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## **Glof Impact, Causes and Mitigation Strategies in Bilhanz and Badswat Villages in Ishkoman, District Ghizer, Gilgit-Baltistan**

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**ABSTRACT:** *During the current study, the causes, impacts, and mitigation efforts related to Glacial Lake Outburst Floods (GLOFs) in Bilhanz and Badswat, Ishkoman Valley, were thoroughly examined between July to September 2024. These events led to significant landscape alterations, transforming once fertile agricultural and forest lands into debris covered areas, as evidenced by satellite and digital camera imagery. A large lake formed in Badswat, destroying extensive agricultural and forest land, which forced the relocation of many residents. Most displaced individuals received housing support from the Aga Khan Agency for Habitat (AKAH), while the government provided limited assistance. The Saudi government also made notable contributions. Between 2018 and 2021, successive GLOF events damaged 186 hectares of agricultural land in both villages in addition to damages and losses to livestock and other life supporting systems. Climate change and deforestation were identified as the primary drivers of these disasters. A multivariate analysis revealed that gender, age, and education had significant impacts on awareness and perceptions of environmental degradation and climate change. Older respondents, particularly those aged 50-60, were the most influential in shaping future disaster preparedness and mitigation efforts. Although education had a smaller effect size, it still played a crucial role in raising environmental awareness. Mitigation strategies proposed include afforestation, carbon capture, renewable energy, and waste reduction. Many respondents emphasized the importance of community involvement and education in addressing environmental issues. However, opinions vary on the most effective methods for controlling soil pollution and improving overall environmental health.*

**Keywords:** *GLOF, Environmental Degradation, Mitigation Strategies, Multivariate Analysis.*

## INTRODUCTION

Environmental degradation is mostly caused by human activity and results from changes in the environment brought about by urbanization, population increase, and economic development (**Choudhary, 2015**). Human interventions that modify natural surface characteristics are widely believed to directly cause significant climatic changes (**Elagib, 2000**). Everything that affects an organism and affects its surroundings is considered part of the environment. Ecosystems are strained by the fast urbanization and population increase, which causes resource inequality, food shortages, and environmental problems like desertification, erosion, and water pollution (**Qasim, 2014**). The Pakistani Himalayas, particularly the Karakoram Range, are witnessing an increase in glacier-related hazards such as flash floods, GLOFs, snow avalanches, and debris flows due to climate change-induced glacier retreat (**Rehman, 2014**). We have observed an increase in Glacial Lake Outburst Flood (GLOF) events across the region in recent years. Landslides in Gilgit Baltistan, particularly, the district of Ghizer have been significantly affected by climate change-induced GLOF events. These events cause degradation in habitat and biodiversity (**Rahim, 2018**).

Ecosystem services are advantaging that people can obtain for their physical, social, and financial well-being from natural ecosystems (**Millennium ecosystem assessment, 2005**). Ecosystem services in high-altitude regions are often undervalued, leading to environmental degradation and biodiversity (**Ali, 2023**). Forests regulate the earth's temperature, hydrologic and carbon cycles, protect soil nutrients, and mitigate floods and droughts. To minimize ecological footprints and environmental degradation, emerging nations such as Pakistan must regulate greenhouse gas emissions, nitrogenous waste, and carbon dioxide emissions to maintain sustainable environmental quality (**Yousaf, 2022**). Pakistan has lost around \$18 billion in the last ten years due to the high risk of natural disasters. The nation, which is ranked ninth on the 2019 Climate Vulnerability Index is vulnerable to extreme weather, especially in its northern regions (**Baig, 2021**). This region, which includes portions of the Himalayan, Karakoram, and Hindu Kush ranges, is prone to avalanches, mudflows, floods, and landslides because of its geology, seismic activity, glaciers, and glacial lakes. Inadequate disaster preparation, unstable glacier lakes, and atmospheric hazards exacerbate the threats to

alpine towns downstream (**Baig, 2021**). The Gilgit Baltistan region in northern Pakistan, covering 72,971 km<sup>2</sup>, is strategically located at the crossroads of China, South Asia, and Central Asia, but remained isolated until the Karakoram Highway was completed in 1978 (**Ullah, 2020**). It is home to some of the world's largest glaciers and tallest mountains, and is increasingly vulnerable to natural disasters due to shifting weather patterns and rising temperatures.

Pakistan's National Climate Change Policy highlights GLOFs as a key hazard, emphasizing the need for monitoring, evacuation planning, and adaptation strategies (**Aslam, 2023**). For disaster management and development agencies in the research area, climate change and catastrophe risk management provide significant problems. To prevent the catastrophic effects of disasters brought on by climate change, we must assume responsibility for detecting, assessing, and reducing the risks connected with climate change (**Shah S. S., 2023**). The government, non-governmental organizations, and Gilgit civil society do, however, encounter difficult institutional obstacles in their efforts to comprehend the dangers of climate change and its effects. This has increased the surrounding communities' susceptibility to natural disasters. This means that institutions must be changed immediately to address the fast-changing climate and extreme disasters (**Shah S. S., 2023**).

