



Research Article

Climate Change and its Impact on Water Resources of Selected Areas in District Chitral with High Climatic Vulnerabilities

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Abstract | Climate change is most significant environmental problem affecting human activity, either directly or indirectly, and it has an impact on every community in the world. This study examines the local community's perception of climate change and its impact on water resources of selected areas in district Chitral with high climatic vulnerabilities. General observations and a survey based on questionnaires were used to collect field data. The questionnaire survey used both closed-ended and open-ended questions as a tool. This study was conducted in the three villages of Upper, middle and lower Chitral (Buni, Garam Chashma and Darkhanandeh) respectively. Of district Chitral, which were most affected by the floods. For field survey, random sampling method was used. A total of 212 respondents including farmers, personnel from government departments and NGOs were interviewed. The results of the survey revealed that almost all respondents were aware of climate change, which has effect on rainfall and seasonal temperature pattern of the area. Almost all the respondents reported that deforestation is the primary factor contributing to climate change. There is moderate decrease in the frequency of summer and winter rainfall. Number of flood events has risen as summer rainfall intensity has increased and its duration has decreased. Similarly, risk of floods has increased because of the change in climate. The foremost reason of this increase in risk of floods has been attributed to increase in rainfall intensity and snow and glacier melt. However, dry periods has increased by 2-3 weeks according to majority of the respondents. All the respondents mentioned that the temperature has changed of the area in the last 25 years, which has resulted in GLOF (Glacial Lake Outburst Floods). Most of the respondents reported that they have experienced the disasters (such as flash floods, drought, GLOF, landslides and windstorms) in the last 25 years. According to majority of the respondents (76%) the discharge of major rivers in Chitral has increased. The quality of surface water has degraded due to sewerage and poor sanitation activities. The water use by farmers for irrigation is diverted from streams and springs on demand basis. Climate change is happening in the area and people are facing its effects on their lives. Therefore, in order to minimize damages by climate change in future, community should be trained on climate change adaptation/mitigation, water quality management and rainwater harvesting practices etc.

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Introduction

One of the biggest issues of the twenty-first century is the global climate change. There is overwhelming evidence that climate change is real and occurring at an unprecedented rate (Gedefaw *et al.*, 2018; Huang *et al.*, 2016; IPCC, 2014). Climate change is having a negative impact on food and livelihood security, causing land degradation and increased displacement, and altering precipitation patterns and frequency of extreme weather events (Zommers *et al.*, 2016; IPCC, 2018, 2019). Currently, 971 million people reside in areas with high or extremely high exposure to climate hazards (Global Peace Index, 2019). In least developed countries, many of the most vulnerable populations live, and among those populations, women, the young, the old, and the poor are the most disfavored and vulnerable to the effects of climate change (IPCC, 2018, 2019). Pakistan is one of the top nine countries where climate risks are most likely to occur (Global Peace Index, 2019). Due to extreme weather events between 1999 and 2018, Pakistan was ranked as the fifth most affected country in the world (Eckstein *et al.*, 2020).

Extreme weather events and climate change effects aggravate the country's already severe problems of poverty and food security. Pakistan experienced 152 extreme weather incidents between 1998 and 2018, which resulted in 9989 deaths and \$3.8 billion in economic losses (Abubakar, 2020). Pakistan has seen a number of natural catastrophes, notably the severe droughts from 1999 to 2003 and the ensuing floods in 2010, 2011, 2012, and 2014 (Khan *et al.*, 2020).

District Chitral has experienced numerous catastrophic events over the past few years, including flash floods, GLOFs, and extremely strong earthquakes. This is because the district is incredibly susceptible to even the slightest variation in atmospheric conditions (Baig *et al.*, 2021). Global warming is predicted to cause more glacier and snow melt in the Hindukush-Karakoram-Himalaya (HKH) regions in the future (Laurent *et al.*, 2020).

In Pakistan, studies on climate change and its impacts on water resources are rare, particularly in the Khyber Pakhtunkhwa (KP) Province, which is extremely exposed to and prone to natural calamities. Such research is necessary to improve future planning, policy development, mitigation and adaption measures.

Therefore, the current research was conducted to know the local community's climate change perception and its impacts on water resources of district Chitral.

Materials and Methods

Description of research site

This research was carried out in Chitral, the largest district in Khyber Pakhtunkhwa with a total area of around 14,850 km². This district lies at 36.25° N and 72.25° E. It is located in Pakistan's north and has borders with Swat and the Dir districts to the south, Gilgit to the east and Afghanistan to the west (Hussain and Hasan, 2014). District Chitral was selected for the study because there is limited work done on climate change in the area and it is the most vulnerable and flood affected district of KP. Map of the district Chitral showing the selected villages in Figure 1.

