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CLIMATE-INDUCED GLACIAL LAKE OUTBURST FLOODS: CHALLENGES AND POLICY RESPONSES IN PAKISTAN

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ABSTRACT

Nine major river systems in Asia receive their headwaters from glaciers, which act as a freshwater reserve and as a lifeline for nearly one third of humanity. The melting of glaciers in recent decades has been demonstrated by tons of evidence. As a result of glacial retreat, more and larger glacial lakes are forming at the new terminal ends, hidden behind the exposed end moraines. Due to these, there is a greater chance that glacial lake outburst floods (GLOF) will occur. Climate change is one of the major reasons for the glacial lake outburst flood. Glaciers and high-mountain ecosystems have been greatly impacted by recent warming. Especially Countries that are more exposed to climate change are more vulnerable to GLOF. Pakistan is one of the countries that is facing climate change issues. This country hosts the world's third largest glacial ice mass, and extreme weather conditions (i.e., from winters to scorching summers and heat waves) in the country often result in catastrophic floods, such as those seen in the second half of 2022, where unprecedented floods occurred as a result of GLOF. The objective of our paper is to evaluate Pakistan's current climate change policy and to oversee the challenges faced by authorities in getting rid of torrential floods. Did Pakistan adopt the policies needed to overcome the floods? If it did, then what are the main causes of its outburst, and where do we lack in policy implementation that needs to be changed? In this study, we assess the extent of the GLOF threat in Pakistan, its impact on the country's people, water security, and economy, and the necessary adjustments to either mitigate or prevent it.

Keywords: Climate Change, Glacial Lake Outbursts Floods, Recent Floods, National Climate Change Policy.

INTRODUCTION

Pakistan as an underdeveloped country is already facing many challenges of weak economic performance, poor governance, and political instability and now the risk of climate change is also at its peak. Pakistan is on 5th among the list of the country's most vulnerable to climate change in the Global climate risk index German watch report 2020, [1] which means Pakistan will be hit hard by climate change in the near future. Pakistan hosts the world's third-largest glacial ice mass after Antarctica and Arctic Circle. The constant raise in temperature as a result of climate change is causing glacial lake outburst floods GLOF that are destroying whole villages in the country.

[1] *Global climate risk index 2020.* German watch. (n.d.). Retrieved December 2022, from https://germanwatch.org/sites/default/files/20-2-01e%20Global%20Climate%20Risk%20Index%202020_14.pdf

Glaciers are one of the most sensitive indicators of climate change because they expand and contract in reaction to changes in air temperature.[2] In response to global warming, most glaciers have been retreating at rates ranging from a few meters to many tens of meters each year, resulting in an increase in the number and size of glacial lakes, as well as an increase in the risk of glacial lake outburst floods (GLOFs).

Every country in the Himalayan region has experienced a glacier lake outburst flood event at some point. Records show 15 GLOF incidents in Nepal, 6 in China's Tibet Autonomous Region, and 5 in Bhutan.[3]

Glaciers in the region are receding today, providing significant evidence of global climate change. If the current trend continues, the long-term depletion of natural freshwater storage would be catastrophic. Lakes typically emerge behind newly exposed terminal moraine as glaciers retreat. The rapid accumulation of water in these lakes can result in a moraine dam breach. A glacial lake outburst flood is the subsequent quick outflow of massive amounts of water and debris (GLOF).[4]

A Glacial Lake Outburst Flood, or GLOF, is the rapid outpouring of water from a lake fed by glacier melt that has formed at the glacier's side, in front, under, beneath, or on its surface. Such events can cause immense damage, with the potential to destroy infrastructure, eroding land, and even cause fatalities in extreme cases. As a result, the prevention and mitigation of glacial lake outburst floods are an important consideration for those living in glaciated regions, as well as the emergency response team.[5]

The annual floods in Pakistan demonstrate the country's serious vulnerability to climate change, even though the country contributes less than 1% of global greenhouse gas emissions. In 2022, these devastating floods will strike Pakistan once more. This year the country has faced extreme weather events where the country entered from winter to direct scorching summer in March which is followed by severe heat waves, fires in multiple forests, severe monsoon rains and then all of these contributed to the catastrophic floods across the country. This catastrophe has exposed the fragility of the people living in this country. One-third of the country has been under water, and 33 million people have been affected. It appears that there are around 8 million displaced people. The devastation from the 2010 floods was dwarfed by the enormity of the tragedy, which is unprecedented in Pakistan. In recent floods, Pakistan's estimated loss is $40 Billion[6] where more than 1300[7] people have so far died and 33 million

[2] The Center for Health and the Global Environment (Author). (n.d.). *Mandala collections sources*. Sources. Retrieved December 21, 2022, from https://sources.mandala.library.virginia.edu/source/climate-change-futures-health-ecological-and-economic-dimensions

[3] The Center for Health and the Global Environment (Author). (n.d.). *Mandala collections sources*. Sources. Retrieved December 21, 2022, from https://sources.mandala.library.virginia.edu/source/climate-change-futures-health-ecological-and-economic-dimensions

[4] K., D. K., Tariq, S. T., & Rasool, G. (2014, January). *Temperature and Precipitation: GLOF Triggering Indicators in Gilgit-Baltistan, Pakistan*. Retrieved December 15, 2022, from https://climateinfo.pk/frontend/web/attachments/data-type/04164.pdf

[5] *Glacial Lake Outburst floods*. ICIMOD. (2021, July 2). Retrieved, from https://www.icimod.org/mountain/glacial-lake-outburst-flood/#:~:text=A%20Glacial%20Lake%20Outburst%20Flood,the%20surface%20of%20a%20glacier

[6] Pakistan flood losses. (n.d.). *Al Jazeera*. Retrieved from https://www.aljazeera.com/news/2022/10/7/pakistan-flood-losses-estimated-at-40bn-ex-finance-minister.