Pollution, which is brought about by urbanization and industrialization, is one of the major causes of environmental degradation in developing countries, especially concerning deforestation and industrial pollution in water, air, and soil (**Hussain A. K., 2022**). Deforestation in Pakistan has increased dramatically with agricultural activities, urban expansion, and overgrazing, which have resulted in soil erosion and low land productivity (**Anjum, 2010**). GLOFs are a major threat to mountainous regions as frequently encountered in Gilgit-Baltistan due to the impacts of climate change. GLOFs happen when the ice dam bursts, which it can do frequently as temperatures increase leading to more ice melt (**Emmer, 2017**). Meltwater lakes are forming on lower glaciers due to atmospheric warming in the Himalayan regions. This trend is likely to exacerbate with climate change and rise the potential of GLOF activity that poses serious social and economic damage threats to the millions of people living downstream. The Karakoram Range also has had 35 devastating

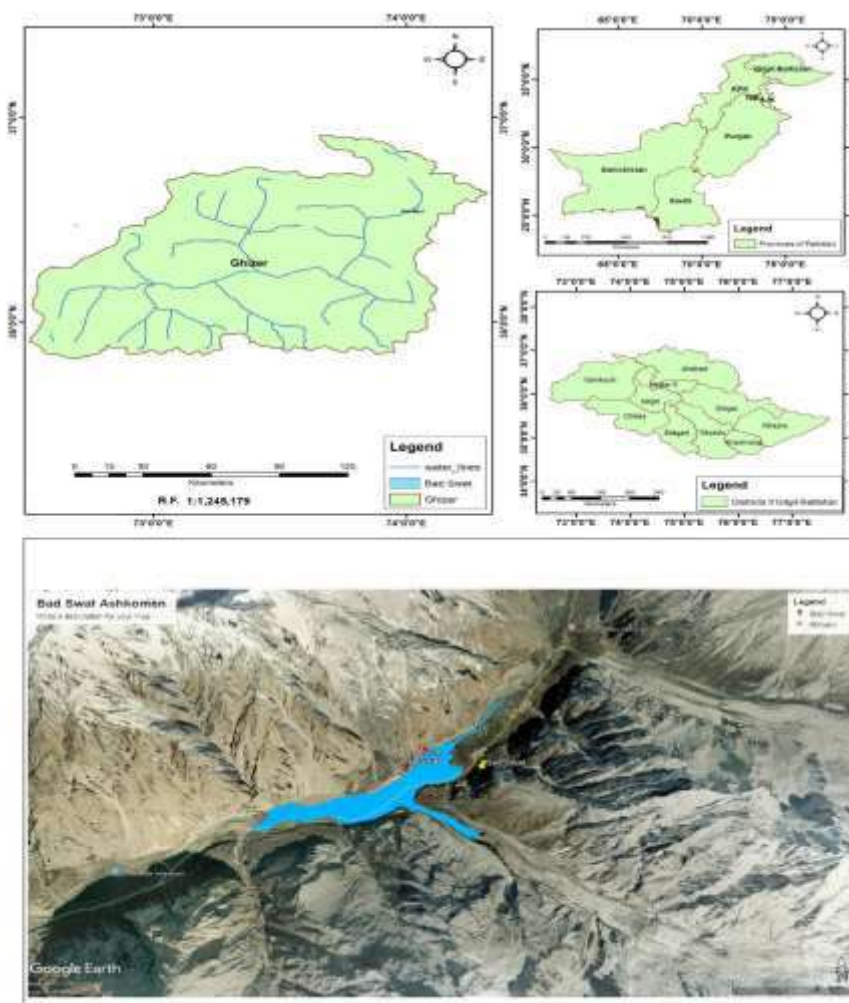
GLOFs in the last 200 years therefore including the areas of possible most-output of GLOFs (Ashraf, 2021). It is affirmed that in Gilgit- Baltistan GLOFs have led to the loss of habitats, infrastructural loss, and a negative impact on agricultural yields (Aslam A. B., 2022). Since 2018 to 2021, experiencing frequent GLOFs in Ishkoman Valley affecting human and ecosystem infrastructure heavily (Shah S. A.-3., 2019). It emphasized reducing the risks of GLOF is somewhat problematic due to the geographical characteristics of the area in which large-numbered high-altitude structures such as dams and flood barriers cannot be constructed efficiently (Setiadi, 2010). underscored GLOFs also adversely affect livelihoods and people entirely in their lives are displaced and emotional problems (Hussain, 2024). Studies reveal that emissions from industries remain uncontrolled in developing countries such as Pakistan: The consequence is increased amounts of pollutants that contribute to global warming (Ilyas, 2010). Industrial waste is often released directly into rivers which worsens water quality and endangers aquatic life and the groups that benefit from these sources for irrigation and domestic water supply (Khan A. S., 2021). The measures to control environmental degradation call for multi-sectoral approaches that seek to address factors that predispose the environment to degradation and impacts of the same (Brancalion, 2017). Afforestation and reforestation processes play important roles in the rehabilitation of degraded ecosystems. The stated practices help to improve the cohesiveness of soils, stock up on carbon, and diversify species (Dignac, 2017). The hazardous GLOF can be minimized by using early warning systems, including remote sensing and geographical information systems (Wang, 2022). It expresses that regional cooperation in climate change adaptation is crucial to improving the ability of the region to cope with the effects of climate change and GLOFs (Karki, 2009). The aim of the current study is to evaluate the impact of GLOF-related events in the remote areas of Gilgit-Baltistan (GB), as these events have a significant and drastic effect on the livelihoods of communities in the region's far-flung areas.