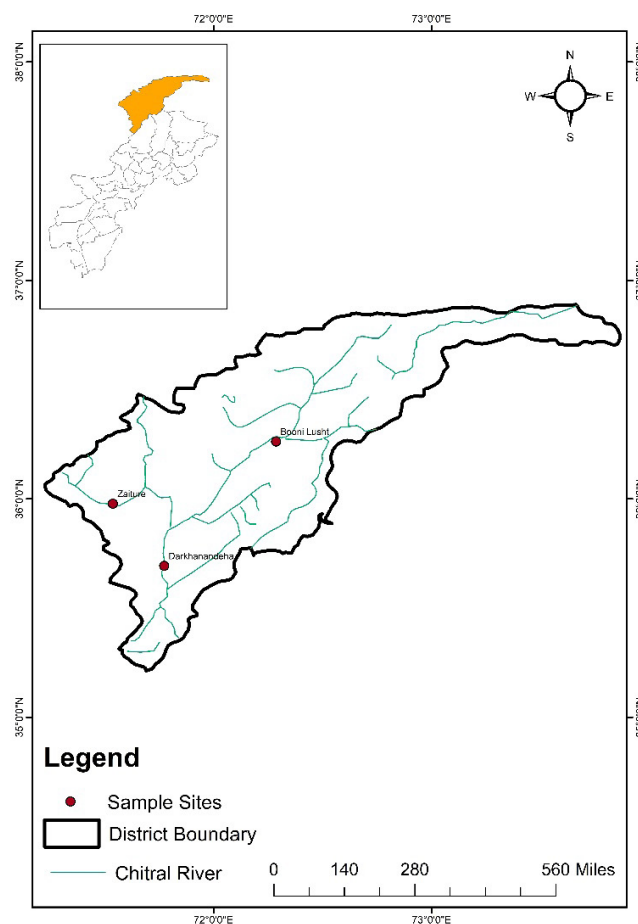


Figure 1: Map of district Chitral showing the sampled sites.

Sample size and data collection

Primary and secondary sources were used to collect field data. For detailed investigation, data were collected randomly from selected three villages

(Buni, Garam Chashma and Darkhanendeh) of Chitral district. To collect data of the study area regarding climate change and water resources a questionnaire was developed. A total of 212 persons were interviewed including farmers, representative of Government departments and NGOs (Table 1).

Table 1: Sample size for the survey in the selected villages of district Chitral.

Name of village	Farmers		Govt/ NGOs	Total
	Male	Female		
Buni	32	30	6	68
Garam Chashma	31	31	6	68
Darkhanendeh	49	22	5	76
Total	112	83	17	212

The Statistical Package for Social Sciences (SPSS) and Microsoft Word (MS Office) were used to analyze the data.

Results and Discussion

Climate of district Chitral

District Chitral has a diverse climate; Lower Chitral is moderate whereas upper Chitral is cold to very cold (Figure 2). Winters are harsh especially in upper Chitral. According to respondents lower Chitral was also cold but now its temperature has increased. Furthermore, snowfall in Chitral has decreased whereas there is an increase in river flow due to climate change. Chitral has a temperate climate, with winter rains mainly caused by western disturbances from December to March. The average annual temperature is 16°C, with minimum averages of 8°C and maximums of 24°C. During winter, temperatures can drop to freezing (Hussain *et al.*, 2013).

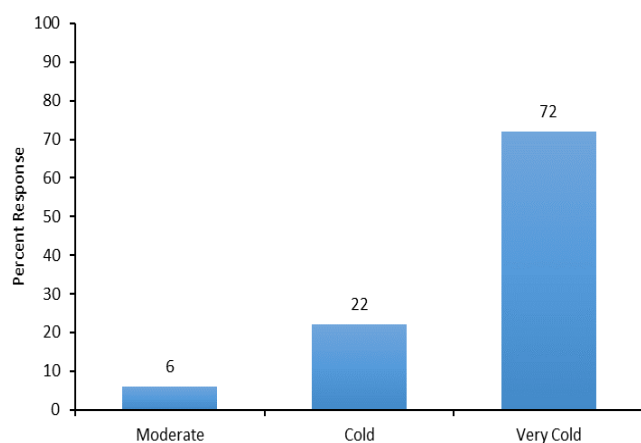


Figure 2: Climate of district Chitral.

Table 2: Main causes of climate change in district Chitral.