[7] After record floods, now Pakistan has to worry about economy. (n.d.). *Al Jazeera*. Retrieved from https://www.aljazeera.com/news/2022/10/7/pakistan-flood-losses-estimated-at-40bn-ex-finance-minister.

people are homeless. Pakistan while being an agricultural country, an overpopulated country, and a country with deficient resources cannot bear such

The federal government and provincial governments have worked relentlessly with local, national, and international partners to oversee the extensive relief activities taking place all around the nation. But the question that comes here is if Pakistan is already at such a high risk of GLOF and Flash floods and also the country experienced extreme weather events and floods were predicted earlier then why the government did not displace the vulnerable communities before damage? Either there is a lack of any policy or law or there is a lack of coordination between state institutions or it's political and economic instability which is always the hurdle of Pakistan's every problem.

In 2012, Pakistan put up its first national climate change policy, which directed the nation to reduce climate change risk in compliance with the Paris Agreement. This strategy, which "aims to ensure that climate change is mainstreamed in the economically and socially vulnerable sectors of the economy and to steer Pakistan towards climate compatible development," was amended in 2021 in light of the growing risk. It is believed that there are two main strategies for addressing climate change: mitigation and adaptation. This policy promotes the government's ten billion tree tsunami program in addition to other measures like the ecosystem restoration initiative, the urban greening project, the clean and green Pakistan campaign, climate resilient urban development, and protected areas & national parks projects. This policy considered Glacial Lake Outburst floods (GLOF) and flash floods as a major issue of Pakistan and thus suggested strategies to combat these issue.

The reason why Pakistan was unable to make sure the implementation of this policy like others is the slow progress of government, lack of coordination between government institutions, political and economic instability, less attention to issues like climate change and lack of proper budget for timely action on these issues.

PROBLEM STATEMENT

Climate change in Pakistan causes the melting of ice from glaciers which increases the frequency and intensity of water resulting in GLOF.

devastating disasters and also it also has enough resources to protect itself from the impacts of climate change.

RESEARCH QUESTIONS

1. Why Pakistan is at high risk of GLOF?
2. Did Pakistan's recent unprecedented floods occur as a result of GLOF?
3. What's the response of the Pakistani government to this risk, and how are they going to curb it?

RESEARCH METHODOLOGY

Study area:

The study area of this paper is Glacial Lake Outbursts Floods (GLOF). As this paper attempted to cover Pakistan's vulnerability to climate change and its impact in form of Glacial lake outburst floods, it covered how much Pakistan is exposed to the risk of Climate change, how this risk is causing floods, and how government institutions are dealing with this risk.

Research techniques:

This research is descriptive and analytical as it uses data from the government's official websites listed in the references. The qualitative approach is used to characterize the impacts of climate change on Glacial Lake Outbursts Floods (GLOF) and the effects it is causing on the country's local community and economy. This paper discusses floods situation at different times (e.g., 2010, 2020 & 2022) and the loss and damages that cost the country. This paper also analyzed the policies framed by the government to address this matter (GLOF) using data from numerous websites, newspapers, journal articles, and publications.

GLOF IN PAKISTAN

It is a truth that we are currently experiencing climate change. Over the past 50 years, there has been a change in the worldwide weather pattern, affecting factors such as humidity, precipitation patterns, and temperature trends. An ongoing investigation indicates that, in contrast to decades after 1939, the rate of temperature growth is 0.32 °C to 0.34 °C every decade. Pakistan is similarly impacted by climate change and global warming as underdeveloped nations are. Pakistan's warming trends vary depending on elevation. For example,

high elevations like Gilgit-Baltistan have almost twice as much warming tendency as low elevations.[8] Over the course of the last 40 years, Pakistan has seen a 0.76 °C rise in temperature; in contrast, the alpine regions home to thousands of glaciers have seen a 1.5 °C spike in temperature. In regions with glaciers, heat waves have also become more frequent and longer in length. These factors have caused an acceleration of glacier melting and consequent glacial retreat; yet, studies show that over 35 glaciers in the Karakorum Range are advancing with 11 remarkable surges.
Climate change poses a serious threat to social, environmental, and economic progress in emerging nations like Pakistan and encourages migration both within and across the country's boundaries. Pakistan is already seeing the effects of global climate change, with more frequent droughts and floods, increasingly erratic weather patterns, adjustments to agricultural practices, a reduction in the availability of fresh water, and a fall in biodiversity.
Both the creation of new lakes and the growth in volume and area of already-existing lakes are the outcomes of the glaciers' shifting behavior. Consequently, there is now a greater chance of an unexpected release of water from these lakes, referred to as a Glacial Lake Outburst Flood (GLOF). Another factor contributing to the rise in GLOF events in the area is the alteration in the pattern of rainfall. A glacial lake's catastrophic pressurized water discharge is known as a GLOF.[9]

GLOFs are additionally addressed in Pakistan's National Climate Change Policy as a possible hazard to the mountain populations.
The creation of melt water lakes on the lower slopes of several glaciers is one of the striking effects of recent atmospheric warming in the Himalayan region. Some of these natural disasters, including glacial lake outburst floods (GLOFs), which have the potential to seriously affect large populations in the Himalayan region on a social and economic level, are expected to become more frequent as a result of climate change. The Karakoram Range has had 35 catastrophic outburst floods in the past 200 years. In the Hindukush-Karakoram-Himalaya (HKH) Region of Pakistan, a systematic use of remote sensing and geographic information systems (GIS) has shown the creation of around 2420 glacial lakes, 52 of which are classified as potentially dangerous GLOF hazards.[10]

RECENT FLOODS:
Destructive floods that have killed people and severely damaged infrastructure have been a frequent occurrence in Pakistan in recent years.