## Methods

### Study area

This study was conducted in the western district of Ghizer, which is one of the ten districts in GB. In district Ghizer the study was done in Badswat and Bilhanz villages because these

two villages had a severe GIOF event in 2018 and 2021. Both GIOF event has a drastic effect on the ecosystem and livelihood of the residents in both villages (Fig. 1 and Fig. 2).



**Figure 1.** Geographic representation of the study area in Ishkoman Valley, Gilgit-Baltistan, highlighting the locations of Badswat and Bilhans villages impacted by GIOF events. The upper panel includes (a) a detailed map of the Ghizer district with major rivers and streams, (b) the regional context of Gilgit-Baltistan within Pakistan, and (c) administrative boundaries of Ghizer district. The lower panel shows a Google Earth image of the Badswat region, illustrating the extent of the glacial lake (blue area) formed due to glacial melting.

### Data collection

Field data collection activity was done in July and September 2024. We collect the data from Badswat and Bilhans, of Ishkoman Ghizer. The data was collected randomly from the GRJNST, Volume: 04 - Issue 2 (2026) / ISSN P: 2790-7643  
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respondents available on the survey's days in both villages. The respondents were further classified into male, female, aged, and young from different professions (farmers, professionals, and students). We traveled to various locations and collected data from the participants who were willing to participate in the study and selected 196 participants from different places in the study area (Ishkoman Ghizer). Data was collected through in-person interviews and surveys, allowing for personalized interaction and accurate data collection.

### **Statistical analysis**

We used the very latest version of R.4.4.1. A survey dataset titled "Questinaire.csv" was utilized. The dataset includes demographic, environmental impact, awareness, and mitigation-related variables.

### **Data cleaning and preparation**

Initial data cleaning involved loading the dataset without modifying column names, converting categorical variables to factors, and capitalizing the first letter of each word in categorical columns. To summarize categorical variables and understand their distributions. Calculated counts and percentages for each category within the categorical variables

To examine the impact of demographic factors on different groups of environmental and awareness variables. Combined demographic data with group-specific data to form a comprehensive dataset for MANOVA. Conducted MANOVA with demographic factors (Age, Gender, Education, Occupation, and Location) as independent variables and group-specific data as dependent variables. Extracted p-values to assess the significance of each factor in influencing the group variables.

## **RESULTS**

This study was designed to investigate the causes, effects, and mitigation strategies following the Glacial Lake Outburst Flood (GLOF) events in Bilhanz and Badswat, located in the Ishkoman Valley. Both areas experienced severe damage due to consecutive GLOF events. (Fig. 3a and Fig. 3b) illustrates Bilhanz village before and after the GLOF events, highlighting its once lush green landscape comprising fields and forests, which is now covered with flood debris that is reflected in captured images of digital camera and satellite images. Similarly, the GLOF event created a significant lake in Badswat village, damaging agricultural land and forested areas (Fig. 3c and 3d). As a result of these massive GLOF

events, residents of both villages were compelled to migrate to higher areas within the same villages or to other parts of Gilgit-Baltistan (Figures 3e and 3f). The houses depicted in (Figures 3e and 3f) were constructed by the Aga Khan Agency for Habitat (AKAH) with minimal contributions from the affected individuals. Table 2 presents the GPS coordinates of the newly built houses for the affected residents in Bilhanz village. Upon inquiry, some respondents indicated they owned inherited land, while most reported purchasing land before the construction of their prototype houses. The affected residents expressed serious concern over a lack of government support during this challenging time. They acknowledged the contributions of the Saudi government and the Aga Khan Agency for Habitat (AKAH) for their tireless efforts during these difficult circumstances.

(Figures 3b and 3d) illustrate the total areas damaged by floods in Badswat and Bilhanz. In these figures 2, the red-marked boxes highlight the damaged areas. During 2018, 123 hectares (or 2,431.52 kanal) of land were affected. On July 17, 2021, another flood event caused damage to 63 hectares (or 1,254 kanal) of land. The total damage recorded between July 17, 2018, and July 16, 2021, amounted to 186 hectares (or 3,677 kanal) of land.