Reasons	Response	Frequency	Percent
Deforestation	Yes	210	99
	No	2	1
Pollution	Yes	149	70
	No	63	30
Population Growth	Yes	135	64
	No	77	36
Urbanization	Yes	121	57
	No	91	43
Biodiversity	Yes	83	39
	No	129	61
Any Others	Yes	65	31
	No	147	69

Main causes of climate change

According to the respondents, main causes of climate change in district Chitral are deforestation and pollution (Table 2). Some of the respondents reported that population growth and urbanization have also contributed to climate change. Other causes of climate change according to the respondents are biodiversity, use of excessive pesticides, fertilizers and loss of pasture etc. Micro level climate change has also occurred due to cutting of trees. These results are consistent with the past studies conducted on climate change in Swat. Bacha *et al.* (2018) reported that deforestation, pollution, greenhouse gases, and the combustion of fossil fuels are the primary contributors to climate change. Hussain and Hasan (2014) also reported that with an increase in deforestation and extensive use of pasture lands, the villages in Shishi valley of district Chitral are hit by flash floods which has resulted in destruction of agricultural land and loss of livestock. Coniferous forests in Chitral extend from Lowari to Golain Gol, while oak forests grow at lower elevations. Upper Chitral contains degraded broadleaved forests and remnants of juniper forests. The Forest Department oversees the protection of these forests from illegal logging and regulates tree removal for local and commercial use (NWFP and IUCN Pakistan, 2004). Shahzad *et al.* (2014) reported severe deforestation in Chitral, western Himalayas, over two decades, with a sharp increase from 2000 to 2009. Minimal forest regeneration and poverty-driven dependence on non-timber forest products worsen the issue, highlighting the need for stronger conservation measures to protect forests and livelihoods. Zeb (2019) analyzed changes in forest cover in Chitral before and after the 1993

logging ban. Despite the implementation of the ban, deforestation and degradation continue at significant levels. The ban has influenced deforestation patterns, with pre-ban activities primarily impacting valuable high-elevation conifer forests, while post-ban trends exhibit distinct characteristics. The [UNFPA Report \(2023\)](#) highlights that while climate change is widely recognized as causing shifts in temperature and weather patterns, local activities such as rapid deforestation, unsustainable reforestation, overgrazing, and heavy construction are also contributing to environmental degradation in Chitral. Additionally, glacier melting, particularly in Upper and Lower Chitral, has raised water levels, leading to soil erosion and increased rockfall risks in areas like Lasht, Booni Gol, and Lower Chitral.

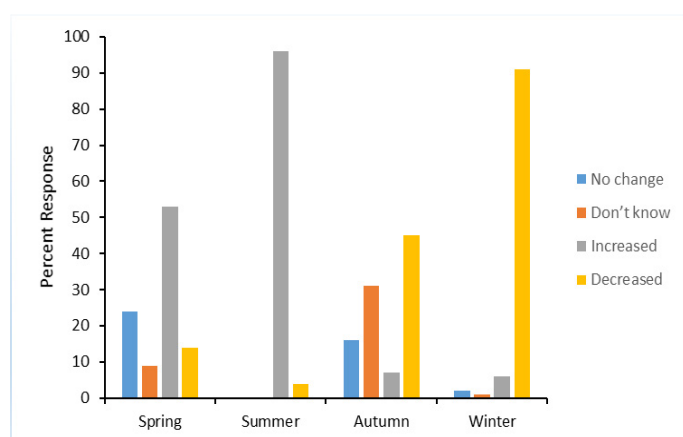


Figure 3: Changes in the seasons of district Chitral over the last 25 years.

Impact of climate change on rainfall

The respondents reported changes in the quantity of rainfall in Chitral over the last 25 years ([Figure 4](#)). Chitral is outside the monsoon range except lower Chitral. The local communities of upper and central Chitral did not observe any monsoon rainfall. However, the residents of lower Chitral have witnessed increase in monsoon rains. The frequency of summer and winter rainfall has moderately decreased. Majority of the respondents (59%) stated that there is a moderate increase in rainfall intensity in summer. According to 38% respondents, the intensity of winter rainfall has slightly increased ([Figure 5](#)). Respondents have different views about duration of rainfall in different seasons. Regarding the duration of rainfall in various seasons, respondents have different views. There is a moderate decrease in the duration of summer rainfall noted by 51% respondents ([Figure 6](#)). There are more flood events than in the past as summer rainfall intensity has risen and duration has decreased.