2020 Floods

Every year, Pakistan is hit by hefty monsoon rains that frequently cause flooding and devastation. The monsoon season began with heavy rains in the provinces of Sindh and Baluchistan on August 6, 2020, and continued until August 7, 2022, without much of an interruption in 2020. Massive flooding was caused in many areas of the country by 24 hours of nonstop rain.

The Sindh province's Dudu, Shaheed Benazirabad, Karachi, and Hyderabad districts all suffered greatly from these floods. Additionally, the Baluchistan province's Jhal Magsi and Jaffarabad districts, as well as Kachhi, Sibbi, Harnai, Naseerabad, and Jaffarabad districts, were impacted. According to reports, the flooding in these areas not

[8] *Glacial Lake Outburst floods*. ICIMOD. (2021, July 2). Retrieved December 21, 2022, from https://www.icimod.org/mountain/glacial-lake-outburst-flood/#:~:text=A%20Glacial%20Lake%20Outburst%20Flood,the%20surface%20of%20a%20glacier

[9] K., D. K., Tariq, S. T., & Rasool, G. (2014, January). *Temperature and Precipitation: GLOF Triggering Indicators in Gilgit-Baltistan, Pakistan*. Retrieved December 15, 2022, from https://climateinfo.pk/frontend/web/attachments/data-type/04164.pdf

[10] A., & Ashraf, A. (n.d.). *Glacial Lake outburst flood hazards in Hindukush, Karakoram and Himalayan Ranges of Pakistan: Implications and risk analysis*. Taylor & Francis. Retrieved December 21, 2022, from https://www.tandfonline.com/doi/full/10.1080/19475705.2011.615344

only severely damaged the homes and infrastructure but also the standing crops.

The majority of the country was hit by yet another round of intense monsoon rains in late August, which persisted intermittently through early September 2020 and caused urban flooding in Karachi and other Sindh regions. In the Khyber Pakhtunkhwa (KP) province, districts Shangla and Swat and Charsadda both experienced extensive flooding. 41 people were killed, and thousands of people in Karachi were severely affected by the city's worst rainstorm in nearly a century. Long stretches of time without electricity were experienced by residents as urban flooding severely damaged the city's infrastructure. The second flooding spell made people's suffering worse and resulted in the eviction of hundreds of thousands of people. Despite the government's best efforts.

Floods 2022:

A combination of flash flooding, riverine flooding, and urban flooding caused an unparalleled tragedy to strike Pakistan between June and August of this year (2022). The floods have affected 33 million people, or one in seven individuals, according to the National Disaster Management Authority (NDMA). Almost 8 million of them have been forced to abandon their homes. Over 1,700 people have died as a result of the floods, with children accounting for one-third of those who lost their lives. Millions of homes and essential infrastructure were devastated by rain-induced floods, hastened glacial melt, and ensuing landslides, which submerged entire villages and eliminated livelihoods. The nation's poverty rate is expected to directly increase as a result of the floods by 3.7–4.0 percentage points.

Floods 2023:

Pakistan is still experiencing terrible floods in 2023 as they did in 2022. More than 6.1 million flood-affected residents in 34 districts received life-saving aid from the government and humanitarian organizations between July 2022 and July 2023. Weeks of intense monsoon rain have flooded Pakistan's Sutlej River since August 17. In numerous locations, the high water level devastated levees and villages, forcing over 162,257 people to flee and submerging 153,231 acres of land that were planted with standing crops. The Punjab Provincial Disaster Management Authority (PDMA) reportedly established 95 medical camps and 178 relief camps in the impacted areas. Ninety villages along the riverbank have been affected by the "extremely high level" of water in the Sutlej River near Bahawalnagar. Pakistan has seen significant rainfall once more since September 1. 394,314 people have been relocated in flood-affected areas since the monsoon began, primarily in Punjab (323,612). Houses and shelters sustained the highest damage in Punjab, Sindh, and Balochistan. As of September 1, 2023, Partners reported 79,489 confirmed cases of positive malaria.

The monsoon rains that have been plaguing various Pakistani provinces, producing major floods and numerous other weather-related catastrophes, have resulted in a rising number of casualties and individuals who have had to be evacuated. According to the National Disaster Management Authority (NDMA), there have been two fatalities in the province of Khyber Pakhtunkhwa (KP) and seven injuries—three in KP and four more in Punjab Province—over the past 24 hours. Furthermore, reports of four damaged residences were received from both provinces. Over 547,400 people have been evacuated and rescued, 226 fatalities, 349 injuries, and over 5,800 damaged homes have been reported nationwide by NDMA since June 25. Along with 249 medical camps and 349 relief camps, NDMA provided assistance to the populace. In order to meet the most urgent needs of those who are vulnerable in the provinces of Balochistan, Sindh, Punjab, and Khyber Pakhtunkhwa, the EU granted an additional EUR 1 million on September 25. Multi-sectoral humanitarian aid (including shelters, non-food products, and cash assistance for many purposes) will be provided by the allocation.

Causes of Recent Floods in Pakistan:

Pakistan is one of the top 10 nations in the world where climate change is having the greatest impact. The nation has seen changes in temperature and precipitation, more frequent and intense tropical storms and coastal rains, melting glaciers, flooding from glacial lake outbursts, rising sea levels, biodiversity loss, desertification, and droughts. Increased frequency and intensity of tropical storms, coastal rains, and seawater intrusion are signs of climate change in Sindh and Baluchistan's coastal regions.