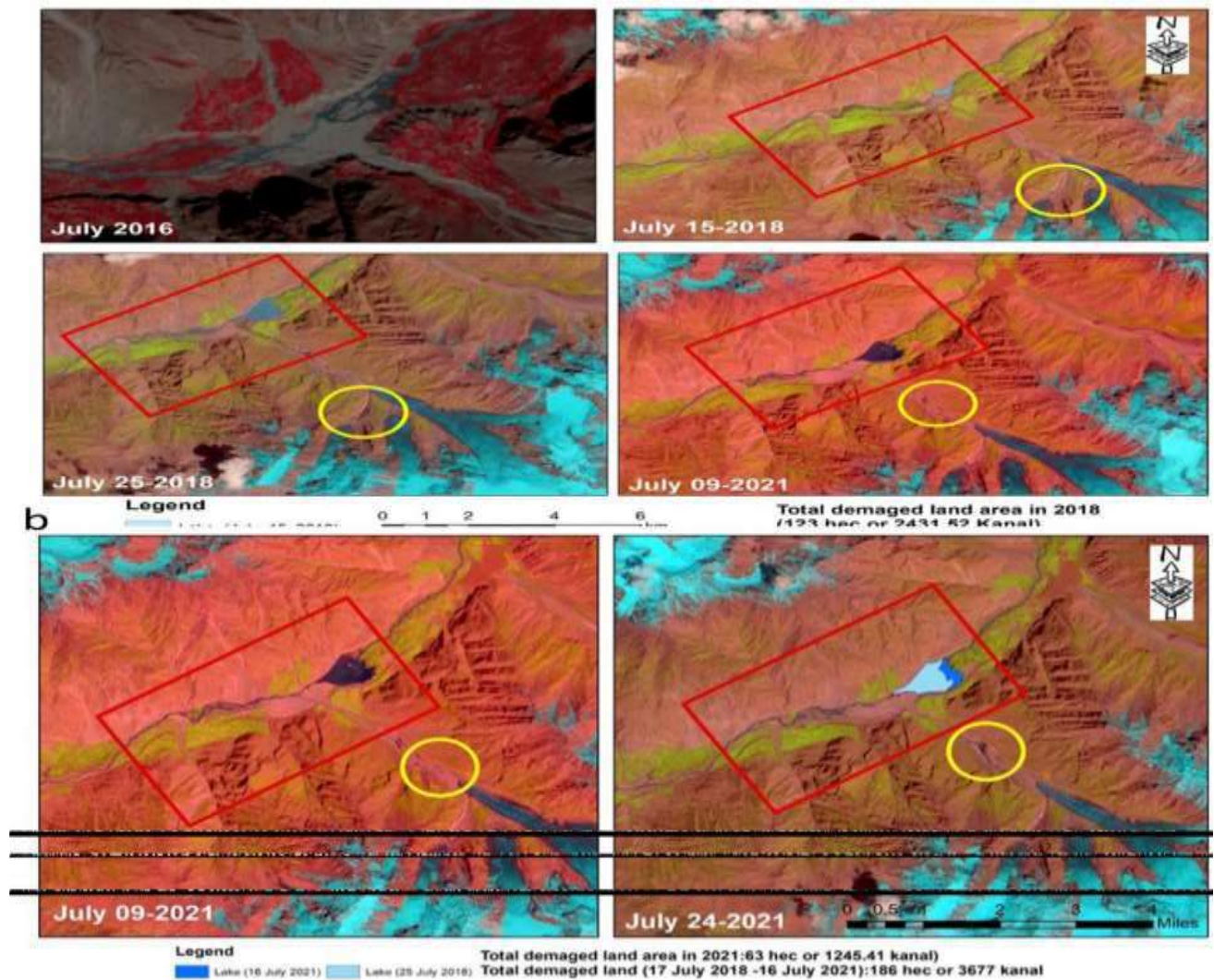


Figure 2. Temporal analysis of glacial lake development and associated land damage in Badswat and Bilhans villages of Ishkoman Valley, Gilgit-Baltistan, between 2016 and 2021. Satellite imagery highlights significant changes in glacial lakes (blue areas) and damaged land (red polygons). The yellow circles identify the most impacted regions. In these figures, the red-marked boxes highlight the damaged areas.



d



f



**Figure 3.** shows the pictures of the study area before and after the GLOF event. (A) shows the village Bilhanz paien. (B) shows the damages caused by the GLOF event to Bilhanz Paien. (C) shows Badswat before the GLOF event and (D) shows the lake emerged after the GLOF event. (A and B) illustrate the total areas damaged by floods in Badswat and Bilhanz. During 2018, 123 hectares (or 2,431.52 kanal) of land were affected. On July 17, 2021, another flood event caused damage to 63 hectares (or 1,254 kanal) of land. The total damage recorded between July 17, 2018, and July 16, 2021, amounted to 186 hectares (or 3,677 kanal) of land.