Similarly, there is moderate decrease in the duration of winter rainfall, as reported by 46% respondents. These findings are consistent with [Hussain and Hasan \(2014\)](#), who reported that the monsoon rains were increased in Shishi and Birirh valleys of district Chitral. They added that recent monsoon rains have been stronger, which is leading to flash floods and snow avalanches. During the winter and spring seasons mixed response was observed regarding rainfall and snowfall. According to [Ali et al. \(2022\)](#), the majority of respondents claimed to have observed changes in rainfall patterns over the past ten years as well as unpredictable or extreme rainfall as storm intensity increased in Pakistan's northern Karakoram Mountains. According to [Nizami et al. \(2019\)](#) the amount of rain has not significantly increased however, there is an increase in rainfall intensity. Flash floods and glacier lake outburst floods (GLOFs) are expected to result from increased precipitation, as indicated by a regression model showing that river flow rises with changes in precipitation. Specifically, for each unit increase in precipitation, river flow is predicted to increase by an average of $0.306 \text{ m}^3/\text{s}$. This increase in river flow is likely to cause downstream erosion ([Baig et al., 2021](#)). The Chitral sub-basin experienced increased precipitation in spring, summer, and autumn, while no significant trend was observed during winter ([Ahmed et al., 2022](#)). Annual precipitation levels in Chitral significantly increased between 1976–1990 and 1991–2005. This rise may be attributed to increased humidity and river flow, as suggested by the current study ([Table 3](#)) ([Salma et al., 2012](#)).

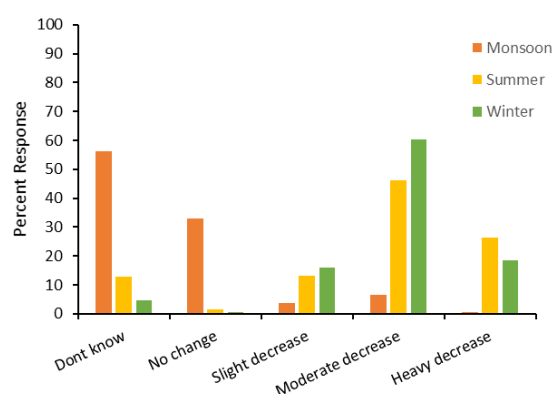


Figure 4: Change in the frequency of rainfall.

Impact of climate change on temperature

All the respondents stated that during the last 25 years, temperature of Chitral has changed. This was supported by the GLOF (Glacial Lake Outburst Floods), which caused flooding in many parts of

Chitral. These results consistent with the findings Hussain and Hasan (2014) who stated that Chitral's temperature has been rising all year. Similarly, Khan *et al.* (2015) also reported changes in temperature of Swat both during the summer and winter seasons. Bacha *et al.* (2018) stated that mean annual temperature of Swat revealed an increase of 0.028°C per year for the last three decades. Temperature increase has also been reported in many other studies conducted in Pakistan (Iqbal *et al.*, 2016; Chaudhry, 2017). Ali *et al.* (2022) also reported the changes in weather patterns and stated that the temperature is rising in the Karakoram Mountains of Northern Pakistan.

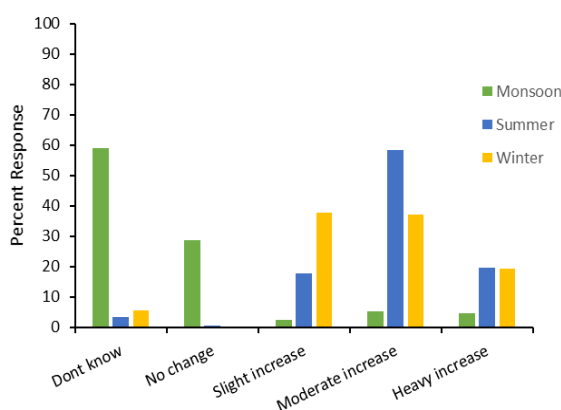


Figure 5: Change in the intensity of rainfall.

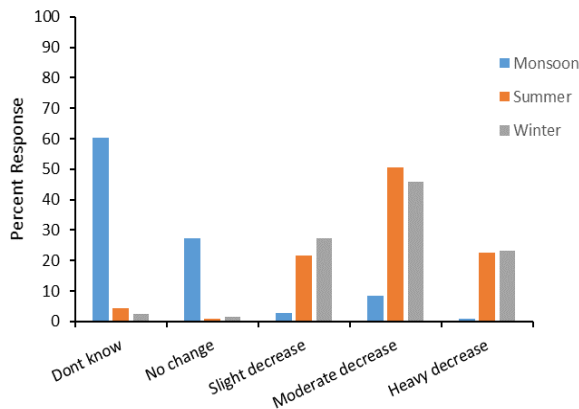


Figure 6: Change in the duration of rainfall.

Table 3: Disastrous event over the last 25 years.