The National Disaster Management Authority reports that at least 81 of the 160 districts in the nation have been designated as "calamity impacted" by the floodwaters.[11]

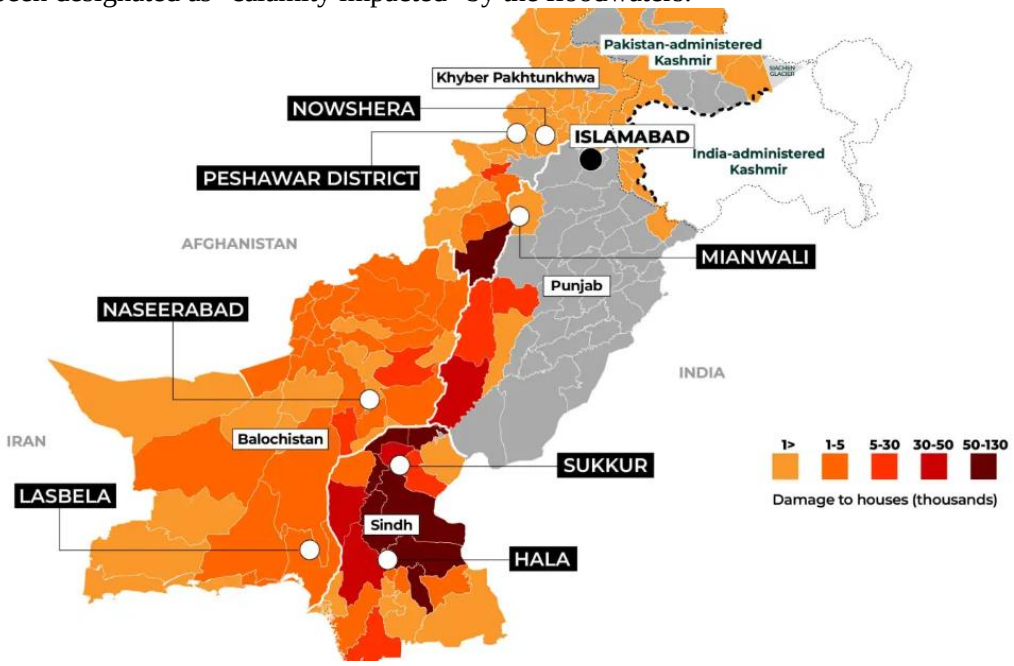

Figure 1: Districts impacted by floods 2022(source: Al Jazeera)

One of the main reason of recent floods is GLOF as ,30 glacial lake outburst flood (GLOF) incidents have so far been confirmed in the mountainous areas of Gilgit-Baltistan and Chitral in the last three weeks of July and the first three weeks of August this year as a result of "unprecedented hot weather" that persisted for several days in northern Pakistan during the summer.

Sherry Rehman, the federal minister for climate change, forewarned provincial disaster management officials in Khyber Pakhtunkhwa and Gilgit-Baltistan of oncoming heavy rains at the start of monsoon season and urged them to take prompt action to prevent fatalities from glacial lake outburst floods because these regions had experienced record-breaking summer temperatures. Chitral and Gilgit-Baltistan's summertime maximum temperatures ordinarily hovered around 40 degrees Celsius, but this year, during the months just before the monsoon season began, these regions had daily highs of 43 degrees Celsius. Due to the rapid melting of the snow and ice in the mountains as a result of recent rainfall, several glacial lakes unexpectedly burst, resulting in flooding that caused damage to bridges, homes, and other structures in these locations.

The Ministry of Climate Change reports that the rapid melting of glaciers in Pakistan's northern mountain ranges—the Hindukush, Himalayas, and Karakorum—caused some 3,044 glacial lakes to form in Gilgit-Baltistan (GB) and Khyber Pakhtunkhwa (KP). This phenomenon is attributed to rising temperatures in the country."Out of the 3044 glacial lakes, about 33 have been classified as being vulnerable to dangerous glacial lake outburst floods" (GLOF). GLOFs are sudden events that have the potential to release millions of cubic meters of water and debris, killing people and destroying homes and

[11] Chughtai, A. (2022, September 16). *Mapping the scale of damage by the catastrophic Pakistan floods*. Infographic News | Al Jazeera. Retrieved December 21, 2022, from https://www.aljazeera.com/news/longform/2022/9/16/mapping-the-scale-of-destruction-of-the-pakistan-floods

livelihoods in remote and underdeveloped mountain communities.[12]

Impact of Recent Floods on Country's People and Economy:

Pakistan's economy is expected to suffer greatly as a result of the floods. It is projected that total damages will amount to PKR 3.2 trillion (US$14.9 billion), or 4.8% of the GDP of FY22. It is anticipated that the services sector will bear over half of the total damages, with agriculture and industry bearing around a quarter of the total costs. Reconstruction and recovery are expected to cost 1.6 times as much as planned for national development in FY23.