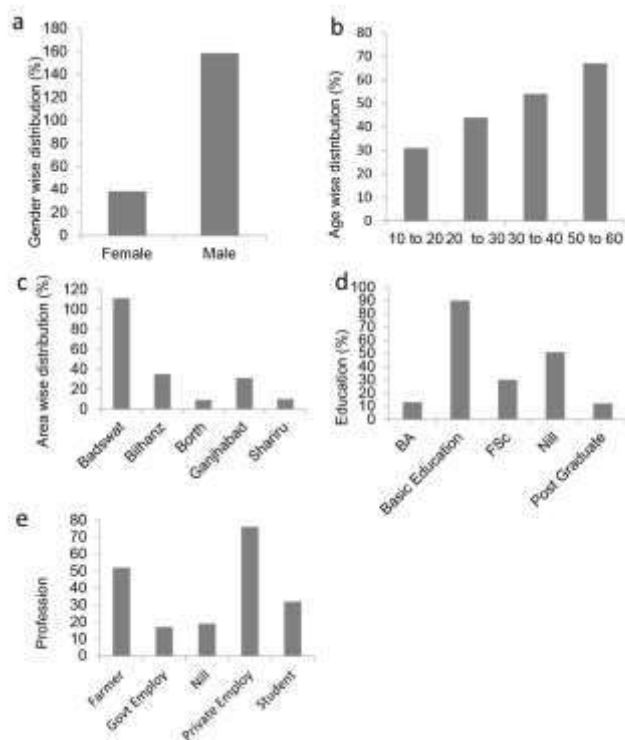
### **Demography of the respondents:**

The data highlights the demographic components of the population, focusing on gender, age, occupation, education, and location of the respondents. Out of a total of 196 respondents, 158 were male (81%) and 38 (19%) were female respectively (Fig.4a). Distribution analysis further depicts that out of a total of 196 respondents, 67 were 50-60-year age group and 54 were 30-40 years (54) (Fig. 4b). During this survey data was preferably collected from senior age respondents because they have strong observation and vast experienced GLOF events in the prone area. The educational background of most of the respondents is Primary School passing (90), some of the respondents have FSc (30) while some of the respondents' educational qualification is Post Graduate (12) (Fig. 4d). The income level is also somewhat mediocre, and education may play a role in causing differences in the opinions of people on environmental and social problems. Most respondents are from the private sector (75.6%), while the smallest proportion of respondents is farmers (54.3%). The variety of occupations means that the data is representative of a broad working-class population and their views on environmental and economic factors might be affected. The largest number of respondents comes from Badswat with 111 followed by Bilhanz with 35 and Borth with 9 (Fig. 4c). This makes it possible that the data obtained is more relevant to a given region and this influences the geographical application of the outcomes.

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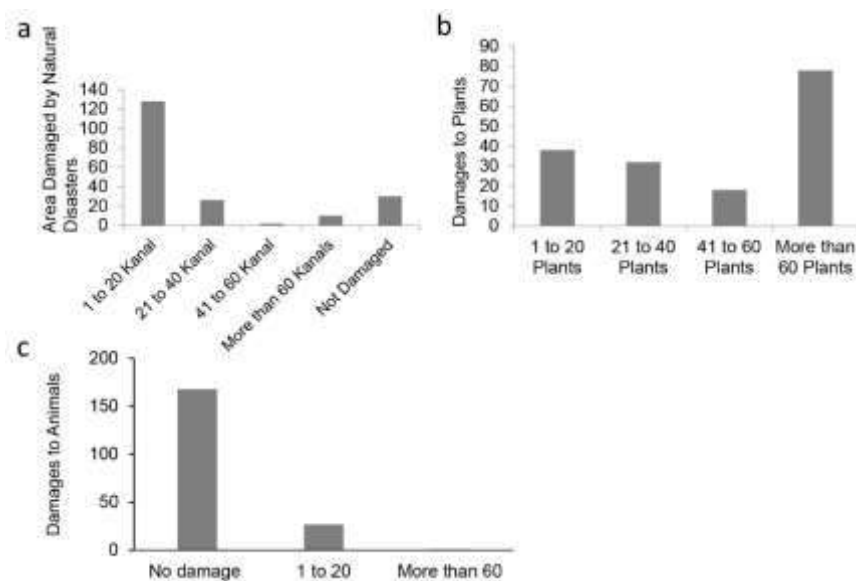
**Figure 4.**

Shows the demographic variables of respondents who participated in this study. (A) male (81%) and 19% were female. (B) 50 to 60-year age group 30to 40-year age group (54). (C) respondents count from Badswat and Bilhanz (D) Basic education (Primary passed) (E) respondents from the private sector.

#### **Damages caused by GLOF:**

The majority of the respondents (128 respondents) estimate 1 to 20 kanal of their land has been damaged with few people reporting loss on larger areas between 21 to 40 kanal (26 individuals). 10 respondents were those whose areas were damaged more than 60 kanal while 30 respondents were those who said not damaged. This means that natural disasters have affected agricultural and residential lands in a proportional though varying manner (Fig 5a). The majority of respondents 78 responded that more than 60 plants were affected by natural disasters while 38 claimed that almost 20 trees were damaged. while 18 individuals responded that 41 to 60 plants were damaged due to natural disasters and 30 respondents

responded as not damaged. This shows how such occurrences affect vegetation, and this may not be very good news for other species within that particular region (Fig 5b). 168 respondents replied that no animal was injured, although a few people mentioned unusual damage like 27 respondents claimed 1 to 20 animals were damaged. Only 1 person said more than 60 animals were damaged due to the disaster. This could also be due to variations in the impact that natural disasters have on fauna, with some regions being more resistant and/or shielded (Fig 5c).