Disaster events	Response	Frequency	Percent
Flood	Yes	207	98
	No	5	2
Drought	Yes	70	33
	No	142	67
Storms	Yes	56	26
	No	156	74
Any Other	Yes	102	48
	No	110	52

Changes in the seasons of district Chitral

Almost all the respondents reported climate change and its effects on rainfall and seasonal temperature patterns. Due to climate change, the duration of the summer season has increased whereas the duration of the winter season has decreased. Whereas autumn has shortened, according to 45% of respondents, and spring season has increased, according to 53% of respondents (Figure 3). They further stated that in the past spring season was from March to April but now it has increased to 4 months (Feb-May). Similarly, the winters are severe compare to the past. These findings are consistent with Hussain and Hasan (2014) who reported that changes in rainfall and seasonal temperature patterns are being brought about by climate change in Chitral. Farmers in the two valleys said that the length of the summer season has increased while the length of the winter and spring seasons has decreased. Maryam *et al.* (2014) also reported that the people of Swat have clearly witnessed that in the previous few years, the climate has changed. The survey's findings indicate growing awareness, all respondents (100%) agreed that the climate is changing (Khan *et al.*, 2015). Ahmad *et al.* (2012) found an increase in runoff in the rivers of the Upper Indus Basin, Northern Pakistan, which may be related to early indications of climate change in Pakistan. The winter and spring temperatures in the district Chitral are rising more quickly, according to Hussain *et al.* (2013).

Change in dry periods

According to the respondents (36%), there is a 2-3 week rise in dry periods. The dry months are typically January, February, April, and October to December. The number of days with heavy precipitation over Pakistan's western, northeast, and northwest areas between 1991 and 2020 was found to have decreased slightly by Abbas *et al.* (2023). Natural catastrophes, such as extreme weather, flooding, and droughts, are occurring more frequently and are more severe now (Waqas *et al.*, 2019; Gul *et al.*, 2020; Anser *et al.*, 2020). At Astore, Bunji, Chilas, Drosh, Dir, and Kakul, spatial variations in yearly precipitation appear to show continuous drying tendencies between 1961 and 2013 (Latif *et al.*, 2018).

Occurrence of disastrous events

Majority of the respondents stated that they have experienced disasters (floods, drought, storms, landslide, GLOF and earthquake) in the last 25 years

(Table 3). According to the respondents, villages are reportedly devastated by these flash floods, which cause damage to their infrastructure, agricultural lands, livestock, and occasionally even valuable lives, as a result of increased deforestation and intense use of pasture lands. In addition to flash floods, glacial sliding and avalanches have also had an impact on the villages of Garam Chashma and Buni. All the respondents reported the change in frequency, timing and intensity of flashfloods over the last 25 years. Most of the people said that floods like 2010, 2015 were more severe than in the past flash floods. Chitral District is located in the Hindukush Mountains. The threats that occur most frequently in the Hindukush region include flash and river floods. The majority of the population lives on high mountains, making them susceptible to flash floods and debris flows. It is vulnerable to landslides, debris flows, and floods because of its proximity to the steep valley slopes (Khan *et al.*, 2013). Floods were mentioned as the primary impact of climate change in the research region, especially in Barikot, by the majority of respondents, according to Bacha *et al.* (2018). Other significant effects that were noted included water shortages, unpredictable rainfall, implications on agriculture, an increase in warm days and a reduction in cold days. Natural disasters are more likely to occur as a result of climate change, and the Himalaya is particularly vulnerable to water-related disasters, which are frequently floods, according to Nellesmann *et al.* (2011). A few Gilgit Biltistan districts are particularly vulnerable to flash floods and glacial lake outburst flooding, according to Hussain *et al.* (2023). Floods are mostly caused by variations in trends of high rainfall during the monsoon season as a result of climate change in all of Pakistan's provinces. Pakistan saw its worst recent flooding as a result of torrential monsoon rainfall. In KP, flash flooding happens as a result of heavy rainfall, prolonged periods of rain, and glacier melting brought on by rising temperature trends. Rahman *et al.* (2022) assessed drought characteristics from 1971 to 2018 using the Reconnaissance Drought Index (RDI). They found rising maximum temperatures, decreasing minimum temperatures, and declining rainfall in the north and northeast regions. Drosh and Kakul stations experienced the highest drought frequency, with an overall increasing drought trend. Using tree-ring data from the Hindu Kush Mountains, Khan *et al.* (2022) reconstructed 500 years of precipitation history for the Kabul River Basin (Pakistan and Afghanistan). The analysis revealed weak trends in high and

median precipitation but a significant decline in low precipitation levels. This has resulted in shorter, more frequent droughts and more frequent wet periods, emphasizing the importance of examining overall rainfall distribution changes rather than just averages.