Region	*Damage*	*Loss*	*Needs*
Balocistan	349B PKR	541B PKR	491B PKR
Khyber Pakhtunkhwa	201B PKR	141B PKR	168B PKR
Punjab	111B PKR	122B PKR	160B PKR
Sindh	1,948B PKR	2,444B PKR	1,688B PKR
Cross-Provincial	587B PKR	14B PKR	975B PKR
Special Regions	7B PKR	11B PKR	10B PKR
Grand Total	3,202B PKR	3,272B PKR	3493B PKR

The entire cost is expected to be PKR 3.2 trillion ($14.9 billion), PKR 3.3 trillion ($15.2 billion), and PKR 3.5 trillion ($16.3 billion) for all needs. The most severely affected industries were housing, which lost PKR 1.2 trillion ($5.6 billion), agriculture, food, livestock, and fisheries, which lost PKR 800 billion ($3.7 billion), and transportation and communications, which lost PKR 701 billion ($3.3 billion). PKR 1.1 trillion ($5.0 billion) is needed for rebuilding and recovery in the transport and communications sector, followed by PKR 854 billion ($4.0 billion) for housing and PKR 592 billion ($2.8 billion) for agriculture, food, livestock, and fisheries. About half and fifteen percent, respectively, of the demands for recovery and reconstruction are in the provinces of Sindh and Balochistan

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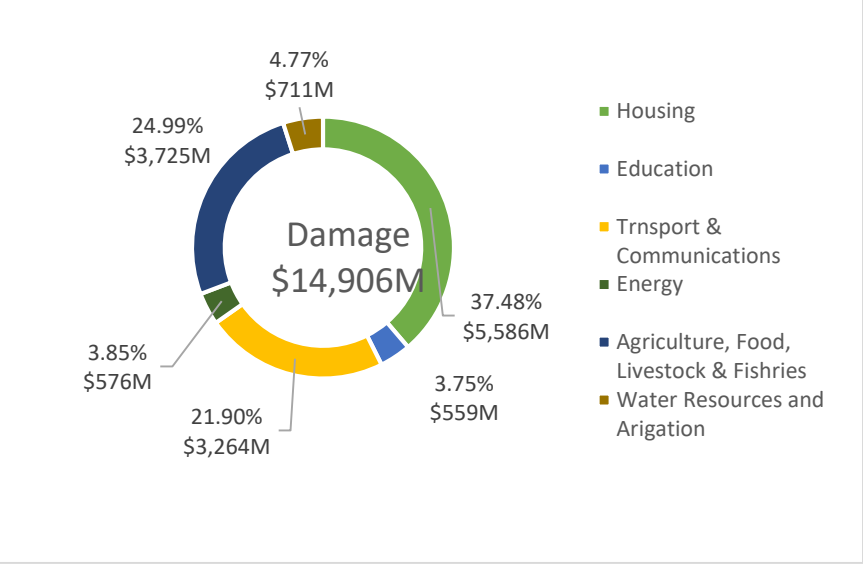
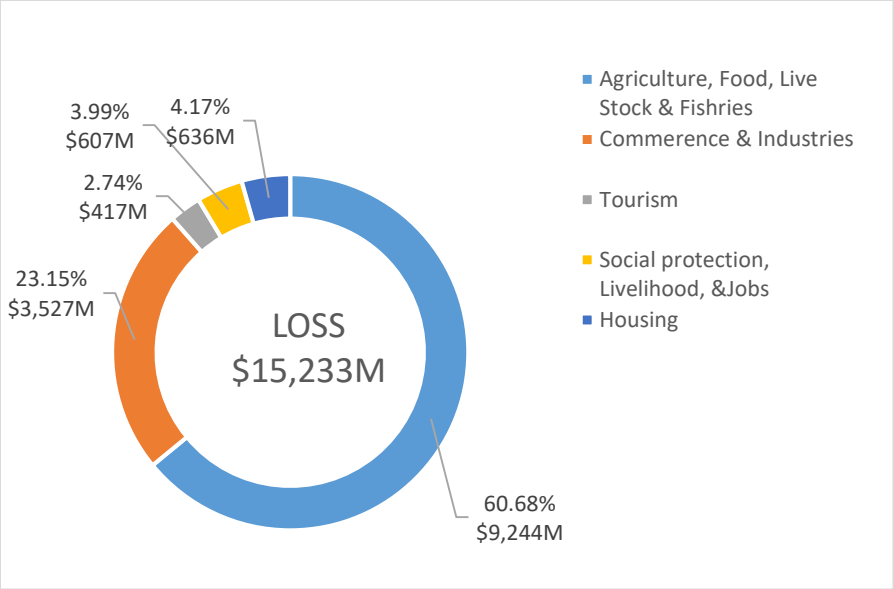


[12] Bhatti, M. W. (2022, August 23). *Over 30 glof incidents reported in northern Pakistan: Officials*. the news. Retrieved December 21, 2022, from https://www.thenews.com.pk/print/984708-over-30-glof-incidents-reported-in-northern-pakistan-officials



Lives have been harmed, economic activity has been disrupted, and a sharp increase in poverty is predicted. Depending on the severity of the floods, how long it takes for the water to recede, the families' current socioeconomic situation, the efficiency and promptness of relief and rehabilitation efforts, and other factors, the magnitude and duration of shocks will vary depending on the location and family. Even in the best-case scenario, it would take time to reverse these detrimental shocks to family welfare, and certain losses—like losses to human capital and productivity—may start longer-lasting declines in welfare that call for further attention.