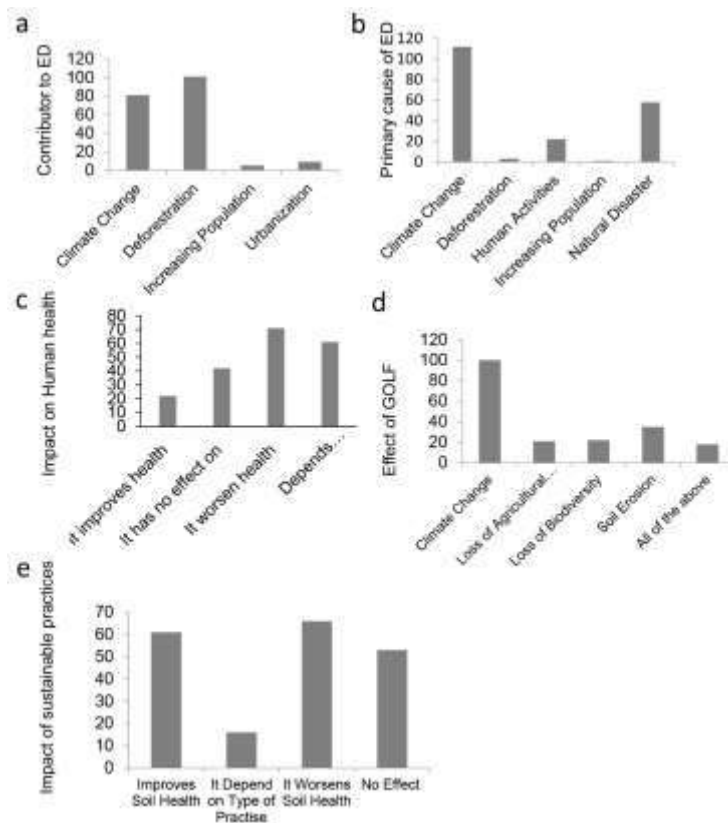


**Figure 5.** shows the damages caused by GLOF in the study area (A) The majority of the respondents estimate 1 to 20 kanal of their land has been damaged. (B) The majority of respondents responded that more than 60 plants were affected by natural disasters. (C) respondents replied that no animal was injured, although a few people mentioned unusual damage like 27 respondents claimed 1 to 20 animals were damaged.

### Effects and Causes of an Environmental Degradation

Our study shows that 101 respondents said deforestation is the main contributor to GLOF events while 81 individuals said it is climate change. Only 5 individuals said it was due to the increasing population 9 respondents thought due to urbanization. They are all pointing to key environmental issues that influence the local and global environment (Fig 6a). Respectively 112 individuals agreed that climate change is the main cause of environmental degradation,

58 people said it is due to natural disasters while 22 people said the main cause is human activities. Only 3 individuals agreed it is deforestation. This indicates a significant level of awareness that climate change is one of the escalating environmental issues (Fig 6b). Respectively 71 individuals believe it worsens health while 61 said it depends on the type of degradation. 41 individuals said it does not affect health while 22 respondents said it improves health. This in turn suggests that there is high awareness of the health consequences resulting from deterioration of the environment (Fig 6c). Respectively 100 individuals said climate change is the environmental effect of GLOF while soil erosion is considered by 35 respondents and 22 individuals followed loss of biodiversity and loss of agricultural land is the environmental effect of GLOF. Global environmental changes have established GLOFs as an important issue supported by the data (Fig 6d). Regarding the effects of sustainable practices on the health of the soil, a splitting of the opinions could be observed as 66 respondents claimed that the latter is damaged by these practices while 61 explained that it was beneficial and 16 individuals said it depends on the type of sustainable practices while 53 individuals said it does not affect soil health. This leads to the question that, there seems to be a divide in sustainability efforts management down the middle (Fig 6e).



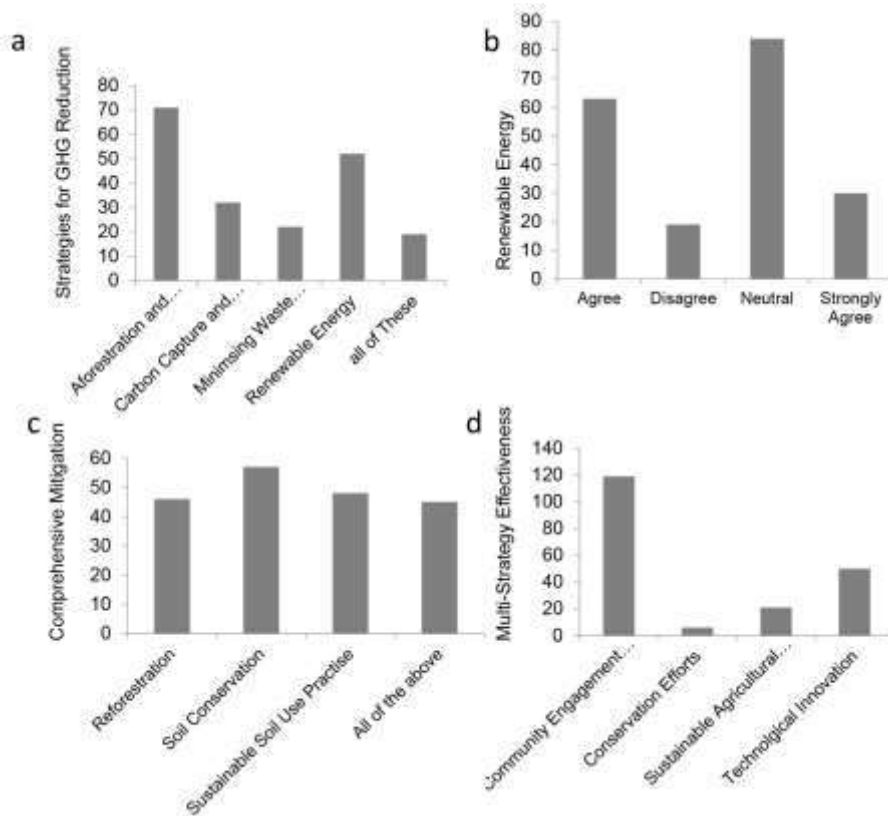
**Figure 6.**

Shows effects and causes on the environment. (A) Deforestation as the primary contributor to GLOF events. (B) climate change is the main cause of environmental degradation. (C) environmental degradation worsens health, suggesting a high awareness of its health consequences. (D) climate change as the primary environmental effect of GLOF. (E) Regarding the impact of sustainable practices on soil health.