Change in crop and livestock productivity

Most of the respondents mentioned that they have observed a change in crop and livestock productivity due to changes in temperature and rainfall in the last 25 years. Increases in temperature have been observed to boost the productivity of livestock and crops. Moreover, it is due to the introduction of fertilizers and new, high-yielding Dir and Swat varieties. However, according to some respondents fruit trees, walnuts, persimmons, apples, peaches and apricots affected due to diseases because increase in temperature and un even rainfall/ less rainfall grasses has decreased therefore livestock affected. Farmers believe that the declining soil moisture and associated loss in agricultural productivity are the results of the rising temperatures, according to Shrestha *et al.* (2022). Moreover, livestock rearing and the production of quality livestock derivative goods have been adversely impacted by the temperature increase. The results of the interviews are consistent with those of Hussain and Hassan (2014), who stated that the supply of fodder has become the main problem, which has led to a decrease in the number of livestock per household. Beneficial insects has died while dangerous has increased.

Yield and cost of production of major crops

Majority of respondents (87%) reported that yield and cost of production of main crops has increased in the last 25 years. Production/yield has increased due to the use of fertilizers and new technology and due to glacier melting water availability increased this is also the reason that production has increased. But according to some respondents that due to lake of awareness, there is no production but if production is high but there is no market for it. According to Hussain and Hassan (2014), in FDGs farmers said that the present higher temperature throughout the year has proven advantageous for crops and gives the ideal heat to harvest greater crops. This is also due to the new high yielding varieties and introduction of fertilizers from Swat and Dir. Farmers believe that increased temperatures have decreased soil moisture, which has led to a decline in agricultural yield, according to Shrestha *et al.* (2022).

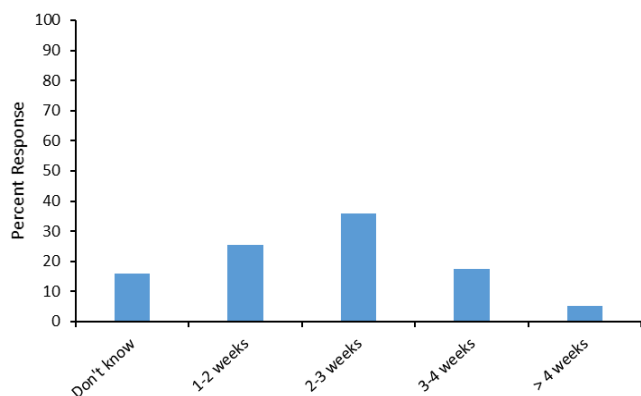


Figure 7: Change in dry periods in the last 25 years.

Adaptation measures to cope with climate change

Majority of respondents (68%) negated any climate change adaptation measures made by local communities. But they opined that Government and some private organizations are working on adaptation while community is working with voluntarily. Working to stop deforestation and started afforestation and similarly overgrazing has also control up to some extent in the area in Buni. [Shah et al. \(2023\)](#) stated that farm households have also implemented cutting-edge farming practices to protect their livelihoods from a variety of risks related to the changing climatic conditions in the study areas (Dera Ismail Khan, Charsada, Peshawar and Nowshera). These practices include planting shade trees, conserving soil, and diversifying crop types. According to [Khan et al. \(2022\)](#), the majority of households (88%) in Satkhira had medium adaptation levels, compared to 44% of households in Patuakhali who had low adaptation levels and 57% of households in Satkhira who had medium adaptation levels (Bangladesh).

Current irrigation practices

Main Source of water supply for crops are irrigation channels, which are a life line of Chitral's agriculture sector. In the study areas, water is diverted from streams with demand (92%) unofficial fixed rotational scheduling method (Warabandi). The respondents also added water requirements are less in winter due to low temperature and snowfall. Common methods of irrigation in Chitral are flooding and furrow. Majority of the respondents (79%) reported that irrigation need of crops has increased due to decrease in rainfall and increase in duration of summer season. Majority of the respondents believed that overall availability of water in Chitral has changed. The respondents stated that because of melting glaciers and snow and possibly due to increased temperatures, there is now more

water available year-round. Irrigation is necessary for crop production across Chitral, particularly in the valleys under study. Crops in many rainfed areas of Chitral could not be grown due to low precipitation. Natural streams and springs are used as the source of irrigation water. According to respondents, it can be challenging to handle the excess water from diversion canals during times of heavy rain or snowfall. The irrigation channels are further harmed by flash floods during the monsoon, which reduces the water supply to the crops. These findings are consistent with [Hussain and Hassan \(2014\)](#), who reported that whole of the Chitral depend on irrigation for crop production.

Quality of surface and ground water

According to respondents the quality of surface water has declined with the passage of time. 25 years ago water of the streams and channels was of excellent quality but now it is just marginal ([Figure 8](#)). Most of the people use water springs and rivers water for domestic purposes. The quality of surface water has degraded due to contamination and pollution resulting from sedimentation.