Floods in 2010 and in 2022:

According to official statistics, similar floods ravaged Pakistan in 2010, killing more than 1,700 people and displacing at least 20 million others. The 2010 floods were riverine, which happens when rivers overflow due to excessive rain, usually more gradually. The floods of this year have been classified as flash floods, which are brought on by powerful storms that drop a lot of rain in a short period of time and because of GLOF as a result of "unprecedented hot weather" during the summer.[13]

[13] Chughtai, A. (2022, September 16). *Mapping the scale of damage by the catastrophic Pakistan floods*. Infographic News | Al Jazeera. Retrieved December 21, 2022, from https://www.aljazeera.com/news/longform/2022/9/16/mapping-the-scale-of-destruction-of-the-pakistan-floods

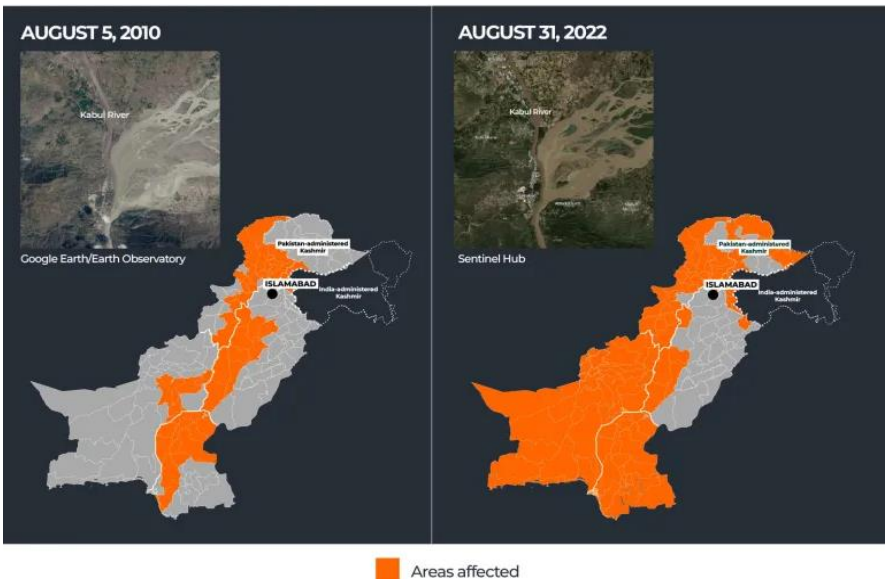


Figure 2: damage by 2010 and 2022 floods (Source: Al Jazeera)

NATIONAL CLIMATE CHANGE POLICY OF PAKISTAN

The social, environmental, and economic advancement of developing nations like Pakistan is gravely threatened by climate change. Pakistan is witnessing an increase in the frequency of droughts and flooding, more unpredictable weather patterns, and modifications to agricultural techniques as a result of global climate change. With this in mind, Pakistan revised its national strategy in 2021 to "ensure that climate change is mainstreamed in economically and socially sensitive sections of the economy and to push Pakistan toward climate-compatible growth." This policy aims to outline the challenges that climate change poses to the nation and offer natural remedies that should be taken into account in the fight against climate change. Vulnerable climate change hazards include extreme weather events, persistent temperature increases, glacier melting, droughts, and floods. Policy interventions are recommended to mitigate these concerns. An increase in the intensity and frequency of precipitation is causing more frequent flash floods and landslides in mountainous locations, while the ongoing temperature rise is causing glacier melting and Glacial Lake Outburst Floods (GLOF). The following policy recommendations are made in order to adapt to these floods:

- Encourage and support the application of glacier grafting techniques in high-altitude regions.
- Provide a community-based, sustainable disaster response and risk management system for Glacial Lake Outburst Floods (GLOFs) and keep it up to date.
- Establish suitable systems to oversee the growth of glacial lakes and formulate plans for escape in the event of Glacial Lake Outburst Floods (GLOF) or areas at risk.
- Install regional flash flood warning and forecasting systems in high-risk regions.
- Bolster the nation's early warning systems, drought monitoring, and flood forecasts.
- Empower the appropriate agencies to improve capacities to address the effects of floods, flash floods, GLOF, droughts, and other events.
- Develop and execute "river flood plain" policies and legislation.

Framework for Implementation of National Climate Change Policy:

Following the national climate change policy, the government of Pakistan developed a framework for the implementation of the National Climate Change Policy (NCCP). This framework is a broader aspect that addresses the concern of how to adapt to the changing impacts of climate as enlisted in the NCCP. This framework provides the detailed objectives, for each sector that is vulnerable to the threat of climate change, and it covers a wide range of strategies that must be implemented in order to enhance capacities

to address the impact of floods, flash floods, glacial lake outburst flooding (GLOF), droughts, and so on.

It is not possible for the country to avoid or prevent natural hazards like flash floods, droughts, and GLOFs etc. But with appropriate adaptive measures and climate resilient development work in risk prone areas, these hazards can be prevented or their impacts can be minimized. The mountains are most likely to be affected by climate change and cause floods. The following strategy and framework for implementation have been developed to overcome flash floods and GLOFs[14]:

Objectives: To map the vulnerability of mountain ecosystems to climate change and establish action strategies for its mitigation.

Strategies: Conducting extensive scientific research in mountain areas to identify the most vulnerable and resilient ecosystems to the negative effects of climate change, and addressing identified challenges with tangible measures

Actions:

- Initiate focused research and establish a research center for scientific information on mountain areas.
- Investigate the effects of climate change and make scientific results public.

Objectives: To protect mountain ecosystems and plains from degradation and pollution

Strategies: Discourage actions that contribute to the loss of mountain ecology while encouraging those that contribute to the restoration of a livable climate at higher elevations.

Actions:

- Undertake GLOF related research and therefore establish projects to safeguard the glaciers of the northern region.
- Create a network of tiny multifunctional da ms in mountainous areas to lower flood intensity.
- Sensitize and take on board the local communities for promoting ecotourism.

