repairing properties that may slip again.

The magnitude of damages resulting from disaster depends on the type of hazard that hits a village. Landslide often results in damaging water supply schemes, roads and other public infrastructure such as schools and power houses. Agricultural lands and water sources are damaged due to river over-flooding. Landslip are unique and occur in steep villages damaging agricultural land, houses and any other construction. Stone rolling, Landslides and avalanches hamper diggings and collection of gemstones. The efforts must be directed at minimizing hazards risks depend on hazard types in a given area and the type of damages potentially inflicted by the hazards. This study for instance narrows down multiple hazards risks to specific villages, including landslips in Murdan and Parsan clusters of villages, river over-flooding in Gabor, Doaba and Susume flash floods in Murdan, stone rolling in Parsan and avalanches and landslides in nearly all the areas. It shows that despite the study area is a one large valley where eight clusters are contiguously located, there are cluster to cluster differences and commonalities in hazards risks helping identify appropriate coping strategies. Figure 11 presents an aggregated hazards severity impact as reported by the clusters.

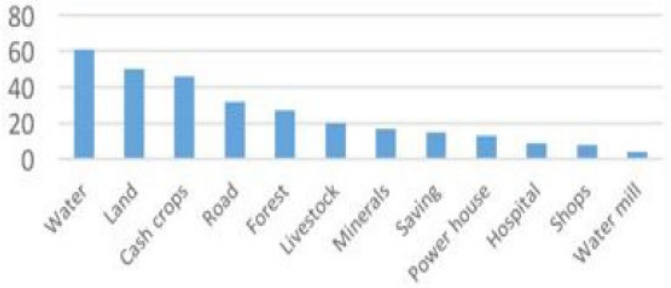

Figure 11: *Hazards Severity Impact on Livelihood Assets.*

In summary, graphically it shows that land, water resources (including piped drinking water), forests, roads, cash crops, minerals and livestock receive the maximum damage from hazards. The loss of resources, especially cash crops impact people's cash reserves, income and overall well-being.

Communities decide on choosing local coping strategies according to magnitude of hazard and its impact on important livelihood assets. Availability of certain livelihood resources influence choice of coping strategies. However, some essential ingredients

for improved coping from hazards may be missing, including but not limited to, human skills such as search and rescue skills for people trapped under avalanches and debris, first aid, and so on. Figure 12 is an aggregate picture of most frequently deployed resources to cope with the situation in case of a disaster. Financial, social and natural resources are the most important in the event of disasters.

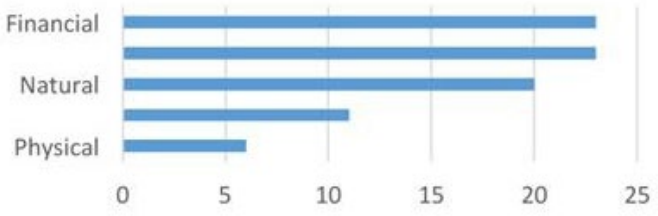

Figure 12: *Livelihood Assets in the order of preference to cope with Hazards.*

There is little support sought from human resources, such as individuals with skills and education and physical resources (buildings, roads).

Comparing this with Figure 6 (livelihood resources), we find several complementarities but also differences. One major difference is that the human and physical resources enlisted by the people as very important, are of not much use in the event of disaster. Personal savings (either in the form of cash, cash crop reserves or livestock) are deployed first in parallel to the support extended by social network of village organizations and volunteers.

Another coping strategy among farming families is temporary migration of men to urban areas for jobs. Most of the men fail to acquire well-pad jobs and send attractive remittances, however the result of this movement is increased burden of responsibilities on women. Women look after farming and water management in addition to their usual chores at household level. Often women are not prepared to handle new responsibilities since they do not have the right skills and experience for the tasks that are usually performed by men and hence they are subject to new place-based vulnerabilities.

The foregoing results are in line with a number of other studies carried out in different regions. Some of these include GoP (2012), Wisner et al. (2004), Agrawal, McSweeney and Perrin (2008), Agrawal and Perrin (2009), Nizami and Ali (2017), Hussain and Hanif (2013) and Akmal et al. (2014).

Conclusions and Recommendations

Chitral's climate induced disasters suggest that there are clear trends in terms of frequency and types of disasters. These disasters/hazards frequently inflict damages to natural assets of the people including land, crops, water and livestock resources. The damage is also done to local minerals which are considered the lifeline for local communities. The coping strategies applied by the people are usually short-term like deploying all of their savings. In very extreme cases, temporary shelters or partial migration are opted to cope with the situation. The response of the local people to disasters is unsustainable as disasters eat up altogether the hard-earned savings of the people and leave them vulnerable to coming disasters.

In addition, climate change has consequences for water regime, growing crop and crop yields. Simultaneously changes in precipitation patterns are occurring that has consequences for the people's daily life as well as for resilience of agricultural systems.

It is therefore recommended that it is high time to formulate policies and encourage investment to substitute short term coping strategies with long term climate change adaptation measures in order to minimize impact of devastating disasters in future. It is crucial that the communities living with risks are supported in taking long term adaptation measures and improving their quality of lives. Adaptation strategies are also needed for managing irrigation water efficiently. There is a need for improved governance of irrigation water management, channel management and effective management techniques for on-farm water.

Author's Contribution

Arjumand Nizami: Conceived research theme, analysis of data, interpretation of results and drafted results.
Jawad Ali: Data collection, review of literature and drafted conclusion of article.
Muhammad Zulfiqar: Reviewed analysis and finalized article.

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