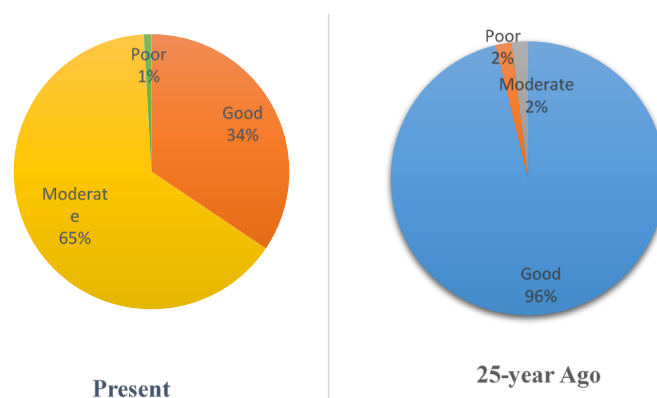


Figure 8: Quality of surface water.

[Ishaque et al. \(2022\)](#) mentioned that Pakistan's drinking water quality is in a terrible situation. In Pakistan, where large tracts of land are still under water and are now contaminated, the latest floods have made the situation worse. Similarly, [Fida et al. \(2022\)](#) revealed that Pakistan's surface and groundwater sources are dangerous for human consumption since they are heavily contaminated with hazardous metals and microbiological pollutants. The water quality of the Basha Valley (Gilgit) is under a major threat as a result of anthropogenic interferences, according to [Fatima et al. \(2022\)](#). Furthermore, a crucial public health concern is the quality of the water and the consumption of potable water ([Jehan et al., 2020](#);

Upreti *et al.*, 2020). The groundwater is good in Chitral, because there is no water contamination like in cities and groundwater is too below. Most of the people use water which comes from spring and rivers. According to them in the past, water was also clean because it was not disturbed and it was too below.

Risk of floods and adequacy of drainage

Majority of the respondents (99%) reported that the risk of floods have increased due to climate change. The main causes of the increase in the risk of floods are excessive rainfall, rapid glacier melting and unplanned construction. In Zaiture village (Garam Chashma) people have constructed houses on the bank of nallas/stream and rivers, thus, highly susceptible to flood damages. While some people opined that risk of flood has decreased in Buni because of the channelization of nallas by Government and AKDN (Agha Khan Development Network). Some of the flood risk mitigation measures taken by the Government, NGOs or communities are: protection walls, check dams, afforestation, rehabilitation and awareness programs etc. Different organizations working on rehabilitation activities in Chitral are; GLOF, ACTED, SRSP, AKDN (AKRSP, AKAH), IC and FOCUS. According to the respondents (82%), the discharge of major rivers in the area has increased due to climate change. They further opined that the path/ course of major rivers has changed. Baig *et al.* (2021) found that changes in precipitation are the main driver of annual variations in Chitral River flow, with a 0.306 m³/s increase in flow linked to rising precipitation, while temperature decreases flow by 0.075 m³/s annually. The study also showed that most hydro-meteorological variables are negatively correlated, meaning an increase in one variable causes a decrease in another, except for precipitation and river flow, which are positively correlated. Hassan and Khan (2022) studied the influence of temperature and precipitation on river flow at Chitral and Gilgit stations. They found that while precipitation alone does not fully explain river flow, it becomes effective when combined with temperature lagged data. Additionally, the combination of temperature and flow lagged series provides a more efficient prediction of river flow dynamics. Syed *et al.* (2022) found that Chitral River's discharge is strongly influenced by precipitation and snowmelt, both vulnerable to climate change. Under RCP4.5, flows increase in early summer and slightly in fall. By mid-century, two peak flow periods emerge, and late-century patterns

show reduced July flows. Under RCP8.5, changes occur more rapidly due to increased snow and glacier melt from rising temperatures.

The drainage system of the area is mostly natural. According to the respondents (69%), the existing drainage system is not adequate to handle runoff from extreme rainfall events. Risk of overtopping of drainage network is low, as reported by 49% respondents (Figure 9).

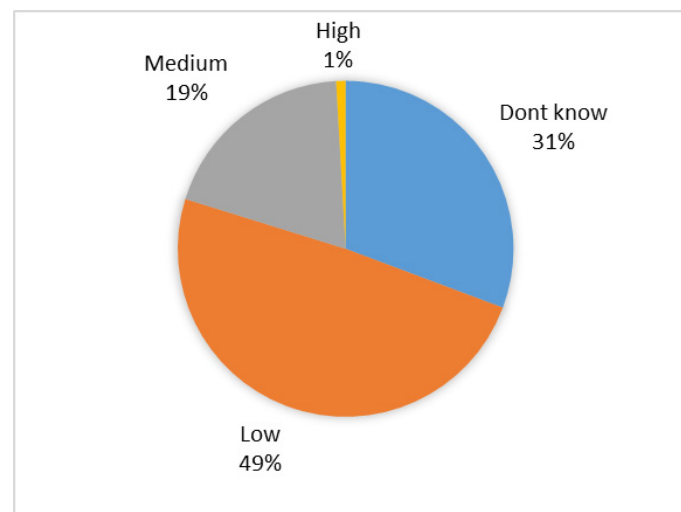


Figure 9: Risk of overtopping of drains in District Chitral.