Objectives: To increase awareness of climate change-related natural disasters' impacts and our capacity to respond

Strategies: Improving awareness of issues related to mitigation of climate change included disasters through public participation

Actions:

- Create methods to formalize and foster robust sectorial collaboration among disaster-management sectors.
- Provide special emergency response training programs for non-profits and volunteer organizations
- Create an integrated information system to manage temporal and spatial climate change and catastrophe risk reduction data.
- Include catastrophe management as a discipline in university curricula.

Objectives: To develop integrated hazard mitigation strategies

Strategies: Create risks zoning and mitigation techniques through management, policy creation, and law enforcement.

Actions:

- Prepare a Pakistani-integrated natural hazard zoning map.
- Identify low-risk flood zones for future land use planning.
- Identify safe sites for people and livestock evacuation in each susceptible locality.
- Encourage village resettlement/relocation outside the floodplain.
- Update river regulations to preserve streams, river banks, and other waterways from invasion.
- Universities should update their flood plain maps for a 100-year return period.

Objectives: To provide reliable natural disaster information and early warning where and when it is needed

Strategies: Developing and strengthening natural hazards early warning system for providing reliable warnings to the users

Actions:

- Update and expand the country's weather monitoring station network
- Establish local flash flood warning centers in hazardous mountain locations
- Install remote sensing and ground-based monitoring systems to track the progress of glacial lake outburst floods (GLOF)
- Create evacuation plans for sensitive locations in the event of a GLOF.

[14] Ministry of Climate Change, Framework for Implementation of National Climate Change Policy (2014 to 2030) (2021). Islamabad, Pakistan; Government of Pakistan.

- Establish a national data center to facilitate the sharing of all climate, water, and weather data.

Progress report of NCCP:

The progress report regarding implementation of national climate change policy (NCCP) and its implementation framework was published in January 2021 by ministry of climate change which contain all the progress of government's workings and projects. Some related to GLOF and flash floods are listed as under[15]:

1. To reduce flash floods and GLOF, GB and KP received money for disaster risk reduction.
▪ $3,906,000 is the adaptation budget designated to mitigate the danger of Glacial Lake Outburst Floods (GLOF I) in Northern Pakistan.
▪ GCF$20,829397 was allocated as funds for elevating glacial lake outburst floods (GLOF) and mitigating their danger under GLOF II.
The Kalpani Nullah Basin in Mardan, Khyber Pakhtunkhwa, will have a flood forecasting and warning system established thanks to funding totaling PKR 230 million.
In Sawabi district, PKR 710.897 million is being spent on building and enhancing irrigation infrastructure, including roads, channels, tube wells, and flood prevention measures.
2. Strengthening the mitigation of Glacial Lake Outburst Floods (GLOF) in Pakistan's northern regions (GLOF II): this four-year initiative aims to "minimize risk and vulnerabilities from GLOF in northern Pakistan from March 2017 to December 2021." A total of US$ 20.829 million was provided to this project by the Green Climate Fund. GLOF II will assist 29 million individuals, or 15% of Pakistan's population, spanning ten districts.
3. Increase urban climate change resilience at the municipal, state, and federal levels to water scarcity brought on by droughts and floods in Rawalpindi and Nowshera. US$6.049 million has been allocated for this project's adaption.
4. Recharge Pakistan: This initiative uses ecosystem-based adaptation for integrated flood risk management to increase Pakistan's resistance to climate change. A total of USD 150 million was allotted for this project between 2019 and 2029.
5. The Asian Development Bank gave Rs 6641 million for a flood emergency rebuilding and resilience project in AJ&K between August 28, 2015, and August 31, 2019.
On March 26, 2020, the ECNEC approved the National Flood Protection Plan IV (NFPP IV) with an amount of Rs. 332.246 billion.
7. In December 2020, the World Bank authorized $300 million for Pakistan to strengthen its resilience to health emergencies and natural catastrophes including floods and droughts.

Challenges Pakistan is facing in Policy Implementation:

Pakistan always faces challenges when it comes to policy implementation and it is because of both structural reasons and Pakistan's current situation[16]. This country has always been turbulent both politically and economically and thus economy, stability and security have been the mainstreams of the government's focus. Risks like climate change are increasing with the passage of time because of less attention from the government's end and these risks then turn into catastrophic hazards which further increase the economic burden on the country.
Less share in Budget: Pakistan consistently ranks highest among the nations most vulnerable to climate change, but governmental investment on this issue is still notably inadequate. Despite its bad performance in other areas, the defense budget makes up a sizable portion of the overall national budget. The budget for the fiscal year 2020–2023 is 9.5 trillion rupees, as illustrated in figure 2. Of this amount, 58% is allocated to loan repayment and defense, and 42% goes toward the development, health, and education sectors. Therefore, it is difficult to implement such programs effectively because of the lack of government attention and the lack of resources.

[15] Ministry of Climate Change, Progress report of framework for Implementation of National Climate Change Policy (2021). Islamabad, Pakistan; Government of Pakistan.

[16] Marco Mezzera. (n.d.). *Challenges of Pakistan's Governance System*. NORWEGIAN PEACEBUILDING CENTRE .