### Mitigation Strategies:

The survey shows that 71 respondents claim that afforestation and reforestation while 32 persons said carbon capture and storage are the most efficient ways of mitigating the effects of greenhouse gases. While 52 individuals claim that renewable energy and 22 said minimizing waste production is the best way. Only 19 respondents claim that all of these are good (Fig 7a). Regarding renewable energy reduction, ED 84 respondents are neutral, 30 people strongly agreed, and 63 are in favor of its utilization for avoiding environmental deterioration. 19 respondents disagree with this statement. It also demonstrates a general

acceptance of the utility of renewable energy sources, but the level of support extends in a continuum (Fig 7b). An overall impression is that practices for mitigating soil pollution 57 individuals claim that soil conservation and 48 said sustainable soil use practices are best practices. 46 individuals said reforestation can mitigate soil pollution while the remaining claim all these are essential (Fig 7c). It is noteworthy, however, that community engagement and education (119 respondents) are perceived much more favorably compared to technological innovation (50). While 21 individuals said sustainable agricultural practices are the most effective strategies for mitigation. This goes to underscore the need for formative social and educational intervention strategies towards the sustenance of environmental health (Fig 7d).



**Figure 7.**

shows the variables representing the mitigation strategies (A) afforestation and reforestation are best strategies for green house reduction. (B) renewable energy reduces the environmental degradation. (C) soil conservation is best strategy for mitigating soil pollution. (D)

community engagement and education is the most effective mitigation strategy for reducing degradation.

Gender's multivariate analysis reveals a significant impact on the dependent variables as well. Gender differences play a substantial role in determining individuals' perceptions of environmental effect, awareness, and mitigation, as evidenced by F-values ranging from 57.36 to 260.96 and p-values  $<0.001$ . The comparatively high F-value ( $F = 260.96$ ) for climate change awareness and natural disasters indicates that there may be significant differences between men and women in this domain (Table 1). The high estimated F-values (407.70) for these factors indicate that the combined effects of natural disasters and climate change awareness have significant multivariate impacts related to age. Since all p-values are less than 0.001, age is a strong predictor of changes across all environmental attitudes and perceptions (Table 1). This suggests that different age groups have varying perspectives or levels of understanding regarding specific environmental factors. Most respondents belonged to the 50-60 age group. This indicates that the responses from this age group on the causes, effects, and mitigation of disasters have a significant impact, which will aid policymakers in future planning. Although the respondents' level of education is relatively lower, it still significantly affects the dependent variables. Education has a notable impact on all dependent variables, although its multivariate effect size is comparatively smaller, as indicated by the lower F-values (e.g.,  $F = 3.42$  for Environmental Impact). This suggests that while education may not have as large of an effect as factors such as age or gender, it still plays a substantial role (with all p-values being less than 0.001) in shaping attitudes and awareness regarding the environment. This analysis highlights the importance of education among respondents compared to age and gender. In this study, the respondents answered questions regarding the causes and effects of mitigation strategies in the context of the GLOF events. Their responses reflect their perceived knowledge, based on both personal observations and acquired information. Occupation has a substantial and notable impact across all categories. Occupation shows larger F-values for Mitigation Strategies and Responsibilities ( $F = 38.42$ ). This indicates that the type of work individuals engage in significantly influences their perspectives on environmental degradation and mitigation. People in different professional sectors tend to hold diverse views on these issues. In this study, we primarily focused on

respondents who had experienced GLOF events and property loss. These respondents belonged to various professions, as detailed in Figure 4. The multivariate analysis also revealed significant differences and high F-values between independent and dependent variables. The location has a significant but varying impact, with p-values  $< 0.001$ , and it also exhibits a notable multivariate effect on the dependent variables. The F-values show that location exerts the greatest influence on opinions regarding environmental strategies and responsibilities ( $F = 41.27$ ). This suggests that individuals residing in different geographic areas may experience or perceive environmental issues differently, potentially due to socioeconomic or local environmental factors (Table 1).

**Table 1**

shows Multivariate analysis for dependent and independent variables

Factor	Group	Approx_F	Value
<b>Age</b>	Environmental Impact	389.80	<0.001
	Awareness and Attitudes	230.17	<0.001
	Environmental Degradation Impacts and Mitigation	279.30	<0.001
	Mitigation Strategies and Responsibilities	231.66	<0.001
	Natural Disasters and Climate Change Awareness	407.70	<0.001
<b>Gender</b>	Environmental Impact	57.36	<0.001
	Awareness and Attitudes	230.20	<0.001
	Environmental Degradation Impacts and Mitigation	75.58	<0.001
	Mitigation Strategies and Responsibilities	105.05	<0.001
	Natural Disasters and Climate Change Awareness	260.96	<0.001
<b>Education</b>	Environmental Impact	3.42	0.003

	Awareness and Attitudes	24.68	<0.001
	Environmental Degradation Impacts and Mitigation	14.40	<0.001
	Mitigation Strategies and Responsibilities	23.38	<0.001
	Natural Disasters and Climate Change Awareness	7.30	<0.001
<b>Occupation</b>	Environmental Impact	25.59	<0.001
	Awareness and Attitudes	32.61	<0.001
	Environmental Degradation Impacts and Mitigation	31.05	<0.001
	Mitigation Strategies and Responsibilities	38.42	<0.001
	Natural Disasters and Climate Change Awareness	15.25	<0.001
<b>Location</b>	Environmental Impact	26.25	<0.001
	Awareness and Attitudes	15.93	<0.001
	Environmental Degradation Impacts and Mitigation	21.46	<0.001
	Mitigation Strategies and Responsibilities	41.27	<0.001
	Natural Disasters and Climate Change Awareness	22.56	<0.001