As temperatures and precipitation rise, there is an increase in runoff. The increase in runoff is a result of increasing precipitation and temperature, which ultimately causes melting of snow and glaciers in Chitral. Past studies also support these findings. According to Gul *et al.* (2020), the melting of snow and glaciers brought on by rising temperatures has increased the flow of the Chitral River basin. Similarly, Khanal *et al.* (2015) reported that the temperature increase causes glacial melt, which causes glacial lakes to develop in the area. Growing glacial lakes in the HKH may increase the risk of outburst floods for populations living downstream as a result of the glacier's retreat.

The majority of the respondents (96%) stated that widening and deepening of streams and gullies is common in the area (Figure 10). They say there is a moderate risk of streams and gullies expanding and deepening.

Majority of the local people responded that because there is an abundance of water in the district, the rainwater harvesting and ground water recharge practices are not applied there.

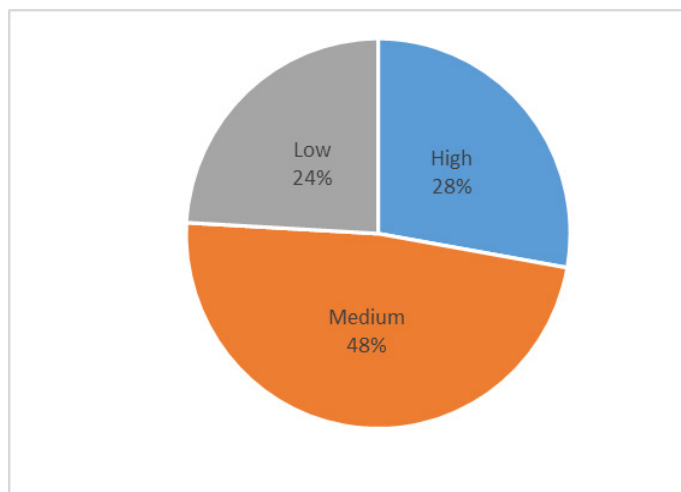


Figure 10: Risk of widening of streams and gullies.

Groundwater depletion

Majority of the respondent didn't have much knowledge about depth of water table, however, some of the respondents reported that in Buni area about 34 springs have dried up due to earthquake. There was a mix response regarding the depth of water table. According to a few local people, the water table depth increased up to 25-150ft, while other areas decreased up to 3 ft. Khan *et al.* (2015) reported that the deterioration in water table (2-5 ft) is due to population growth, increased water consumption, deforestation, and a decline in winter snowfall.

Conclusions and Recommendations

Chitral, like other mountainous regions, has been adversely impacted by climate change. The local community is becoming more aware of climate change as a result of its harmful effects, but lack proper knowledge and training to adapt and mitigate the adverse impacts of climate change. The temperature of district Chitral has increased compared to the last 25 years. There has been increase in the duration of summer season, whereas winter season has shortened. With the increase in deforestation, number of disastrous events, especially flash floods has increased, hence, bringing destruction to the infrastructure, agricultural land, livestock and sometimes even precious lives are lost. Moreover flash floods, the villages of Garam Chashma and Buni have been affected by glacial melting and avalanches. Over the last 25 years, both the yield and the cost of production of the major crops have increased. Irrigation need of crops due to decreased rainfall and prolonged summers has increased. Overall quantity of water has increased but the quality has degraded. To handle runoff from

extreme rainfall events, the current drainage system is inadequate. Rainwater harvesting practices are used in a few villages (Drosh in lower Chitral and Mulkoh in upper Chitral), which are facing water shortages.

New crop varieties which are high yielding, drought tolerant and less vulnerable to heavy rains should be introduced in the area. The community needs external assistance for protection from flash floods and avalanches. Early warning systems and other flood risk mitigating techniques should be installed. Management and protection of irrigation channels require assistance. Awareness and training programs on climate change, adaptation, afforestation, water quality, rainwater harvesting need to organize in Chitral cope with climate change problem.

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Novelty Statement

This study uniquely captures local perceptions of climate change impacts on water resources in Chitral's most flood-prone villages, revealing a community in urgent need of targeted adaptation training, improved water management, and flood mitigation strategies.

Author's Contribution

Saiqa Jehan carried out research and prepared the manuscript. Prof. Dr. Tahir Sarwar supervised the study. All members of supervisory guided in planning the research study, analysis of data and write-up.

Conflict of interest

The authors have declared no conflict of interest.

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