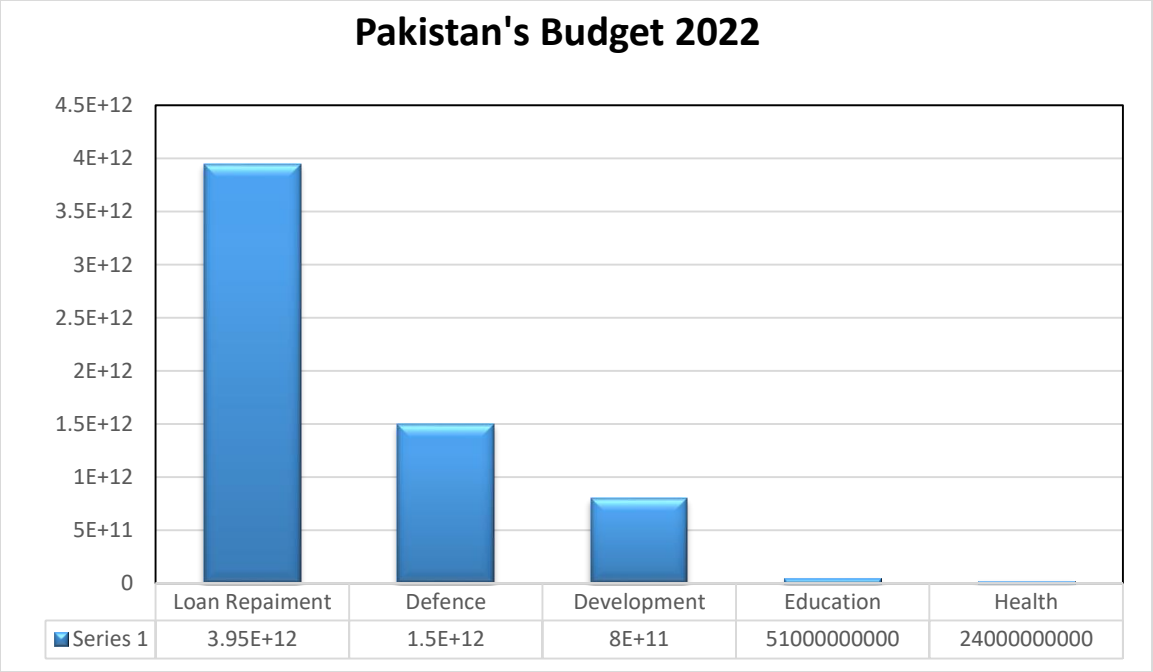


Figure 3: Pakistan's Budget 2022[17]

Internal stability is another big challenge for the Pakistani government[18] when it comes to working on issues that are considered secondary. Because of internal political instability, Pakistan can pay very less attention to issues other than policies, political parties or traditional security threats. Recently in 2022 when floods badly hit the country the officials were not able to evacuate the communities before loss because the country was facing severe instability issues.

Secondly, one party comes and takes government and make policies but soon another government comes over all old policies are considered worthless. NCCP was updated by Imran Khan's regime but before it can be implemented properly his government was ousted and the new government had to bear the brunt of this flood

The coordination between institutions of government is also not strong enough to make and take quick action that is the need of the hour. Government notifications and actions come through long and slow processes that thus communities pay the cost in the form of lives and properties.

Furthermore, issues like corruption and mismanagement play an important role in the lack of policy implementation in all disciplines

CONCLUSION AND RECOMMENDATIONS:

The world's largest store of snow and glaciated ice outside of the Polar Regions is found in the Hindukush-Karakorum-Himalayas (HKH) Mountains in northern Pakistan. Pakistan is also home to the junction of three major mountain ranges in the world, with heights ranging from 366 to 8611 meters above sea level. This area's snow and ice provide an abundance of water to the Indus River and its tributaries, which supports a significant agricultural area in Pakistan's agrarian economy downstream.

Climate change and global warming pose a special threat to the delicate alpine terrain. Glacial Lake Outburst Floods (GLOF) cause more severe floods in Pakistan each year than in previous years. The government is failing to adequately address this issue as the frequency and severity of these floods are rising. In principle, the government's attention to this

[17] ARYNews. (2022-2023). *Budget 2022-2023.* Karachi: ARY News. Retrieved from https://www.instagram.com/tv/CeovrlRgCcD/?igshid=MTg0ZDhmNDA=

[18] Raja, S. H. (2022, May 26). *Seven Challenges of Pakistan & response*. Medium. Retrieved December 21, 2022, from https://shahidhraja.medium.com/seven-challenges-of-pakistan-response-7165eb8ec1dc

risk is minimal, and in reality, it is practically nonexistent. Pakistan won't be able to join GLOF in the future if the government's pace for such important issues stays the same.

While the floods in 2010 were bad, the one in 2022 was disastrous, submerging a third of the nation and destroying residences, companies, cattle, transportation infrastructure, and a host of other items. It's still not too late to address climate change and the myriad concerns that stem from it, and if action is not made promptly, the nation may see very devastating floods.

Increasing high-resolution knowledge, coordination, and capacity building are necessary to help target populations become more prepared and reduce risk. It is possible to successfully monitor these lakes on a regular basis in order to reduce flood risk risks in the future by combining high resolution satellite data with ground information.

Climate change must be examined more thoroughly in order to deal with the extent of its impact on the glacial environment, particularly in GLOF-prone areas. In distinct river basins, detailed investigations of hot point GLOF lakes should be conducted.

To provide a complete policy framework in the face of increased global warming, hazard and risk assessment analysis, as well as risk mitigation techniques, are required. Non-structural interventions include hazard modeling and monitoring of GLOF areas using techniques such as remote sensing and hydrodynamic modelling in conjunction with ground surveys for better risk mitigation and early warning.

And the most important thing government needs to do is focus more on practice and less on theory because National Climate Change Policy 2021(NCCP) is a landmark policy and covers every aspect theoretically. Action plans provided under the framework made for the implementation of this policy are also incredible but practically we are not able to save local communities in vulnerable areas and cannot ease the economic burden of the government at the time of natural hazards such as flash floods or GLOF, it means we should focus on the implementation of these policies in order to get fruitful results and reduce the risk or prevent our communities from this risk.