## Discussion

On the cause, impact and measures of prevention of the GLOF in Bilhanz and Badswat villages, in the Ishkoman valley, this research unveiled the following findings. The data reveal that GLOF events have a significant impact on agriculture land, forest and sometimes infrastructure. Views of respondents and coordinates also report a severe environmental and socio-economic concern. Numerous factors that contribute to Environmental degradation and GLOFs with regards to the causes of environmental degradation and GLOFs in the area, the majority 112 of the respondents stated that climate change was the leading factor. Several

investigations by **(Harrison, 2018)** indicate that temperature change is relative to the time taken by glaciers to melt hence, contributing to the frequency of GLOF events. This is similar to what has been established by **(Bazai, 2021)** who noted that in the Karakoram Range, the fast melting of glacial provides natural dams which when breach GLOFs occur.

Another question was asked about the cause of environmental degradation, the deforestation, and as many as 101 respondents pointed it out. **(Khosro, 2024)** also found the same result showing that deforestation leads to an increase in soil erosion and loss of biodiversity all of which act as catalysts for the occurrence of GLOFs. The connectivity of human activities including deforestation and GLOFs are highlighted in this paper. Amid this overwhelming conformity as to the existence of climate change and deforestation, only 22 respondents identified human activities as direct contributors to environmental depletion. There is almost no awareness of the contribution of such factors as deforestation for agriculture and overgrazing to environmental deterioration. One hundred respondents focused on the environmental impact of GLOFs encompassing soil erosion and loss of agricultural land and precious biodiversity. This is in concordance with **(Lützow, 2023)** who explained that many GLOF events in the Himalayas lead to dramatic downstream flooding and increased infrastructural loss including farming land and habitats. Satellite data gathered for this research, along with field data evidence indicate that this conclusion is plausible given the extent of 186 hectares of affected land between the years 2018 to 2021. The socioeconomic impacts are worst off resulting in 128 respondents arguing that large portions of their land were ravaged and most of them had to relocate to higher grounds or other areas in the neighboring regions. This is in concordance with **(Bhattarai, 2021)** who similarly observed similar displacement patterns after the GLOFs in Nepal. In similar ways, this loss rather puts pressure on rural communities that leave these places losing their only resources for means of life. The psychological effects of such displacements were also pointed out by the respondents who complained of psychological trauma occasioned by the loss of their homes and their ancestral lands. Similarly, **(Gul, 2024)** described the first line of work of the climate change crisis in the areas of Pakistan and emphasized the need for the mental health of people affected by these disasters.

Regarding the measures to prevent the impacts related to GLOFs, the respondents, of whom 71, stated that afforestation and reforestation are the best practices to limit greenhouse gas emissions and to contain soil loss. This is in line with (Khan M. B., 2021), who also discovered that afforestation programs in the northern part of Pakistan have effectively contributed to the mitigation of soil erosion and enhanced water holding capacity of the areas in the glaciated zones of the country. Likewise, the mitigation strategy of promoting renewable energy was favored by 63 respondents and people are beginning to raise consciousness on the use of sustainable energy to minimize resources' impact on the environment. (Uyigüe, 2010) Discussed that the role of renewable energy in combating climate change is more crucial, and the present study established that the adoption of solar and wind energy in Gilgit-Baltistan helps in the reduction of carbon emissions. Nonetheless, the poor support of all the respondents indicates that more awareness creation is needed regarding the benefits of renewable energy (Irfan, 2021). To a question asking which strategies are preferred to enhance resilience, 119 of the respondents chose community engagement/education. This consideration fits well within the withdrawal of the agency-centric disaster response that established as viable with community-based GLOF risk reduction approaches in the area. Like them, (Khan M. B., 2021) also noted that enhanced community environmental awareness facilitated better implementation and mitigation measures and different responses to natural calamities.

When these results were compared to global developments, observe the same issues. In the Andes, where GLOFs have destroyed agricultural societies. For these two scenarios, afforestation, and the community base disaster risk reduction programs were the main forms of mitigation. However, the government support in these regions differs greatly often about the actual needs. In this study, the respondents stated that the government did not provide much support however (Huggel, 2020) noted that the high and increased governmental intervention enhanced the implementation of mitigation measures in Peru. As highlighted in this study, the proposed results, which focus on the mobilization of support from the community as well as international organizations such as the Aga Khan Agency for Habitat (AKAH), are eco-friendly. (Lassa, 2018) claim that NGOs are indispensable in making up for

the gap of access of the vulnerable communities to the agencies a situation identified in the Ishkoman Valley as well as in other districts affected by the GLOF.

### Conclusion

GLOF events in both villages have created a significant loss of land forest and agricultural land and effect on the surrounding ecosystem and the livelihood of the communities. The data of this study revealed that afforestation, soil conservation, and renewable energy are significant mitigating solutions. The data also indicated the primary causes that contribute to GLOF in this region were climate change and deforestation.

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